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The impact of the COVID-19 pandemic on daily rhythms of movement

Keywords: life routines, wearables, daily rhythms of movement, COVID-19 pandemic, longitudinal study

Extended abstract

Over the last few years, the COVID-19 pandemic has imposed unprecedented levels of constraints on daily lives. Numerous studies have identified a decline in physical activity levels [1], deterioration of mental health [2] and well-being [3]. These adverse impacts have been felt to a higher degree by different groups and communities, such as women [4], LGBTQ [5], and migrant populations [6]. Daily rhythms of activities and their consistency over time play an important role in people's lives, both in terms of fulfilling the roles they play in society as well as at the individual level (e.g., their mental and physical well-being) [7]. Our study aims to investigate the changes in daily rhythms, such as exercise, work, and movement, during the pandemic, and to analyze the differences in these changes across various socio-demographic factors, such as gender, age, and immigrant status. Furthermore, we aim to understand whether these routines have returned to pre-pandemic levels within the given time period.

Over the course of one year (June 2021-June 2022), fitness tracker records and questionnaire data were collected from 128 working adults to investigate changes in physical activity during the pandemic compared to the pre-pandemic period. To capture changes in daily rhythms that can occur over both short (day-to-day) and long periods of time (due to seasonal, work, or life situation changes), two metrics were proposed to measure the daily rhythms of movement and their consistency over time using step count data from fitness trackers, namely the *short-term movement consistency"* and the *long-term movement consistency"*. The former metric is sensitive to changes in daily rhythms that occur on a day-to-day basis, while the latter is better suited for longer timescales (over a month, a season, or a year). The movement consistency metric was computed by constructing temporal distributions of daily step count for each participant, which enabled the calculation of daily movement rhythms. The level of movement consistency was then quantified using the inverse of the Earth mover's distance (see Figure 1 and Figure 2). The socio-demographic factors that contribute to predicting movement consistency were explored using a linear mixed-effects model (LMM). Another LMM was built to investigate the relationship between movement consistency and work routine. Furthermore, using questionnaires at different time points, we investigate how routines of exercising and working have changed throughout the pandemic for different people.

The findings presented in Table 1 reveal that individuals who live alone and migrants have lower consistency in their daily movement rhythms compared to their counterparts. Additionally, Table 2 suggests that individuals who work at a physical workplace tend to exhibit more uniform daily movement patterns, which could be indicative of a more organized and structured routine that accounts for commuting to and from work. Using answers from questionnaires, the results from Table 3 demonstrate that the pandemic has led to a shift in exercise routines, with a decrease in time spent on non-walking physical exercises and no significant change in time spent walking. Sub-population analysis (see Figure 3) reveals no significant difference in the

time spent walking between males and females during the pre-pandemic stage. However, during the early stage of the pandemic, females show a significantly higher amount of time spent walking. Conversely, in regards to non-walking exercises, females tend to spend significantly less time during the early stage of the pandemic compared to males. Finally, men and migrants returned to on-site work faster after the pandemic-induced restrictions were lifted.

Our findings highlight the unequal effects of the pandemic on different sub-populations and open up new avenues for research to understand why certain groups have a slower pace in returning to on-site work, exercise levels, and daily rhythms of movement compared to pre-pandemic times. These results can inform organizations and policymakers to provide more support and adapt to the different needs of various groups in the post-pandemic era and during future crises.

References

[1] Bohman H, Ryan J, Stjernborg V, Nilsson D. A study of changes in everyday mobility during the Covid-19 pandemic: As perceived by people living in Malmö, Sweden. Transport policy. 2021;106:109-19.

[2] Zandifar A, Badrfam R. Iranian mental health during the COVID-19 epidemic. Asian journal of psychiatry. 2020;51.

[3] Zhang SX, Wang Y, Rauch A, Wei F. Unprecedented disruption of lives and work: Health, distress and life satisfaction of working adults in China one month into the COVID-19 outbreak. Psychiatry Research. 2020 Jun;288:112958.

[4] Reisch T, Heiler G, Hurt J, Klimek P, Hanbury A, Thurner S. Behavioral gender differences are reinforced during the COVID-19 crisis. Scientific reports. 2021;11(1):1-12.

[5] Yuan Y, Verma G, Keller B, Aledavood T. The Impact of COVID-19 Pandemic on LGBTQ Online Communitie. arXiv preprint arXiv:220509511. 2022.

[6] Clark E, Fredricks K, Woc-Colburn L, Bottazzi ME, Weatherhead J. Disproportionate impact of the COVID-19 pandemic on immigrant communities in the United States. PLoS Neglected Tropical Diseases. 2020;14(7):e0008484.

