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Momentary Associations Between Physical Activity, Affect, and Purpose in Life

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Abstract

Background Physical activity is associated with both the hedonic (e.g., affect) and eudaimonic (e.g., purpose in life) aspects of well-being. While there is evidence linking momentary physical activity and affect in daily life, the examination of momentary purpose remains largely unexplored.

Purpose This study investigates the bidirectional associations between physical activity, positive and negative affect, and momentary purpose using Ecological Momentary Assessment (EMA) and accelerometer data.

Methods Middle-aged participants (40–70 years old, n = 291) wore accelerometers and completed three daily EMA surveys on momentary experiences for 8 consecutive days. Physical activity (active time and counts) from 20- to 60-min periods before and after EMA surveys were used in the analyses. Multilevel models were adjusted for temporal and contextual factors, age, sex, education, work status, and race/ethnicity.

Results When participants were more physically active than usual, they reported feeling more purpose-driven and positive affect. Similarly, when participants reported feeling more purpose-driven or experiencing positive affect, they engaged in more physical activity in the subsequent time period. These associations were similar for physical activity from 20- to 60-min periods before and after the EMA survey. Physical activity and negative affect were not related in either direction.

Conclusions In middle-aged adults' daily lives, physical activity has bidirectional relations with purpose and positive affect. This study highlights the dynamic associations between physical activity and the positive aspects of both hedonic and eudaimonic well-being. Future interventions or public health programs should integrate physical activity and mental well-being to maximize mutual benefits.

Lay Summary

This study examined how physical activity relates to feelings of purpose and positive and negative affect in daily life among middle-aged adults (aged 40–70). Participants wore activity trackers and completed surveys on their smartphones about their feelings three times a day for 8 days. The study found that when participants were more physically active than usual, they experienced higher levels of purpose and more positive emotions. Conversely, feeling more purposeful or positive also led to more physical activity later on. The results suggest that physical activity and positive well-being are interconnected and reinforce each other in daily life.

Keywords Exercise · Sedentary behavior · Mental health · Mood · Ambulatory assessment · Naturalistic setting

Introduction

Physical activity has many health benefits [1], including mental health [2, 3]. Meta-analyses suggest that both structured exercise interventions [2, 3] and acute exercise sessions [4–6] can enhance positive affect and decrease negative affect. The converse direction—affect as an antecedent of physical activity—has received less scrutiny. Yet, emerging evidence suggests that affect predicts subsequent physical activity [7].

Ecological Momentary Assessment (EMA) studies have evaluated the bidirectional, momentary associations between physical activity and affect in daily life. Reviews of studies published before 2015 suggested a consistent positive momentary association between physical activity and positive affective states, while the association between physical activity and negative affective states is less consistent [8, 9]. However, fewer than half of the studies included in these reviews used accelerometers, and many were limited to selected student samples [8, 9]. Recent studies with diverse adult samples measured with accelerometers are consistent with these earlier findings. That is, when individuals are more physically active than their average, they report more positive affect than their average [10–13]. Conversely, when individuals experience more positive affect than their average, they are more physically active than usual in the subsequent time frame [9, 10, 14]. As with the earlier studies, the association between momentary negative affect and physical activity is not consistent: some studies find no association between negative affect and physical activity [12, 13], while other studies find a negative association, particularly in the direction of more negative affect predicting less physical activity [9, 10, 14].

Previous studies of momentary well-being have focused on affect. Affect is a component of hedonic well-being that focuses on pleasure and emotional responses [15]. Another aspect of well-being important for health is eudaimonic well-being [16]. The eudaimonic approach to well-being refers to meaning and self-realization in life [16]. One key aspect of eudaimonic well-being critical for health is a sense of purpose (also referred to as purpose in life), which refers to having personally meaningful goals and a direction in life [17]. Purpose in life is consistently associated with better health [18, 19], in part because individuals with more purpose tend to adopt health-promoting behaviors [18], including physical activity [20–22]. These associations are bidirectional and also apparent within person: a higher sense of purpose predicts subsequent physical activity, and vice versa [20, 23].

Although purpose in life is typically considered a relatively consistent construct studied from a between-person perspective, it may also vary within-person at a state level [24, 25]. The fluctuating nature of purpose might stem from engaging in activities that are more or less personally meaningful, such as social, voluntary, or physical activities [24, 26]. State-level, momentary purpose is crucial because it can be enhanced through meaningful activities, and fostering state-level purpose may also increase overall purpose in life [24, 27]. Some studies have examined the purpose and physical activity self-reported in daily life. One study found that engagement in physical (and mental or social) activities was associated with higher levels of purpose compared to engagement in mentally passive or sedentary activities [26]. Another study found that higher self-reported physical activity on one day was associated with higher purpose in life the following day [28]. To our knowledge, no previous study has examined momentary purpose and accelerometer-measured physical activity.

Physical activity may boost positive affect and purpose through various mechanisms, such as enjoyment, goal-achievement, stress relief, and neurotransmitter changes (e.g., an increase in dopamine levels) [4], which are likely to occur at specific time windows. Physical activity in daily life may occur through two systems: the reflective process involving conscious decision-making and the impulsive process involving non-conscious systems, such as habits [29]. It is suggested that affect may trigger the automatic behavior regulation processes leading to physical activity [14]. While purpose is typically linked to deliberative processes and intentional activities, individuals may also engage in purposeful activities automatically in a habitual way [24]. These processes, explaining why affect and purpose may boost physical activity, are also likely to occur within specific time windows.

