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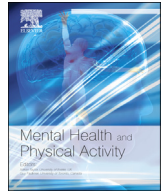
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The relationships between off-job physical activity and vigor at work across time: Testing for reciprocity

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ABSTRACT

Purpose of the study: The main objective of the present study was to examine the reciprocal relationships between off-job moderate to vigorous physical activity (MVPA) and vigor at work.

Method: 128 workers (60% females) from different companies, with a mean age of 39.40 years old, comprising lower supervisory and technical employees, intermediate occupations and professional and managerial workers, completed a questionnaire twice with an interval of two months, comprising measures of vigor at work (Shirom-Melamed Vigor Measure; Shirom, 2004), and self-rated levels of off-job MVPA (International Physical Activity Questionnaire; Craig et al., 2003).

Results: Structural equation modeling revealed that the level of vigor at T1 predicted the level of off-job MVPA at T2 ($\beta = 0.22, p < .05$) but that the level of off-job MVPA at T1 did not predict the level of vigor at T2.

Conclusion: The findings suggest that high vigor at work has the potential to prompt individuals to engage in off-job MVPA. Conversely, in the present study high levels of off-job MVPA were not linked to enhanced vigor at work. As a result, strategies designed to enhance vigor at work may result in higher levels of off-job MVPA and in the long term to the adoption of a healthy lifestyle beneficial for physical and mental health.

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In the literature, most research on health and well-being at work has focused on the negative effects of stressors (e.g., burnout, Toker & Melamed, 2017). Positive work-related experiences have not been much studied. These positive experiences at work, such as vigor seem relevant to be studied when one is interested in the health and well-being at work. Vigor is defined as the sense of possessing physical strength, emotional energy and cognitive liveliness (Shirom, 2011). At work, it embodies a positive affective response to one's ongoing interaction with specific elements of the workplace and with the work situation as a whole (Shirom, 2011). Investigating vigor is important because most people want to feel vigorous or energetic and view it as a significant aspect of their affective experiences (Shraga & Shirom, 2009). Based on the Conservation Of Resources (COR) theory (Hobfoll, 1989; Hobfoll, Halbesleben, Neveu, & Westman, 2018), vigor is conceptualized

as a multidimensional construct comprising *physical strength* (i.e., one's physical capabilities), *emotional energy* (i.e., one's ability to express sympathy and empathy to significant others), and *cognitive liveliness* (i.e., the flow of one's thought processes and mental agility, Shirom, 2011). The COR theory offers a rather general model of health and well-being at work. The resources (i.e., objects, personal characteristics, and energy that are either valued for survival, or that serve as a means of achieving these resources, Hobfoll, 1989) represent a key concept within this theory. It is argued that certain resources can be restored, for example, by taking a break or by investing other resources on other activities (such as leisure time activities). On the other hand, it has been assumed that possessing resources at work, and thus experiencing vigor, can lead to several positive consequences, such as motivation, increased job performance, organizational efficiency, and physical and mental health (Shirom, 2011).

Given the positive benefits of vigor, it is important to investigate the conditions that facilitate it. Among these, physical activity (PA) plays a central role. While previous work has shown positive links between vigor and physical activity (e.g., O'Connor & Puetz, 2005), understanding of the role of off-job PA on vigor at work can be

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deepened in at least three ways. (a) Firstly, the reciprocal relationship between off-job PA and workplace vigor needs to be addressed. Previous studies have largely examined the influence of physical activity on workplace vigor (e.g., Oerlemans & Bakker, 2014) and ignored the possibility that workplace vigor can influence the amount of off-job PA practiced. It can be hypothesized that a lack of vigor could be associated with low off-job PA. (b) Secondly, most studies that have looked at the link between off-job PA and vigor at work have adopted a daily-level approach. Although this approach adds valuable insight, as vigor and time spent on off-job PA can fluctuate from day to day (e.g., Sonnentag & Natter, 2004), we do not know how these day-level findings generalize to other time frames. (c) Finally, most of the previous work on the relationship between off-job PA and vigor at work measured the latter as a one-dimensional construct, and did not take into account the multidimensional perspective proposed by Shirom (2011).