[7] Carney CE, Edinger JD, Meyer B, Lindman L, Istre T. Daily activities and sleep quality in college students. Chronobiology international. 2006;23(3):623-37.

Tables and Figures

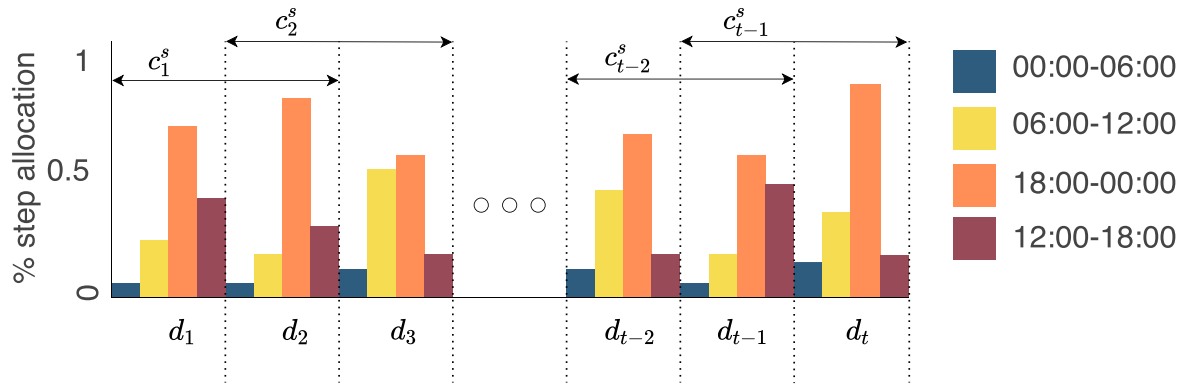

Figure 1: Short-term movement consistency computation. The short-term movement consistency is denoted as $c_t^s = 1/D(\mathbf{d}_t, \mathbf{d}_{t+1})$ (D is the Earth's mover distance) and quantified as the inverse of the distance in step count distribution between $\mathbf{d}_t$ and $\mathbf{d}_{t+1}$ of an individual.

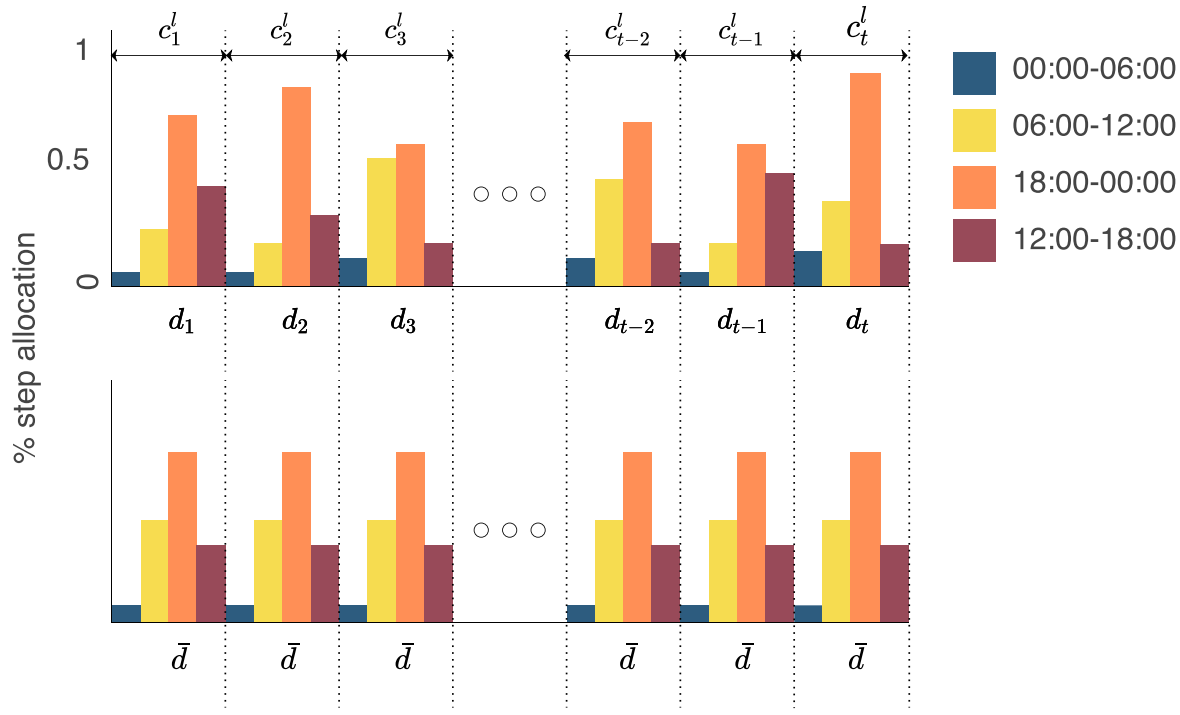

Figure 2: Long-term movement consistency calculation. The long-term movement consistency is denoted as $c_t^l = 1/D(\mathbf{d}_t, \bar{\mathbf{d}})$ (D is the Earth's mover distance) and quantified as the inverse of the distance in step count distribution between $\mathbf{d}_t$ and the average distribution $\bar{\mathbf{d}}$ of an individual.

