Wearable activity trackers for monitoring adherence to home confinement during the Covid-19 pandemic: a worldwide picture

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Submitted to: Journal of Medical Internet Research
on: May 01, 2020

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Abstract

Background: In the context of Covid-19 home confinement, objective, real-time data are needed to assess the population's adherence to home confinement in order to adapt policies and control measures.

Objective: To determine whether data collected from wearable activity trackers can be used to monitor adherence to home confinement at the population level.

Methods: Wearable activity trackers provide continuous monitoring of people's natural activity patterns whatever their location. We analyzed data on number of steps per day from over 660,000 individuals around the world.

Results: We showed physical activity patterns in several representative countries with total, partial or no home confinement. The decrease in steps per day in regions with strict total home confinement is striking.

Conclusions: Aggregate analysis of activity tracker data, with the potential for a daily update, can inform governments on the adherence to home-confinement policies.

(JMIR Preprints 01/05/2020:19787)
DOI: https://doi.org/10.2196/preprints.19787

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Wearable activity trackers for monitoring adherence to home confinement during the Covid-19 pandemic: a worldwide picture

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Word Count: main text 873; abstract 117

Abstract

Introduction: In the context of COVID-19 home confinement, objective, real-time data are needed to assess the population's adherence to home confinement in order to adapt policies and control measures.

Methods: Wearable activity trackers provide continuous monitoring of people's natural activity patterns whatever their location. We analyzed data on number of steps per day from over 660,000 individuals around the world.

Results: We show physical activity patterns in several representative countries with total, partial or no home confinement. The decrease in steps per day regions with strict total home confinement ranged from -25 to -54%.

Conclusion: Aggregate analysis of activity tracker data, with the potential for a daily update, can inform governments on the adherence to home-confinement policies.

Keywords: Wearable activity trackers; pandemic; COVID-19; home confinement; lockdown; monitoring

Introduction:

Nationwide total home confinement is the most spectacular measure taken to prevent the spread of the COVID-19 infection [1]. Currently over 3 billion people worldwide, a quarter of the world's population, are confined to their homes. However, the timing and stringency of governmental decisions have been heterogeneous, from total lockdown to partial or no confinement. Objective, real-time measures to assess the population's adherence to confinement are essential in order to adapt policies and control measures.

We asked whether wearable activity trackers could provide such information, because of their capacity for seamless and continuous monitoring of people's natural activity patterns whatever their location [2]. Data from activity trackers enables the compilation of synchronized big-data resources on human behavior with high geographical and temporal resolution. In the context of the COVID-19 pandemic activity trackers provide a precious dataset objectively documenting the time-course of adherence to home confinement worldwide in response to the outbreak.

Methods: We analyzed data from around 742,000 individuals using Withings™ activity trackers, counting average daily number of steps in a number of representative nations adopting different modalities of restrictions to citizens' activities (Figure 1). We selected the nations according to a compromise between their exposure to the COVID-19 pandemic, rules of lockdown, and availability of data from a large number of activity tracker users.

The pre-pandemic period was used as a reference (Figure 1). For each individual, we calculated the average daily number of steps between December 1, 2019 and the date of lockdown (excluded) representing the "pre-pandemic period" and the average daily number of steps between the date of lockdown and the analysis time point (4 weeks for China). These data were then aggregated across countries or regions. A paired Wilcoxon non-parametric test was used for comparison in number of steps per day before and during lockdown. The data presented extend up to April 13, 2020 and are averaged by days and over countries or provinces.

The activity tracker used was a wrist-worn watch with an embedded accelerometer to count the steps. Its performance is one of the best of among available devices [3]. The study activity tracker provided the most accurate measures of step count under all three important physiological conditions (i.e. treadmill, over-ground, and 24-hour conditions).

The same accelerometer and algorithm were used for all individuals included in the analysis. All tracking activity wearers were informed that the anonymized data collected could be used for research purposes and they signed informed consent before starting to use the activity tracker. They are allowed to withdraw their consent at any time and ask for deletion of their individual data.

Results: Table 1 shows number of users per country or region, sex ratio, lockdown initiation dates, rules and percentage of steps decrease during lockdown. The most demonstrative countries are presented in Figure 1 illustrating the time-course of step count, enhancing data of Table 1. Before the epidemic, all countries showed a stable mean number of steps per day, with periodic and reproducible decreases during weekends. In countries adopting a total lockdown, a marked decrease (from 25 to 54%) in number of steps following the official dates of home confinement can be clearly identified (Figure 1A). Partial lockdown (characterized by social distancing measures, such as school and bar/restaurant closures and cancellation of public meetings, but without strict home confinement) appears not have a significant clinical impact people's activity compared to the pre-pandemic period (Figure 1B) with similar activity patterns to those in nations without any restriction orders (Figure 1C).

