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Evolution of the association between self-control resources and physical activity during a major context change

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Abstract

Objective. Perceived self-control resources, defined as the perceived amount of energy available for the self to initiate a self-control act, are an important factor for regulating health behaviors. However, how self-control resources relate to physical activity across a major context change remains unexplored. This study examined how the association between self-control resources and physical activity evolved during and after Covid-19 lockdown. In this major context change, we predicted that self-control resources would be key to engage in physical activity. We also examined if this association was moderated by usual physical activity participation before the lockdown.

Design. A seven-wave longitudinal design spanning from the onset of the lockdown to two months after its end.

Methods. Two hundred fifty-three adults living in France (N = 253, Age_{mean} = 33.43, 67% women) filled up self-reported questionnaires. Questions included moderate-to-vigorous physical activity, perceived self-control resources operationalised as subjective vitality, and usual before-lockdown physical activity levels.

Results. Mixed-effects models revealed that self-control resources were significantly associated with moderate-to-vigorous physical activity, both at the between-person (B = 84.75, p < .001) and within-person (B = 65.85, p < .001) levels. In addition, results showed significant time × self-control resources interactions at both between-person and within-person levels and simple slope analyses revealed that the strength of the associations between self-control resources and PA increased over time. We found no evidence that usual before-lockdown physical activity level moderated the associations.

Conclusions. These results provide support to the role of perceived self-control resources in practicing regular physical activity, especially as the lockdown progressed.

Finally, we did not find evidence that being usually active before the lockdown reduced the need to rely upon self-control ressources to engage in physical activity.

Keywords: Self-control resources, physical activity, usual health behavior, Covid-19

What is already known on this subject?

- Self-control resources are associated with healthy behaviors, such as physical activity.
- Covid-19 lockdown has negatively impacted habits, especially in before-lockdown active individuals.

What does this study add?

- The strength of the association between perceived self-control resources and physical activity increased as the lockdown progressed, both at the within and between-person levels.
- Usual physical activity before the lockdown did not moderate these associations.
- Usually active individuals were more physically active than usually inactive individuals (when controlling for self-control resources), but only after the end of the lockdown.

Evolution of the association between self-control resources and physical activity during a major context change

Self-control, defined as the ability to prioritize distal motivations over conflicting proximal ones (Fujita, 2011), is a concept that has gained considerable attraction in the past decades. This ability is related to a host of beneficial outcomes, including academic and financial success, better interpersonal relations, and healthier behaviors (e.g., physical activity, healthy eating) (e.g., de Ridder et al., 2012). Different conceptualizations of self-control have been formulated (e.g., Inzlicht et al., 2021). One proposition considers that a central component of self-control is perceived self-control resources, defined as the perceived amount of energy available for the self to initiate a self-control act (Clarkson et al., 2016; Forestier, de Chanaleilles, Boisgontier, et al., 2022). Such resources have been shown to positively predict self-control success in the health domain (Forestier et al., 2018; Major et al., 2020; Maltagliati et al., 2022; Rojas-Sánchez et al., 2021; Rouse et al., 2013). For example, Forestier et al. (2018) and Forestier et al. (2023) observed that self-control resources were positively associated with physical activity and healthy diet, and negatively to sedentary behaviors and tobacco consumption. However, the current literature is dominated by cross-sectional studies that disregard the context in which people behave. The extent to which self-control resources are needed to engage in a certain behavior may yet vary depending on the context in which people evolve. The present study investigated if self-control resources predict physical activity during a major context change: the Spring 2020 Covid-19 lockdown.

This context seemed relevant to examine such question as physical activity was particularly impacted by lockdown restrictions in the country in which the study was conducted [redacted]: people were authorized to leave their homes one hour per day only, for a few reasons including work, basic needs purchases, medical reasons, or physical activity in a one-km perimeter from home. As such, most of the stable contextual cues associated with physical activity disappeared (e.g., time of day, exercise partners, type of physical activity, location) (e.g., Celina et al., 2021; Furman et al., 2021). This resulted in an overall decrease of physical activity habits (e.g., Maltagliati et al., 2021), a process by which a stimulus automatically initiates an impulse towards action, based on learned stimulus-response association (Gardner, 2015).

In this habit-disrupting context, self-control resources may have been particularly important to engage in physical activity. Indeed, these resources may facilitate an effortful regulation of behaviors through self-control acts (Forestier et al., 2023; Maltagliati et al., 2022; Rouse et al., 2013). For example, among adolescents, Maltagliati et al. (2022) observed that perceived energy, a possible operationalization of self-control resources, was positively associated with physical activity through the mediating role of action planning and self-monitoring, two self-regulation strategies that necessitate effort to be enacted. Such an effortful regulation of behavior may be particularly needed when habits are disrupted. Indeed, people with low healthy habits – be they relate to the eating, sleep or physical activity domains – have been shown to need more effort to enact these behaviors, and feel more tempted by competing ones (snacking and sedentary behaviors), than people with strong habits (Galla and Duckworth, 2015). The contextual disruption of habits might have precisely left some individuals unable to rely upon such an effortless and automatic mode of behavioral regulation (Fujita, 2011; Wood et al., 2005).

