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The association between working from home and physical activity among university employees: a cross-sectional study

Supplementary Information

The online version of this article (https://doi.org/10.1007/s12662-026-01097-6) contains supplementary material, which is available to authorized users.

Introduction

Empirical evidence suggests that regular physical activity (PA) positively affects human somatic and mental health (Ekelund et al., 2019; Gordon et al., 2018; Kraus et al., 2019; Warburton & Bredin, 2017). The World Health Organization (WHO) recommends that adults accumulate at least 150 min of moderate-intensity PA (MPA) or 75 min of vigorous-intensity PA (VPA) per week (World Health Organization, 2020). However, following current global comparative estimates, approximately 30% of adults worldwide do not meet the recommended levels of PA and are therefore physically inactive (Strain et al., 2024). In addition to contributing to a major economic burden worldwide (Ding et al., 2016), physical inactivity is known to increase the risk of many chronic diseases, such as cardiovascular diseases, certain types of cancer, and type 2 diabetes (Gaetano, 2016).

With approximately 7 hours a day (Eurostat, 2022) and 90,000 hours over a lifetime (Pryce-Jones, 2010), people spend a large amount of their time at work. In light of the substantial proportion of working time, and the interrelationship between humans and their environment, the workplace represents an important setting that determines health-related behavior such as PA (World Health Organization, 2019). According to socio-ecological models (e.g., Sallis et al., 2006), health-related behavior is influenced by interactions between individuals and the physical and social structures in their environment, which can either facilitate or hinder PA. Many previous studies examining the relationship between the work environment and PA have focused on office-based settings, as office workers' daily life is characterized by low levels of PA and high levels of sedentary behavior (Clemes et al., 2014; Johansson et al., 2020; Michalchuk et al., 2022). However, evidence has shown that individuals across a wide range of occupations are insufficiently physically active in their everyday working lives. For example, a recent study (Fountaine et al., 2014) found that university employees spent only a small proportion of their working day in PA, increasing health risks due to physical inactivity.

With the transformation of work toward a higher level of spatial flexibility, new environments, such as one's home, have become more common workplaces (Mariotti & Tagliaro, 2024). Recent data emphasize the central role of working from home (WFH) in everyday working life, either within working models that incorporate solely working remotely (e.g., from home) or within the context of hybrid work models that incorporate working remotely (e.g., from home) and on-site work. In Germany, for example, the number of employees who usually or sometimes WFH nearly doubled in comparison with levels before COVID-19 (Destatis, 2024). However, from a health perspective, WFH may be linked to adverse health effects, as several studies suggest that WFH negatively affects PA (Argus & Pääsuke, 2021; Brusaca et al., 2021; Hallman et al., 2021; Sers et al., 2023; Widar et al., 2021). Possible explanations include the lack of active commuting to the traditional workplace or differences in the spatial configuration of each work environment (e.g., a shorter distance to a printer or a coffee machine at home; Fukushima et al., 2021). At the same time, WFH may also create opportunities to be physically active, for example by reallocating the time saved from commuting to engage in PA. Finally, following a socio-ecological approach (Sallis et al., 2006), WFH may affect PA by altering time proportion and time allocations across domains (i.e., transport, leisure, work, household)—thereby reshaping contextual factors that interact with individual-level attributes (e.g., preferences, barriers) to enable or constrain PA behavior. For instance, employees WFH may lose the opportunity for active commuting to the workplace, such as walking or cycling, which reduces their daily transport-related PA. At the same time, WFH may offer greater flexibility to incorporate short exercise breaks throughout the day or to engage in household and leisure-time PA, depending on their personal routines and home environment.