In the present study, we aim to enhance insight into the association between off-job PA and work-related vigor by addressing these three issues and testing the reciprocal influence between the quantity of off-job moderate to vigorous PA (MVPA) and the level of vigor at work (using a multidimensional perspective) during a two-month period. Taken together, two hypotheses are tested, which are described in more detail in the following paragraphs.

1. Levels of off-job PA predict change in levels of vigor at work

Research has provided evidence of the benefits of PA on well-being and especially vigor. Precisely, it has been demonstrated that time spent on PA was positively related to vigor (O'Connor & Puetz, 2005; Oerlemans & Bakker, 2014; Sonnentag & Natter, 2004; ten Brummelhuis & Bakker, 2012), increases in well-being (e.g., good mood, Sonnentag, 2001), and positive affects (Feuerhahn, Sonnentag, & Woll, 2014; Nägel, Sonnentag, & Kühnel, 2015). However, all these studies have examined the daily influence of PA on vigor, and have measured vigor as a unidimensional state.

Research on recovery processes has suggested that recovery from work during off-job time can predict an increase in well-being (Sonnentag, Venz, & Casper, 2017). Thus, off-job time experiences and leisure activities that offer the opportunity to recover from job stress and to restore one's resources are essential for maintaining one's well-being. Among these leisure time activities, off-job PA has been considered as having a particularly high potential for recovery. Sonnentag and Fritz (2007) suggested four distinct recovery experiences. *Control* corresponds to the degree to which a person can decide which activity to pursue during off-job time, as well as when and how to pursue this activity. *Mastery experiences* are the result of challenging situations that result in some kind of success or achievement when individuals engage in off-job PA. *Psychological detachment* is the ability of off-job PA to make individuals forget about their work during off-job PA, to have the feeling of leaving work behind, and "switching off". Finally, *Relaxation* describes the ability of off-job PA to provide experiences of low sympathetic activation. Studies have confirmed the existence of these four recovery experiences, and shown that off-job PA predicts higher levels of psychological detachment from work (Feuerhahn et al., 2014; ten Brummelhuis & Bakker, 2012), higher levels of relaxation (ten Brummelhuis & Bakker, 2012), and higher levels of mastery (Ragsdale & Beehr, 2016). Sonnentag and Fritz (2007) have shown that recovery experiences diminish the need for recovery (i.e., "the sense of urgency to take a break from the demands", p.331, Sonnentag & Zijlstra, 2006) which is an indicator of the effectiveness of recovery (Veldhoven, 2008). Need for recovery is also considered as an early indicator of the development of psychosomatic health problems and poor well-being in the longer term (de

Croon, Sluiter & Frings-Dresen, 2003; Sonnentag & Zijlstra, 2006; Taylor & Dorn, 2006). As a result, PA has the potential to improve recovery experiences and need for recovery, as well as vigor.

Hypothesis 1: Based on previous findings, and considering that off-job PA has the potential to foster recovery from work, it is hypothesized that higher levels of off-job PA predict higher levels of work-related vigor two months later, controlling for the initial level of vigor.

2. Levels of vigor at work predict change in level of off-job PA

Research on the potential impact of the working situation on levels of off-job PA has shown that the experience of job stressors may hinder people from engaging in PA during off-job time. Indeed, individuals may seek to regulate negative psychological states (e.g., fatigue) by avoiding to engage in PA in favor of stimulants such as caffeine, or low-energy expenditure activities such as watching TV. An accumulation of inactivity would in turn reduced the available energy (Taylor & Dorn, 2006). Longitudinal research has shown that job stress is negatively related to physical activity (Stults-Kolehmainen & Sinha, 2014). Moreover, a meta-analysis showed that people who experience high demands and low control in their jobs have the highest risk of physical inactivity compared to people in other jobs (Fransson et al., 2012). In daily studies, it has been shown that individuals in jobs with high demands and low control engage less in off-job PA than people in jobs with low demands and high control (Payne, Jones, & Harris, 2002). In a study by Sonnentag and Jelden (2009), situational constraints experienced at work were negatively related to time spent exercising during the evening. However, these studies were all interested in the work situation represented by work strain and work stress, and they did not examine the role of states experienced at work such as the levels of vigor.

