Impact of the COVID-19 pandemic on objectively measured physical activity and sedentary behavior among overweight young adults: A year-long longitudinal analysis

Victoria Lawhun Costello, Guillaume Chevance, David Wing, Shadia J Mansour-Assi, Sydney Sharp, Natalie M Golaszewski, Elizabeth A Young, Michael Higgins, Anahi Ibarra, Britta Larsen, Job G Godino

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Abstract

Background: The COVID-19 pandemic impacted multiple aspects of daily living, including behaviors associated with occupation, transportation, and health. It is unclear how these changes to daily living impacted physical activity and sedentary behavior.

Objective: To examine the impact of the COVID-19 mitigation strategies on physical activity and sedentary behavior among young adults enrolled in an ongoing weight loss trial using longitudinal data acquired from wrist-worn activity monitors over the course of 1 year in San Diego, CA.

Methods: Date were collected in 315 participants between 11/01/2019 and 10/30/2020 using the Fitbit Charge 3. After strict filtering for valid consistent wear (more than 10 hours per day for 250+ days), data from 97 participants were analyzed to detect multiple structural changes in time series of physical activity and sedentary behavior.

Results: After initiation of the shelter-in-place order in CA on 03/19/2021, there were significant decreases in step counts (-2872 steps per day, 95% CI [-2734; -3010]), light physical activity (-41·9 minutes, 95% CI [39·5, 44·3]), and moderate-to-vigorous physical activity (-12·2 minutes, 95% CI [10·6, 13·8]), as well as significant increases in sedentary behavior (+52·8 minutes, 95% CI [47.0, 58.5]). Decreases were greater than expected declines observed during winter holidays, and as of 10/30/2020, they had not returned to levels observed prior to shelter-in-place orders.

Conclusions: In young adults, physical activity decreased and sedentary behavior increased concurrent with COVID-19 mitigation strategies. Health conditions associated with sedentary lifestyle may be additional unintended costs of the COVID-19 pandemic. Clinical Trial: NIH 5R01HL136769-03)

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Impact of the COVID-19 pandemic on objectively measured physical activity and sedentary behavior among overweight young adults: A year-long longitudinal analysis

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Abstract

Background

The Coronavirus Disease 2019 (COVID-19) pandemic impacted multiple aspects of daily living, including behaviors associated with occupation, transportation, and health. It is unclear how these changes to daily living impacted physical activity and sedentary behavior.

Objective

In the present study, we add to the growing body of research on the health impact of the COVID-19 pandemic by examining longitudinal changes in objectively measured daily physical activity and sedentary behavior in overweight or obese young adults participating in an ongoing weight loss trial in San Diego, California (CA).

Methods

Data were collected from 315 overweight or obesity (BMI between 25.0-39.9 kg/m2) participants between the ages of 18 to 35 years old between 11/01/2019 and 10/30/2020 using the Fitbit Charge 3. After strict filtering for valid consistent wear (more than 10 hours per day for 250+ days), data from 97 participants were analyzed to detect multiple structural changes in time series of physical activity and sedentary behavior. An algorithm was designed to detect multiple structural changes that allowed for the automatic identification and dating of these changes in linear regression models with confidence intervals. The number of breakpoints in regression models were estimated with Bayesian Information Criterion (BIC) and Residual Sum of Squares (RSS), with the optimal segmentation corresponding to the lowest BIC and RSS. To quantify the changes in each outcome during the periods identified, linear mixed effects were conducted. The 97 participants included in the present analyses did not differ from the 210 participants who were excluded.

Results

After initiation of the shelter-in-place order in CA on 03/19/2021, there were significant decreases in step counts (-2872 steps per day, 95% CI [-2734; -3010]), light physical activity (-41.9 minutes, 95% CI [39.5, 44.3]), and moderate-to-vigorous physical activity (-12.2 minutes, 95% CI [10.6, 13.8]), as well as significant increases in sedentary behavior (+52·8 minutes, 95% CI [47.0, 58.5]). Decreases were greater than the expected declines observed during winter holidays, and as of 10/30/2020, they had not returned to levels observed prior to shelter-in-place orders.