While studies suggest consistent reciprocal associations between positive affect and physical activity, the timeframe of the association is less clear [8, 30]. Previous studies have used different timeframes for physical activity, typically from 15 min to 3 h, and found associations with each timeframe [9, 10, 12, 13]. Few studies, however, have compared timeframes. Among adults with at least moderate depression, for example, physical activity only in the preceding 1-hr time period was associated with momentary affect, but it was not in a 3-hr time window [11]. A study of working adults compared physical activity with a range of timeframes from 5 to 120 min with a 5-min bin and found that while physical activity did not predict affect in any time window, affective arousal (interested vs. tired) predicted sedentary behavior across a wide range of time but physical activity only in longer time windows from 110 to 120 min [30]. In other studies, positive affect has predicted physical activity in time windows ranging from 1 to 30 min [31] to an almost 6-hr time window covering the evening after work [14]. Studies in laboratory settings indicate that the effect of acute exercise on positive affect is the highest right after the exercise and then slowly diminishes, particularly after 30 min [6]. Thus, the associations between physical activity and affect may depend on time, and the same is likely to be the case for physical activity and purpose.

Given these critical gaps in the existing literature, the present study examined the momentary associations between physical activity, positive and negative affect, and purpose among middle-aged adults. The first research aim was to explore whether physical activity during the preceding 20 or 60 min predicts momentary affect and purpose. The second research aim was to explore whether affect and purpose predict physical activity in the subsequent 20 or 60 min.

Methods

Study methods and results are reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement for cross-sectional studies [32]. This study included adults in the USA who participated in the Couples Healthy Aging Project (CHAP) (n = 308). Individuals were recruited into CHAP through social media advertisements, community events, and snowball sampling. To be eligible, both members of a couple needed to be (i) between 40 and 70 years old, (ii) in a committed relationship for at least 1 year and cohabit, and (iii) both members had to be willing to participate. The Institutional Review Board of Florida State University (ID: STUDY00000472) granted the study's approval, including its procedures and materials. Materials used to conduct the study are available: https://osf.io/74y9d/.

Individuals who met the eligibility criteria were invited to an online interview. After obtaining informed consent, participants completed a series of cognitive tests. A study-provided smartphone and accelerometer were delivered to participants, accompanied by instructions to wear the accelerometer and complete the ambulatory assessment for 8 consecutive days. The smartphone prompted participants at three semi-random intervals to complete a brief momentary assessment and a survey about their day each night (Fig. 1). The timing of these prompts was based on participants' self-reported wake-up times, with six potential alert profiles. The morning window was from 6 am to 12 pm (averaging 9:14 am), the mid-day window was from 11 am to 5 pm (averaging 2:29 pm), and the afternoon window was from 3 pm to 9 pm (averaging 6:20 pm). For example, a participant who reported waking up before 5 am received the first prompt between 6 and 7 am, the second prompt between 11 am and 12 pm, and the third prompt between 3 and 4 pm.

Data collection spanned from February 2020 to October 2021. Out of the 308 participants enrolled in CHAP, valid

Ecological Momentary Assessments of Purpose and Affect
8 consecutive days of measurements

Beep 1 Morning	Beep 2 Mid-day	Beep 3 Afternoon
6AM-12PM*	11AM-5PM*	3PM-9PM*

*Varied based on reported wake-up times with 6 beep profiles: waking up at 4-5AM, 5-6AM, 7-8AM, 8-9AM, and 9-10AM.

Fig. 1. The schedule of momentary purpose and affect assessments.

EMA data was obtained from 98% (n = 303); five participants did not have EMA data due to technical issues with the phone. A total of 96% (n = 296) wore the provided accelerometers. The final analytical sample consisted of individuals who had information on both EMA and physical activity from at least one day (n = 291). The sample with complete data did not exhibit any sociodemographic, health-related, or cognitive differences compared to participants without complete data [33].

Measures

Affect and purpose in life

At each smartphone assessment, participants were asked to rate how they felt the moment they were beeped on a visual analog scale from 0 (not at all) to 100 (extremely) for both affect and purpose. Negative affect included *tense/anxious*, *angry/hostile*, *depressed/blue*, and *unhappy*; positive affect included *happy* and *enjoyment/fun*. For positive and negative affect, the mean scores from items were calculated for each momentary assessment. The purpose was assessed with a single item (*How PURPOSE-DRIVEN were you feeling when you were beeped?*).

Physical activity

Physical activity was measured with an ActiGraph (ActiGraph Corp., Pensacola, FL) wrist-worn tri-axial accelerometer (Centrepoint Insight Watch) over 8 days. Participants were instructed to wear the device continuously on their wrists, except during showers and water-based activities. ActiGraph data were first analyzed within the ActiLife (ActiGraph Manufacturing Technology Inc., FL) Software. Non-wear time was identified as 90 consecutive minutes of zero vector magnitude counts (VMC) [34, 35]. The analyses included days with at least 10 hr of recorded wear time [36]. The data were analyzed in 60-s epochs and divided into sedentary and active time. The cut-points applied for differentiation were <2,303 VMC per minute (cpm) for the dominant wrist and <1,853 cpm for the non-dominant wrist [37]. In the present study, we used active time (in minutes) representing all non-sedentary moments to indicate physical activity of any intensity, and counts (VMC) to indicate the overall amount and intensity of physical activity.

The time stamps from the smartphones and accelerometers were synchronized to align the timing of EMA prompts with the accelerometer data. The analysis was further refined using custom-written MATLAB (version R2019b, The MathWorks Inc., Natick MA, USA) scripts. These scripts facilitated the extraction of specific time intervals (20 and 60 min) before and after each EMA assessment. The cases with zero VMC within 60 min were excluded from the analysis. We also calculated the time gap between the latest physically active minute and the EMA assessment, as well as between the EMA assessment and the first physically active minute after that.

Covariates

In the primary interview, participants reported their age (in years), sex (0 = male, 1 = female), race/ethnicity (0 = white, 1 = person of color or multiple options selected), years of education, and work status (0 = unemployed or other, 1 = currently working full-time or part-time). These demographic characteristics are associated with the variables of interest [15, 38].

