

DAILY REPORTS ON WORK ENGAGEMENT, PRODUCTIVITY, COGNITIVE ABILITY, AND PSYCHOLOGICAL DETACHMENT FROM WORK FOR ADULTS WITH OR WITHOUT PHYSICAL ACTIVITY AFTER WORK

Velta Krūpena,¹ Sanita Šaitere

Abstract

The long-term benefits of physical activity (PA) on both physical and psychological well-being are well proven (see meta-analysis by Reed & Ones, 2006). The association between PA and important organizational variables as employees' psychological detachment from work during leisure time, next day's work engagement, productivity, and cognitive ability, however, has not been sufficiently examined in the context of organizations. The aim of this study was to compare adult groups that engaged in PA after work to those who did not in order to study daily dynamics of these variables. In this study, 42 participants, aged 21 to 52, 33 women and nine men - took part over the duration of 5 days. Between groups, there were no significant differences found in any of the organizational variables, however, a significant day effect of the measurement was observed in daily (state) work engagement (SWE) and its subscale vigor, as well as in productivity and cognitive ability. The effect of the interaction between the measurement day and the group was significant for psychological detachment measure.

Keywords: work engagement, productivity, psychological detachment from work, cognitive ability, physical activity

¹ Corresponding author: University of Latvia, Department of Psychology, Faculty of Education, Psychology and Art, Imantas 7. linija 1, Riga, LV-1083, Latvia. Email: vel_ta@yahoo.com

The role of PA in health improvement has been discussed since the early 1980s (Biddle et al., 2000; Faulkner & Taylor, 2005). PA is becoming increasingly important for long-term health in today's sedentary work environment (Owen et al., 2009). Meta-analytic studies have shown the long-term positive effects of PA on both physical health and psychological well-being (Reed & Ones, 2006, 477–514).

Organizations have begun to implement various programs to enhance employees' physical and psychological well-being (e.g., by providing support for sports activities), but there is a lack of scientific research to explain the benefits and promote the implementation of employee health promotion in organizations (Calderwood et al., 2015). There is a need to specify when, how, and why employee's physical activity affects job performance, even though it is commonly acknowledged that it has an impact on employee wellbeing and healthcare expenses for organizations (Calderwood et al., 2020).

Work engagement

A popular definition for work engagement is “[...] a positive, fulfilling, work-related state of mind that is characterized by vigor, dedication, and absorption” (Schaufeli et al., 2002, p. 74). Employee engagement is a highly valued outcome for both individuals and organizations, as engaged employees have high levels of energy, they are enthusiastically involved in their work, believe in themselves, offer valuable feedback, and have values that are aligned with the organization (Schaufeli et al., 2002). State work engagement (SWE) has been defined as a transient, work-related experience that fluctuates within individuals over a short period of time (Sonnentag et al., 2010). The diary research method or daily study helps to uncover the dynamic part of SWE and provides an opportunity to test the most important predictors of work engagement (Xanthopoulou et al., 2009). Off-job activities (e.g., physical activity) contribute to recovery to the extent that they allow employees to replenish their personal resources. The relationship between off-job activities and recovery is described as a mediated process: activities lead to recovery through relaxation and psychological detachment from work outside working hours (Fritz & Sonnentag, 2006, as cited in ten Brummelhuis & Bakker, 2012).

Hypothesis 1: General work engagement is positively related to SWE.

Productivity

Productivity is a measure of efficiency of a person completing a task (Clear, 2018). The more productive employees are on everyday basis, the greater the cumulative effect on not only their overall performance, but also an organization's

broader success (Vogel et al., 2021). Research over the past decade has shown that a particularly important factor driving employee productivity is the level of employee engagement at work (e.g., Christian et al., 2011; Parke et al., 2018; Rich et al., 2010, as cited in Vogel et al., 2021).

Hypothesis 2: SWE is positively related to productivity.

Psychological detachment from work

For employees to be engaged at work, it is necessary to be psychologically detached from work for a certain period of time (Sonnentag et al., 2008). Psychological detachment from work is a basic experience through which employees can reduce symptoms of stress and replenish their resources. These resources, in turn, promote engagement at work through vigor, dedication and absorption (Schaufeli & Bakker, 2004; Xanthopoulou et al., 2009). When employees stop thinking about work and psychologically disengage from work, recovery from work effort and strain occurs (Sonnetag & Fritz, 2015). By disengaging from work issues and problems, employees stop using the resources that were being consumed by actively engaging at work. Moreover, psychological detachment from work leads to replenishment of resources used and has a positive impact on well-being (ten Brummelhuis et al., 2012).

Hypothesis 3: previous evening psychological detachment from work is positively related to the next day's SWE, vigor, and productivity.

Cognitive ability

This study focuses on cognitive ability such as working memory and attention, which are part of executive functions (according to Diamond, 2013). Working memory capacity is considered a crucial factor in cognitive ability and it is assumed that general intelligence can be well predicted by working memory alone (Sternberg, 2016). Working memory is a central cognitive function that enables the encoding, storage, and manipulation of information over short periods of time (Miyake & Shah, 1999). Attention can be defined as “the resources by which we actively process a limited amount of information from the tremendous amount of information available through our senses, memory and other cognitive processes” (Sternberg & Sternberg, 2012, 137). Individual differences in working memory capacity show performance at different levels of complexity, ranging from simple tasks such as following simple instructions and taking notes to more complex tasks involving reasoning and problem solving (Engle et al., 1999), performing multiple tasks in parallel (Hambrick et al., 2010), learning (Lewandowsky, 2011) and decision-making (Franco-Watkins et al., 2016) (as cited in Edwards et al., 2017).

Working memory can be an important indicator of employee productivity and performance in organizations. In a study by Bosco and colleagues, working memory predicted employee performance as highly as general psychological ability, and in some cases exceeded it (Bosco et al., 2015). Therefore, it is important to examine PA (type, intensity and duration) as way of detachment from work to enhance working memory and attention, as these are significant performance-related variables.

Physical activity

PA is any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985, p. 126). PA can be categorised in different sub-categories e.g., according to its type (Caspersen et al., 1985) as sport (e.g., fitness training), leisure-time PA (e.g., walking), housework (e.g., cleaning) and other PA. A growing body of research suggests that exercise has positive effects on cognitive function and affective experiences in addition to the well-documented physical health advantages – more details in the next chapter.