While prior research has mainly focused on analyzing the relationship between WFH and PA in samples of office workers, only a comparably small body of evidence on the relationship between WFH and PA in samples of university employees exists, despite the fact that WFH has also become widespread in the organizational context of universities (Feiten Haubrich & Hafermalz, 2022). Office workers constitute an occupational group whose tasks predominantly involve intensive networked computer use, resulting in high WFH ability across this population (Sostero et al., 2020). University employees, however, encompass a broader range of job roles and work areas, each with different tasks varying in their ability to be performed from home (Fountaine et al., 2014). Administrative employees, for example, primarily perform office-based tasks with high WFH ability, whereas both technical and academic employees perform tasks with varying WFH ability, ranging from activities that can be completed from home (e.g., IT support among technical employees; data analysis among academic employees) to tasks requiring on-site presence (e.g., managing and maintaining infrastructure or equipment among technical employees; conducting laboratory work among academic employees). The resulting variation in WFH patterns across job roles makes university employees an informative sample for examining the WFH-PA relationship. To the best of our knowledge, to date, only one cross-sectional study (Seludo-Ballena et al., 2021) and one diary study (Borowski et al., 2021) have examined the relationship between WFH and PA among university employees. While the findings of Seludo-Ballena et al. (2021) showed low overall PA levels among WFH university employees, the study by Borowski et al. (2021) did not find an association between WFH days and daily PA. Hence, existing studies investigated only PA while WFH and the within-subject relationship between WFH and PA by using a dichotomous operationalization of the work environment (i.e., WFH vs. working on-site). However, considering the relevance of hybrid work environments under post-pandemic conditions, the role played by the extent of WFH between different individuals may provide additional valuable insights into the association between WFH and PA among university employees. Therefore, this study aimed (a) to assess possible differences in PA outcomes (i.e., MPA levels, VPA levels, compliance with PA guidelines) between university employees who WFH and those who do not and (b) to examine how the extent of WFH (1–100%) influences PA outcomes (i.e., MPA levels, VPA levels, compliance with PA guidelines) of university employees. Moreover, following the results of a recent study (Kitano et al., 2024) that found interaction effects for several person- and work-related variables moderating the relationship between WFH and PA, additional analyses were conducted to investigate whether the relationships between both (a) the work environment (WFH vs. non-WFH) and PA and (b) the extent of WFH and PA were confounded by other factors such as gender, age, work area, or decision latitude. Given the limited evidence on the relationship between WFH and PA among university employees, this study follows an exploratory approach aimed at generating hypotheses for future confirmatory research rather than testing a priori hypotheses.

Methods

The current article is guided by the strengthening the reporting of observational studies in epidemiology (STROBE) statement (von Elm et al., 2007). The full STROBE checklist can be found in online Supplemental File 1.

Study design

Within this cross-sectional study, an online survey using the German platform SoSci Survey (https://www.soscisurvey.de; SoSci Survey GmbH, Munich, Germany) was conducted. All regular employees of the Karlsruhe Institute of Technology (KIT) were invited to participate in the survey via the institutional employee mailing list, with no additional exclusion criteria applied. The questionnaire was provided in German and English and was designed to be answered within 20 minutes. Data were collected between January and March 2024. Participation in the survey was voluntary and anonymous. The first page of the questionnaire included all the necessary information about the survey, its objectives, and the research group responsible for analyzing the data. This allowed individuals to make an informed decision about participating in the survey. The study was performed in accordance with the Declaration of Helsinki and was approved by the KIT Human Research Ethics Committee.

Procedure and participants

Participation in the survey was voluntary. Of the 10,034 participants invited, 2932 individuals completed the survey. Inclusion criteria were that participants were aged 18 years or older and not currently in an apprenticeship.

Measures

Working from home. Participants first indicated whether they used the option to work remotely (i.e., WFH or from other locations than the officially agreed on-site workplace) during the lecture period (yes/no). In line with previous research (Golden & Veiga, 2005), respondents who stated that they used the option to work remotely were asked to indicate the proportion of an average working week that they spent WFH (%). Using the information on the option of working remotely and the extent of WFH, a new dichotomous variable (*work environment*) was created distinguishing between participants who used the option of WFH and those who did not. If participants reported that they did not use the option to work remotely or use the possibility to work remotely but indicated 0% of an average working week as WFH, they were assigned to the group of non-WFH employees. Otherwise, they were assigned to the group of WFH employees.