The broaden-and-build model (B&B; Fredrickson, 1998) is a relevant theory which has examined the mechanisms by which vigor leads to positive cognitive and behavioral consequences. This theory holds that vigor has the potential to widen the array of thoughts and actions. The B&B model states that repeated vigor over time is able to broaden people's attention and thinking, enabling them to draw on higher-level connections and on wider perceptions or ideas in the long-term. In turn, these broadened viewpoints often help people to discover and build important personal resources. These resources can be cognitive (e.g., the ability to mindfully attend to the present moment), psychological (e.g., the ability to maintain a sense of mastery over environmental challenges), social (e.g., the ability to give and receive emotional support), and/or physical (e.g., the ability to gain physical skills or prevent illness, Fredrickson, 1998). As a result, the B&B model suggests that the accumulation of personal resources over time at work could prompt the individual to engage in more off-job PA.

Hypothesis 2: Based on previous findings, and considering that vigor at work has the potential to prompt the individual to pursue a wider range of thoughts and actions, it is hypothesized that higher levels of vigor experienced by workers predict higher levels of off-job PA two months later, controlling for the initial level of off-job PA.

3. Method

3.1. Participants and procedure

After ethical approval was secured from the Ethics Committee for Non-Interventional Studies of the authors' University, the questionnaire was distributed as a web survey to employees of different companies. Informed consent was secured before

participants had access to the survey. 200 workers were then contacted to participate in the study and all the volunteers were included in the study. Among them, 128 workers completed the questionnaire entirely (i.e., allowing their data to be used) twice during a 2-month period. This 2-month period was chosen in order to not include a vacation period during the study. Indeed, these vacation periods are considered as recovery periods and can also be periods during which participants have more opportunities to practice physical activity, therefore this may represent a bias in the measurements made. Power analysis calculation with a statistical power level of 0.80 and a probability level of 0.05 revealed that the minimum sample size required to detect a medium effect is 90 participants, and the minimum sample size required given the structural complexity of the model is 100 participants (Soper, 2017). The participants (77 females and 51 male) who completed the survey had a mean age of 39.40 years old ($SD = 10.67$; age range: 21–59) and comprised 52 lower supervisory and technical employees, 14 intermediate occupations and 62 professional and managerial workers.

3.2. Measures

Shirom-Melamed Vigor Measure (SMVM). A French translation of the SMVM (Shirom, 2004) with 12 items scored on a 7-point frequency scale ranging from 1 (*almost never*) to 7 (*almost always*), assessing *physical strength* (5 items, Cronbach's $\alpha_{T1} = 0.95$ and Cronbach's $\alpha_{T2} = 0.96$; e.g., “I feel energetic”), *emotional energy* (4 items, Cronbach's $\alpha_{T1} = 0.82$ and Cronbach's $\alpha_{T2} = 0.87$; e.g., “I feel able to show warmth to others”), and *cognitive liveliness* (3 items; Cronbach's $\alpha_{T1} = 0.84$ and Cronbach's $\alpha_{T2} = 0.88$ e.g., “I feel able to be creative”) was used. The subscales were built by averaging the scores on the corresponding items of each subscale. High scores on a subscale reflect high vigor while low scores reflect low vigor. Respondents were requested to indicate the frequency of experiencing each of the described states during the previous 30 workdays. Past study of Wefald, Mills, Smith, and Downey (2012) have provided evidence of construct validity of the SMVM and reported reliabilities of 0.93 for physical strength, 0.91 for emotional energy and 0.81 for cognitive liveliness.