The relationship between off-job physical activity, psychological detachment from work, next day work engagement, productivity, and cognitive ability

Today's organizations expect their employees to be proactive, take responsibility for their own professional development and ensure high quality standards. Employers need employees who feel energised, dedicated, and absorbed in their daily work (Bakker & Schaufeli, 2008). Trying to meet the high-quality job demands, employees can leave feeling overworked, and lose motivation and passion for their work (Peeters et al., 2005). To maintain health and psychological well-being, employees need to recover; they need time to rest and replenish resources depleted at work (Zijlstra et al., 2014). Psychological detachment from work is an essential experience for employees to relieve symptoms of stress and replenish their psychological resources (Schaufeli & Bakker, 2004; Xanthopoulou et al., 2009). Leisure-time activities such as PA are one way of psychologically detaching yourself from work. Leisure activities (social, low-intensity activity or PA) can be meaningful and exciting activities that give employees an experience of being away from work (Kaplan, 1995). Off-job activities influence recovery through relaxation and psychological detachment from work (ten Brummelhuis & Bakker, 2012). There is strong evidence that higher levels of PA help maintain optimal cognitive function and slow cognitive decline with ageing (Biddle et al., 2021). Moderate- and high-intensity exercise lasting between 5 and 30 minutes

is associated with better psychological well-being and positive affect (Barton & Petty, 2010; Cox et al., 2006; Daley & Welch, 2004; Hansen et al., 2001, as cited in Hogan et al., 2013). PA reduces tension, stress and anxiety, thereby improving employees' productivity at work (Lindwall et al., 2014), and PA after work or on weekends is associated with better physical and mental health (Cho & Park, 2018, Wiese et al., 2018). Research in organizations shows that PA after work promotes recovery, increasing the likelihood that an employee will feel more energised and recovered the next day (Feuerhahn et al., 2014; ten Brummelhuis & Bakker, 2012). Based on theories about the different variables that are critical for organizations and their relationship to PA, the study addresses the following two hypothesis:

Hypothesis 4: There is a difference between the PA group and no PA group in SWE, productivity, cognitive ability, and psychological detachment from work.

Hypothesis 5: SWE, productivity, cognitive ability, and psychological detachment from work changes over the course of the study (within one working week).

Method

The study employed diary design for capturing daily dynamics (e.g., Iida et al., 2012) of the variables in two groups, i.e., a daily study of group with PA after work and group without PA, by collecting repeated measurements for SWE, productivity, cognitive ability, and psychological detachment from work.

The study was conducted in three stages: a pre-pilot study, a pilot study, and a main quasi-experimental study. Important notice, the study took place in 2021–2022 under various restrictions related to pandemic Covid-19, which also affected the work of organizations and life of employees. The pre-pilot study ($N = 4$, two participants in the PA group and two in the no PA group) was conducted for 2 days. Its purpose was to test the design administration, and technical aspects of the online data collection. The pilot study ($N = 9$) was conducted for 5 consecutive working days. Its objectives were to test the process and gain expertise in conducting the diary study (i.e., data monitoring, sending reminders, communicating with participants, retaining participants, checking the responsiveness of surveys and tests on mobile devices and computers, as well as other questions) and collecting feedback from participants.

During the pre-pilot study and the pilot study, a number of issues were identified and taken into account in designing the main study's design and procedure. Two participants strongly preferred to do PA *before* work and two participants actually worked shift work. Both conditions were incompatible with the study procedure. Several participants did not respect the time frame for the surveys, e.g., they delayed completion of the survey scheduled for the morning until the evening. For this reason, the data collection for the main study was carefully monitored several times daily and reminders were sent for missing surveys. It was not possible

to randomize participants into groups because some participants did not agree to change their lifestyle even for a week (e.g., participants with an active lifestyle did not agree not to exercise during the study week). Therefore, the main study was designed as a 2 × 5 quasi-experiment (5 days by 2 groups).

Participants

Latvian residents, persons aged 18 and over, employed full-time and working regular working hours (8 hours per day, within 8 am to 6 pm, from Monday to Friday) were invited to participate in the study. The sample was chosen based on the principle of availability – the snowball effect. Participants were approached by an application form published on the social networking platform Facebook. The application questionnaire called for voluntary participation for 5 consecutive workdays of research on various off-job activities and work. In addition to the survey, short videos were also posted on the Facebook and Instagram inviting participants to sign up for the study. Sixty-three respondents applied for participation in the study by filling out the survey. After receiving detailed information about the study, including the daily activities and reports, 31% of the respondents recalled their participation, thus, 49 participants started the study. Forty-two participants completed the study, i.e., adhered to the study protocol and submitted all surveys. Five participants dropped out during the study, and 2 participants were excluded from further data analysis because they did not comply with the study procedure.

Measures

Utrecht Work Engagement Scale (UWES-9, Schaufeli & Bakker, 2003), adapted in Latvian by Kronberga (2013). This is one of the most widely used surveys in organizations worldwide to study employee engagement at work (Schaufeli et al., 2006). The method consists of nine statements measured by a Likert scale from 0 to 6, where 0 is *never* and 6 is *always/every day*. The survey distinguishes three dimensions of engagement: *Vigor* (e.g., “At my job I feel strong and vigorous”), *Dedication* (e.g., “I am enthusiastic about my job”), *Absorption* (e.g., “I feel happy when I am working intensely”). The overall internal consistency of the General (trait) Work Engagement Survey was at an excellent level: $\alpha = 0.91$ (original $\alpha = 0.93$, Schaufeli & Bakker, 2004, Latvian version $\alpha = 0.92$, Kronberga, 2013), subscale reliability is at a good and acceptable level (vigor $\alpha = 0.84$, dedication $\alpha = 0.80$, absorption $\alpha = 0.67$). This survey and the survey of the demographic indicators (gender, age, level of education, work tenure in the current workplace, position level) were administered once, on the weekend preceding the workweek of the diary study.