Taken together, these results suggest that self-control resources may be an important predictor of physical activity in a habit-disrupting context such as the lockdown, at least in its beginning. Then, as the lockdown progressed and people developed new physical activity habits (e.g., Maltagliati et al., 2021), self-control resources may have become less predictive of physical activity.

Self-control resources and physical activity in a context change

In addition to examining whether the association between self-control resources and physical activity evolved as one moved away from the beginning of the lockdown, we investigated if this association was moderated by usual (or habitual) physical activity behavior before the lockdown. As people who are frequently active are likely to have developed stronger physical activity habits than usually inactive people (e.g., Rebar et al., 2018), one could expect the former to need less self-control resources to enact physical activity than the latter in a usual daily life setting. However, during a major context change where habits are disrupted, whether usually active individuals rely less on self-control resources to engage in physical activity than usually inactive ones remains an open question.

The present study

We hypothesized that self-control resources would be positively associated with physical activity during lockdown (H1a), and we expected this association to decrease across time (H1b). We also explored whether the association between self-control resources and physical activity would be moderated by before-lockdown usual physical activity (H2a), and if this interaction would be moderated by time (H2b). To do so, we used a longitudinal design in which the variables of interest were measured seven times: five times once a week during the Spring 2020 lockdown (T1 to T5), a few days after the end of this lockdown (T6), and two months later (T7). All hypotheses were investigated at the between-person and within-person levels, in order to disentangle the role of individual differences in self-control resources from the role of within-person fluctuations in these resources.

Methods

Participants and procedure

The Spring 2020 lockdown was implemented from March 17 to May 11, 2020 in France. Participants residing in France and aged 18 and over were recruited to complete a first online survey between March 30 and April 10. The questions of this survey included intention towards physical activity, controlled and autonomous motivation towards physical activity, perceived stress and sociodemographic information (these measures are not presented in this paper). Participants were recruited by word of mouth and on social media (i.e., Twitter and Facebook). At the end of the questionnaire, participants were asked if they wanted to complete an additional weekly questionnaire on their physical activity behaviors, during and after the lockdown. An online informed consent form was read and signed before completing the questionnaire.

During the lockdown, each participant received an email with an invitation to respond to four surveys every nine days starting from their first survey completed, and with a delay of three days to answer it. The sixth measurement wave took place two weeks after the end of the lockdown, and the final measurement was held two months and a half after the end of the lockdown (for more details see Figure 1).

Participants who completed the questionnaire at least two times were included in the study (N = 259; 66% women; M_{age} = 34.02 years, SD_{age} = 13.41 years). The measurement times at which the participants reported having no intention at all to do physical activity (i.e., who answered 1 on the seven-point intention item) were excluded from the analyses ($N_{\text{observations}}$ = 27). Indeed, self-control resources are supposed to be needed only when individuals' long-term goal confronts competing motivational forces, such as that conflicts with surrounding temptations (e.g., Forestier, de Chanaleilles, Deschamps, et al., 2022). As such, people who do not pursue at all the goal to be physically active are unlikely to have to deal with motivational conflicts when they experience a desire toward sedentary behaviors, and are therefore unlikely to use their self-control resources in order to overcome it and be physically active.

Because of time constraints (i.e., the duration of the lockdown was unknown when the government announced it, therefore the number of repeated measures was unknown at the beginning of the study), we were not able to carry an a priori power analysis.

Measures

Physical activity was assessed using an adapted version (Teran-Escobar et al., 2021) of the International Physical Activity Questionnaire (IPAQ, Craig et al., 2003) at each measurement time. Precisely, given the movement restrictions imposed by the lockdown, participants were asked to report the minutes per week spent in six categories of physical activities: walking outside; running outside; climbing the stairs of their building/housing; doing muscle strengthening exercises (abs, push-ups, squats) or balance or stretching exercises (tai chi, yoga); cycling; rowing; or doing cardio activities. These categories were based on Chen et al. (2020)'s typology of physical activities that can be undertaken during a lockdown. Participants could also mention any activity that was not included in the list. All activities were classified into moderate-to-vigorous physical activity when they were superior or equal to 3 METS, according to the compendium of physical activity of Ainsworth et al. (2011). Therefore, minutes of moderate-to-vigorous physical activity per week was the dependent variable.

