Postpandemic Sedentary Behavior and Physical Activity Among IT Workers

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Objective: We assessed postpandemic work arrangements among information technology (IT) workers at high risk for sedentary behavior (SB) and insufficient physical activity (PA), and examined factors influencing both SB and PA. **Methods:** A cross-sectional, mixed-methods study collected data from 80 IT workers between November 2023 and April 2024. Accelerometry and survey data for both SB and PA were analyzed using descriptive statistics and negative binomial regression; qualitative data were analyzed using content analysis. **Results:** Participants averaged 10.76 hours of SB, including 3.72 hours in prolonged SB, 221 minutes of light PA, and 21 minutes of moderate-to-vigorous PA per day. Hybrid workers were more sedentary than other groups. Individual perceptions and workplace social support were influencing factors. **Conclusions:** Hybrid IT workers need targeted interventions employing multilevel strategies, including behavioral education and supportive work environments.

Keywords: information technology, occupational groups, teleworking, exercise, sedentary behavior, accelerometry

LEARNING OUTCOMES

- Describe the current levels of sedentary behavior and physical activity among American IT workers, especially hybrid workers, as obtained through accelerometry and survey data.
- Identify the individual, interpersonal, and organizational factors that are significantly associated with sedentary behavior and physical activity in IT workers.

Chronic diseases like stroke, heart disease, and type 2 diabetes affect about a third of all adults in the United States.[1,2] Increasing regular physical activity (PA) and decreasing sedentary behavior (SB) are known to reduce the risk of these illnesses.[1,2] Increasing PA and decreasing SB also reduce other chronic conditions and confer individual health benefits.[3–5] However, 2 US government reports focusing on leisure time stated that up to three-quarters of American adults do not meet the recommendations of 150 minutes per week of moderate- to vigorous-intensity PA (MVPA) and 2 days per week of muscle-strengthening activities.[4,5] We note, however, that the reports do not account for individuals' total waking hours, such as those spent in occupational activity.

Occupational activity significantly shapes overall activity patterns.[3,6] During the COVID-19 pandemic, isolation and social restrictions led to reduced PA across all age groups including workers,[7] heightening their risks of developing chronic diseases. Previous literature has shown a negative correlation between occupational PA and SB[3] and that excessive occupational SB negatively impacts individuals' overall PA.[8] Work tasks and environments are also known to influence individuals' activity levels,[3,9] and workers with excessive sedentary time or sedentary job tasks are at greater risk of chronic conditions.[10,11] Among adult workers, office workers are known to exhibit the highest levels of SB and the lowest levels of light PA.[8,12] This information is particularly relevant today, because technological advancements over time have led to over 27.6 million US workers currently working remotely on computer-based tasks.[13] Meanwhile, there is no clear or agreed-upon definition for "office worker," nor is there a consensus on which occupations or industries should be classified as having predominantly sedentary job tasks.[12]

There is thus a need to investigate current SB and PA levels among working adults with specific work-related characteristics, such as job tasks and work arrangements (ie, remote work vs hybrid home-office setups vs traditional workplace arrangements). While sedentary job tasks have increased rapidly over the past few decades, the COVID-19 pandemic introduced a variety of new work arrangements with the potential to further increase SB and reduce PA.[8,9,14] During the early pandemic years, for instance, home-based workers experienced a 16% increase in SB and a concomitant decrease in PA.[15] The impact of these work arrangements highlights the importance of understanding remote workers' SB and PA.

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Ethical considerations: The study protocol and instructions were reviewed and approved by the Institutional Review Board (Protocol # HUM00239582) before the initiating the data recruitment. All participants were thoroughly informed about the study's objective, protocol, and risks and benefits in engaging in the study from the study team members, and voluntarily consented to the study participation.
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Accurate quantifications of SB, PA, and associated factors can expand our understanding of workers' movements and guide strategies for improving their levels of SB and PA. To date, few studies have used accelerometry to examine current levels of SB and PA among particularly vulnerable working populations, or identified factors associated with these patterns. In this study, we chose to focus on "information technology (IT) workers."[16] There were two reasons for this choice: (1) IT workers' job tasks are predominantly sedentary and center around computer use, which is a common feature across industries and sectors; and (2) IT workers follow diverse work arrangements, including new arrangements implemented during the COVID-19 pandemic. Our study aims were (1) to estimate current levels of SB and PA among IT workers, and (2) to identify the multilevel factors (ie, individual, interpersonal, organizational, and environmental) related to work characteristics that may be associated with IT workers' SB and PA.

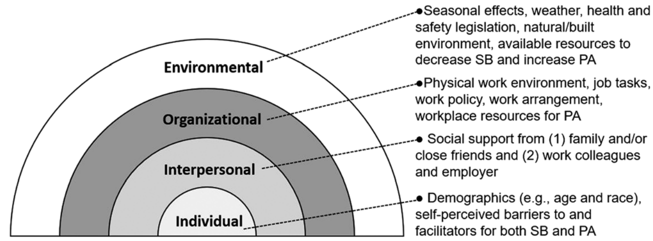

FIGURE 1. Conceptual framework.