Temporal covariates included weekend (weekend = 1, weekday = 0) to account for weekly rhythm, day in the study (range 1–8) to account for time-dependent variation between days, and time window (1 = morning, 2 = mid-day, 3 = afternoon) to account for time-dependent variation within the day [39]. Contextual covariates included work (0 = other, 1 = work) and company (0 = alone, 1 = presence of other people) at the time of each momentary survey to account for momentary external factors [39].

Statistical Analysis

The data underwent preparation for analysis and quality checks following recommendations [40]. Descriptive statistics were computed with IBM SPSS Statistics Version 28.0.1.1. (IBM Corp. in Armonk, NY).

Given the hierarchical structure of the data that included multiple data points over time for each participant, we employed multilevel modeling (MLM) to investigate the bidirectional associations between physical activity and measures of purpose, positive affect, and negative affect. Before model estimation, we calculated intra-class correlations (ICCs) to ascertain whether there was adequate variance at both within- and between-person levels. Additionally, we explored a third level, assessments nested within participants within couples, to accommodate participants recruited in pairs. As the inclusion of the third level did not change the results, the results for the two-level structure are presented.

Mplus Version 7.3 [41]. was used for MLM analyses. An example of the model structure is shown in Fig. 2. The models examined whether physical activity in the preceding 20 or 60 min predicted mental well-being (purpose, positive affect, or negative affect) (path a in Fig. 2) and if mental well-being predicted physical activity in the subsequent 20 or 60 min (path b), accounting for the preceding physical activity (path c). The models were adjusted for within-person temporal covariates of weekend, day in the study, and time of the day, to account for weekly rhythms and possible changes within the study period and the day. Contextual covariates were work and company of others. The filled circles at the end of the arrows represent random intercepts that vary across clusters [41]. In the between-person level, the models were adjusted for age, education, sex, race/ethnicity, and work status. The random intercepts for the outcomes are shown in circles as they are continuous latent variables. The within-person predictors were person-mean centered (i.e., each momentary value minus the person means across assessments; 0 represents the within-person mean for each participant), while the between-person variables age and education were grand-mean centered (i.e., person overall mean minus grand mean; 0 represents the mean for all participants). The models were estimated separately for each well-being variable using physical activity (active time or counts) from either a 20- or 60-min time window. Additionally, models including all

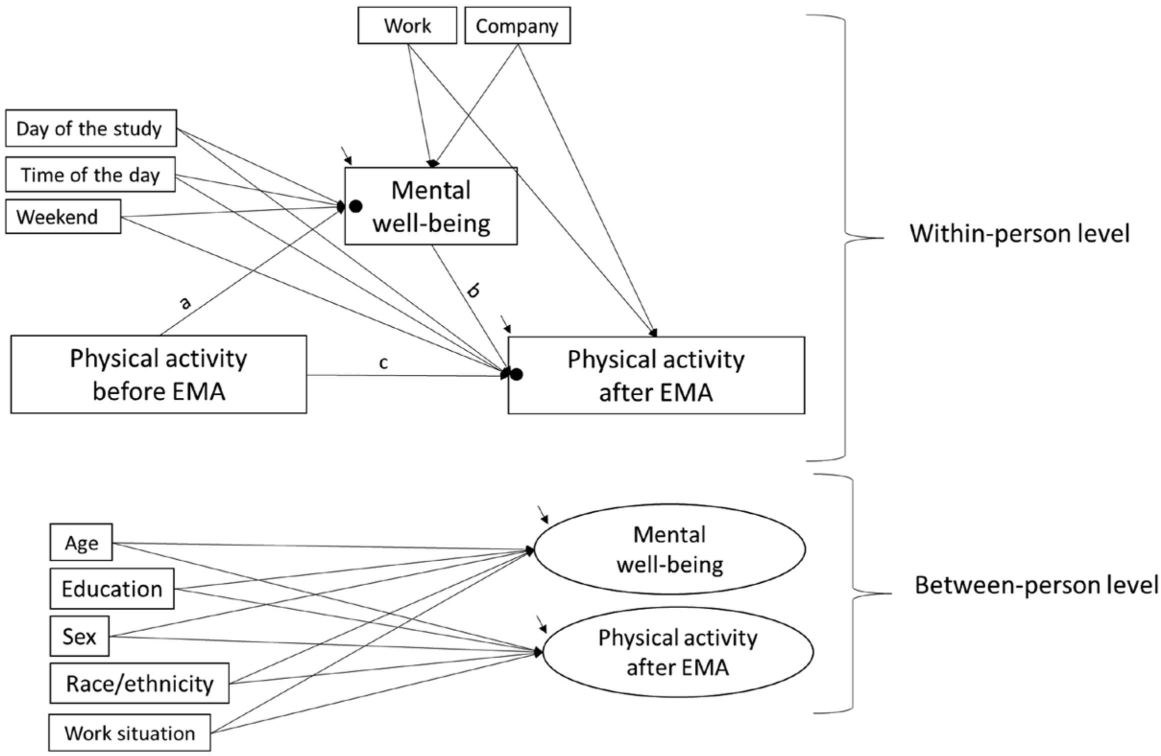

Fig. 2. The structure of multilevel models. The models examined whether physical activity predicted mental well-being (path a) and whether mental well-being predicted physical activity (path b), accounting for the preceding physical activity (path c). The models were adjusted for within-person temporal and contextual covariates and for between-person covariates.

three mental well-being variables together were estimated to examine whether the associations remained similar when these variables were taken into account simultaneously. We conducted also supplementary models assessing whether the time gap between the last activity minute and the EMA assessment predicted well-being, or whether the well-being variable predicted the time gap between the EMA assessment and the first activity minute after that; these analyses explore whether there were meaningful differences due to the timing of physical activity before or after the EMA. Unstandardized coefficients are presented in the tables and standardized coefficients are in the figures.