Figure 3: Time allocation for different activities of sub-populations. during each stage of the pandemic. Comparisons are made using Mann-Whitney U test. Asterisks denote the significance of the results. $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

	Model 1a (short-term)		Model 1b (long-term)	
	Est.	95% CI	Est.	95% CI
(Intercept)	0.22	-0.08 – 0.53	**0.48**	**0.06 – 0.91***
Role (service staff)	-0.08	-0.36 – 0.21	-0.17	-0.56 – 0.22
Gender (male)	-0.16	-0.45 – 0.15	-0.11	-0.30 – 0.08
Live alone (yes)	**-0.33**	**-0.61 – -0.05***	**-0.78**	**-1.15 – -0.40*****
Have children (yes)	-0.10	-0.40 – 0.19	-0.29	-0.70 – 0.11
Origin (foreign)	-0.19	-0.50 – 0.10	**-0.61**	**-1.01 – -0.20****
Age	0.01	-0.12 – 0.14	-0.02	-0.19 – 0.15
Have children (yes) x Gender (male)	0.22	-0.26 – 0.70	0.31	-0.37 – 0.98
Random effects				
σ^2	0.74		0.34	
$\tau_{00_{participant}}$	0.25		0.61	
ICC	0.25		0.64	
N $_{participant}$	111		111	
Observations	885		912	
Marginal R^2 / Conditional R^2	0.025 / 0.271		0.131 / 0.687	

Table 1: Results for socio-demographic variables predicting short and long-term consistency. Asterisks denote the significance of the results. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

	Est.	95% CI
(Intercept)	**0.30**	**0.22 – 0.37*****
Long-term workday consistency	**0.07**	**0.04 – 0.09*****
Role (service staff)	**-0.12**	**-0.17 – -0.07*****
Gender (male)	**0.12**	**0.06 – 0.17****
Live alone (yes)	**0.08**	**0.03 - 0.13*****
Have children (yes)	-0.10	-0.06 – 0.04
Origin (migrant)	**0.13**	**0.08 – 0.18*****
Age	**0.02**	**0.00– 0.04***
Have children (yes) x Gender (male)	-0.01	-0.10 – 0.07
Random effects		
σ^2	0.08	
$\tau_{00_{month}}$	0.01	
ICC	0.08	
N $_{month}$	11	
Observations	912	
Marginal R^2 / Conditional R^2	0.151 / 0.223	

Table 2: Results for socio-demographic variables and long-term workday consistency predicting on-site work attendance rate. Asterisks denote the significance of the results. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Attributes	Pandemic stage		
	Pre	**Early**	**Late**
Avg. hours per week for walking			
All	5.33	4.83	5.97
Male	4.53	3.67	4.93
Female	5.68	5.43	6.61
Non-migrant	5.37	5.17	6.07
Migrant	5.33	4.18	6.00
Avg. hours per week for non-walking exercises			
All	3.62	2.58***	2.76**
Male	3.71	3.37	3.04
Female	3.54	2.21***	2.57**
Non-migrant	3.42	2.15***	2.45**
Migrant	4.03	3.51	3.33
% of working time spent on-site			
All	83.64	9.94***	32.56***
Male	83.42	13.57***	43.27***
Female	83.75	8.20***	27.44***
Non-migrant	82.38	8.62***	27.87***
Migrant	86.54	12.97***	43.32***

Table 3: Average amounts of activities at different stages of the pandemic compared to the pre-pandemic time. The average amount of weekly walking and non-walking exercise, as well as the percentage of working time spent on-site, is represented for three time periods: pre-pandemic, early, and late stages of the pandemic. The comparison of the percentage of work time spent on-site during the late stage of the pandemic is based on participants who have responded to at least 5 monthly surveys. The pre-pandemic stage is set as the reference level and the mean of each of the other two stages is compared to the pre-pandemic value of the mean for a given activity and sub-population. All comparisons are made using Wilcoxon signed rank test. Asterisks denote the significance of the results. $^*p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.