METHODS

Study Design and Conceptual Framework

We conducted a mixed-method, cross-sectional study, collecting both quantitative and qualitative data to capture organizational and environmental factors influencing SB and PA across different work arrangements. Our study data were mostly obtained using quantitative methods (ie, accelerometry and a self-reported survey with established measures). However, we also used open-ended interview questions because no valid and reliable measure is currently available to assess influences on SB, differences between home and on-site work, or impacts of work at home on PA. We used the social ecological model (see Fig. 1)[17] as a conceptual framework to guide the study to identify factors influencing SB and PA at multiple levels. The social ecological model provides comprehensive conceptualizations of health behaviors and addresses multilevel interactions between the individual, the group or community, and physical, social, and environmental factors to broadly understand worker health.[17–19]

Sample

Eighty IT workers participated in this study. The required sample size was calculated with G*Power 3.1.[20] For the multiple linear regression model,[20] we set a significance level of 0.05, an effect size of 0.20, a power of 80%, and six expected predictors (e.g., sex assigned at birth). We then adjusted the calculated sample size of 75 to allow for a 5% incomplete or dropout rate, resulting in a final sample size of 80. This sample size is reasonable for a study collecting data from two accelerometer devices (activPAL and ActiGraph).

Participants were eligible for study participation if they (1) were affiliated with an IT department in one urban area in Southeast Michigan; (2) could speak and comprehend English; (3) were willing to give a voluntary blood sample (this analysis will be reported in a later manuscript); and (4) were willing to wear the activPAL and ActiGraph devices for 1 week. Study exclusion criteria were (1) skin sensitivity or allergy reaction to tape, which is used to attach the activPAL device to the right thigh; (2) disease or injury that limits PA; (3) compromised immune system, which can lead to skin breakdown from the tape used to attach the activPAL; (4) skin disease on the lower extremities, which can also affect use of tape for the activPAL; or (5) pregnancy, which can potentially change SB and PA patterns.

The study protocol and instructions were reviewed and approved by the institutional review board at the University of Michigan (IRB No. HUM00239582). All participants were thoroughly informed by study team members about the study's objective, protocol, and risks and benefits, and voluntarily consented to study participation.

Data Recruitment and Collection

From November 2023 to April 2024, we recruited participants from two organizations (a university and a university-affiliated hospital) using multiple recruitment methods: (1) sending emails with the study flyer to IT working groups chosen by each organization based on job titles and classification categories; (2) distributing study flyers face-to-face at local social events that aimed to foster a collaborative and innovative learning environment for IT workers and to strengthen community bonds across departments[21]; (3) using organizational platforms (ie, a research organization registry and an employee health and well-being program); and (4) asking IT directors, as cultural brokers, to distribute the study flyer across their departments.

Individual IT workers interested in the study used the QR code or the host institution's REDCap link on the flyer to access and complete the eligibility questionnaire. Eligible individuals were then asked to sign an e-consent form on the REDCap system. Next, the research team scheduled a 1-hour appointment with each participant to administer the study survey and apply the two accelerometry devices. For the study survey, each participant was first assigned a unique ID number to protect confidentiality, then asked to respond to study-specific questionnaires on the REDCap system using a laptop computer provided by the research team. After the structured questionnaire was completed, a research team member asked the participant a set of open-ended questions and entered the answers into REDCap.

During that same appointment, the participant received two accelerometry devices: (1) an activPAL, which was applied to the participant's right thigh with tape; and (2) an ActiGraph, which was worn on the right waist starting the day after the appointment. Participants were asked to wear the two devices every day for 7 days (including workdays and nonworking days), to complete daily logs that included work dates and hours, and to track the times they removed the ActiGraph for sleeping and for water activities (e.g., showering, swimming). After a week, participants met the research team again to return the devices and receive a health behavior consultation with the principal investigator. Once their data collection was completed, each participant received an electronic gift card worth $60.

Measures

SB and PA

SB and PA were measured by accelerometry as dependent variables. Both activPAL and ActiGraph devices are widely used, with strong evidence for reliability and validity.[22]

SB was measured via the activPAL device, which is considered the gold standard for measuring SB (we used both activPAL 3 and activPAL 4 devices in this study).[22] Participants were asked to wear the device continuously on the thigh (attached by waterproof tape) for 7 consecutive days. The activPAL measured time spent sitting, sedentary time (ie, sitting and lying), sedentary bouts lasting over 1 hour, number of upright transitions, and standing time. For this study, a sedentary bout was defined as over 1 hour of continuous SB, wherein activity intensity falls within the sedentary range with no interruptions.[11] An upright transition was defined as an instance of standing up from a seated position. All participants wore the activPAL 24/7 throughout the data collection period. In accordance with established procedures, we applied PALanalysis version 9.1.0.102[23] to reduce the activPAL data to only valid waking and wear-time data. At least 4 days of valid data were required, with a valid day consisting of at least 10 hours of data.