Models were evaluated with a chi-square test (acceptable fit $p > .05$), comparative fit index (CFI) (acceptable fit >0.95), and standardized root mean square residuals (SRMR) (acceptable fit <0.08) [42, 43]. The data were analyzed with Maximum likelihood with robust standard errors (MLR) estimation using all available data to estimate the model parameters. Missing values were expected to be missing at random. The information on temporal and contextual covariates was available for all assessments and information on between-person covariates for all participants.

Analytic codes used to conduct the analyses and results presented in this study are available: https://osf.io/e4v3u/.

Results

The participants' characteristics are shown in Table 1 for participants who had at least one day of accelerometer data with at least 10 hr of wear time from the EMA days (n = 291). The bi-variate correlations between study variables are in Supplementary Table S1.

Participants (n = 291) completed 90.4% (n = 6,319) out of 6,984 possible assessments (24 assessments × 291 participants = 6,984). Of the 291 participants, all had information on purpose and affect from at least seven sessions (83% of participants completed 20 or more sessions). Positive and negative affect were available from all completed EMA assessments (n = 6,319), while purpose was missing from two cases (n = 6,317). Accelerometer data were available for 97.4% of the completed EMA assessments, resulting in 6,153 cases for the analysis.

Multilevel Models

The ICCs suggested that 36% of the total variance in purpose was between participants, while 64% was within participants. Corresponding values were 41% and 59% for positive affect and 44% and 56% for negative affect. Regarding active time and counts, 13%–14% of the total variance during the 20-min before or after EMA assessments was between participants, and 86%–87% was within participants. For the 60-min, the proportions were 19%–20% and 80%–81%, respectively.

Participants reported feeling more purpose-driven when they were at work and with somebody (Tables 2 and 3). Among the between-level covariates, being older and white were associated with a higher purpose. Positive affect was higher and negative affect was lower on weekends compared to weekdays, later in the day, and when participants were not at work and with someone. Additionally, positive affect increased over the study period. Among the between-level factors, age was associated with higher positive affect and lower negative affect, while education was associated with higher negative affect. Participants had more physically

Table 1 Descriptive Statistics for the Sample (n = 291)

	M/n	*SD*/%	Range
Sex			
Women, %	159	54.6	
Men, %	132	45.4	
Race/ethnicity			
White, %	215	73.9	
Person of color, %	68	23.4	
Both, %	8	2.7	
Work status			
Unemployed or other	42	14.4	
Working full-time or part-time	249	85.6	
Age, years	51.9	7.4	40–70
Education, years	16.6	3.3	7–30
Complete EMA day sessions	21.7	2.9	7–24
EMA level	***M***	**SD**	**ICC**
Positive affect	63.73	15.27	0.41
Negative affect	13.53	11.31	0.44
Purpose in life	69.05	16.00	0.36
Active time 60 min before[a], mins	25.3	7.5	0.19
Active time 20 min before[a], mins	8.7	2.7	0.14
Active time 60 min after[b], mins	24.6	7.2	0.20
Active time 20 min after[b], mins	8.4	2.5	0.13
VMC 60 min before[a], 10^4	14.0	4.5	0.19
VMC 20 min before[a], 10^4	4.8	1.5	0.14
VMC 60 min after[b], 10^4	13.7	4.1	0.20
VMC 20 min after[b], 10^4	4.6	1.4	0.14

Means (*M*) and standard deviations (*SD*) aggregated across assessments.
VMC Vector magnitude counts.
[a]Data from 60/20 mins period before each EMA session.
[b]Data from 60/20 mins period after each EMA session.

active minutes (Table 2) and higher counts (Supplementary Table S3) on weekends compared to weekdays and when they were not at work, with both metrics decreasing over the study period. Women were more physically active than men in terms of both active time and counts, and younger participants had higher counts.

The full multilevel models are presented in Tables 2 and 3 for active time, and in Supplementary Tables S3 and S4 for counts. The simplified results for the within-person level are shown in Figs. 3 and 4. All models showed a good fit to the data (model fit indices presented in Supplementary Table S2).

Participants reported feeling more purpose-driven and higher positive affect after being more physically active than usual. This association was held for physical activity from both 20- and 60-min periods before the momentary assessment and for both active time and counts as indicators of physical activity. The associations were stronger for purpose than for positive affect. For example, each 1-min increase in active time during the 60-min period before the momentary assessment was associated with a 0.30-unit increase in purpose (B = 0.30, SE = 0.03, p < .001) and a 0.10-unit increase in positive affect (B = 0.10, SE = 0.02, p < .001). Similarly, when participants reported feeling more purpose-driven or positive affect, they engaged in more physical activity in the subsequent period. This association was statistically significant for models predicting active time and counts in the following 20 and 60 min, except for positive affect not predicting counts in the following 60 min. Physical activity and negative affect were not related to each other in either direction. When purpose, positive affect, and negative affect were included in the same model (results shown in Supplementary Figs. 1 and 2), only purpose remained a statistically significant predictor of physical activity, whereas positive affect did not.

The associations were similar in the 20-min window than in the 60-min window. For example, each 1-min increase in active time during the 20-min period before the momentary assessment was associated with a 0.69-unit increase in purpose (B = 0.69, SE = 0.06, p < .001), while each 1-min increase during the 60-min period was associated with a 0.30-unit increase in purpose (B = 0.30, SE = 0.03, p < .001) (Table 3), but in a standardized scale, the association was relatively similar (Fig. 3: β = .23, SE = 0.02, p < .001 vs. β = .21, SE = 0.02, p < .001).

The results for the time gap are shown in Supplementary Table S5. The time gap between the last activity minute and the EMA assessment did not predict purpose, positive affect, or negative affect. Similarly, purpose, positive affect, and negative affect were not associated with the time gap between the EMA assessment and the first activity minute after that.