Physical activity. To assess PA, the short version of the International Physical Activity Questionnaire (IPAQ-SF; IPAQ Research Committee, 2005a) was used. The IPAQ includes six items to assess the duration and frequency of VPA, MPA, and walking performed during the last 7 days (e.g., "During the last 7 days, on how many days did you do vigorous physical activities like heavy lifting, digging, aerobics, or fast bicycling?" or "How much time did you usually spend doing vigorous physical activities on one of those days?"). Data cleaning was performed following the standardized IPAQ Scoring Protocol (IPAQ Research Committee, 2005b). Previous research (Craig et al., 2003) has shown acceptable reliability and validity in measuring PA. Using PA data, an additional dichotomous variable (*compliance with PA guidelines*) was created to obtain information on whether participants met the international guidelines on PA of ≥ 150 min of MPA or ≥ 75 min of VPA per week declared by the WHO (World Health Organization, 2020) or not.

Person-related and work-related variables. In addition to the measures specified above, the following variables were assessed: age (18–35 years vs. 26–49 years vs. 50 years or older), gender (female vs. male vs. diverse), work area (science vs. administration vs. technical infrastructure), contractual scope (part-time vs. full-time), BMI (kg/m^2), and commuting duration to university (minutes/one-way). Finally, decision latitude, which refers to the extent to which an employee has the ability to manage their tasks and behavior throughout the workday (Karasek, 1979), was measured using three items from the Salutogenetic Subjective Work Analysis Questionnaire (SALSA; e.g., "You have the opportunity to make many decisions on your own"; Rimann & Udris, 2018). Items were assessed on a 5-point Likert scale ranging from 1 (*isn't true at all*) to 5 (*absolutely true*). Finally, values were averaged and categorized as follows: low (1.0–< 2.5), moderate (2.5–3.5), and high (> 3.5–5.0). The SALSA questionnaire has been evaluated as a reliable and valid measurement tool to assess subjective work characteristics in a previous study among German employees (Rimann & Udris, 1997). The decision latitude subscale demonstrated an internal consistency of Cronbach's alpha = 0.50 and satisfactory validity across occupational groups (Rimann & Udris, 1997; Richter et al., 2006).

Statistical analysis

Due to the result of Little's missing completely at random (MCAR) test ($p > 0.05$), missing data were excluded pairwise (Jekauc et al., 2012). With regard to the first objective, statistically significant (two-sided) differences between WFH and non-WFH employees in terms of MPA and VPA levels were determined via independent samples t tests, in compliance with PA guidelines via the chi-square goodness-of-fit test. Additionally, eight two-way factorial analyses of variance (ANOVAs) were applied to examine whether differences in MPA and VPA levels between WFH and non-WFH employees are dependent on person-related variables (i.e., gender, age) and work-related variables (i.e., work area, decision latitude). With regard to the second objective, a total of three regression models were applied. First, two multiple linear regression models were calculated to analyze the effect of the extent of WFH on MPA and VPA levels. Second, one multivariate logistic regression model was calculated to analyze the effect of the extent of WFH on compliance with PA guidelines. Prior to the analyses, model assumptions including linearity, multicollinearity, outliers, and distribution of the residuals were checked. In all regression models, person-related (i.e., age, gender, BMI) and work-related variables (i.e., job characteristics, work area, decision latitude, commuting time) were included as covariables. In addition, to test whether person-related variables (i.e., gender, age) and work-re-

Abstract

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The association between working from home and physical activity among university employees: a cross-sectional study