Usual physical activity before lockdown was assessed at Time 1, using an adapted version of the Saltin-Grimby Physical Activity Questionnaire (Grimby et al., 2015), with the following question: "In general, what did your "profile" look like in terms of physical activity over the past year? If your activity varied greatly from week to week, try to estimate an average". Participants answered this question using the following scale: 1 (almost completely inactive), 2 (some physical activity), 3 (regular physical activity) and 4 (regular hard physical activity).

Self-control resources were operationalized by subjective vitality, and was assessed at each measurement time using the five-item subjective vitality scale (Ryan & Frederick, 1997), as done in past research to reflect self-control resources (e.g., Emile et al., 2015; Forestier et al., 2018; Rojas-Sánchez et al., 2021). This scale contains items such as « During the past seven days, I felt alive and vital”, with answers ranging from 1 (completely disagree) to 7 (completely agree). This scale showed good reliability in the present sample (α = 0.93, ω = 0.95).

Intention towards physical activity was assessed at each measurement time using a single item (Godin, 2012) : “For the next seven days, to what extent do you intend to do 30 minutes of moderate to vigorous physical activity at least 5 days a week, as recommended by health authorities?”. The scale ranged from 1 (no intention at all) to 7 (very strong intention).

Sociodemographic data included age and gender and were measured at Time 1.

Statistical analysis

Because our data were nested with multiple observations for each subject, hypotheses were tested with linear mixed-effects models in R studio version 3.4.1 (R Core Team, 2021), using the lmer and the lme4 packages (Bates et al., 2015). Moreover, the interactions were decomposed using the interaction package (Long, 2019) to estimate and plot simple slopes of significant interactions.

The between-person predictor (i.e., subjective $\text{vitality}_{\text{between}}$ and before-lockdown usual physical activity) was grand-mean centered (e.g., Iacobucci et al., 2016; Shieh, 2011). Moreover, the within-person predictor (i.e., subjective $\text{vitality}_{\text{within}}$) was centered at the individual mean as recommended by Enders and Tofighi (2007).

Model 1 tested H1a and H1b by including subjective $\text{vitality}_{\text{within}}$, subjective $\text{vitality}_{\text{between}}$, linear time, quadratic time, and the interaction terms between linear time and subjective vitality, and between quadratic time and subjective vitality as predictors of physical activity. A statistically significant effect of subjective vitality would indicate that self-control resources predicted physical activity at the within- and/or between-person levels

(H1a), and a statistically significant interaction with time (linear or quadratic) would indicate that these relationships depended on measurement time (linear or quadratic) (H1b).

Model 2 tested H2a and H2b by adding before-lockdown usual physical activity to Model 1, as well as its interactions with subjective vitality at the between and within-person levels, time (linear and quadratic), and the three-way interaction between usual physical activity, subjective vitality, and time (linear and quadratic). A statistically significant interaction effect between subjective vitality and usual physical activity would indicate that the relationship between self-control resources and physical activity at the within- and/or between-person levels differed depending on usual physical activity (H2a). A statistically significant three-way interaction effect would indicate that this interactive effect differed depending on the time of measurement (linear or quadratic) (H2b).

Models were inspected using the performance package (i.e., linearity, homogeneity of variance, collinearity, normality of residuals, normality of random effects and influential observations, Lüdecke et al., 2021). We also have compared each most constrained model to the precedent simpler model using an ANOVA (i.e., comparing Model 0 to Model 1, and comparing Model 1 to Model 2), to evaluate if the augmented model better fit the data (Bliese, 2005; Finch & Bolin, 2017).

Results

Descriptive statistics and preliminary analyses

The means, standard deviations, intraclass correlations, and the description of our variables are presented in Table 1. The correlations between variables and boxplots of physical activity and subjective vitality at each measurement time are displayed in Supplementary Material (Tables S1, S2 and S3, Figures 2 and 3).

Were self-control resources positively associated with physical activity (H1a)? Did this association evolve over time (H1b)?

Model 0 showed that moderate-to-vigorous physical activity was significantly and positively predicted by linear time (*B* = 1889.43, 95% CI [1142.99, 2635.86], $p < .001$), and quadratic time (*B* = 691.98, 95% CI [186.37, 1197.59], $p = .007$).