The intensity of PA was measured using the ActiGraph GT9X Link device worn at the right waist. Each participant was requested to wear the device at all times during their waking hours except during any water activities, and to complete a daily log to report their sleeping time and workday time. The ActiGraph measured time spent in light PA, moderate PA, and MVPA, as well as MVPA bouts. Data for participants with 4 or more valid days of wear time (≥10 hr/d)[24] were included for analysis via ActiLife version 6.13.4, with Freedson et al.'s (1998) cut points applied.[25] In addition, we used Choi et al.'s algorithm[26] to distinguish between wear and nonwear time,[26] and we deleted the data for nonwear time.

We analyzed data from participants who provided at least 4 valid days of data; these could be all workdays or a combination of workdays and nonworking days. Our initial analyses showed no significant differences in outcomes (for SB or PA) when using only workdays versus a combination of workdays and nonworking days. Thus, for our final analysis, we chose to include data for all participants who had recorded at least 4 valid device-wearing days. This resulted in a slightly larger sample for analysis (activPAL data for 78 participants and ActiGraph data for 77) than if we had required 4 valid working days (activPAL: 70; ActiGraph 73).

Factors Influencing SB and PA

We used a structured questionnaire and open-ended questions to identify influencing factors at multiple levels. For individual-level factors, we used two questionnaires: (1) individual level factors influencing PA were measured with the modified short version of the Perceived Benefits and Barriers Scale[27]; and (2) individual factors influencing SB were measured with Nooijen et al.'s (2018) questionnaire,[28] which focuses on perceived barriers and facilitators to reducing SB. A higher, positive score on the PA scale indicates more benefits than barriers, while a lower, negative score reflects more barriers than benefits.

For interpersonal-level factors, we used the modified version of the Social Support and Exercise Survey[29] to ask participants about support from both close relationships (ie, family and friends) and work colleagues (including employers). Higher scores indicate having more social support.

To assess the influence of organizational- and environmental-level factors, we used broad open-ended questions such as "Can you give me a brief description of your work?" and "Can you tell me about your work environment?" (to address their home and/or on-site office). Organizational factors addressed in the open-ended questions included work-related characteristics (e.g., descriptions of actual job tasks, workplace climate, work arrangements), physical work environment, and workplace policies aimed at improving PA and reducing SB (e.g., work-wellness PA programs). Engagement in work-wellness PA programs was categorized into three main types: (1) participating in personal or team-based activity tracking events, (2) using workplace gym facilities, and (3) attending workplace PA classes. During the principal investigator's interviews with each participant, they were asked to report engagement in any work-wellness PA program from the time they started their current job. With regard to environmental factors, the open-ended questions covered seasonal (weather) effects on SB and PA, health and safety legislation, and any engagement in activities offered by community or neighborhood services/resources to increase PA and/or decrease SB.

Data Analysis

Stata 18.0 and R 4.4.1 were used for the analysis of the descriptive statistics and quantitative data. For the quantitative analysis, binomial negative regressions were applied to identify significant factors influencing IT workers' SB and PA, such as work arrangements and participation in work-wellness PA programs. All regressions were controlled for age, work years, sex at birth, marital status, and race and ethnicity. NVivo 14 was used for the qualitative analysis (content analysis[30]). For the qualitative analysis, two research team members conducted an initial content analysis independently and then reached a consensus for each theme and significant statement.

RESULTS

The structured survey was completed by 80 participants, and 79 provided accelerometer data. After the accelerometry data validation and reduction process, final SB data were available for 78 participants, and final PA data were available for 77 participants. However, among the 77 participants, we excluded one extreme outlier—a participant with 80 min/d of MVPA—for the regression analysis. This outlier potentially reflected a Type 1 error in our data analyses, an error exacerbated by the small sample size.[31]

As shown in Supplementary Table 1 (http://links.lww.com/JOM/C124), participants' mean age was 46.8 (SD, 11.8) years, with a range of 21 to 69 years. Most participants were White (75%), married or living with a partner (75%), and had completed more than a bachelor's degree (88%). A majority had worked more than 5 years at their current workplace (58%) and were following a hybrid work arrangement (50%), with an average of 2.8 days per week worked remotely.

Estimates of SB and PA for IT Workers

The majority of time, over 73%, was spent in SB (see Table 1). The average SB time was 10.76 hours a day, with 45.5 sedentary breaks per day (ie, upright transitions) and 3.72 hours a day of prolonged sedentary bouts (lasting over 1 hour). Fully remote workers had the least SB (10.18 hours), hybrid workers had the most SB (11.19 hours), and both groups had similar amounts of prolonged sedentary bouts (remote: 3.80 hours; hybrid 3.79 hours).

For PA intensity, 24.5% of the total device wear time was spent in light PA, while 2.4% was spent in MVPA. The participants recorded an average of only 0.43 bouts of MVPA lasting at least 10 minutes (per day). The ActiGraph data for the total sample showed a daily average of 221 minutes in light PA, 20 minutes in moderate PA, and 21 minutes in MVPA (Table 1). The on-site workers had the highest PA (274 minutes per day in light PA; 26 minutes per day in MVPA), and the hybrid workers had the lowest PA (209 minutes per day in light PA; 20 minutes per day in MVPA). However, remote workers had the highest number of MVPA bouts lasting at least 10 minutes—0.48 bouts per day—while on-site workers had only 0.37 bouts per day.