Abstract

In recent years, the home environment has become an integral part of many adults' daily working lives. While previous research has primarily focused on the general working population or the population of office workers, studies on the behavioral consequences of working from home (WFH) on physical activity (PA) among university employees are lacking. This study aimed to provide insights into the relationship between WFH and PA by comparing PA levels of WFH and non-WFH employees and exploring the role of the extent of WFH. A cross-sectional online survey ($n = 2932$) assessed WFH characteristics during an average working week and PA levels. Contrary to most previous findings, our results suggest that neither the work environment (i.e., WFH vs. non-WFH) nor the extent of WFH (1–100%) is associated with moderate-intensity PA (MPA), vigorous-intensity PA (VPA), and PA guideline compliance. However, we found a significant interaction effect for work area moderating the association between the work environment and MPA. Additionally, our analyses focusing on WFH employees revealed that age influenced MPA, while age, gender, BMI, and decision latitude influenced VPA. Interestingly, employees aged 50+ reported spending significantly more weekly MPA than those aged 18–35 years. Given the moderating role of work area, focusing on specific occupations or conducting occupation-specific analyses is crucial. In hybrid work arrangements, daily PA may fluctuate throughout the week.Therefore, future studies may explore the dynamic within-subject relationship between WFH characteristics and PA.

Keywords

Health behavior · Physical activity guidelines · Flexible work arrangements · Teleworking · University staff

Table 1 Participant characteristics for all workers, WFH workers, and non-WFH workers.

Characteristics	All workers	WFH workers[a]	Non-WFH workers
N	2710	1750	665
Age			
18–35 years	983 (37.7)	672 (38.7)	228 (35.0)
36–49 years	761 (29.2)	534 (30.8)	159 (24.4)
≥ 50 years	862 (33.1)	530 (30.5)	264 (40.6)
Gender			
Female	1385 (54.1)	985 (57.6)	281 (43.8)
Male	1177 (45.9)	726 (42.4)	360 (56.2)
BMI (kg/m²)	24.8 ± 4.4	24.6 ± 4.4	25.3 ± 4.4
Work area			
Science	1347 (50.2)	899 (51.5)	325 (49.4)
Administration	952 (35.5)	680 (39.0)	167 (25.4)
Technical infrastructure	383 (14.3)	166 (9.5)	166 (25.2)
Job characteristics			
Full-time	1917 (71.0)	1207 (69.1)	510 (77.0)
Part-time	782 (29.0)	541 (30.9)	152 (23.0)
Decision latitude			
Low	88 (4.3)	45 (3.0)	39 (7.4)
Moderate	469 (22.7)	316 (21.1)	142 (26.9)
High	1508 (73.0)	1140 (75.9)	347 (65.7)
One-way commuting time (min)	34.8 ± 34.6	35.8 ± 32.8	30.2 ± 19.1

Data are presented as mean ± standard deviation for continuous variables and ***n*** (%) for categorical variables, ***BMI*** body mass index, ***WFH*** working from home

[a]Participants who indicated that ≥ 1% of their average working week was spent WFH were assigned to the group of WFH employees

lated variables (i.e., work area, decision latitude) confounded the relationship between the extent of WFH and levels of MPA and VPA, eight moderation models including WFH as a predictor variable, the respective person- or work-related variable as the moderator, and the interaction of the two were calculated. Only significant interaction terms were included in the final regression models (Field, 2009). Participants who identified as gender-diverse were removed from further analyses, as the number of cases was below the recommended minimum of observations per independent variable in regression analysis (Harrell et al., 1996; Stoltzfus, 2011). All statistical analyses were performed using SPSS Statistics version 29 (IBM, 2022), except for the application of the eight two-way factorial ANOVAs to gain additional insights into the relationship between the work environment (WFH vs. non-WFH) and PA. As SPSS does not support the implementation of corrections based on the Welch procedure, robust versions of the two-way factorial ANOVAs were performed in R Version 4.4.1 via the WRS package (Mair & Wilcox, 2020). The alpha level was set a priori to 0.05. To control for potential type 1 errors due to multiple testing, Holm–Bonferroni sequential corrections were applied to significant results for the main predictor (i.e., work environment [WFH vs. non-WFH], extent of WFH [1–100%]) across each set of tests addressing objective 1 and 2, as well es within the additional analyses (Kowalski & Enck, 2010). For the eight two-way factorial ANOVAs, significant interaction effects were followed by Bonferroni adjusted post hoc tests (Kowalski & Enck, 2010), and partial eta-square (η^2_p) was calculated as an estimate of effect size (Cohen, 1973).