Model 1 showed that moderate-to-vigorous physical activity was significantly and positively predicted by linear time (*B* = 2610.72, 95% CI [1780.50, 3440.95], $p < .001$), quadratic time (*B* = 599.57, 95% CI [26.26, 1172.88], $p = .040$), subjective $\text{vitality}_{\text{between}}$ (*B* = 84.75, 95% CI [54.18, 115.33], $p < .001$), and subjective $\text{vitality}_{\text{within}}$ (*B* = 65.85, 95% CI [49.41, 82.30], $p < .001$). Moreover, the interaction between subjective $\text{vitality}_{\text{between}}$ and linear time (*B* = 799.46, 95% CI [48.25, 1550.68], $p = .037$), and the interaction between subjective $\text{vitality}_{\text{within}}$ and linear time (*B* = 952.92, 95% CI [226.16, 1679.68], $p = .010$, conditional $R^2 = 0.69$) were significant (see Table 2). In other words, at the between-person level, although the association between subjective vitality and physical activity was significant at all time points, the strength of this association linearly increased over time (see Figure 2). For example, at Time 1, the slope of the association was b = 55.99 ($p < .001$), against b = 84.75 ($p < .001$) at Time 4, and b = 113.54 ($p < .001$) at Time 7. At the within-person level, the association between subjective vitality and physical activity also linearly increased over time and was significant from Time 2 to Time 7 (see Figure 3 and Supplementary Table S7). No significant quadratic effect of time was found.

Finally, the ANOVA comparing Model 1 with Model 0 showed that the most constrained model better fitted the data than the simplest model (*F* = 94.125, $p < .001$). Specifically, Model 0 showed that physical activity was significantly associated to time, both in a linear (*B* = 1889.43, 95% CI [388.17, 456.26], $p < .001$) and quadratic (*B* = 691.98, 95%

CI [186.37, 1197.59], *p* = .007) manner (see Supplementary Figure 4). Finally, the robustness of the model was acceptable (See Supplementary Figure 5).

Was the association between self-control resources and physical activity moderated by usual physical activity? Did this moderation evolve over time?

Results of Model 2 showed no significant three-way interactions indicating that H2b was not confirmed. However, two-way interactions were observed between usual regular physical activity and quadratic time (*B* = 4274.91, 95% CI [528.26, 8021.56], *p* = .025, conditional R^2 = 0.66), and between usual regular hard physical activity and quadratic time (*B* = 4150.17, 95% CI [322.86, 7977.48], *p* = .034). Simple slope analyses of these interactions (see Supplementary Table S8) showed that individuals practicing regular physical activity before the lockdown tended to do more physical activity than inactive individuals, but only after the end of the lockdown (Time 6 and 7). For example, at Time 1, the slope of the association between usual physical activity (regular vs. inactive profiles) and moderate-to-vigorous physical activity was b =-40.30 (*p* = .741), against b = 226.11 (*p* = .088) at Time 6 and b = 226.34 (*p* = .088) at Time 7. In addition, simple slope analyses showed that individuals regularly practicing hard physical activity were significantly more physically active than usually inactive individuals only after the end of the lockdown. Specifically, at Time 1, the slope of the association between usual physical activity (regular hard vs. inactive profiles) and moderate-to-vigorous physical activity was b = 42.26 (*p* = .732), against b = 300.89 (*p* = .025) at Time 6 and b = 301.11 (*p* = .025) at Time 7. Finally, the ANOVA showed that Model 2 was more informative than Model 1 (*F* = 60.45, *p* < .001). Finally, the robustness of the model was acceptable (See Supplementary Figure 6).

Discussion

Main findings

The current research investigated whether and among whom self-control resources predicted physical activity during the Spring 2020 Covid-19 lockdown, a context that was likely to disrupt healthy habits (e.g., Furman et al., 2021; Maltagliati et al., 2021). Results revealed that self-control resources positively predicted physical activity at the between- and within-person levels. In other words, people with higher self-control resources were more physically active during this period than people with lower resources, and people were more physically active when they experienced higher self-control resources than their average level, and conversely, they were less active when they had lower self-control resources than their average level. These observations corroborate the importance of self-control resources in regulating health behaviors. Interestingly, and in contrast to our hypothesis, the strength of these associations increased over time, both at the within and between-person levels. In addition, theses associations were not significantly moderated by individuals' usual physical activity before the lockdown. Finally, individuals being usually active before the lockdown (at regular and regular hard levels) were more physically active than usually inactive individuals, but only after the end of the lockdown.

Comparison with other studies

Although the association between self-control resources and physical activity is in line with past studies (e.g., Forestier et al., 2018; Maltagliati et al., 2022; Rojas-Sánchez et al., 2021), the increase in the strength of this association observed throughout the lockdown is more unexpected. Indeed, one may have expected self-control resources to be more important at the beginning of the lockdown. At this moment, the contextual cues necessary to trigger physical activity habits vanished, making an effortful regulation of behavior more needed.

Then, as time passed and people developed new habits, such effortful regulation – and therefore self-control resources – may have become less necessary.