Starting on Monday morning, daily measurements were made with four questionnaires and one test:

Daily work engagement survey (State Work Engagement (SWE), Breevaart et al., 2012; based on the Utrecht Work Engagement Scale – UWES-9, Schaufeli & Bakker, 2003), adapted in Latvian by Berga, 2016). The survey consists of nine statements that measure engagement at work on a given day (e.g., “Today at my job I felt strong and vigorous”), measured by a 6-point Likert scale (0 – *strongly disagree* to 6 – *strongly agree*). The internal consistency of SWE survey is excellent $\alpha = 0.94$ – 0.96 ($\alpha = 0.93$ in the original study, Breevaart et al., 2012 and $\alpha = 0.93$ in the Latvian version, Berga, 2016).

Psychological detachment from work (Sonnetag & Fritz, 2007, adapted in Latvian by Berga, 2016) consisting of four statements (measured by a 5-point Likert scale where 1 – *strongly disagree*, 5 – *strongly agree*). Survey questions were asked about the employee’s ability to psychologically detach oneself from work the night before, in the free time (e.g., “Today, I was able to distance myself from my work”). The Cronbach’s alpha for the psychological detachment scale is at the good to excellent level: $\alpha = 0.88$ – 0.95 ($\alpha = 0.85$ in the original study, Sonnetag & Fritz, 2007 and $\alpha = 0.91$ in the Latvian version, Berga, 2016).

Self-assessment of daily work productivity (2 questions created by the author about the perceived productivity of the current working day, i.e., “Today, I rate my overall productivity (compared to my average daily work performance) as”: *low*, *medium* or *high* and “Were there any special or atypical circumstances that greatly increased or decreased your performance today”: *yes, it greatly increased*; *yes, it greatly decreased*; or – *no, it was a typical working day*”).

Self-assessment of daily PA (for the PA group only) (3 questions about performed PA: type of activity by participants’ choice, duration (minimal requirement was 20 min), intensity: *low*, *medium*, *high*), and how pleasant it was (rated on 3-point Likert scale, from 1 (*not so pleasant*) to 3 (*very pleasant*). Both groups had control questions – the PA group about whether they exercised for at least 20 minutes after work, and the no PA group about whether they rested quietly and avoided physical exertion.

Self-assessment of sleep quality (“how do you rate the quality of sleep last night” (from 1–5) and “how many hours did you sleep last night”) was introduced as control variable as sleep quantity and quality affect cognitive ability.

Digit Span test (Terman, 1916; Vanags & Ekmanis, 2018) on the online test platform www.exploro.lv. The test is used to measure verbal short-term or verbal working memory ability (Richardson, 2007). The test is widely used in cognitive, neuropsychological test batteries (i.e., Wechsler, Halstedt-Reitan test batteries). The numerical memory test, computerized version (Vanags & Ekmanis, 2018) was created using the Binet-Simon subtest paradigm (Terman, 1916). The task is to memorize strings of numbers shown on the screen and enter the correct numbers

in the correct order in the blank spaces. The number of digits gradually increases and as soon as the number of errors reaches the critical level, the test is finished. The test has two parts: first, numbers must be entered in the presented order, measuring the efficiency of attention and working memory capacity, in the second part, numbers must be entered in the reverse order - measuring information updating and switching functions (Vanags & Ekmanis, 2018).

Procedure

The participants provided informed consent, after received full information about study procedure and after their eligibility for the study was tested by the introductory survey. Participants had the option to choose a study group according to their lifestyle: the group with PA after work (PA group) or the group with physical *rest* after work (no PA group). Each participant received a YouTube link to the corresponding video instruction as the protocol differed for each of the conditions. The PA group had to do at least 20 minutes of PA every day after work, while the no PA group had to do quiet activities after work, such as relaxation, homework, etc. of their choice, avoiding physical exertion of more than 20 minutes even in daily activities (household tasks etc.). Each evening, along with the day's last questionnaire, both groups were asked a control question about adherence to the group procedure. Before the diary measurements started on Monday, participants were invited to complete the trait work engagement and demographics questionnaire once over the weekend. See Table 1 for the daily protocol and diary measures.

Table 1. The daily protocol and diary measures

Time of day	PA ^a group	no PA ^b group	Saturday or Sunday	Monday to Friday
All day	☑	☑	Demographic data & Trait work engagement questionnaire	
Morning (6 am–11 am)	☑	☑		Self-assessment of sleep quality Digit Span Test
Afternoon (4 pm–7 pm)	☑	☑		SWE questionnaire Self-assessment of work productivity
Evening (after work)	☑	☑		Intervention: PA Self-assessment of PA
Evening (before sleep)	☑	☑		Psychological detachment from work scale

^a PA – group with PA after work, ^b no PA – group without PA after work

All communication related to the study was done electronically – links to the study surveys were sent via email and reminders were sent via the participant's preferred channel (email, WhatsApp or text message). Participants received three links per day, Monday to Friday, at three times: in the morning before work, after work, before bedtime; in addition, the PA group received a reminder to exercise and a link to a questionnaire about it. The survey questionnaires were administered by QuestionPro online survey software, and the cognitive ability test was provided on the Exploro.lv platform.

At the end of the study, participants were offered an online debriefing session and were invited to share their experience of the study by completing a short survey (optionally). There was no monetary reward for participation in the study, but there was a prize draw for participants who successfully completed the weekly study (two cinema tickets for one winner for each week of the study), as well as two optional offers: for the individual cognitive ability test result with a description and a free individual consultation. The draw for the cinema tickets was conducted electronically using a digital lottery tool and the results were communicated to the participants via email.

Data analysis was carried out using IBM SPSS Statistics V22.0 and JASP Team V0.16.2. Given the repeated measures design used in the study, group differences were analysed using a parametric two-way analysis of variance (ANOVA). The measurement day was used as a within-group factor with 5 levels, and the PA group was used as a between-group factor with 2 levels, i.e., a 2×5 within-between ANOVA was used to analyse each day's work engagement, vigor, productivity, cognitive ability, and psychological detachment scores. The normal distribution was tested with Shapiro-Wilk test. For the measurements of cognitive ability (Digit Span test), the MANOVA method was first applied, and then separate ANOVA tests were used. Effect size was measured by partial eta squared. Contrast analysis was followed to determine the differences between measurement days. P-value correction for multiple comparisons was done according to the Holm method. Spearman's Rank Correlation Coefficient was used to test the hypotheses. P-values below 0.1 were considered as statistically significant, in line with the recommendations for small sample sizes (e.g., Thieme et al., 2016).