Results

Participant characteristics

After the exclusion of 222 participants due to several reasons (< 18 years old: $n = 23$; in an apprenticeship: $n = 155$; insufficient data: $n = 44$), data from 2710 participants were included in the statistical analyses. Characteristics of the study population are presented in **Table 1**.

Differences in PA between WFH employees and non-WFH employees

On average, WFH employees reported lower MPA levels ($M = 221.9$ min/week, $SD = 254.0$) and VPA levels ($M = 161.0$ min/week, $SD = 184.6$) than non-WFH employees (MPA: 249.8 min/week ± 300.0; VPA: 165.6 ± 224.8). However, the results of the independent *t* tests indicated no significant differences between WFH and non-WFH employees regarding both their MPA levels—$t(839) = 1.94$, $p = 0.053$—and their VPA levels, $t(822) = 0.43$, $p = 0.67$. Additional robustness analyses excluding employees with WFH extents of 10% and below ($n = 286$) from the group of WFH employees revealed that the difference in PA levels between WFH and non-WFH employees remained nonsignificant for VPA: $t(834) = 0.53$, $p = 0.60$. However, the effect of the work environment on MPA reached statistical significance—$t(875) = 2.03$, $p = 0.042$—just below the alpha level of 0.05.

Robust versions of the two-way factorial ANOVA revealed significant interaction effects between the work environment (WFH vs. non-WFH) and the work area ($F = 14.18$, $p = 0.002$, $\eta^2_p = 0.014$; see online Supplemental File 2, Supplemental Figure S1) and age ($F = 7.96$, $p = 0.020$, $\eta^2_p = 0.008$) on MPA levels. However, after performing a Bonferroni–Holm sequential correction for multiple tests, the interaction between the work environment and age was no longer statistically significant ($\alpha_{adjusted} = 0.007$). Robust post hoc tests using a Bonferroni-adjusted alpha level of 0.0167 indicated that the difference in MPA levels between WFH and non-WFH differed significantly in (a) scientific employees and technical employees ($p < 0.01$) and (b) in administrative employees and technical employees ($p < 0.01$). Descriptive statistics of MPA levels by work environment and work area are presented in Supplementary Table S1

Table 2 Regression analyses to predict MPA time, VPA time, and compliance with PA guidelines among WFH workers