Table 2 Associations Between Physical Activity (60-min Periods) and Mental Well-being

	Purpose			Positive affect			Negative affect		
	B	*SE*	*p*	*B*	*SE*	*p*	*B*	*SE*	*p*
Fixed effects on well-being									
Intercept	60.96	6.56	<.001	65.74	5.61	<.001	8.88	3.82	.020
Active time → WB	0.30	0.03	<.001	0.10	0.02	<.001	−0.00	0.01	.766
Weekend → WB	−1.60	0.86	.062	4.69	0.64	<.001	−1.93	0.48	<.001
EMA day → WB	0.20	0.16	.209	0.33	0.13	.011	0.01	0.08	.923
Time of the day → WB	−0.86	0.36	.017	2.45	0.28	<.001	−0.73	0.19	<.001
Company → WB	1.48	0.69	.032	5.69	0.60	<.001	−1.36	0.48	.005
Work → WB	9.09	0.93	<.001	−5.39	0.93	<.001	3.66	0.59	<.001
Age → WB	0.42	0.14	.004	0.46	0.13	<.001	−0.29	0.09	.001
Education → WB	0.12	0.28	.657	−0.38	0.25	.166	0.38	0.18	.040
Gender → WB	−1.02	1.81	.575	−1.67	1.79	.350	−0.46	1.40	.744
Race/ethnicity → WB	−4.76	2.15	.027	−1.38	2.03	.497	1.27	1.43	.377
Work status → WB	0.47	3.04	.877	0.76	2.78	.784	−2.63	2.14	.219
Fixed effects for active time									
Intercept	17.60	2.46	<.001	17.61	2.46	<.001	17.63	2.46	<.001
WB → Active time	0.03	0.01	.003	0.02	0.01	.039	−0.01	0.01	.580
Active time → Active time	0.24	0.02	<.001	0.25	0.02	<.001	0.25	0.02	<.001
Weekend → Active time	1.30	0.50	.009	1.16	0.50	.020	1.25	0.50	.012
EMA day → Active time	−0.15	0.07	.039	−0.15	0.07	.036	−0.15	0.07	.044
Time of the day → Active time	−0.12	0.26	.650	−0.20	0.26	.453	−0.15	0.26	.555
Company → Active time	0.08	0.43	.845	0.00	0.44	.997	0.11	0.43	.790
Work → Active time	−1.37	0.67	.040	−0.99	0.67	.142	−1.08	0.67	.108
Age → Active time	−0.07	0.05	.185	−0.07	0.05	.187	−0.07	0.05	.187
Education → Active time	−0.12	0.09	.186	−0.12	0.09	.186	−0.12	0.09	.185
Gender → Active time	1.99	0.68	.003	1.99	0.68	.003	1.99	0.68	.003
Race/ethnicity → Active time	−0.63	0.87	.472	−0.62	0.87	.475	−0.62	0.87	.476
Work status → Active time	2.01	1.16	.082	2.01	1.26	.082	2.01	1.26	.082
Variances									
WB: intercept	212.59	20.38	<.001	196.76	17.32	<.001	113.28	13.15	<.001
WB: residual	384.77	19.08	<.001	282.34	12.01	<.001	145.29	8.67	<.001
Active time: intercept	23.27	2.99	<.001	23.34	3.00	<.001	23.31	3.00	<.001
Active time: residual	165.79	3.98	<.001	165.95	4.00	<.001	166.08	4.00	<.001

WB Well-being variable, that is, purpose, positive affect, or negative affect. Reference categories weekday (weekend), alone (company), not at work (work), male (gender), white (Race/ethnicity), not working (work status). *n* = 6,153.

Discussion

The present study investigated bidirectional associations between physical activity and momentary mental well-being in a real-world environment. The results showed that participants felt more purpose-driven and reported higher positive affect after being more physically active than usual. Participants were also more physically active after feeling more purpose-driven or positive affect than usual. These reciprocal associations remained consistent within 20- and 60-min time windows and when using both active time and counts as physical activity indicators. As the models predicting physical activity were adjusted for the physical activity preceding the affect and purpose assessment, it seems that positive affect and purpose are related to subsequent physical activity over and above the physical activity prior to the assessment. Physical activity and negative affect were unrelated in both directions.

The findings align with previous research suggesting bidirectional associations between momentary positive affect and physical activity, with less consistent connections to negative affect [8, 9, 12, 13]. Physical activity, in particular, has been linked to high arousal and positive valence, such as happiness and excitement, rather than low arousal positive feelings like calm [8, 13]. In this study, we captured this energetic aspect of positive affect through items like "happy" and "enjoyment/fun," while we had no item to capture low arousal positive affect. It appears that physical activity may induce immediate pleasant feelings and vitality, which in turn increases the likelihood of being physically active.

In addition to momentary positive emotions, physical activity was associated with feeling purposeful. These associations between momentary purpose and accelerometer-based physical activity align with previous studies suggesting bidirectional connections between purpose in life and physical

Table 3 Associations Between Physical Activity (20-min Periods) and Mental Well-being