Therefore, observing a stronger association between self-control resources and physical activity at the end of the lockdown than at its beginning may seem surprising. However, a closer look at the physical activity data may allow to better understand these findings. As indicated by Model 0, physical activity was lower at the beginning of the lockdown than at its end. This could suggest that people had other priorities than being physically active when the lockdown began, such as handling the organizational changes resulting from lockdown restrictions at work and at home. In this case where physical activity was not a priority, self-control resources were therefore less necessary. Then, as time passed, people may have developed a more stable organization of their daily-life activities, and were therefore more prone to re-engage in healthy behaviors. In this case, self-control resources may have become more necessary to engage in physical activity.

Our findings also revealed that the association between self-control resources and physical activity did not depend on usual physical activity before the lockdown. Yet, one may have expected self-control resources to be less necessary in individuals who adopt physical activity behaviors more frequently, as they are more likely to adopt an automatic mode of behavioral regulation than inactive ones (Rebar et al., 2018). These results are however not surprising in a habit-disrupting context such as the Covid-19 lockdown, as Maltagliati et al. (2021) observed that physical activity habits were particularly disrupted in people with strong before-lockdown habits. The non-significant moderation suggests that usual physical activity did not have a protective role on physical activity during the lockdown. Another explanation lies in the idea that usual (or habitual) behaviors involve different processes than habits: while habit is an effortless process, usual behaviors necessitate effortful processes to be enacted (Gardner, 2015). Therefore, self-control resources may be needed to enact physical activity even in usually active people. This may explain why habits, but not usual behaviors, were shown to moderate the association between self-control resources and healthy behaviors.

In contrast, we observed that usually active and very active individuals did more physical activity than inactive ones (when controlling for self-control resources) after the end of the lockdown. This again suggests that usually active people are not necessarily more able to adapt their physical activity level in a major change context than inactive ones. However, once the lockdown ended, usually active and very active individuals became more physically active again than usually inactive ones. It is probable that finding back the contextual cues that used to trigger their physical activity habits before the lockdown (e.g., time of day, exercise partners, type of physical activity, location) helped usually active individuals to quickly restore their physical activity participation.

Strengths and limitations

At the theoretical level, this study contributes to the self-control literature, by showing that the strength of the association between self-control resources and physical activity evolved across a major context change. Future research should identify the mechanisms underlying this observation (e.g., evolution of the strength of the physical activity goal, or of the desire strength toward conflicting temptations). In addition, our study shows that being usually active was not helpful to do more physical activity during the lockdown, corroborating past research indicating that habits were disrupted during this period (e.g., Furman et al., 2021; Maltagliati et al., 2021). Interestingly, our results extend this line of research by revealing that as soon as the lockdown ended, usually active individuals restored their physical activity levels or at least, the pre-existing difference in physical activity levels was “back to normal”. This highlights the importance of stable contextual cues triggering habits in order to perform a habitual behavior. At the methodological level, one main strength of this study is its longitudinal design with multiple measures across the 2020 Spring Covid-19 lockdown in France and after the end of the lockdown, which provides a fine-grained perspective of the evolution of the variables and of their relative association associations at both between- and within-person levels. However, this study is not exempt of limitations.

Despite these strengths, this study is not exempt of limitations. A first limit is the use of a self-reported measure of physical activity, which may be more biased than device-based measures (i.e., accelerometry) (Dyrstad et al., 2014; Van Hoye et al., 2014). A second limit is the imbalance in the number of participants across the four usual physical activity groups. Indeed, a larger number of people reported being active, which might indicate a bias in the recruitment of participants and may have biased statistical estimations. A third limit is that we did not examine the directionality of the relationship between self-control resources and physical activity. A fourth limit is that we have interpreted a null result (i.e., the absence of moderation of the self-control resources – physical activity relationship by usual physical activity), which should be made with precaution, as a null result could be due to a lack of statistical power to detect it.

Practical implications

In terms of practical implications, this study highlights the importance of self-control resources to engage or maintain healthy behaviors across a disrupting context. In such contexts, a main challenge for governments and public health policies is to provide incentives or opportunities to engage or reengage people in healthy behaviors. For example, it could be relevant to provide microrewards for returning to physical activities in gyms or other structures (Milkman et al., 2021), to encourage the engagement in activities that satisfy basic needs to enhance self-control resources (Ryan & Deci, 2008) or to support the enactment of self-regulatory skills (e.g., goal setting or action planning), or to insist on the need to perform healthy behaviors in a regular manner in stable contexts (Hagger, 2019). Future studies and interventions need to examine whether targeting self-control resources is efficient for promoting physical activity and adoption of other health behaviors such as physical activity.

Conclusions

This study examined the evolution of the association between self-control resources and physical activity during a context likely to disrupt healthy habits: the Covid-19 lockdown. Moreover, we investigated if this association was moderated by the usual before-lockdown physical activity level. Our results indicated that self-control resources positively predicted engagement in physical activity during and after the lockdown, and more and more throughout the lockdown. Our findings also indicated that being usually active before the lockdown was helpful in being physically active only after the end of the lockdown.