International Physical Activity Questionnaire. Participation in PA was assessed using the International Physical Activity Questionnaire (IPAQ) that was developed as an international surveillance tool for PA (Craig et al., 2003). This study used the short form IPAQ which asked participants to estimate how often they had taken part in MVPA that lasted at least 10 consecutive minutes over the last 7 days. The questionnaire provides information concerning PA frequency (times per week and duration) and intensity (low, moderate, high). Separate items were used to assess moderate and vigorous physical activity. In the present study, the sum of minutes per week spent in MVPA during off-job time was used (i.e., walking was not included in this sum). Several studies have provided evidence of the validity of the IPAQ (e.g., Bauman et al., 2009; Craig et al., 2003; Lee, Macfarlane, Lam, & Stewart, 2011).

Control variables. In the statistical analysis, we controlled for the possible confounding effects of age, gender (i.e., 1 = female and 2 = male), and socio-professional category (i.e., 1 = professional and managerial workers, 2 = intermediate occupations, and 3 = lower supervisory and technical employees). We controlled for age, gender and socio-professional category. These variables were controlled because past studies have suggested differences in vigor levels corresponding with these variables (Shirom, 2011).

3.3. Data analysis

Firstly, descriptive statistics and bivariate correlations were

calculated for all study variables. Moreover, in order to examine whether the effect of PA at T1 on vigor at T2 is not moderated by the initial level of vigor, and whether the effect of vigor at T1 on PA at T2 is not moderated by the initial level of PA, we performed moderation analyses. Secondly, structural Equation Modeling (SEM) was used to examine the reciprocal relationships between vigor and MVPA after controlling for age, sex and socio-professional category. In the model, the means on the three sub-dimensions of the SMVM were used as observed indicators of a vigor latent variable. To investigate the reciprocal associations between physical activity and vigor, a model including lagged effects from PA at T1 to PA at T2, lagged effects from vigor at T1 to vigor at T2, a path from PA at T1 to vigor at T2, and a path from vigor at T1 to PA at T2 were used. Age, gender, and socio-professional category were added as covariates to this model and were modeled to be related to PA and vigor at T2. As we entered variables measured on T1 as a predictor into the analyses, we controlled for T1–T2 stability effects. Accordingly, the SEM results indicate how two variables predict each other over time. The structural model was tested using maximum likelihood estimation with AMOS 21 program. Based on the suggestions made by several researchers (e.g., Brown, 2015; MacCallum & Austin, 2000), multiple indices were chosen to assess model fit: the Comparative Fit Index (CFI), the Root Mean Square Error of Approximation (RMSEA), the Standardized Root Mean Squared Residual (SRMR), and the Tucker-Lewis Index (TLI). A good model fit is indicated by $RMSEA \leq 0.05$, with the lower value of the 90% confidence interval including or being very near zero (or no worse than 0.05) and the upper value being less than 0.08, $SRMR \leq 0.05$, and $TLI, CFI \geq 0.95$; a reasonable model fit is indicated by $RMSEA, SRMR < 0.08$, and $TLI, CFI \geq 0.90$ (Brown, 2015).

4. Results

4.1. Descriptive statistics, bivariate correlations and preliminary analysis

Inspection of data normality revealed a normal distribution with skewness and kurtosis values for all variables under 2 (Gravetter & Wallnau, 2014). Descriptive statistics and bivariate correlations are displayed in Table 1. MVPA at T1 was significantly and positively correlated to vigor at T1, and MVPA at T2 was significantly and positively correlated with vigor at T2. Moreover, MVPA at T2 was significantly and positively correlated with MVPA at T1, and vigor at T1. Vigor at T2 was significantly and positively correlated to vigor at T1, and was not significantly correlated to MVPA at T1.