Country	Region/ state	Mean age (years)	Women (%)	Lockdown date	Lockdown rules	Number of users	Baseline steps/ day	Lockdown steps/day	Decrease in steps (%)	*P*-Value
Australia		42	42%	2020-03-23	Partial	10 000	5 765	5 302	8%	*P* < .01
Canada		43	38%		None	10 000	5 049	4 708	7%	*P* < .01
China		36	19%	2020-01-23	Total	10 000	4 108	3 034	26%	*P* < .01
China	Hubei	35	14%	2020-01-23	Total	100	4 375	1 943	56%	*P* < .01
France		43	43%	2020-03-17	Total	100 000	4 604	3 342	27%	*P* < .01
Germany		46	37%	2020-03-16	Partial	100 000	5 349	5 416	-1%	*P* < .01
Ireland		42	38%	2020-03-28	Total	10 000	5 326	5 356	-1%	*P* < .01
Italy		45	31%	2020-03-10	Total	10 000	5 445	3 918	28%	*P* < .01
Italy	Provincia di Lodi	45	29%	2020-02-21	Total	100	5 640	5 035	11%	*P* < .01
Japan		43	29%	2020-04-07	Total	100 000	5 460	4 581	16%	*P* < .01
Netherlands		44	38%		None	10 000	5 193	5 180	0%	*P* < .01
Singapore		41	33%		None	1 000	6 127	5 860	4%	*P* < .01
Spain		46	36%	2020-03-15	Total	10 000	6 215	3 638	41%	*P* < .01
Sweden		44	34%		None	10 000	5 681	6 004	-6%	*P* < .01
Switzerland		44	40%	2020-03-16	Partial	10 000	5 325	4 947	7%	*P* < .01
United Kingdom		43	39%	2020-03-23	Total	100 000	5 690	5 249	8%	*P* < .01
United States		43	43%	2020-03-22	Partial	100 000	5 287	4 912	7%	*P* < .01
United States	California	43	38%	2020-03-19	Total	100 000	5 508	5 013	9%	*P* < .01
United States	Florida	46	44%	2020-03-17	Partial	10 000	5 303	5 225	1%	*P* < .01
United States	Illinois	42	41%	2020-03-21	Total	10 000	5 415	4 966	8%	*P* < .01
United States	New Jersey	43	38%	2020-03-21	Total	10 000	5 297	4 693	11%	*P* < .01
United States	Pennsyl-vania	44	43%	2020-03-19	Partial	10 000	5 186	4 974	4%	*P* < .01
United States	New York	42	39%	2020-03-22	Partial	10 000	5 776	4 499	22%	*P* < .01
United States	Nevada	45	42%	2020-03-21	Partial	1 000	5 391	4 902	9%	*P* < .01