Results

Demographics and Additional Measurements (Control Variables)

The data from both research weeks were merged for use in the subsequent data analysis because no significant differences in demographic and main variable results were found when comparing means between the two weeks during the descriptive statistical analysis. The demographic data characterizing the PA and no PA groups are presented in Table 2.

Table 2. Demographic characterizing of respondent groups (N = 42)

Demographic variable	Description	PA group (n = 21)		No PA group (n = 21)	
		n	%	n	%
Gender	Woman	17	81%	16	76%
	Man	4	19%	5	24%
Age range	21–24 years	4	19%	2	10%
	25–34 years	9	43%	5	24%
	35–44 years	7	33%	10	48%
	45–52 years	1	5%	4	19%
Education	Secondary	4	19%	3	14%
	1st level higher	2	10%	1	5%
	Higher	15	71%	17	81%
Work tenure (in the current position)	Up to 1 year	3	14%	4	19%
	1–3 years	7	33%	4	19%
	4–8 years	7	33%	6	29%
	9–15 years	2	10%	6	29%
	16–26 years	2	10%	1	5%
Position level	Skilled worker/ Professional	4	19%	5	24%
	Office worker/ Specialist	12	57%	12	57%
	Senior specialist/Mid-level manager	5	24%	3	14%

Additionally, measurements of sleep duration and quality (as a control variable) were made. Participants in the PA group slept an average of 7.16 hours every day, compared to 7.04 hours for those in the no PA group. Between the study groups, there were no significant differences in the measurements of sleep duration ($t(40) = 0.49, p = .96$). Weekly sleep quality for both groups is average ($M = 3.51$ for the PA group and $M = 3.31$ for the no PA group, range 1–5). When examining sleep quality by day, the following days show a significant difference between groups: D1 ($t(40) = -1.94, p = .058$), D3 ($t(40) = 1.80, p = .079$), and D5 ($t(40) = 1.82, p = .076$).

Physical activity – PA group intervention

Walking (51%), yoga or pilates (20%), and strength training (14%) were the most prevalent physical activities during the research week. The PA was, on

average, of low to medium intensity (D1: $M = 1.67$, D2: $M = 1.52$, D3: $M = 1.81$, D4: $M = 1.57$, D5: $M = 1.48$) (range 1–3). On average, only 11.4% of the participants took part in high intensity activity daily. The participants reported that performed activity felt moderately to very pleasant (D1: $M = 3.0$, D2: $M = 2.7$, D3: $M = 2.7$, D4: $M = 2.8$, D5: $M = 2.8$) (range 1–3). The average daily time spent in PA was 58.04 minutes (range 20 to 200, daily means D1: $M = 61.33$, D2: $M = 50$, D3: $M = 59.52$, D4: $M = 59.52$, D5: $M = 62.14$).

Analysis of variance

There were no significant effects found between groups in SWE, work vigor, psychological detachment from work and cognitive ability, as well as the effect is exceedingly small or small in all cases (see Table 3 for ANOVA results). There was a significant effect of the day of measurement in the following variables: SWE ($F(4,160) = 3.8$, $p < .01$) (medium to large effect), vigor ($F(4,160) = 2.1$, $p = .08$) (medium effect size), productivity ($F(4,160) = 6.13$, $p < .01$) (medium effect size) and cognitive ability (medium to large effect size).

Table 3. ANOVA test results for state work engagement (SWE), vigor, productivity, psychological detachment, and cognitive ability ($N = 42$)

Variable	Sphericity assumed $\chi^2(9)$	Effect of study day $F(1, 40)$ $\eta^2 p^a$	Effect of study group $F(4,160)$ $\eta^2 p$	Interaction effect between study day and group $F(4,160)$ $\eta^2 p$
SWE	11.24	.04 .00	3.8*** .09	1.4 .03
Vigor	11.07	.01 < .01	2.1* .05	1.3 .03
Psychological Detachment	6.76	.04 < .01	0.48 .01	2.80* .07
Productivity	15.46	.00 < .01	6.13*** .06	1.72 .02
Digit Span Test: Correct items forward ^b	16.56*	.21 .01	7.98*** 0.17	0.71 .02
Correct answers forward	11.78	0.52 .01	5.90*** 0.13	0.46 .01
Correct items backward ^b	26.26***	.01 < .01	2.76** .06	2.03* .05
Correct answers backward ^c	27.06***	.03 < .01	2.88* .07	2.13* .05

^a $\eta^2 p$: effect size

^b Greenhouse-Geisser correction was applied

* .05 < p < .1, ** .01 < p < .05, *** p < .01

Differences between days were found in all four measures of the Digit Span Test: correct verses in the forward direction (digits are entered in the test in the order in which they were presented ($F(3,130) = 7.98, p < .01$)), in the direction of correct answers forward ($F(3,130) = 5.90, p < .01$)), correct verses in backward direction (numbers must be entered in reverse order) ($F(2,117) = 2.76, p = .05$) and correct answers in the backward direction ($F(2,118) = 2.88, p = .04$)).

The interaction effect between measurement day and group was significant for the psychological detachment score ($F(4,160) = 2.80, p = .03$) (medium effect size), indicating a different study day effect in each group. Significant between-group differences were observed in psychological detachment scores on day 1 (PA vs no PA group: $0.57, p = .057$). A significant interaction effect was also observed in the measurements of cognitive ability: correct sentences in the backward direction ($F(4,160) = 2.03, p = .09$) and correct answers in the backward direction ($F(4,160) = 2.13, p = .08$)).

Differences were observed for SWE in the no PA group D2-D1: $0.79, p = .04$; $0.79, p = .04$; D3-D1: $0.77, p = .01$. In terms of productivity, significant differences were found both in the no PA group D2-D1: $.67, p = .03$; D3-D1: $0.81, p < .01$; D4-D1: $0.71, p = .02$; D5-D1: $0.57, p = .01$. The means and standard errors of SWE, vigor, productivity, and psychological detachment in the study groups are shown in Figure 1.