Factors Influencing SB for IT Workers

A binomial regression indicated that perceived benefits and barriers to exercise (individual level), social support from close friends and family and from work colleagues (interpersonal level), and work-wellness PA engagement (organizational level) were all significantly ($P < 0.05$) associated with SB (Table 2). The individual-level factors were the most influential to several SB outcomes (sedentary time, sedentary bouts, sitting time, and upright transitions) when compared to the interpersonal and organizational factors. Higher scores for perceived benefits and barriers to exercise were associated with lower total sedentary time, fewer sedentary bouts, less sitting time, and more upright transitions. SB was also influenced by workers' years of experience and race: workers who had more years of experience and were White had higher SB compared to workers with fewer years of experience and were not White.

Meanwhile, high social support for PA from close friends and family was associated with fewer sedentary bouts, less sitting time, and more upright transitions. With the social support from close friends and family, workers' years of experience negatively influenced SB bouts and sitting time; that is, workers with longer tenures tended to be more sedentary. Women recorded more upright transitions than

TABLE 1. Descriptive Results for Participating IT Workers' SB and PA (n = 76)

Health Behaviors	Variable	Median	M	SD	95% CI Lower	95% CI Upper	% of Total Wear Time Spent in each Activity[a]
SB (n = 78)[b]	Total SB time (min/d)	651.55	645.69	101.41	622.82	668.55	SB: M 73.1 (SD, 7.3)
	On-site	620.06	657.82	98.47	582.13	733.51	
	Remote	586.63	610.90	76.87	582.70	639.09	
	Hybrid	669.63	671.19	113.12	634.01	708.37	
	Upright transitions (no. sit-to-stands)	43.92	45.48	12.35	42.70	48.27	
	Sitting time	526.59	527.08	116.45	500.82	553.33	
	Standing time	210.99	214.25	74.04	197.55	230.94	
	Sedentary bouts[c] (min/d)	207.28	223.17	126.49	194.65	251.69	
	On-site	159.77	189.71	142.65	80.06	299.36	
	Remote	208.60	227.86	137.67	177.36	278.35	
	Hybrid	210.64	227.27	115.00	189.47	265.07	
PA (n = 76)[a]	Light PA (min/d)	209.20	220.78	64.60	206.02	235.54	Light PA: M 24.5 (SD, 6.5)
	On-site	273.20	274.46	94.44	201.87	347.05	
	Remote	212.05	220.58	52.51	200.22	240.94	
	Hybrid	198	208.54	59.69	189.19	227.89	
	Moderate PA (min/d)	17.85	20.46	14.43	17.16	23.75	MVPA: M 2.4 (SD, 1.9)
	MVPA (min/d)	19	21.44	15.42	17.91	24.96	
	On-site	22.3	25.92	15.86	13.73	38.11	
	Remote	20.15	21.46	17.45	14.69	28.23	
	Hybrid	17.6	20.38	13.93	15.87	24.90	
	MVPA bouts per day[d]	0.29	0.43	0.47	0.32	0.53	
	On-site	0.14	0.37	0.50	−0.02	0.75	
	Remote	0.43	0.48	0.55	0.27	0.69	
	Hybrid	0.29	0.40	0.40	0.27	0.53	

Note. Two participants did not provide SB data; two participants did not provide PA data; one participant did not meet the criteria for ≥4 valid days of PA data; and one participant was excluded due to an extreme outlier of PA.

M, mean; MVPA, moderate-to-vigorous PA; PA, physical activity; SB, sedentary behavior; SD, standard deviation.

[a]Measurements from ActiGraph: average daily wear time was 15.06 hr (SD, 1.4 hr).

[b]Measurements from activPAL: worn 24/7 by all participants; average daily wear time during waking period was 15.21 hr (SD, 1.5 hr), and SB% was 71.5 based on activPAL data.

[c]Counted as sedentary bouts of >1 hour in length.

[d]Counted as the number of bouts of MVPA lasting at least 10 minutes was counted, with each 10-minute bout defined as 10 or more consecutive minutes of activity at moderate intensity or higher during wear time.

men. High social support from work colleagues contributed to reduced sedentary bouts (0.02-minute reduction in sedentary bouts per unit increase in social support). At the organizational level, workers engaging in work-wellness PA programs had less SB than nonengaged workers. Yet again, more years of work experience was associated with both longer sedentary bouts and increased SB (Table 2).

Factors Influencing PA for IT Workers

Compared to the factors influencing SB, there were fewer factors showing significant ($P < 0.05$) influences on PA (see Table 3). Statistically significant factors included an individual-level factor (perceived benefits and barriers to exercise), an interpersonal factor (social support from work colleagues), and an organizational factor (work arrangements). Greater perceived benefits for exercise were associated with increased amounts of light PA (0.01 minutes per unit increase) and MVPA (0.03 minutes per unit increase). Social support from work colleagues also contributed to higher levels of light PA (0.01 minutes increase per unit). Finally, work arrangements significantly impacted light PA, with remote workers having less light PA than on-site workers ($P < 0.05$). In addition, workers with more years of experience showed lower levels of light PA than workers with less experience (0.01-minute reduction per additional year of work experience).