Moderation analyses were found to be non-significant. Therefore, the effect of PA at T1 on vigor at T2 was not moderated by the initial level of vigor (interaction term [i.e., vigor at T1 \times MVPA at T1] = $-0.14, p = .10$), and the effect of vigor at T1 on PA at T2 was not moderated by the initial level of MVPA (interaction term [i.e., vigor at T1 \times MVPA at T1] = $0.12, p = .20$).

Table 1
Descriptive statistics and bivariate correlations.

	Mean	SD	1	2	3	4	5	6
1 Age	39.40	10.67						
2 Sex			-0.04					
3 SPC			-0.11	-0.01				
4 MVPA T1	154.91	113.60	0.12	0.03	-0.05			
5 MVPA T2	158.42	111.75	0.13	0.01	-0.01	0.46***		
6 Vigueur T1	5.13	0.73	-0.02	0.12	0.01	0.19*	0.27**	
7 Vigueur T2	5.03	0.81	-0.06	0.18*	0.08	0.14	0.22*	0.73***

Note. SPC = Socio-Professional Category, MVPA = Moderate to Vigorous Physical Activity, * = significant at $p < .05$; ** = significant at $p < .01$; *** = significant at $p < .001$.

4.2. Reciprocal relationships between MVPA and vigor

The model revealed good fit to the data ($\chi^2(35) = 36.947, TLI = 0.99, RMSEA = 0.02 [90\% CI = 0.00; 0.07], CFI = 0.99, SRMR = 0.06$). Autoregressive paths between vigor at T1 and vigor at T2 ($\beta = 0.69, p < .001$), and MVPA at T1 and MVPA at T2 ($\beta = 0.43, p < .001$) were both significant. The cross-lagged path between vigor at T1 and MVPA at T2 was significant ($\beta = 0.22, p < .05$), while the cross-lagged path between MVPA at T1 and vigor at T2 was not significant ($\beta = 0.04, p > .05$). The model explained 51% of the variance in vigor at T2, and 27% of the variance in MVPA at T2. Control variables (i.e., age, sex and socio-professional category) were all non-significantly linked to vigor and MVPA at T2 (β between -0.07 and $0.13, p > .05$) (see Fig. 1).

5. Discussion

The current longitudinal study focused on the reciprocal relationships between the time spent in PA during off-job time and the level of vigor at work. It expands previous studies by examining the longitudinal (i.e., over a two-month period) reciprocal relationship between off-job PA and workplace vigor considering the multidimensional perspective of this latter construct. In line with the recovery potential of PA on vigor at work (Sonnentag, 2001; Sonnentag, Kuttler, & Fritz, 2010), it was hypothesized that the time spent in off-job PA may increase the level of work-related vigor two months later. Reciprocally, in line with the B&B model (Fredrickson, 1998), it was also hypothesized that the level of vigor at work may increase the time spent in off-job PA two months later. Present study results partly confirmed these hypotheses and revealed that T1 vigor at work predicted T2 levels of off-job PA controlling for the potential confounders. As a result, the present study confirms the broaden-and-build model (Fredrickson, 1998) assumptions that vigor has the potential to widen the array of thoughts and actions, and to prompt the individual to engage in off-job activities such as PA. Conversely, the results in the present study failed to confirm the hypothesis regarding the influence the level of T1 off-job PA on the level of T2 vigor. However, as the vigor construct was rather stable over time (autoregressive regression

weight $\beta = 0.69$), a large proportion of the variance in vigor was already accounted for by the same indicator measured two months earlier. This means that the proportion of variance left to be explained was rather small.