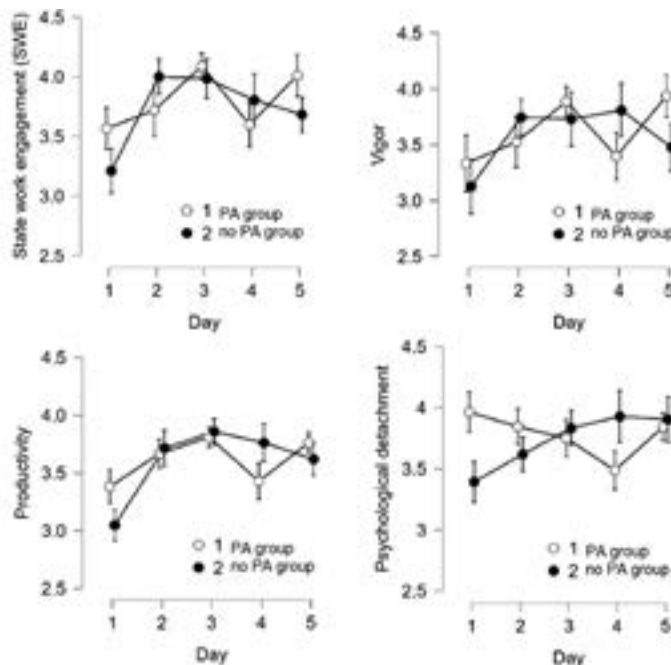


Figure 1. Means and standard errors of state work engagement, vigor, productivity, and psychological detachment

Differences between study days were significant for cognitive ability (correct items forward) in PA group (D3-D1: 10.48, $p = .022$; D4-D1: 12.05, $p = .011$; D5-D1: 11.19, $p = .034$; D4-D2: 8.24, $p = .019$; D5-D2: 7.38, $p = .085$); correct answers in the forward direction in both PA group, and no PA group (D4-D1: 1.24, $p = .08$; D5-D1: 1.52, $p = .07$); correct items backward only in no PA group (D2-D1: 7.57, $p = .08$; D3-D1: 8.43, $p = .06$; D4-D1: 10.05, $p = .08$) and correct answers backwards only in the no PA group D3-D1: 1.62, $p = .02$). The mean scores of the study groups on the cognitive ability (Digit Span Test) are shown in Figure 2.

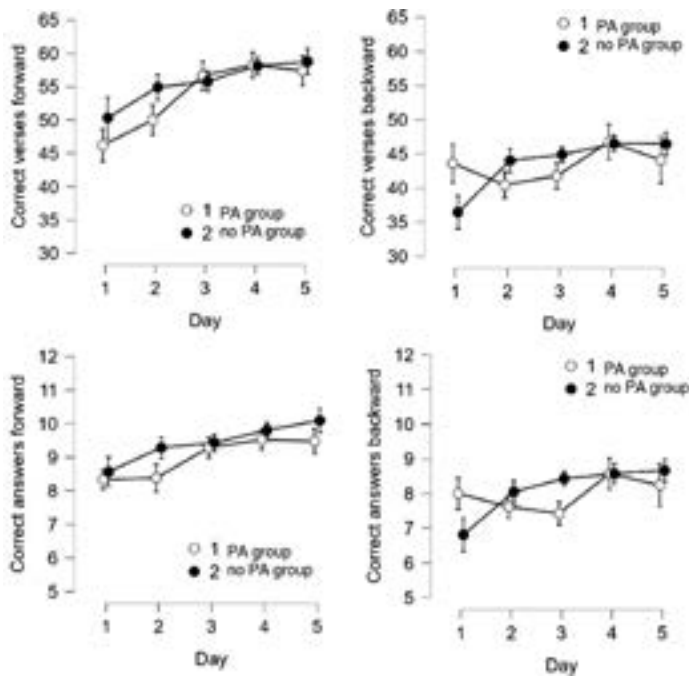


Figure 2. Means and standard errors of cognitive ability (Digit Span Test)

Correlation Analysis

The correlation analysis results indicate a significant and close correlation for general work engagement with SWE on each study day (D1: $r_s = .60$, $p < .01$, D2: $r_s = .61$, $p < .01$, D3: $r_s = .71$, $p < .01$, D4: $r_s = .49$, $p = .01$, D5: $r_s = .58$, $p < .01$) and close correlation of SWE with productivity on each study day (D1: $r_s = .72$, $p < .01$, D2: $r_s = .63$, $p < .01$, D3: $r_s = .68$, $p < .01$, D4: $r_s = .71$, $p < .01$, D5: $r_s = .65$, $p < .01$) (see Table 4).

Table 4. Spearman correlation coefficients for state work engagement (SWE), general work engagement and productivity ($N = 42$)

SWE (day)	Variable	
	General (trait) work engagement	Productivity (the same day)
1.	0.60***	0.72***
2.	0.61***	0.63***
3.	0.71***	0.68***
4.	0.49**	0.71***
5.	0.58***	0.65***

* $p < .05$, ** $p < .01$, *** $p < .001$

There was no significant correlation between psychological detachment from work the previous evening and the next day's SWE and productivity, but the work vigor dimension shows a significant but weak correlation with psychological detachment on study day 4 (detachment D3 – vigor D4: $r_s = .31$, $p = .04$).

Discussion

The aim of this quasi-experimental diary study was to investigate whether there are differences in SWE, productivity, cognitive ability, and psychological detachment from work between groups of adults with and without PA after work, and to evaluate daily dynamics of the variables and to investigate associations between general (trait) and daily (state) work engagement, its subscale vigor, productivity, cognitive ability, and psychological detachment from work. The general (trait) work engagement measurement was conducted before the daily study, which showed that both study groups were equally engaged in the work, so both groups started the study at the same starting point.

Although there were no significant differences found between the PA and no PA groups in SWE, productivity, cognitive ability and psychological detachment from work (hypothesis 4), significant differences in SWE were found in the no PA group between the first and second day of the study, as well as between the first and the third day. Productivity in the no PA group on all days was significantly different from the first day of the study (scores increased), in the PA group the overall day effect was significant but there were no significant differences between days.

There was a significant interaction effect between study days and group on the psychological detachment score, suggesting a different effect of study day in

each group. There is a significant interaction effect for cognitive ability (visual verbal working memory) – attention efficiency and working memory capacity on measures of information updating and switching functions, but for the latter a significant study-day effect is only observed in the no PA group.

The fifth hypothesis was supported: there was a difference between study days in SWE, its subscale vigor, productivity and cognitive ability, although it was observed during data analysis that, significant differences by day were not always detected.