	Model 1_a: MPA time (min/week)				Model 1_b: VPA time (min/week)				Model 1_c: Compliance with PA guideline (no/yes)	
	b (SE)	Stand. BC	t	p	b (SE)	Stand. BC	t	p	OR	95% CI
Intercept	252.85 (56.41)	–	4.48	< 0.001	324.33 (41.35)	–	7.84	< 0.001	11.24	–
Extent of WFH	−0.05 (0.35)	−0.005	−0.15	0.879	−0.09 (0.26)	−0.010	−0.35	0.73	1.00	1.00, 1.01
Female[a]	−3.24 (16.27)	−0.006	−0.20	0.842	−42.41 (11.94)	−0.113	−3.56	< 0.001	0.68	0.51, 0.92
Age: 36–49 years[b]	33.29 (18.14)	0.062	1.84	0.067	−40.96 (13.30)	−0.101	−3.08	0.002	0.83	0.60, 1.14
Age: ≥ 50 years[b]	80.26 (18.50)	0.146	4.34	< 0.001	−21.67 (13.63)	−0.053	−1.59	0.11	1.20	0.86, 1.70
BMI	−1.88 (1.72)	−0.032	−1.09	0.276	−4.03 (1.26)	−0.092	−3.19	0.001	0.95	0.92, 0.98
Commuting time	0.22 (0.21)	0.031	1.05	0.292	0.01 (0.16)	0.002	0.06	0.96	1.00	1.00, 1.00
Decision latitude: low[c]	−15.86 (42.51)	−0.011	−0.37	0.709	1.03 (31.47)	0.001	0.03	0.97	0.83	0.40, 1.75
Decision latitude: moderate[c]	−28.32 (18.58)	−0.045	−1.52	0.128	−27.58 (13.61)	−0.059	−2.03	0.04	0.73	0.53, 1.01
Full-time job[d]	−5.40 (16.34)	−0.010	−0.33	0.741	13.82 (12.02)	0.034	1.15	0.25	1.12	0.84, 1.49
Work area: science[e]	−7.00 (25.93)	−0.014	−0.27	0.788	−27.03 (19.04)	−0.072	−1.42	0.16	1.12	0.70 1.77
Work area: administration[e]	−28.55 (27.09)	−0.055	−1.05	0.292	−21.92 (19.88)	−0.056	−1.10	0.27	1.10	0.68, 1.78
	$n = 1230$; $R^2 = 0.020$				$n = 1248$; $R^2 = 0.039$				$N = 1255$; −2 log Likelihood = 1414.22; $R^2 = 0.037$	

MPA moderate-intensity physical activity, *VPA* vigorous-intensity physical activity, *WFH* working from home, *CI* confidence interval, *SE* standard error, *OR* odds ratio
[a]Compared to males
[b]Compared to participants aged 18–35 years
[c]Compared to participants with high decision latitude
[d]Compared to participants with a part-time job
[e]Compared to work area: technical infrastructure

(see online Supplemental File 2). No significant interaction effects of gender ($F = 0.93$, $p = 0.333$) and decision latitude ($F = 0.87$, $p = 0.650$) on the relationship between the work environment (non-WFH vs. WFH) and MPA levels were found. Regarding the relationship between the work environment (non-WFH vs. WFH) and VPA levels, no significant interaction effects of gender ($F = 1.46$, $p = 0.228$), age ($F = 1.49$, $p = 0.478$), work area ($F = 0.83$, $p = 0.662$), and decision latitude ($F = 0.77$, $p = 0.685$) were found.

The percentage of WFH employees who met the PA guidelines (74.3%) was greater than the percentage of non-WFH employees (70.9%). Nonetheless, no significant differences were found between WFH and non-WFH employees in terms of their compliance with PA guidelines ($\chi^2 = 2.39$, $df = 1$, $p = 0.12$).

Influence of the extent of WFH on PA

Table 2 shows the results of the regression analyses on MPA time (model 1_a), VPA time (model 1_b), and compliance with PA guidelines (model 1_c). In all models, the extent of WFH did not significantly predict PA outcomes. However, several covariates were significantly associated with PA outcomes. For example, age significantly influenced MPA time. Specifically, participants aged > 50 years spent 80 min more time per week in MPA than participants aged 18–35 years (see **Table 2** for more details). Based on the results of the moderation models, no interaction terms were included in the final regression models predicting MPA time (model 1_a) and VPA time (model 1_b).

Discussion

The current study aimed to provide insights into the relationship between WFH and PA among university employees by focusing on differences between WFH and non-WFH employees and on the role played by the extent of WFH between different individuals. Our results provide first evidence that neither the work environment (i.e., WFH vs. non-WFH) nor the extent of WFH (1–100%) is associated with PA outcomes (i.e., MPA levels, VPA levels, compliance with PA guideline) in a sample of over 2500 university employees. Nonetheless, our results emphasize that the association between the work environment and MPA varies according to the area of work.