Authors contribution

A.C and C.T.E. formulated research goals and designed the analyses. C.T.E. collected the data. C.T.E. and C.F. analysed the data. C.T.E., S.M. and A.C. drafted the manuscript. All authors critically appraised and approved the final version of the manuscript.

Data availability statement

The R code and the dataset for this research can be found in the open platform OFSHOME: https://osf.io/cjeqz/?view_only=1e7799d6ca6841a4a7dbbeab14ead1b5

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Conflict of interest

The authors do not have any conflict of interest to declare.

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Tables

Table 1

Means, standard deviations, and description of variables

Variable	Mean	SD	Median	Min-Max	Range/unit
Outcome					
MVPA	440.1	402.43	359.5	0 – 4050	Minutes per week
Predictors					
Usual PA before the lockdown					
Inactive	10 (3.95%)				
Some PA	52 (34.78%)				
Regular PA	102 (40.32%)				
Regular hard PA	88 (20.55%)				
Subjective vitality	4.58	1.39	4.8	1 – 7	1 – 7
Sociodemographic variables					
Age	34.43	13.94	30.00	18 – 81	
Gender					
Men	83 (32.8%)				
Women	170 (67.2%)				

Note: *N* = 253, MVPA = Moderate-to-vigorous physical activity, PA = Physical activity, Mean = Grand mean, SD = Standard Deviation.

Table 2

Results of the linear mixed-effects models testing the hypotheses of interest

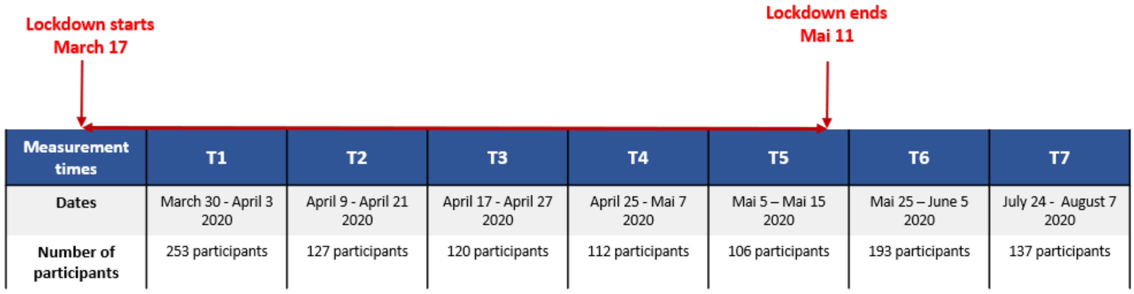
Predictor	**b [95% CI]**	**SE**	**p**
	Model 0: PA depending on time		
Intercept	**422.22*** [388.17, 456.26]**	**17.35**	**<.001*****
Time	**1889.43*** [1142.99, 2635.86]**	**380.36**	**<.001*****
Time^2	**691.98** [186.37, 1197.59]**	**257.64**	**.007****
	Model 1: PA depending on subjective vitality × time		
Intercept	**454.62*** [421.27, 487.96]**	**16.99**	**<.001*****
Time	**2610.72*** [1780.50, 3440.95]**	**423.03**	**<.001*****
Time^2	**599.57* [26.26, 1172.88]**	**292.13**	**.040***
Subjective vitality$_{between}$	**84.75*** [54.18, 115.33]**	**15.58**	**<.001*****
Subjective vitality$_{within}$	**65.85*** [49.41, 82.30]**	**8.38**	**<.001*****
Time × Subjective vitality$_{between}$	**799.46* [48.25, 1550.68]**	**382.78**	**.037***
Time^2 × Subjective vitality$_{between}$	37.19 [-480.85, 555.23]	263.97	.888
Time × Subjective vitality$_{within}$	**952.92* [226.16, 1679.68]**	**370.32**	**.010****
Time^2 × Subjective vitality$_{within}$	-506.84 [-1249.43, 235.75]	378.38	.181
	Model 2: PA depending on subjective vitality × time × usual PA		
Intercept	**379.88*** [167.60, 592.16]**	**108.16**	**<.001*****
Time	835.00 [-4867.97, 6537.97]	2905.86	.774
Time^2	**--3109.43^{t} [-6718.88, 500.01]**	**1839.14**	**.091^{t}**
Subjective vitality$_{within}$	57.02 [-67.73, 181.78]	63.57	.370
Subjective vitality$_{between}$	90.48 [-128.71, 309.68]	111.69	.418
Some PA	56.77 [-176.88, 290.41]	119.05	.634
Regular PA	78.14 [-141.45, 297.73]	111.89	.485
Regular Hard PA	157.24 [-64.43, 378.91]	112.95	.164
Some PA × Subjective vitality$_{within}$	15.96 [-116.14, 148.06]	67.31	.813