The correlation results show that there is a significant and strong correlation for general work engagement with SWE on each day of the study, so the first hypothesis is confirmed. The second hypothesis of the study is also confirmed: SWE is positively related to productivity on each study day. There is no significant relationship between the psychological detachment from work the previous evening and the next day's work engagement and productivity, however, the work vigor dimension shows significant but weak correlation with the psychological detachment from work on day 4 of the study, thus partially confirming the third hypothesis.

As previous research has shown, off-job activities contribute to recovery to the extent that they allow employees to replenish their personal resources. This is the perspective from which PA was considered in this study. The relationship between off-job activities and recovery is described as a mediated process: off-job activities lead to recovery through relaxation and psychological detachment from work outside working hours (Fritz & Sonnentag, 2006, as cited in ten Brummelhuis & Bakker, 2012). Drawing on the literature on the relationship between psychological detachment and work engagement – psychological detachment is an important experience through which employees can reduce strain and increase their psychological resources and, in turn, these resources can enhance engagement through dimensions of work engagement such as vigor, dedication and absorption (Schaufeli & Bakker, 2004; Xanthopoulou et al., 2009). Hence, it can be inferred that the quality of psychological resource renewal the previous evening may influence work engagement the next day. Contrary to expectations, improvements in SWE in this study were observed in the no PA group and not in the PA group. The no PA group was asked to rest after work, avoiding PA and other physical effort. According to Sonnentag (2003), work engagement is higher when employees feel fully recovered during their free time. In this study, previous evening psychological detachment was not associated with higher next day's SWE levels, in contrast to a study by ten Brummelhuis and Bakker (2012). It is possible that the no PA group's chosen non-physical off-job activities may have helped them better to detach themselves psychologically from work. Peaceful leisure activities after work have an impact on recovery through relaxation and psychological detachment from work (ten Brummelhuis & Bakker, 2012). The results

could possibly be explained by the quality of psychological detachment, as well as the type of non-work activity and activity control (the degree to which an individual can decide what, how, and when to do in their free time (Sonnentag & Fritz, 2007). It should be noted that the average psychological detachment scores for both groups were in the middle range, indicating that this sample did not demonstrate high rates of psychological detachment from work. It is possible that participants used the same resources after work as they used at work (e.g., reading work emails, answering calls), so there was no noticeable physical or psychological detachment from work issues and problems. Not being detached from work in free time, reduces the possibility to fully immerse in off-job experiences (Sonnentag et al., 2008). The no PA group did not have to report their after-work activities in detail; thus, it is unknown exactly what they did. Another explanation is that PA group participants were engaged in the study, and it lessened their work engagement for this work week. Also, it should be mentioned that there are more aspects that might affect work engagement, e.g., workload, work environment, meaningful work etc. (after Maslach et al., 2001). Alternatively, although PA is a well-documented method for detachment, the intensity and/or type and/or duration of the activity might be not enough for more proper detachment.

There are no differences between the study groups for the work engagement dimension – *vigor*, but there is a significant measurement day effect in both study groups. There is a significant measurement day effect in the *work productivity* variable in both the no PA group and the PA group, but no significant differences between measurement days. The correlation analysis results indicate a significant and strong correlation of SWE with productivity per survey day, which is consistent with research over the last decade that shows that the level of employee engagement at work is a highly significant driver of employee productivity (e.g., Christian et al., 2011; Parke et al., 2018; Rich et al., 2010, as cited in Vogel et al., 2021).

Overall, it can be concluded that there are no significant between-group effects for SWE, vigor subscale, psychological detachment from work and cognitive ability, and the effect sizes are very small or small in all cases.

Regarding the PA intervention of the PA group, it is important to mention that during the study week, low and moderate intensity PA such as walking, pilates and yoga predominate. Several studies have shown beneficial effects of more intensive or effortful exercise on memory, e.g., aerobic exercise (Roig et al., 2013, as cited in Cuttler et al., 2018) and strength training (Hsieh et al., 2016; Weinberg et al., 2014; Zach & Shalom, 2016 as cited in Cuttler et al., 2018). Another explanation for the PA group not showing the predicted effect during the study week is the possible fatigue of the PA group from requirement for exercising every day after work for 5 working days.

In conclusion, although there were no significant differences between the groups, there were changes between the study days in SWE, vigor, productivity,

and cognitive ability that could be related to interventions – off-job activities, either physical or non-physical. The strengths of the study include the high reliability of the surveys, the study of the dynamics of the variables over 5 consecutive days, and the design for management and monitoring of the study. As the measurements were taken several times a day, this helped to reduce retrospective bias, which is considered a notable advantage of diary studies. The submitted data were monitored (no respondents skipped any surveys, no extreme deviations in the results were observed), so the results can be considered quite accurate. A significant contribution of the study is examining the relationship between PA and productivity, and other important organizational variables that are relatively less studied together with PA; and analyzing the daily dynamics of these variables, which is usually not focused on in organizational studies.

A major limitation of the study is a relatively small sample size (42 participants, 21 in each study group). Additional limitations are related to remote completion of Digit Span Test (risk of using additional tools) and self-reporting of PA (not all participants agreed to register it directly via a device like fitness band or mobile app that would render more reliable results). It will be of great value to replicate the study with larger sample size and by randomizing study groups both for controlling self-selection effect and related demographic and lifestyle variables (e.g., sleep), using wearable fitness tracking devices and test the findings of this study. It has to be noted that additional effort for securing respondent participation will be needed as the study found that people are not willing to change their preferred lifestyle even for a short time and might feel that too much is required from them. While non-monetary incentives were offered for completed participation, this might not be enough if more input is required from participants.

Future research should also look at the direct effect of PA on important variables in organizations (e.g., SWE, productivity, cognitive ability), as recent studies outline a new paradigm that even short PA (e.g., 10 minutes) several times a day can have beneficial effects on physical and psychological health. From this perspective, PA is viewed as a way of life and can contribute to improvements regardless of the duration of PA (Jakicic et al., 2019). In addition, it would be of practical value to study the efficiency of different reminders (e.g., email, text message, phone call, group chat) as tools for both research and interventions in organizations. As this study did not measure the leisure (after-work) activities of the no PA group, it should be investigated how the type, duration, and timing of off-job activities, and individual control over these factors affect psychological detachment. The future diary research should examine whether performance (and other variables) is affected by the day of measurement or the day of the work-week (i.e., either by doing the same activity several days in a row, and/or by the dynamics of the work-week). This study looked at PA after work, but a future study could investigate the effects of PA at different times of the day (before work, lunchtime, after work).