Additional Organizational and Environmental Factors Influencing SB and PA

In their responses to open-ended questions, participants identified four factors that helped increase PA: (1) work adjustments to facilitate PA, (2) reminders to break up SB, (3) physical supports such as treadmill desks to improve PA and reduce SB, and (4) personal factors like motivation (see Supplementary Table 2, http://links.lww.com/JOM/C124). Regarding barriers to reducing SB, participants mentioned (1) the lack of a support system to interrupt SB and (2) the sedentary nature of IT jobs. To understand the nature of these jobs, we categorized participants' descriptions of tasks into five thematic areas: (1) analysis, (2) digital communication, (3) leadership and management, (4) software development, and (5) technical services. With the exception of technical services and some aspects of leadership and management, IT job tasks were computer-based and predominantly involved sitting.

Within the theme of "current work environment," participants highlighted several factors relevant to SB and PA: (1) the benefits of working from home compared to on-site, such as having more space at home; (2) the availability of supportive workstations, like sit-to-stand desks (adjustable desks); and (3) the importance of physical space to facilitate movement. Participants also discussed the influence of workplace culture on their SB and PA, noting that even minimal reminders to increase PA and reduce SB prompted them to reflect on and potentially adjust their behaviors. The theme we identified as "motivations and barriers to engaging in organizational resources" to support PA and reduce SB encompassed the following four elements: (1) monetary incentives, (2) health benefits, (3) social support, and (4) alignment with personal preferences for being active and breaking SB.

Environmental factors identified included the "seasonal (weather) effect" and "motivations and barriers to engaging in community/neighborhood resources" to support PA and reduce SB. Some participants

TABLE 2. A Binominal Panel Regression Analysis of Factors That Significantly Influenced Sedentary Behavior ($n = 78$)

DV	IV	b	SE	z	95% CI Lower	95% CI Upper
Individual level: Perceived benefits and barriers to exercise						
Total sedentary time	(Constant)	6.55	0.08	77.49**	6.39	6.72
	Perceived benefits and barriers to exercise	−0.004	0.002	−2.45*	−0.01	−0.001
	Work years	0.005	0.002	2.11*	0.0003	0.01
	Race	−0.07	0.04	−2.05*	−0.15	−0.003
SB bouts	(Constant)	5.57	0.36	15.59**	4.87	6.27
	Perceived benefits and barriers to exercise	−0.02	0.01	−2.19*	−0.03	−0.002
Sitting time	(Constant)	6.22	0.12	51.57**	5.98	6.45
	Perceived benefits and barriers to exercise	−0.01	0.002	−3.20*	−0.01	−0.003
Upright transitions	(Constant)	3.88	0.16	24.62**	3.57	4.19
	Perceived benefits and barriers to exercise	0.007	0.003	2.31*	0.001	0.01
Interpersonal level: Social support from close friends and family						
SB bouts	(Constant)	5.76	0.37	15.76**	5.04	6.48
	Social support from close friends and family	−0.02	0.01	−2.93*	−0.03	−0.01
	Work years	0.02	0.01	2.48*	0.01	0.04
Sitting time	(Constant)	6.21	0.12	51.00**	5.97	6.44
	Social support from close friends and family	−0.01	0.002	−2.92*	−0.01	−0.002
	Work years	0.01	0.003	2.10*	0.0005	0.01
Upright transitions	(Constant)	3.86	0.15	25.27**	3.56	4.16
	Social support from close friends and family	0.01	0.003	3.03*	0.003	0.01
	Sex	−0.12	0.06	−2.09*	−0.24	−0.01
Interpersonal level: Social support from work colleagues						
SB bouts	(Constant)	5.62	0.36	15.69**	4.91	6.32
	Social support from work colleagues	−0.02	0.01	−2.39*	−0.04	−0.003
	Work years	0.03	0.01	3.04*	0.01	0.05
Organizational level: Work-wellness PA engagement						
Total sedentary time	(Constant)	6.54	0.08	78.99**	6.37	6.70
	Work-wellness PA engagement	−0.08	0.03	−2.56*	−0.15	−0.02
	Work years	0.01	0.002	2.37*	0.001	0.01

All regressions were controlled for age, work years (years at current job), sex assigned at birth, marital status, and race and ethnicity. The reference group is female, married, White, and participants who did not engage in a work-wellness PA program.

DV, dependent variable; IV, independent variable; PA, physical activity; SB, sedentary behavior; SE, standard error.

* $P < 0.05$; ** $P < 0.001$.

were less active during winter due to colder weather, which led to increased sitting time. There were three factors related to engaging in community resources: (1) challenges to engagement, such as time conflicts and personal demotivation; (2) use of outdoor activities with social support to increase PA and reduce SB; and (3) the recognition of the health benefits of PA as a motivation for engagement.