Conclusions

In overweight or obese young adults, physical activity decreased and sedentary behavior increased concurrent with COVID-19 mitigation strategies. Health conditions associated with sedentary lifestyle may be additional unintended costs of the COVID-19 pandemic.

Keywords:

COVID-19, young adults, physical activity, sedentary behavior, activity monitor

Introduction

Beginning in March 2020, many states in the US implemented public health restrictions to reduce transmission of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and the incidence of Coronavirus Disease 2019 (COVID-19), including mandatory stay-at-home orders that have forced individuals to alter their family, work, education, and social routines. As a result, health behaviors are likely to have been affected[1], [2]. These health behaviors include engaging in physical activity and minimizing sedentary behavior; the benefits of which have been well-documented across the life span[2],[3],[4],[5]. Importantly, increasing evidence suggests that these health behaviors are also associated with risk of infection from SARS-Cov-2 and the development of serious COVID-19 illness[2],[4],[5], making an understanding of how they might have changed in response to COVID-19 mitigation strategies, including the introduction of the tiered reopening strategy introduced at the end of August 2020[6], a critical area of research.

The temporary closures of businesses and shifts of in-person occupational and educational activities to remote settings, may have introduced new barriers to engaging in physical activity and reducing sedentary time, including limiting access to recreation spaces, increasing screen time[2],[7], and altering sleep patterns[4]. Alternatively, the reductions in other activities, such as commuting and social gatherings, may have increased the time available for engagement in physical activity. Therefore, it is unclear if changes in daily behavior are mitigating or exacerbating the separate ongoing health crisis of low physical activity and high sedentary behavior[2],[5],[8].

The morbidity and mortality from COVID-19 has been highest in patients who are advanced in age, overweight or obese, and have associated comorbidities such as type 2 diabetes mellitus and cardiovascular disease[9],[10]. This is the same population that has the most to benefit from engagement in risk-reducing health behaviors; even a 2-week period of physical inactivity and increased sedentary behavior can measurably increase the risks of developing comorbidities[11],[12]. While advanced age is an important risk factor in COVID-19 complications, young adults are not impervious to serious COVID-19 illness, especially those young adults who are overweight or obese[13],[14]. In recent decades, this demographic has experienced serious declines in physical activity and increases in sedentary behavior[4],[15],[16],[17].

A growing number of studies show that physical activity has decreased while sedentary behavior has increased during the period of time that COVID-19 mitigation strategies have been in effect [2], [12],[7],[18],[19]. These findings, while significant, are limited by cross-sectional study designs, frequent use of convenience sampling with limited characterization of the study population, and self-reported data of limited reliability and validity[2],[14],[15],[16]. In the present study, we add to the growing body of research on the health impact of the COVID-19 pandemic by examining longitudinal changes in objectively measured daily physical activity and sedentary behavior in young adults aged 18-37 years prior to and throughout the ongoing pandemic (November 1st, 2019-October 30th, 2020).

Methods

Participants and Setting

The current analyses use data from the SMART 2.0 (Social and Mobile Approaches to Reduce weight) trial; an ongoing 24-month (96 week) parallel-group randomized control trial conducted in San Diego, California (CA). SMART 2.0 targets weight loss in overweight and obese young adults aged 18 to 35 years using multiple modalities, including an activity monitor, wireless scale, and app; text messaging; social media platforms with social networking capabilities; and technology-mediated health coaching. Intervention content in SMART 2.0 focuses primarily on self-regulatory mechanisms to promote health engagement in physical activity, diet, and sleep to achieve weight loss.