Regular PA × Subjective $vitality_{within}$	12.50 [-115.62, 140.62]	65.28	.848
Regular Hard PA × Subjective $vitality_{within}$	-1.48 [-131.15, 128.19]	66.07	.982
Some PA × Subjective $vitality_{between}$	34.36 [-200.09, 268.80]	119.46	.774
Regular PA × Subjective $vitality_{between}$	-6.63 [-231.74, 218.48]	114.70	.954
Regular Hard PA × Subjective $vitality_{between}$	-27.18 [-255.05, 200.70]	116.11	.815
Time × Subjective $vitality_{within}$	-1487.60 [-6327.98, 3352.77]	2466.34	.547
$Time^2$ × Subjective $vitality_{within}$	-522.15 [-5213.77, 4169.48]	2390.55	.827
Time × Subjective $vitality_{between}$	-1859.86 [-8456.73, 4737.01]	3361.34	.580
$Time^2$ × Subjective $vitality_{between}$	-2389.42 [-7195.81, 2416.98]	2449.03	.329
Some PA × Time	3584.18 [-2618.83, 9787.19]	3160.65	.257
Some PA × $Time^2$	1233.87 [-2862.54, 5330.28]	2087.26	.555
Regular PA × Time	2169.61 [-3706.95, 8046.17]	2994.31	.469
Regular PA × $Time^2$	**4274.91*** **[528.26, 8021.56]**	**1909.05**	**.025***
Regular Hard PA × Time	1448.88 [-4512.71, 7410.47]	3037.64	.633
Regular Hard PA × $Time^2$	**4150.17*** **[322.86, 7977.48]**	**1950.15**	**.034***
Some PA × Subjective $vitality_{within}$ × Time	1599.26 [-3630.41, 6828.93]	2664.70	.549
Some PA × Subjective $vitality_{within}$ × $Time^2$	-2163.92 [-7272.46, 2944.62]	2602.98	.406
Regular PA × Subjective $vitality_{within}$ × Time	2449.27 [-2573.42, 7471.97]	2559.24	.339
Regular PA × Subjective $vitality_{within}$ x $Time^2$	189.88 [-4690.12, 5069.87]	2486.53	.939
Regular Hard PA × Subjective $vitality_{within}$ × Time	3790.59 [-1255.57, 8836.74]	2571.19	.141
Regular Hard PA × Subjective $vitality_{within}$ × $Time^2$	1224.74 (-3684.05, 6133.52]	2501.20	.624
Some PA × Time × Subjective $vitality_{between}$	3222.63 [-3640.05, 10085.32]	3496.78	.357
Some PA × $Time^2$ × Subjective $vitality_{between}$	502.89 [-4580.53, 5586.31]	2590.18	.846
Regular PA × Subjective $vitality_{between}$ × Time	2868.95 [-3852.95, 9590.85]	3425.04	.402
Regular PA × $Time^2$ × Subjective $vitality_{between}$	1866.40 [-3029.13, 6761.9]	2494.44	.455
Regular Hard PA × Subjective $vitality_{between}$ × Time	2959.67 [-3835.57, 9754.92]	3462.41	.393

Regular Hard PA × $Time^2$ × Subjective $vitality_{between}$	2867.64 [-2057.78, 7793.07]	2509.68	.253

Dependent variable is minutes of moderate-to-vigorous physical activity per week transformed in squared root. *N* of $participants_{Model0}$ = 250, *N* of $participants_{Model1}$ = 250, *N* of $participants_{Model2}$ = 251. *N* of $observations_{Model0}$ = 963, *N* of $observations_{Model1}$ = 936, *N* of $observations_{Model2}$ = 950. PA = Physical Activity, *B* = raw coefficient, *SE*= Standard error of betas, * represents $p < .05$, ** $p < .01$, *** $p < .001$. The reference group for Some PA, Regular PA, and Regular Hard PA before lockdown is inactive individuals. Values between brackets represent confidence intervals.

Figures



Measurement times	T1	T2	T3	T4	T5	T6	T7
Dates	March 30 - April 3 2020	April 9 - April 21 2020	April 17 - April 27 2020	April 25 - Mai 7 2020	Mai 5 – Mai 15 2020	Mai 25 – June 5 2020	July 24 - August 7 2020
Number of participants	253 participants	127 participants	120 participants	112 participants	106 participants	193 participants	137 participants

Figure 1. Time schedule of the study.