	Purpose			Positive affect			Negative affect		
	B	*SE*	*p*	*B*	*SE*	*p*	*B*	*SE*	*p*
Fixed effects on well-being									
Intercept	61.73	6.63	<.001	66.41	5.66	<.001	8.87	3.83	.021
Active time → WB	0.69	0.06	<.001	0.15	0.05	.001	−0.01	0.03	.814
Weekend → WB	−1.46	0.85	.087	4.73	0.64	<.001	−1.93	0.48	<.001
EMA day → WB	0.19	0.16	.233	0.32	0.13	.013	0.01	0.08	.924
Time of the day → WB	−0.70	0.36	.051	2.52	0.28	<.001	−0.74	0.19	<.001
Company → WB	1.49	0.69	.031	5.78	0.69	<.001	−0.68	0.43	.112
Work → WB	9.64	0.93	<.001	−5.28	0.94	<.001	3.66	0.49	<.001
Age → WB	0.42	0.15	.004	0.46	0.13	<.001	−0.29	0.09	.001
Education → WB	0.11	0.28	.692	−0.38	0.25	.127	0.38	0.18	.040
Gender → WB	−0.68	1.83	.709	−1.51	1.79	.399	−0.46	1.40	.741
Race/ethnicity → WB	−4.80	2.17	.027	−1.37	2.03	.499	1.27	1.44	.377
Work status → WB	0.82	3.09	.791	0.97	2.79	.728	−2.64	2.14	.217
Fixed effects for active time									
Intercept	5.22	0.81	<.001	5.22	0.81	<.001	5.23	0.81	<.001
WB → Active time	0.01	0.00	<.001	0.01	0.00	.008	−0.01	0.01	.261
Active time → Active time	0.30	0.02	<.001	0.31	0.02	<.001	0.31	0.02	<.001
Weekend → Active time	0.16	0.19	.393	0.09	0.19	.636	0.13	0.19	.484
EMA day → Active time	−0.04	0.03	.221	−0.04	0.03	.202	−0.04	0.03	.239
Time of the day → Active time	−0.10	0.10	.317	−0.14	0.10	.171	−0.12	0.10	.239
Company → Active time	0.18	0.17	.307	0.13	0.17	.447	0.19	0.17	.275
Work → Active time	−0.74	0.26	.005	−0.55	0.27	.040	−0.59	0.27	.028
Age → Active time	−0.01	−0.02	.748	−0.01	0.02	.752	−0.01	0.02	.752
Education → Active time	−0.02	0.03	.446	−0.02	0.03	.447	−0.02	0.03	.444
Gender → Active time	0.63	0.23	.007	0.63	0.23	.007	0.63	0.23	.007
Race/ethnicity → Active time	−0.32	0.29	.266	−0.32	0.29	.268	−0.32	0.29	.269
Work status → Active time	0.67	0.40	.093	0.67	0.40	.093	0.67	0.40	.092
Variances									
WB: intercept	215.94	20.68	<.001	197.86	17.24	<.001	113.28	13.15	<.001
WB: residual	386.17	19.29	<.001	283.38	12.10	<.001	145.29	8.67	<.001
Active time: intercept	2.33	0.33	<.001	2.32	0.33	<.001	2.33	0.33	<.001
Active time: residual	28.74	0.58	<.001	28.77	0.59	<.001	28.80	0.59	<.001

WB Well-being variable, that is, purpose, positive affect, or negative affect. Reference categories weekday (weekend), alone (company), not at work (work), male (gender), white (Race/ethnicity), not working (work status). $n = 6{,}153$.

activity across months [20] and years of follow-up [23]. Physical activity had even stronger associations with purpose than with positive affect. Even though sedentary activities may also require and arouse the experience of purpose, it is suggested that participation in physical activities contributes to the experience of being purpose-driven in daily life compared to sedentary activities [26]. Feeling purposeful in daily life may also contribute to decision-making processes and guide individuals toward long-term goals instead of instant pleasure [44]. When individuals feel more purposeful, they may be more likely to implement their physical activity intentions or engage in other activities that involve unintentional physical activity. Physical activity interventions may utilize this information by emphasizing the meaningfulness of physical activities. Encouraging individuals to focus on activities they find personally meaningful could enhance not only their sense of purpose [27] but also their engagement in physical activity [45].

When purpose, positive affect, and negative affect were included in the same model, only purpose remained a statistically significant predictor of subsequent physical activity. This finding suggests that positive affect does not have a unique predictive value for physical activity when the momentary purpose is taken into account. Purpose and positive affect are closely related at both the between-person and within-person levels [25, 46, 47]. While experiencing purpose may lead to more positive feelings, experiencing tasks or events positively may also enhance the sense of purpose [47]. On a daily level, people with higher purpose may be less prone to fluctuations in positive affect after positive events [46]. While our results suggest that at the momentary level, purpose and positive affect exhibit variation and may fluctuate differently (within-person correlation $r = .15$, $p < .001$), feeling purpose-driven was a more important predictor of physical activity than positive affect. These findings indicate that even though enhancing both purpose and positive affect in daily life is important for