Table 1: characteristics of the studied population

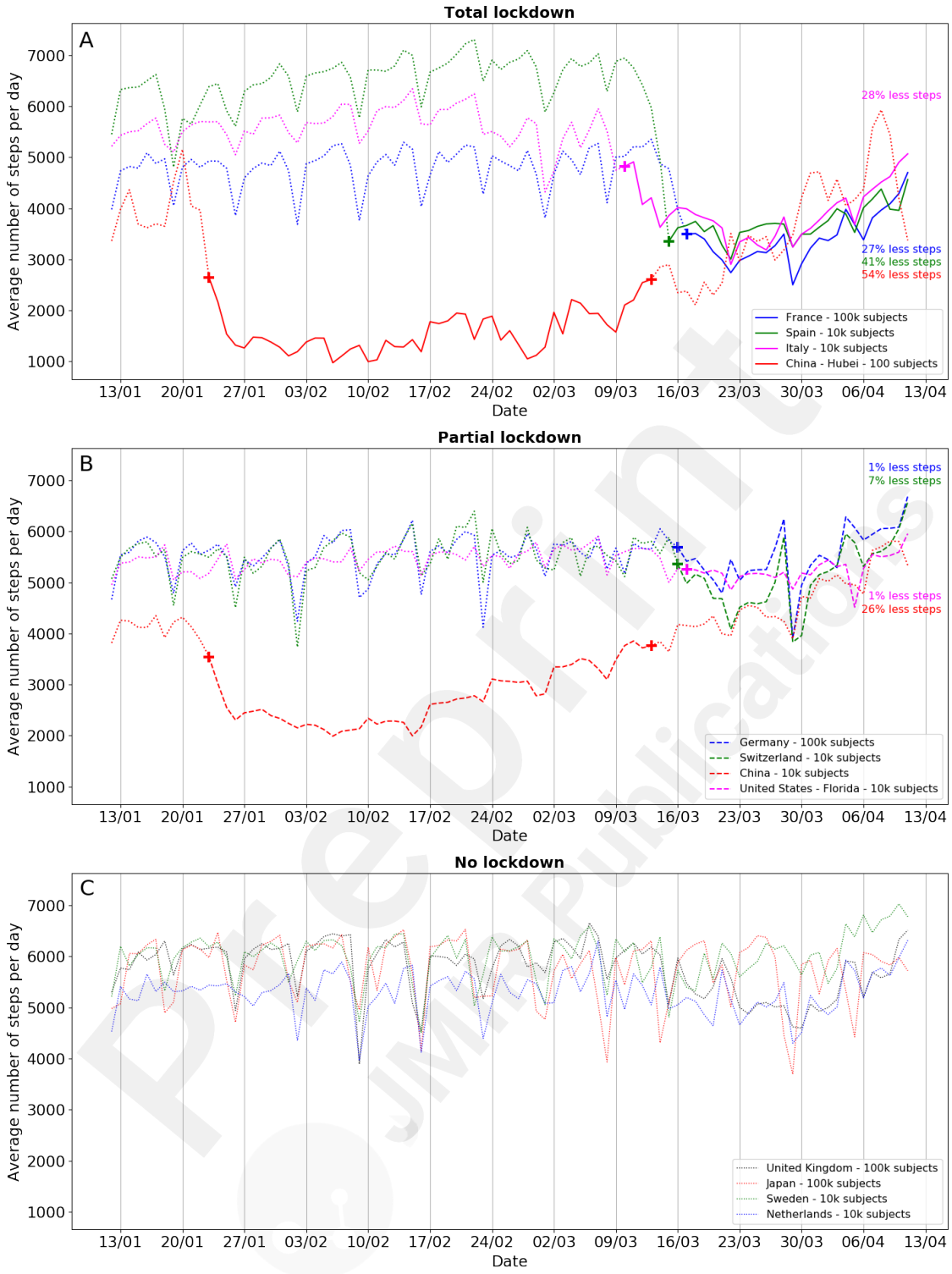

Figure 1: Trajectories of average daily number of steps recorded by activity trackers from 13 Jan 2020 to 13 Apr 2020 in a number of representative countries worldwide adopting total (A), partial (B) or no (C) lockdown. Solid lines are used for total lockdown periods, dashed lines for partial lockdown, dotted lines for no lockdown. A cross indicates start date and end of lockdown in the different countries.

Discussion: The absolute level of physical activity under total home confinement in

European countries is around two-fold compared to that achieved in China (Table 1), possibly suggesting stricter governmental rules or different national temperaments. Interestingly, in some countries such as France and Spain, physical activity started gradually decreasing even before official commitment to lockdown, as a result of initial milder restriction orders and/or self-quarantine. However, physical activity had begun to increase again in the last two weeks suggesting a decrease in compliance to confinement orders. Countries with partial or no lockdown policies had marginal or no changes in walking habits. Only Ireland who enforced confinement had no change in step counts. One might question the magnitude and significance of changes. All differences were highly significant in statistical terms ($p<0.01$), because of the large number of users and because of consistent trends among users (a vast majority of users changed in the same direction, even for small changes). Clinical significance is thus arbitrary, and weekly trends give a hint at spontaneous group changes (decrease in weekends). Fully locked down countries decreased more than the maximum decrease during weekends, with the exception of Ireland, showing overall good compliance with the rules.

In conclusion: Aggregate analysis of activity tracker data, with the potential for a daily update, can inform governments and stakeholders on the adherence to home-confinement policies and on their efficacy, without violating citizens' privacy [4]. They allow comparisons of the effectiveness of different government policies. Finally, quantification of physical activity patterns, in particular leisure versus occupational and their consequences on cardio-metabolic health would be of importance since sport and leisure physical activity has been shown to have a positive effect on cardio-metabolic health, whereas occupational physical activity did not [5]. Data emerging from studies conducted during lockdown will help to address this issue.

Acknowledgement

We thank Alison Foote (Grenoble Alpes University Hospital, France) for critically editing the manuscript.

Funding

JLP is supported by a research grant from the French National Research Agency (ANR-12-TECS-0010) in the framework of the "Investissements d'avenir" program (ANR-15-IDEX-02) and the "e-health and integrated care" and "Trajectories Medicine" (MIAI @ Grenoble

Alpes, (ANR-19-P3IA-0003)) Chairs of excellence University Grenoble Alpes. RY, VV and PJ are employees of Withings.

Author contributions

JLP and PB conceived the study, RY, VV and PJ acquired and analyzed the data; JLP, RMB, PE and PB drafted the manuscript and significantly revised it.

Competing interests

RY, VV and PJ are employees of Withings (a manufacturer of wearable activity tracking systems); PE is a remunerated scientific advisor to Withings; JLP and PB are informal unpaid scientific advisors to Withings; and RMB has no competing interests

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Supplementary Files

Figures