TABLE 3. A Binominal Panel Regression Analysis of Factors that Significantly Influenced Physical Activity ($n = 76$)

DV	IV	b	SE	z	95% CI Lower	95% CI Upper
Individual level: Perceived benefits and barriers to exercise						
Light PA	(Constant)	5.13	0.17	30.81**	4.81	5.46
	Perceived benefits and barriers to exercise	0.01	0.003	3.16*	0.004	0.02
MVPA	(Constant)	3.64	0.50	7.32**	2.67	4.62
	Perceived benefits and barriers to exercise	0.03	0.01	2.99*	0.01	0.05
	Work years	−0.03	0.01	−3.28*	−0.06	−0.01
Interpersonal level: Social support from work colleagues						
Light PA	(Constant)	5.21	0.16	31.67**	4.89	5.54
	Social support from work colleagues	0.01	0.004	2.54*	0.002	0.02
	Work years	−0.01	0.004	−2.54*	−0.02	−0.003
Organizational level: Work arrangements						
Light PA	(Constant)	5.24	0.17	30.10**	4.90	5.58
	Work arrangements					
	Hybrid work	0.02	0.07	0.26	−0.12	0.15
	On-site work	0.27	0.11	2.54*	0.06	0.48

All regressions were controlled for age, work years (at current job), sex assigned at birth, marital status, and race and ethnicity. The reference group is female, married, White, and working remotely.

DV, dependent variable; IV, independent variable; MVPA, moderate-to-vigorous physical activity; PA, physical activity; SB, sedentary behavior; SE, standard error.

* $P < 0.05$; ** $P < 0.001$.

DISCUSSION

To the authors' knowledge, this is the first study to use accelerometry to measure SB and PA among IT workers. Findings showed that the average IT worker exhibits high SB, spending approximately 11 waking hours per day sedentary (73% of total wear time, across workdays and nonworking days), with about 4 hours in prolonged sedentary bouts. The average IT worker spends 25% of their waking hours (wear time) in light PA and 2% in MVPA. Notably, hybrid workers had the highest amount of SB (>11 hr/d) and the lowest amount of light PA (209 min/d) and MVPA (20 min/d) compared to workers with other work arrangements (ie, on-site or fully remote).

We note that the IT workers in our study exhibited both higher SB and lower PA than reported by office workers in previous literature.[12,14] Most IT workers in our study would need to increase their MVPA to meet the American guidelines for PA. While the participants' average MVPA time (150.08 min/week) just met the guideline (150 min/week), individual IT workers showed a large variation of MVPA time per week (ranging from 2.8 to 406 min/d), even when we excluded the extreme outlier (576.8 min/week). In our total sample, 56% of the IT workers (44 out of 78) did not meet the American PA guideline.

Among the IT job categories, technical services roles involve less sitting than software development, digital communication, and management roles, all of which primarily involve prolonged sitting at a computer. This may be one reason that office workers, desk-based workers, and regular remote workers may exhibit substantial variation in levels of SB and PA, depending on their specific industry and work role characteristics.[32] Although the dramatic variation across individual participants in this study calls for caution when interpreting the findings, we also suggest that there is a clear need to increase PA among IT workers and other workers with largely computer-based tasks.

Defining and categorizing IT job roles presents challenges, as job classifications vary across organizations and lack uniformity in defining occupational groups. The use of national standardized codes such as North American Industry Classification System[33] and Standard Occupational Classification[34] can help represent occupational classifications in the United States but may not adequately capture the sedentary nature of specific jobs within these classifications. Assessing work contexts in O*Net[16] is a great source for information on occupational movement, with occupational codes and job task information all available together. For example, the O*Network context shows our target group of "information technology" and category of "computer system" workers to have a higher fraction of sitting time than other occupations.[16]

Further studies are needed to identify the highest-risk occupational groups—characterized by prolonged sedentary bouts, higher SB, and lower PA—and thus to enable targeted interventions for these populations. To address this gap in research, we suggest exploring work contexts with high sitting and less active occupation[16] as well as occupations with high percentages of regular remote workers.[35] This might include specific categories of office workers with work contexts that have high SB, such as actuaries and insurance underwriters,[16] as well as occupations that have shown the largest gains in remote workers, such as computer systems and publishing industries.[35] Examining SB and PA in these specific populations could provide valuable insights for designing effective interventions. Our findings suggest that interventions should also consider workers' years of experience, as IT workers with more years in the workforce exhibited higher SB and lower levels of light PA and MVPA.

We found a negative relationship between SB and light PA, which is consistent with prior research.[36] Factors such as perceived benefits and barriers to exercise, as well as social support from work colleagues, were shown to reduce SB and increase light PA. There are several already established methods to reduce SB and increase PA, including behavior change techniques, education on the benefits and health consequences of PA, incentivization, training, and environmental restructuring.[32,37,38] The most effective approach, as highlighted in previous studies,[39,40] appears to be a multifaceted strategy that combines behavior change education, social support in the workplace, and provision of supportive workstations. Notably, based on our content analysis results, potential means of improving PA and decreasing SB regardless of specific work arrangement include setting a reminder alarm as an individual-level strategy, providing organizational support (e.g., requiring breaks during Zoom meetings and establishing the acceptability of standing during meetings), and offering environmental support (e.g., providing sit-to-stand desks). Our results highlight the importance of individual motivation, social support, and adjustments to the workplace environment to promote PA and reduce SB.