Our observation of no association between the work environment and PA for the entire sample of university employees is both in line with and in contrast to the results of previous investigations (Fukushima et al., 2021; Loef et al., 2022; Prince et al., 2024).A recent study by Prince and colleagues (2024) revealed that persons teleworking were not more likely to meet the PA recommendations compared to persons working at a fixed workplace. By contrast, Loef et al. (2022) showed that home workers were less likely to meet the PA recommendations than workers who worked on-site or in multiple locations during the pandemic, and Fukushima et al. (2021) reported lower moderate-to-vigorous PA levels among individuals WFH compared with individuals who do not WFH. A possible explanation for divergent findings may be the use of different samples. While our study focused on the population of university employees, the other studies (Fukushima et al., 2021; Loef et al., 2022; Prince et al., 2024) analyzed data from the general working population, which includes a wide range of occupational groups. Considering the results of a previous study (Prince et al., 2019) showing occupational group-related differences in PA while working on-site, possibly due to differences in work-related tasks, work organization (e.g., schedule autonomy), health literacy (e.g., awareness of PA recommendations), and behavioral patterns (e.g., active commuting routines), a high heterogeneity of occupational groups within study samples may affect results on the association between WFH and PA. The results of our analyses support this assumption, as the work area was found to be a moderator of the relationship between the work environment and PA. To address this challenge, we call for future studies to either focus on specific subgroups of workers (e.g., specific occupational groups) or to conduct subgroup-specific analyses when examining the relationship between WFH and PA. Another possible reason for this inconsistency between observations may be the respective data collection periods. While we collected data under post-pandemic conditions, the aforementioned studies collected data during the COVID-19 pandemic, when measures to contain the spread of the virus were implemented, which in turn may have affected PA levels (Wunsch et al., 2022). In light of the results of our robustness analyses, which revealed differences in MPA levels between work environments when employees with minimal WFH engagement ($\leq 10\%$) were excluded, future research would also benefit from examining how the extent of WFH engagement in the definition of WFH groups may influence findings when comparing work environments.

Following the suggestion of a previous review to examine potential moderators of the relationship between WFH and PA (Sers et al., 2025), our exploratory analyses revealed no significant interaction effects for age, gender, and decision latitude. By contrast, Kitano and colleagues (2024) identified age, gender, and job type as effect modifiers. Methodological discrepancies may provide a possible explanation underlying this inconsistency across observations: Whereas Kitano and colleagues (2024) focused on the overall amount of PA, our analyses focused on MPA and VPA, which may reduce variance and statistical power to detect moderation effects. Moreover, Kitano et al. (2024) used a more liberal significance threshold for interaction tests ($p < 0.20$), whereas we applied a conservative threshold with Bonferroni–Holm correction ($p < 0.05$), further decreasing the likelihood of detecting subtle interactions.

In contrast to our results on the relationship between the extent of WFH and PA, two previous studies (Fukushima et al., 2021; Kitano et al., 2024) found differences in PA levels between WFH subgroups categorized by their WFH frequency. In both studies, the highest PA levels were observed in the subgroups with the lowest WFH frequency, whereas the lowest PA levels were observed in the subgroups with the highest WFH frequency, suggesting a possible dose–response relationship. One reason that may explain the inconsistency of results depicts the operationalization of PA and WFH. While the analysis of Fukushima et al. (2021) focused solely on work-related PA, thus not considering the influence of WFH on other domains (e.g., leisure-time), Kitano et al. (2024) operationalized the extent of WFH as days per week (i.e., 1–2 days, 3–4 days, ≥ 5 days). Given the potential inclusion of both full-time and part-time workers, the assessment of days may introduce bias into the evidence on the relationship between WFH and PA, as this operationalization does not account for the actual extent of work performed from home. Conversely, assessing the extent of WFH by using the percentage of work time spent WFH allows for a more accurate examination of the relationship between WFH and PA when examining both part-time and full-time employees. However, to fully understand the dose–response relationship between WFH and PA, future studies may need to capture not only the extent of WFH but also the actual distribution of working hours and leisure-time across a predefined timeframe (e.g., day or week).