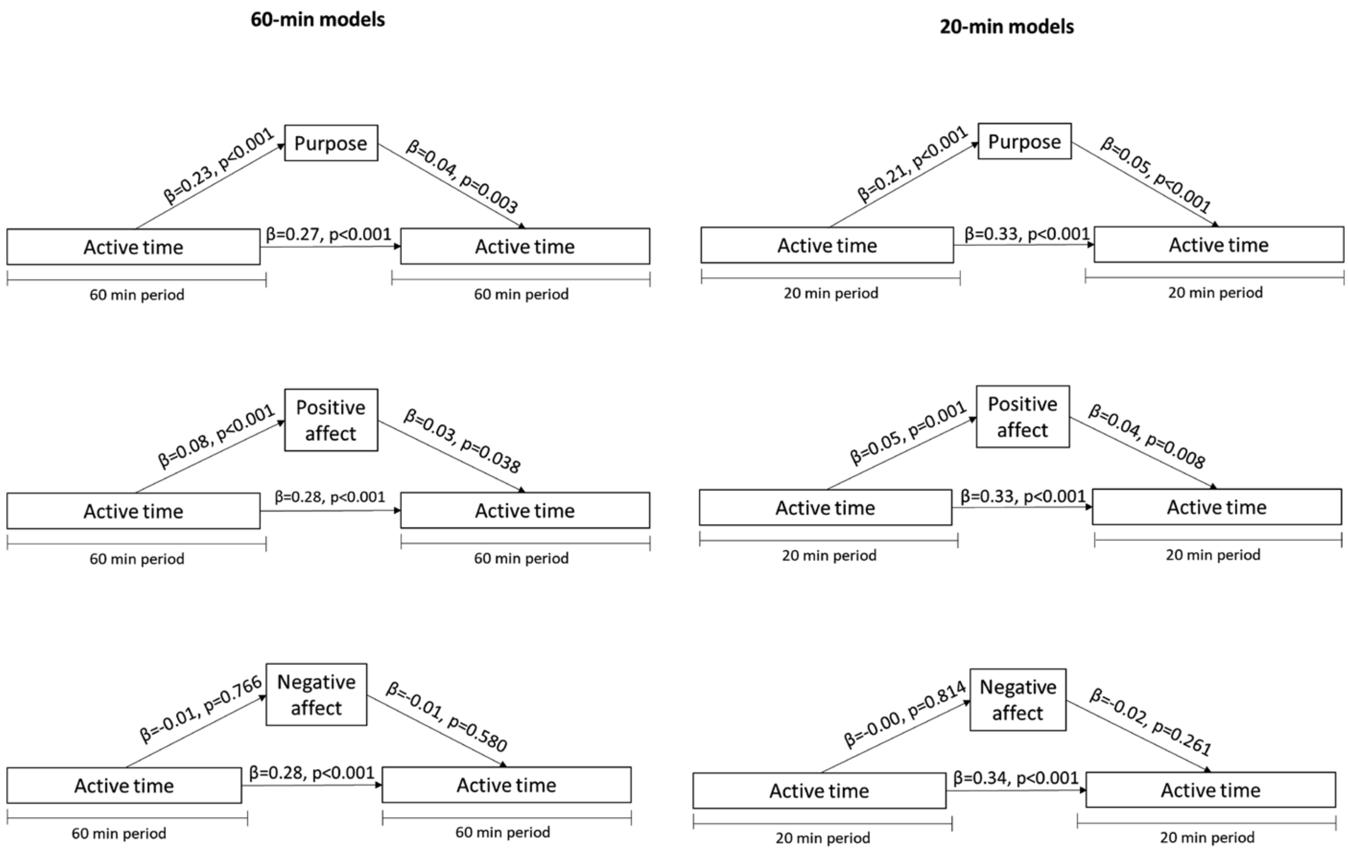

Fig. 3. Simplified visualization of the within-person associations between active time, purpose, positive affect, and negative affect. Models adjusted for between-person covariates of age, gender, education, race/ethnicity, and work status, and within-person covariates of the weekend, day of the study, time of the day, company, and work. β standardized regression coefficient.

overall mental well-being and may contribute to physical activity, interventions focusing particularly on increasing purpose may be beneficial for promoting physical activity.

The absolute predictive value of physical activity for both positive affect and purpose was stronger in the 20- than 60-min time window (e.g., for purpose $B = 0.69$ vs. $B = 0.30$). This suggests that adding 1 min of active time to the preceding 20 min has a stronger association with subsequent purpose or positive affect than adding 1 min of active time to the preceding 60 min. However, the standardized regression coefficient suggested that the relative importance of physical activity was comparable for both time frames. The supplementary analyses with time gaps indicated that the timing of the last activity minute is not related to the purpose or affect, and similarly, purpose and affect did not predict how soon active time is started after the assessment. Additionally, the associations were similar with both active time and count as indicators of physical activity. This suggests that purpose and positive affect are associated with both the overall amount and intensity of physical activity, as well as non-sedentary time. Future studies should focus more on the timing of the associations, such as how long the positive association of a physical activity bout with purpose and positive affect lasts, and vice versa.

Although the effect sizes are relatively small (e.g., every 1 min increase in active time during the last 20 min is associated with a 0.15 unit increase in positive affect and 0.69 unit increase in purpose), they are in line with previous momentary relationships [13]. Even if modest, momentary associations may recur numerous times in everyday life, and these cumulative associations may be considerable [13]. In the pursuit of happiness, individuals benefit from experiencing positive affective states more frequently, as the importance of the frequency of these states outweighs their intensity [48, 49]. Similarly, even small benefits to having a purpose in life may be meaningful [50].

This study has a few limitations. The participants were relatively healthy middle-aged adults and limited to a specific geographic area. Thus, the results may not apply to other populations and should be replicated in diverse samples. Without a diary or other self-reported data on physical activity context, it was not possible to separate exercise-type physical activity from habitual physical activity. It would be interesting to study whether the associations between physical activity and momentary affect and purpose are similar regardless of the context of physical activity. It should be noted that momentary positive affect was assessed with only two items and purpose with only one item. However, this brevity was necessary to keep the momentary assessment short enough to reduce participant burden with repeated EMAs. Finally, we adjusted the analysis for common temporary covariates (work, company, weekend, time of the day, and study day) but were not able to control or analyze all possible mediators for the associations. While we controlled the models predicting physical activity for physical activity before the EMA assessment, we did not control the models for affect and purpose using previous assessments of the same items. This decision was due to the long gaps between EMA assessments, which averaged around 4–5 hr during the day.