Our findings also highlight a lack of workplace resources to promote SB breaks compared to resources for improving PA, and a lack of work-wellness programs and other organizational resources or policies specifically designed to break SB and increase PA in home work (remote) settings. Furthermore, despite the significant and persistent rise in remote work since the COVID-19 pandemic,[35] there has been limited investigation into how workplace policies and resources have adapted to address these changes.[41] No studies have yet explored interventions to reduce SB and increase PA for both remote and on-site workers in the postpandemic era to assess their relative effectiveness. Given these research gaps, we suggest that future studies focus on evaluating changes in workplace policy and resources for remote workers specifically and on investigating the effectiveness of tailored interventions for these workers. Such efforts could provide critical insights into how to support active and healthy work environments across diverse work arrangements.

Notably, because hybrid workers showed the highest SB and lowest MVPA, they should be the focus of new organizational policies to interrupt prolonged SB, along with physical and virtual means of support for hybrid/remote work, and increase health promotion. These policies should be collectively implemented with focus on individual-level strategies for facilitating PA and reducing SB as well as work-wellness programs that hybrid/remote workers can access. Additionally, special attention should be given to workers with longer tenures to interrupt their sedentary tendencies.

Limitations

This study has several limitations. First, the study employed a relatively small sample size drawn from participants at two organizations in southeastern Michigan, recruited through purposive sampling methods via community engagement events and targeted organizational affiliations. This limited sample size and geographic specificity constrain the generalizability of findings to the broader IT workforce. Second, wear time for the two devices (ie, the activPAL and ActiGraph) differed. The activPAL's CRE algorithm excluded the first day of wear if the setting was not initiated to record from midnight, regardless of when participants actually applied the device, unlike the ActiGraph. The fact that activPAL data automatically dropped the first day for all participants' datasets, unlike ActiGraph data, is addressed as a limitation in the text. In future studies, we will ensure both devices are set to begin recording at midnight. Third, the distribution of participants across work arrangements was uneven, and this imbalance may have affected the study findings. Future research with more balanced samples across different work arrangements could provide a better understanding of the differences between on-site, remote, and hybrid workers' experiences.

CONCLUSIONS

Our study highlights the patterns of high SB and low PA among IT workers, a population at increased risk for associated health issues. Work arrangement significantly impacted these behaviors, and hybrid workers were identified as the most vulnerable group. Future research should explore broader occupational contexts, including those specific to IT workers, refine classification systems to better represent sedentary job tasks, and evaluate the long-term effectiveness of interventions tailored to different work arrangements Overall, our study identified key factors that included individual perceptions, social support, and organizational engagement. These findings underscore the importance of multilevel intervention strategies such as behavior change education, supportive work environments, and workplace policies.