Interestingly, in contrast to most previous studies that have shown declining rates of PA across the lifespan (Dumith et al., 2011), in our sample, employees aged 50 years or older spent significantly more time per week in MPA than participants aged 18–35 years. Differences in life or career stages and associated differences in time use may explain why MPA differs by age. Whereas younger people often have a range of family responsibilities, such as caring for children (Marcum, 2013), and are at an early stage in their careers, requiring extended working hours to cope with work demands (Fontinha et al., 2019), older people tend to have more leisure time that could be used for MPA.

In our study, we focused on differences between WFH and non-WFH employees, as well as on variations in the extent of WFH among employees, resulting in between-subject findings on the relationship between WFH and PA. Nonetheless, recent studies (Sers et al.,

2023) indicate that the relationship between WFH and PA may vary depending on the methodological approach used (i.e., within-subject perspective vs. between-subject perspective). Therefore, future studies would benefit from collecting intensive longitudinal data on PA and the work environment to enable dynamic within-subject analyses (i.e., day-to-day), which are particularly important when analyzing the association between WFH and PA in the context of hybrid work arrangements combining days WFH and days working on-site. Moreover, it might be interesting to capture the specific work tasks (e.g., administrative, teaching, technical) during participants' everyday life to provide a more complete picture of PA behavior across different work environments.

Limitations and delimitations

Finally, this study has some limitations and delimitations that should be acknowledged. First, PA constructs were assessed via an online questionnaire. As self-reports are prone to both response and recall biases, PA levels may be over- or underestimated (Prince et al., 2008). However, we were only able to examine such a large sample of university employees by applying an online survey. Second, we cannot exclude the influence of hidden or unmeasured third variables which may have affected the findings. Nonetheless, we adjusted for the potential confounding role of several person- and work-related variables in our analyses and performed several moderation analyses. To further deepen the understanding of the relationship between WFH and PA, future research may benefit from an interdisciplinary perspective exploring the influence of job resources and demands, perceived workload, and work culture. Third, we used listwise deletion to handle missing data, despite the fact that some researchers insists that this method may introduce bias in the estimation of the parameters. However, if the MCAR assumption is met, it is known that listwise deletion will produce unbiased estimates and conservative results (Kang, 2013). Fourth, due to the cross-sectional design of this study, no causal conclusions on the effect of WFH on PA can be drawn. Future research may be interested in conducting longitudinal studies and experiments to further examine how WFH affects PA. Finally, our analyses focused exclusively on university employees, potentially limiting the generalizability of results to other occupational groups able to WFH.

Conclusion

Contrary to the findings of most previous studies, working from home (WFH) was not associated with levels of moderate-intensity physical activity (MPA), vigorous-intensity PA (VPA), and compliance with the World Health Organization PA guideline in our sample of university employees. However, due to the moderating role of work area on the relationship between the work environment (i.e., WFH, non-WFH) and MPA levels, we call for future studies to either focus on specific occupations or to perform occupation-specific analyses. Concerning the sample of university employees, future research may be interested in elucidating dynamic within-subject associations between WFH and PA in the context of hybrid work arrangements to provide a more comprehensive understanding of the behavioral consequences of WFH.

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Declarations

Conflict of interest. S. Sers, H. Wäsche, M. Giurgiu, C. Hildebrand, P. Bachert, K. Wunsch and A. Woll declare that they have no competing interests.

The study fully conformed to the Declaration of Helsinki. All participants gave fully informed consent prior to completing the survey. Full ethical approval was obtained from the Ethics Committee of the Karlsruhe Institute of Technology (19 September 2023).

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