References

- Bakker, A. B., & Schaufeli, W. B. (2008). Positive organizational behavior: Engaged employees in flourishing organizations [Editorial]. *Journal of Organizational Behavior*, 29(2), 147–154. <https://doi.org/10.1002/job.515>
- Berga, L. (2016). *Ikdienas iesaiste darbā, ārpusdarba aktivitātes un psiholoģiskā distancēšanās no darba*. Maģistra darbs. Rīga: Latvijas Universitāte. Unpublished Manuscript.
- Biddle, S. J., Fox, K. R., & Boutcher, S. H. (Eds.). (2000). *Physical activity and psychological well-being* in Lindwall, Gerber, Jonsdottir, Borjesson, Ahlberg (2013). The Relationships of Change in Physical Activity With Change in Depression, Anxiety, and Burnout: A Longitudinal Study of Swedish Healthcare Workers. *Health psychology: official journal of the Division of Health Psychology, American Psychological Association*. <https://doi.org/10.1037/a0034402>.
- Biddle, S. J. H., Mutrie, N., Gorely, T., & Faulkner, G. (2021). *Psychology of Physical Activity: Determinants, Well-being and Interventions*. (4th ed.) Taylor and Francis Inc. <https://doi.org/10.4324/9781003127420>
- Bosco, F., Allen, D. G., & Singh, K. (2015). Executive attention: An alternative perspective on general mental ability, performance, and subgroup differences. *Personnel Psychology*, 68, 859–898
- Breevaart, K., Bakker, A. B., Demerouti, E., & Hetland, J. (2012). The measurement of state work engagement: A multilevel factor analytic study. *European Journal of Psychological Assessment*, 28(4), 305–312. <https://doi.org/10.1027/1015-5759/a000111>
- Calderwood, C., ten Brummelhuis, L.L., Patel, A.S., Watkins, T., Gabriel, A.S., & Rosen, C.C. (2020). Employee physical activity: A multidisciplinary integrative review. *Journal of Management*, 47, 144–170.
- Caspersen, C. J., Powell, K. E., & Christenson, G. M. (1985). Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public health reports (Washington, D.C.: 1974)*, 100(2), 126–131.
- Calderwood, Charles & Gabriel, Allison & Rosen, Christopher & Simon, Lauren & Koopman, Joel. (2015). 100 years running: The need to understand why employee physical activity benefits organizations. *Journal of Organizational Behavior*. 37. 10.1002/job.2064.
- Cho, S., & Park, Y. (2018). How to benefit from weekend physical activities: Moderating roles of psychological recovery experiences and sleep. *Stress and Health*, 34(5), 639–648. <https://doi.org/10.1002/smi.2831>
- Clear, J. (2018). *Atomic habits: an easy & proven way to build good habits & break bad ones; tiny changes, remarkable results*. New York: Avery, an imprint of Penguin Random House.
- Cuttler, C., Connolly, C. P., LaFrance, E. M., & Lowry, T. M. (2018). Resist forgetting: Effects of aerobic and resistance exercise on prospective and retrospective memory. *Sport, Exercise, and Performance Psychology*, 7(2), 205–217. <https://doi.org/10.1037/spy0000112>
- Diamond A. (2013). Executive functions. *Annual review of psychology*, 64, 135–168.
- Edwards, D. B., Franco-Watkins, M. A., McAbee, T. S. & Faura, L. with Wallace, C., Zugec, L. & Poteet, M. L. (2017). The Bridge: Connecting science and practice: The case for using working memory in practice. *The Industrial-Organizational Psychologist (TIP)*, 55(1).

- Engle, R. W., Kane, M. J., & Tuholski, S. W. (1999). Individual differences in working memory capacity and what they tell us about controlled attention, general fluid intelligence, and functions of the prefrontal cortex. In A. Miyake & P. Shah (Eds.), *Models of working memory: Mechanisms of active maintenance and executive control* (pp. 102–134). Cambridge University Press.
- Faulkner, G. E. J., & Taylor, A. H. (Eds.). (2005). *Exercise, Health and Mental Health: Emerging relationships* (1st ed.). Routledge. <https://doi.org/10.4324/9780203415016>
- Feuerhahn, N., Sonnentag, S., & Woll, A. (2014). Exercise after work, psychological mediators, and affect: A Day-level study. *European Journal of Work and Organizational Psychology, 23*(1), 62–79. <https://doi.org/10.1080/1359432X.2012.709965>
- Hambrick, D. Z., Oswald, F. L., Darowski, E. S., Rench, T. A., & Brou, R. (2010). Predictors of multitasking performance in a synthetic work paradigm. *Applied Cognitive Psychology, 24*(8), 1149–1167. <https://doi.org/10.1002/acp.1624>
- Hogan, C. L., Mata, J., & Carstensen, L. L. (2013). Exercise holds immediate benefits for affect and cognition in younger and older adults. *Psychology and Aging, 28*(2), 587–594. <https://doi.org/10.1037/a0032634>
- Iida, M., Shrout, P. E., Laurenceau, J.-P., & Bolger, N. (2012). Using diary methods in psychological research. In H. Cooper, P. M. Camic, D. L. Long, A. T. Panter, D. Rindskopf, & K. J. Sher (Eds.), *APA handbook of research methods in psychology, Vol. 1. Foundations, planning, measures, and psychometrics* (pp. 277–305). American Psychological Association. <https://doi.org/10.1037/13619-016>
- Jakicic, J. M., Kraus, W. E., Powell, K. E., Campbell, W. W., Janz, K. F., Troiano, R. S., Sprow, K., Torres, A., Piercy, K. L. (2019). Association between bout duration of physical activity and health: Systematic review, *Medicine & Science in Sports & Exercise, 51*(6), 1213–1219.
- Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology, 15*(3), 169–182. [https://doi.org/10.1016/0272-4944\(95\)90001-2](https://doi.org/10.1016/0272-4944(95)90001-2)
- Lewandowsky, S. (2011). Working memory capacity and categorization: individual differences and modeling. *Journal of experimental psychology. Learning, memory, and cognition, 37*(3), 720–738. <https://doi.org/10.1037/a0022639>
- Lindwall, M., Gerber, M., Jonsdottir, I. H., Börjesson, M., & Ahlberg, G., Jr. (2014). The relationships of change in physical activity with change in depression, anxiety, and burnout: a longitudinal study of Swedish healthcare workers. *Health psychology: official journal of the Division of Health Psychology, American Psychological Association, 33*(11), 1309–1318. <https://doi.org/10.1037/a0034402>
- Maslach, C., Schaufeli, W. B., & Leiter, M. P. (2001). Job burnout. *Annual review of psychology, 52*, 397–422. <https://doi.org/10.1146/annurev.psych.52.1.397>
- Miyake, A., & Shah, P. (Eds.). (1999). *Models of working memory: Mechanisms of active maintenance and executive control*. Cambridge University Press.
- Owen, N., Bauman, A., & Brown, W. (2009). Too much sitting: a novel and important predictor of chronic disease risk? *British Journal of Sports Medicine, 43*(2), 81–83. <https://doi.org/10.1136/bjism.2008.055269>
- Peeters, M. C. W., Montgomery, A. J., Bakker, A. B., & Schaufeli, W. B. (2005). Balancing Work and Home: How Job and Home Demands Are Related to Burnout. *International Journal of Stress Management, 12*(1), 43–61. <https://doi.org/10.1037/1072-5245.12.1.43>
- Reed, J. & Ones, D. (2006). The effect of acute aerobic exercise on positive activated affect: A meta-analysis. *Psychology of Sport and Exercise, 7*, 477–514.