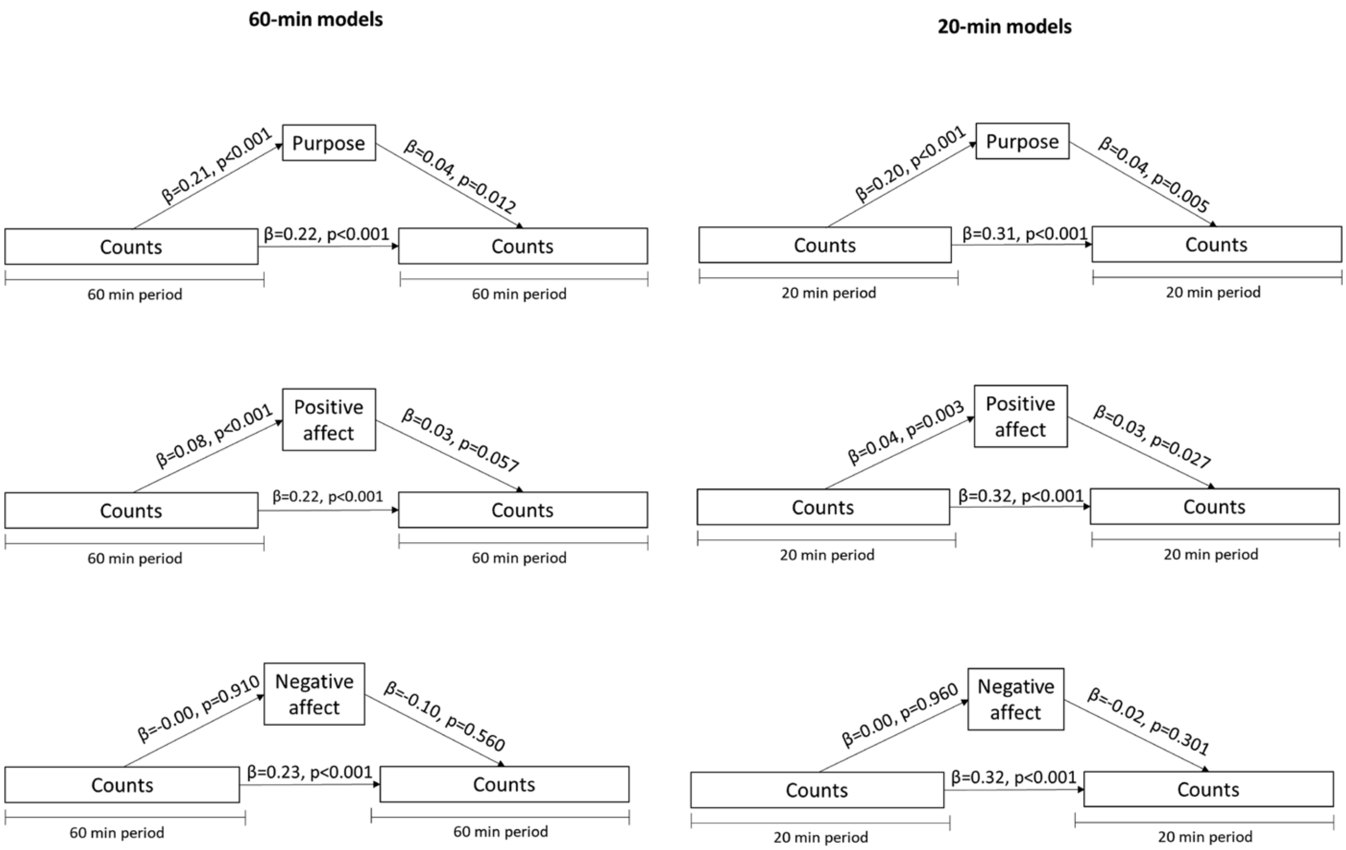

Fig. 4. Simplified visualization of the within-person associations between counts, purpose, positive affect, and negative affect. Models adjusted for between-person covariates of age, gender, education, race/ethnicity, work status. and wearing accelerometer in dominant/non-dominant wrist, and within-person covariates of the weekend, day of the study, time of the day, company, and work. β standardized regression coefficient.

In the present study, the focus was on all activity minutes and counts within the time window, which could have occurred in single or multiple bouts and in longer or shorter bouts. This approach aligns with current physical activity recommendations, which indicate the importance of breaking up sedentary behavior as often as possible and counting all bouts of physical activity [51]. In future studies, it would be interesting to explore whether the patterns (e.g., length of the bouts) or the context (e.g., exercise or running errands) of physical activity play a role in the associations with affect and purpose.

Conclusions

To our knowledge, this was one of the first studies investigating momentary associations between purpose and physical activity using a novel combination of EMAs with smartphones and accelerometers. Participant compliance with both assessment methods was high. The results suggest that purpose and positive affect have bidirectional momentary associations with physical activity in everyday life. Middle-aged adults feel more purposeful and report more positive affect after they have been physically active. Similarly, they are more physically active after feeling more purposeful or more positive affect. This study highlights the dynamic associations between physical activity and mental well-being in daily life. In future interventions or public health programs, it is important to consider physical activity and mental well-being together to harness their potential to boost each other.

Supplementary Material

Supplementary material is available at *Annals of Behavioral Medicine* online.

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Compliance with Ethical Standards

Authors' Statement of Conflict of Interest and Adherence to Ethical Standards The authors declare that they have no competing interests.

Authors' Contributions Tiia Kekäläinen (Conceptualization [equal], Data curation [supporting], Formal analysis [lead], Methodology [equal], Visualization [lead], Writing – original draft [lead]), Martina Luchetti (Conceptualization [supporting], Data curation [equal], Investigation [equal], Methodology [equal], Validation [lead], Writing – review & editing [equal]), Antonio Terracciano (Conceptualization [equal], Investigation [equal], Methodology [equal], Resources [equal], Writing – review & editing [equal]), Alyssa A. Gamaldo (Conceptualization [equal], Methodology [equal], Writing – review & editing [equal]), Martin Sliwinski (Conceptualization [equal], Methodology [equal], Writing – review & editing [equal]), and Angelina Sutin (Conceptualization [equal], Funding acquisition [lead], Investigation [lead], Methodology [equal], Project administration [lead], Supervision [lead], Writing – review & editing [equal])

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. All procedures and materials were approved by the Institutional Review Board of the Florida State University (ID: STUDY00000472).

Informed consent Informed consent was obtained from all individual participants included in the study.

Transparency Statements

Study registration: This study was not formally registered. *Analytic plan pre-registration*: The analysis plan was not formally pre-registered. *Analytic code availability*: Analytic codes used to conduct the analyses and results presented in this study are available: https://osf.io/e4v3u/. *Materials availability*: Materials used to conduct the study are available: https://osf.io/74y9d/.

Data Availability

The datasets generated and/or analyzed during the current study are not publicly available because the restricted geographical location from which participants were recruited increases the risk of re-identification but are available from the corresponding author upon reasonable request.

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