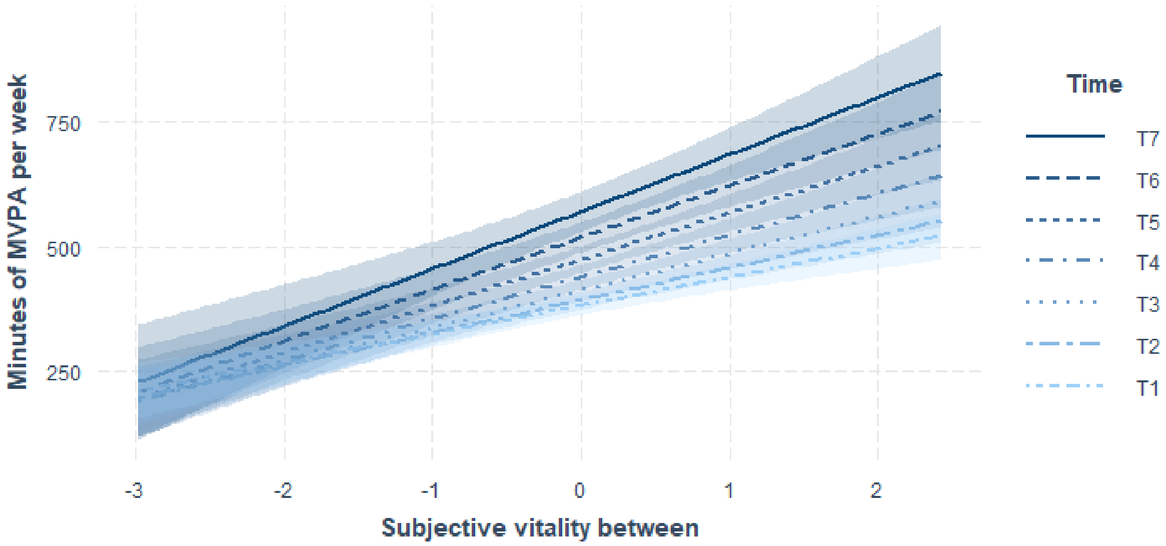


Figure 2. Time × subjective vitality$_{between}$ on minutes of moderate-to-vigorous physical activity (MVPA) per week. The shaded areas indicate 95% confidence intervals.

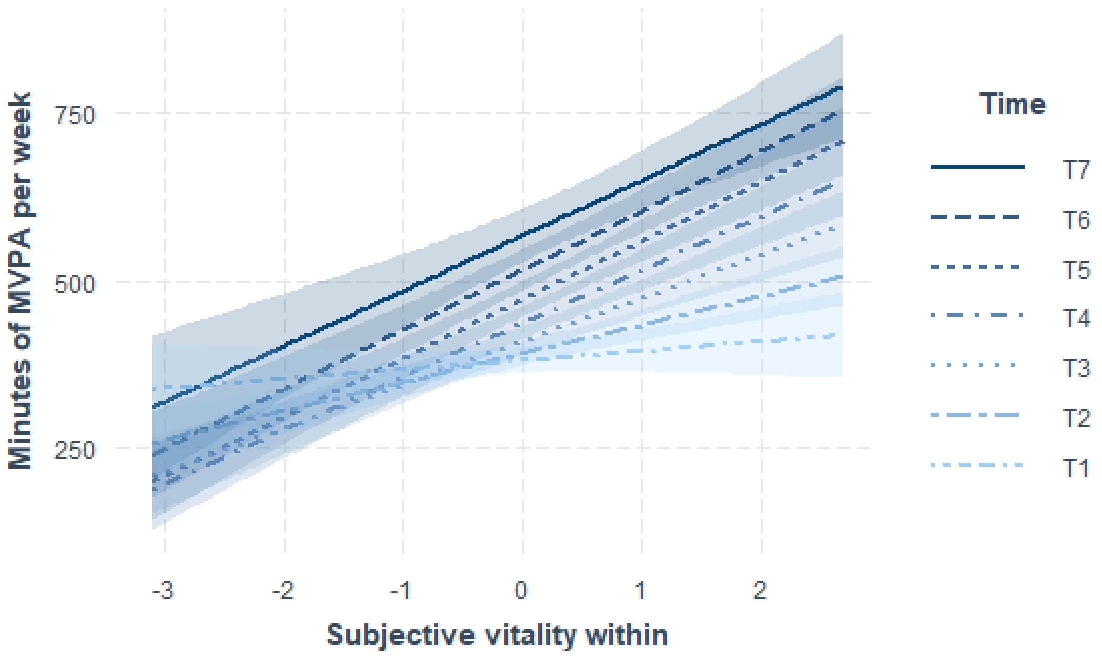


Figure 3. Time × subjective vitality$_{within}$ on minutes of moderate-to-vigorous physical activity (MVPA) per week. The shaded areas indicate 95% confidence intervals.