- Richardson, J. T. E. (2007). Mental models of learning in distance education. *British Journal of Educational Psychology*, 77(2), 253–270.
- Schaufeli, W. B., & Bakker, A. B. (2004). Job demands, job resources, and their relationship with burnout and engagement: A multi-sample study. *Journal of Organizational Behavior*, 25, 293–315.
- Schaufeli, W. B. & Bakker, A. B. (2003) *UWES-Utrecht Work Engagement Scale: Test Manual*. Unpublished Manuscript, Department of Psychology, Utrecht University, Utrecht.
- Schaufeli, W. B., Bakker, A. B., & Salanova, M. (2006). The measurement of work engagement with a brief questionnaire: A cross-national study. *Educational and Psychological Measurement*, 66, 701–716.
- Schaufeli, W. B., Salanova, M., González-Romá, V., & Bakker, A. B. (2002). The measurement of engagement and burnout: A two sample confirmatory factor analytic approach. *Journal of Happiness Studies: An Interdisciplinary Forum on Subjective Well-Being*, 3(1), 71–92. <https://doi.org/10.1023/A:1015630930326>
- Sonnentag, S. (2003). Recovery, Work Engagement, and Proactive Behavior: A New Look at the Interface Between Nonwork and Work. *Journal of Applied Psychology*, 88(3), 518–528.
- Sonnentag, S., & Fritz, C. (2007). The Recovery Experience Questionnaire: Development and validation of a measure for assessing recuperation and unwinding from work. *Journal of Occupational Health Psychology*, 12(3), 204–221. <https://doi.org/10.1037/1076-8998.12.3.204>
- Sonnentag, S., Dormann, C., & Demerouti, E. (2010). Not all days are equal: The concept of state work engagement. In M. P. Leiter & A. B. Bakker (Eds.), *Work engagement: A handbook of essential theory and research* (pp. 25–38). New York: Psychology Press.
- Sonnentag, S., & Fritz, C. (2015). Recovery from job stress: The stressor-detachment model as an integrative framework. *Journal of Organizational Behavior*, 36(S1), S72–S103.
- Sonnentag, S., Mojza, E. J., Binnewies, C., & Scholl, A. (2008). Being engaged at work and detached at home: A week-level study on work engagement, psychological detachment, and affect. *Work & Stress*, 22(3), 257–276. <https://doi.org/10.1080/02678370802379440>
- Sternberg, R. J. (2016). Testing: For better and worse. *Phi Delta Kappan*, 98(4), 66–71. <https://doi.org/10.1177/0031721716681780>
- Sternberg, R. J. & Sternberg, K. (2012). *Cognitive Psychology* (6th ed.). Belmont, CA: Wadsworth Cengage.
- ten Brummelhuis, L. L. & Bakker, A. B. (2012). Staying engaged during the week: The effect of off-job activities on next day work engagement. *Journal of Occupational Health Psychology*, 17, 445–455.
- Terman, L. M. (1916). *The measurement of intelligence: An explanation of and a complete guide for the use of the Stanford revision and extension of the Binet-Simon intelligence scale*. Boston: Houghton Mifflin.
- Thiese, M. S., Ronna, B., & Ott, U. (2016). P value interpretations and considerations. *Journal of thoracic disease*, 8(9), E928–E931. <https://doi.org/10.21037/jtd.2016.08.16>
- Vanags, E., Ekmanis, J. (2018). *Affect arousal and valence recognition from EDA asymmetry and HRV measurements during computerised cognitive ability testing*. The 4th international conference of the European Society for Cognitive and Affective Neuroscience (ESCAN).
- Vogel, R. M., Rodell, J. B., & Agolli, A. (2021). Daily engagement and productivity: The importance of the speed of engagement. *Journal of Applied Psychology*.

- Wiese, C. W., Kuykendall, L., & Tay, L. (2018). Get active? A meta-analysis of leisure-time physical activity and subjective well-being. *The Journal of Positive Psychology, 13*(1), 57–66. <https://doi.org/10.1080/17439760.2017.1374436>
- Zijlstra, F. R., Cropley, M., & Rydstedt, L. W. (2014). From recovery to regulation: an attempt to reconceptualize ‘recovery from work’. *Stress and health: journal of the International Society for the Investigation of Stress, 30*(3), 244–252. <https://doi.org/10.1002/smi.2604>
- Xanthopoulou, D., Bakker, A. B., Demerouti, E., & Schaufeli, W. B. (2009). Work engagement and financial returns: A diary study on the role of job and personal resources. *Journal of Occupational and Organizational Psychology, 82*, 183–200.