5.1. Limits and perspectives

This study has several limitations, firstly, the type of PA was unknown. Different types of PA could have distinct effects on vigor. There are reasons to believe that PA as part of household chores is not beneficial for vigor, whereas sport activities performed for pleasure are (Sonnentag et al., 2017). Secondly, in the current study, we used a self-reported PA measure. It might be relevant to replicate this study with an objective measure of PA. Indeed, past studies have shown that self-reported PA methods are often inadequate with issues of recall and response bias (e.g. social desirability, inaccurate memory) and the inability to capture the absolute level of PA (Prince et al., 2008). Thirdly, there was relatively small across-time variation in vigor with a relatively high mean (i.e., of 5 on a 7-point scale which correspond to relatively healthy workers). This could lead to a restriction of range leading to an underestimation of the true relationships found in the current study. Future research should cover a longer time interval in order to investigate the impact of change in PA on vigor. Finally, given the relatively small sample size, and the possibly unrepresentative sample in the present study, the study needs to be replicated with a larger sample size including a variety of occupations and controlling for potential influences of other factors (e.g., other psychological/social resources, stress).

6. Conclusion

Despite these limitations, this study sheds light on the association between vigor at work and off-job PA. Our findings suggest that high vigor at work has the potential to prompt individuals to engage in PA. Health agencies should be aware of this relationship. Strategies designed to enhance vigor at work may result in higher levels of PA and, in the long term, to the adoption of a healthy lifestyle beneficial to physical and mental health. Finally, it would

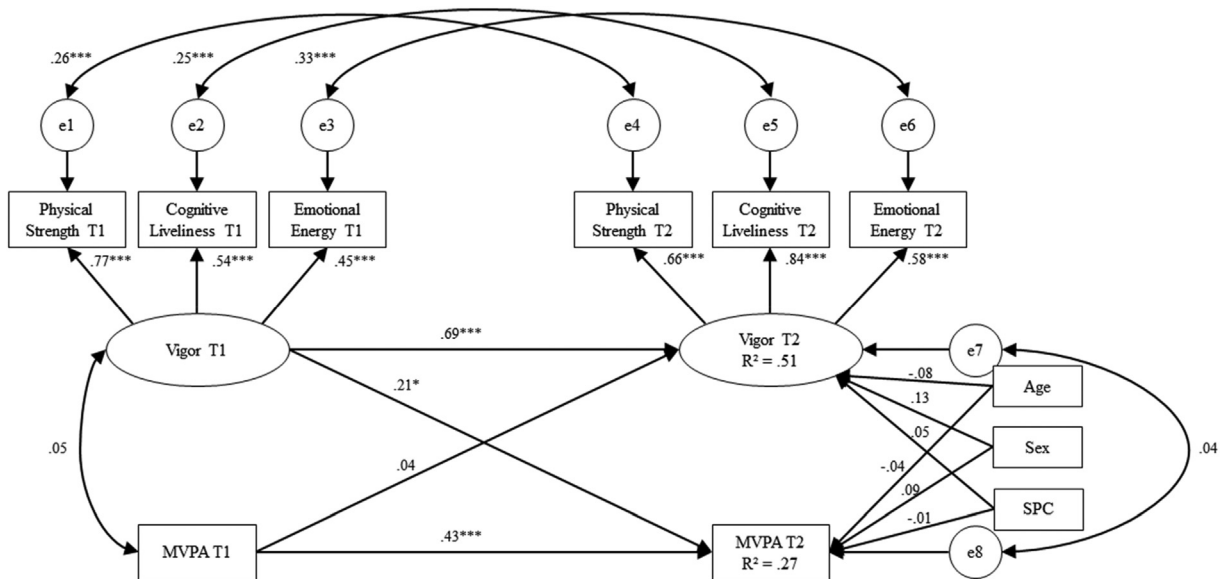


Fig. 1. Regression weights, factor loadings and level of explained variance of the structural equation model of the reciprocal relationships between vigor and MVPA. Note. MVPA = Moderate to Vigorous Physical Activity, SPC = socio-professional category; * = significant at $p < .05$; ** = significant at $p < .01$; *** = significant at $p < .001$.

also be interesting to focus on workers with lower levels of vigor in future workplace physical activity interventions, as they might be more likely to develop physically inactive lifestyles.

Conflict of interest statement

The authors declare that there are no conflicts of interest.

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