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REFERENCES

1. Bovolini A, Garcia J, Andrade MA, Duarte JA. Metabolic syndrome pathophysiology and predisposing factors. *Int J Sports Med* 2021;42:199–214.
2. National Heart, Lung, and Blood Institute. Metabolic syndrome - what is metabolic syndrome? 2022. Available at: https://www.nhlbi.nih.gov/health/metabolic-syndrome. Accessed February 14, 2024.
3. Smith L, McCourt O, Sawyer A, et al. A review of occupational physical activity and sedentary behaviour correlates. *Occup Med (Lond)* 2016;66: 185–192.
4. Centers for Disease Control and Prevention. Physical activity. 2022. https://www.cdc.gov/physicalactivity/index.html. Accessed February 14, 2024.
5. U.S. Department of Health and Human Services. *Physical activity guidelines for Americans*. 2nd ed. Washington, DC: U.S. Department of Health and Human Services; 2018.
6. Prince SA, Rasmussen CL, Biswas A, et al. The effect of leisure time physical activity and sedentary behaviour on the health of workers With different occupational physical activity demands: a systematic review. *Int J Behav Nutr Phys Act* 2021;18:100.
7. Wunsch K, Kienberger K, Niessner C. Changes in physical activity patterns due to the Covid-19 pandemic: a systematic review and meta-analysis. *Int J Environ Res Public Health* 2022;19:2250.
8. Lusa S, Punakallio A, Mänttäri S, et al. Interventions to promote work ability by increasing sedentary workers' physical activity at workplaces – a scoping review. *Appl Ergon* 2020;82:102962.
9. Rhodes RE, McEwan D, Rebar AL. Theories of physical activity behaviour change: a history and synthesis of approaches. *Psychol Sport Exerc* 2019;42:100–109.
10. Motuma A, Gobena T, Roba KT, Berhane Y, Worku A. Long sedentary time is associated with worsened cardiometabolic risk factors among university employees in Eastern Ethiopia. *Sci Rep* 2022;12:22431.
11. Honda T, Chen S, Yonemoto K, et al. Sedentary bout durations and metabolic syndrome among working adults: a prospective cohort study. *BMC Public Health* 2016;16:888.
12. Park S, Lee S, Woo S, et al. Sedentary behaviors and physical activity of the working population measured by accelerometry: a systematic review and meta-analysis. *BMC Public Health* 2024;24:2123.
13. de Lucas Ancillo A, Gavrila Gavrila S, del Val Núñez MT. Workplace change within the COVID-19 context: the new (next) normal. *Technol Forecast Soc Change* 2023;194:122673.
14. Prince SA, Elliott CG, Scott K, Visintini S, Reed JL. Device-measured physical activity, sedentary behaviour and cardiometabolic health and fitness across occupational groups: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act* 2019;16:30.
15. Wilms P, Schröder J, Reer R, Scheit L. The impact of "home office" work on physical activity and sedentary behavior during the COVID-19 pandemic: a systematic review. *Int J Environ Res Public Health* 2022;19:12344.
16. OnLine ON. Work Context — Spend Time Sitting. Available at: https://www.onetonline.org/find/descriptor/result/4.C.2.d.1.a. Accessed November 20, 2024.
17. McLeroy KR, Bibeau D, Steckler A, Glanz K. An ecological perspective on health promotion programs. *Health Educ Q* 1988;15:351–377.
18. Ingram M, Wolf AMA, López-Gálvez NI, Griffin SC, Beamer PI. Proposing a social ecological approach to address disparities in occupational exposures and health for low-wage and minority workers employed in small businesses. *J Expo Sci Environ Epidemiol* 2021;31:404–411.
19. Spence JC, Lee RE. Toward a comprehensive model of physical activity. *Psychol Sport Exerc* 2003;4:7–24.
20. Faul F, Erdfelder E, Lang A-G, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods* 2007;39:175–191.
21. McCullagh MC, Sanon MA, Cohen MA. Strategies to enhance participant recruitment and retention in research involving a community-based population. *Appl Nurs Res* 2014;27:249–253.
22. Steeves JA, Bowles HR, McClain JJ, et al. Ability of thigh-worn ActiGraph and activPAL monitors to classify posture and motion. *Med Sci Sports Exerc* 2015; 47:952–959.
23. *PALanalysis* [computer program]. Version 9.1.0.102: PAL Technologies Ltd.
24. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sports Exerc* 2008;40:181–188.
25. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. *Med Sci Sports Exerc* 1998;30:777–781.
26. Choi L, Liu Z, Matthews C, Buchowski M. Validation of accelerometer wear and nonwear time classification algorithm. *Med Sci Sports Exerc* 2011;43:357–364.
27. Ishii K, Inoue S, Ohya Y, et al. Sociodemographic variation in the perception of barriers to exercise among Japanese adults. *J Epidemiol* 2009;19:161–168.
28. Nooijen CFJ, Kallings LV, Blom V, Ekblom Ö, Forsell Y, Ekblom MM. Common perceived barriers and facilitators for reducing sedentary behaviour among office workers. *Int J Environ Res Public Health* 2018;15:792.
29. Sallis JF, Grossman RM, Pinski RB, Patterson TL, Nader PR. The development of scales to measure social support for diet and exercise behaviors. *Prev Med* 1987;16:825–836.
30. Lindgren BM, Lundman B, Graneheim UH. Abstraction and interpretation during the qualitative content analysis process. *Int J Nurs Stud* 2020;108:103632.
31. Gress TW, Denvir J, Shapiro JI. Effect of removing outliers on statistical inference: implications to interpretation of experimental data in medical research. *Marshall J Med* 2018;4:9.
32. Wang R, Blom V, Nooijen CFJ, Kallings LV, Ekblom Ö, Ekblom MM. The role of executive function in the effectiveness of multi-component interventions targeting physical activity behavior in office workers. *Int J Environ Res Public Health* 2021;19:266.
33. North American Industry Classification System. Available at: https://www.census.gov/naics/. Accessed June 05, 2024.
34. Standard Occupational Classification. Available at: https://www.bls.gov/soc/. Accessed June 5, 2024.
35. Pabilonia SR, J. The rise in remote work since the pandemic and its impact on productivity. *Beyond the Numbers: Productivity* 13: Available at: https://www.bls.gov/opub/btn/volume-13/remote-work-productivity.htm. Accessed December 3, 2024.
36. Mansoubi M, Pearson N, Biddle SJ, Clemes S. The relationship between sedentary behaviour and physical activity in adults: a systematic review. *Prev Med* 2014;69:28–35.
37. Morton S, Fitzsimons C, Jepson R, Saunders DH, Sivaramakrishnan D, Niven A. What works to reduce sedentary behavior in the office, and could these intervention components transfer to the home working environment?: a rapid review and transferability appraisal. *Front Sports Act Living* 2022;4:954639.
38. Shrestha N, Kukkonen-Harjula KT, Verbeek JH, Ijaz S, Hermans V, Pedisic Z. Workplace interventions for reducing sitting at work. *Cochrane Database Syst Rev* 2018;6:Cd010912.
39. Wipfli B, Wild S, Hanson G, et al. Effectiveness and durability of a workplace sedentary behavior intervention based on the Total Worker Health® approach. *Behav Sci (Basel)* 2024;14:1051.
40. Taylor WC, Paxton RJ, Shegog R, et al. Impact of booster breaks and computer prompts on physical activity and sedentary behavior among desk-based workers: a cluster-randomized controlled trial. *Prev Chronic Dis* 2016;13:E155.
41. Geldart S. Remote work in a changing world: a nod to personal space, self-regulation and other health and wellness strategies. *Int J Environ Res Public Health* 2022;19:4873.