Participants were between the ages of 18 to 35 years old at enrollment; overweight or obese (BMI between 25.0-39.9 kg/m^2); affiliated with either the University of California, San Diego (UCSD), San Diego State University (SDSU), or California State University, San Marcos (CSUSM);

a Facebook user or willing to begin using; and owned a smartphone. Exclusion criteria included having any comorbidities of obesity that require a clinical referral (i.e., pseudotumor cerebri, sleep apnea, orthopedic problems, type 2 diabetes), psychiatric or medical conditions that prohibit compliance with study protocol, or a cardiovascular event within 6 months of enrollment. Participants were also excluded if they were currently being treated for malignancy (other than non-melanoma skin cancer), an eating disorder, planning to have weight loss surgery or engage in any other weight loss interventions or programs within 24 months of enrollment, or were pregnant or actively planning to become pregnant within 24 months of enrollment.

All participants provided written informed consent prior to enrollment. Incentive payments of $20, $25, $25, and $30 are provided to participants at the 6-, 12-, 18-, and 24-month follow-up measurement visits. All participant study data is deidentified. The study procedures were approved by the UCSD Institutional Review Board (approval number 181862). The trial is sponsored by National Institutes of Health (NIH 5R01HL136769-03) is registered with ClinicalTrials.gov (NCT03907462). The funder had no role in the research.

Demographic information was gathered through a self-reported survey at baseline, as shown in Table 1. All participants received weight loss goals that they were instructed to attempt to achieve throughout participating in the study (i.e., all participants were actively receiving intervention). All participants were given the Fitbit Charge 3, a wrist-worn activity monitor which measures physical activity, sleep, and heart function. They were instructed to wear the device daily. The device contains a triaxial accelerometer, optical heart rate monitor, altimeter, and vibration motor. The Fitbit uses a proprietary algorithm to determine activity levels defined as vigorous, moderate, light, or sedentary[20]. Studies have shown the Fitbit to have an accuracy rating of 85.4% in distinguishing activity levels, specifically sedentary and light activity from moderate to vigorous[21]. Evidence also shows acceptable levels of accuracy for measuring daily steps taken[22],[23]. Data from these devices were retrieved and aggregated using Fitabase software developed by the Small Steps Labs, LLC[24], a third-party research platform designed to collect data from multiple Fitbit devices over time.

Variables of interest included minutes of moderate to vigorous physical activity (MVPA, 3 or more metabolic equivalent of task (METs), light physical activity (less than 3 METs), step count (ambulation), and sedentary behavior (less than 1.5 METs). Data were acquired from Fitabase at the minute level for heart rate and at the daily level for all other metrics of interest (time in sedentary, light, moderate, and vigorous activity; total steps; time asleep). Heart rate data were analyzed and aphysiologic data were removed (defined as unlikely heart rates above 200 or below 50 beats per minute.). A new metric of total number of minutes with heart rate per day was calculated and used as a proxy measure for wear time. This was further adjusted to create a variable of "day wear" by subtracting the number of sleep minutes calculated by Fitbits' proprietary algorithm for each calendar day (i.e., the minutes from 00:00 to 23:59 that usually spans two sleep periods). Days were included in analysis if there were greater than 600 minutes of "day wear". The data was then cleaned using heart rate as an arbiter. Participant's data was valid if they had a wear time variable of 600+ minutes a day, for at least 250 days out of the year [25],[26].

Statistical Analysis

Changes in physical activity outcomes were first identified using an algorithm designed to detect multiple structural changes in time series[27] and implemented within the R package "*strucchange*". This method allows the automatic identification and dating of structural changes in linear regression models with confidence intervals. The optimal number of breakpoints in regression models were estimated with Bayesian Information Criterion (BIC) and Residual Sum of Squares (RSS), with the optimal segmentation corresponding to lowest BIC and RSS. To further quantify the changes in each outcome during the periods identified, linear mixed effects were conducted. These analyses were implemented with the package "*Lme4*", and post-hoc comparison between periods were conducted with the package "*emmeans*". Mixed effects models included a random intercept, and post-hoc comparisons were adjusted with the “Bonferroni” method. Finally, the four-time series for steps, MVPA, light PA, and sedentary time were plotted with the package “ggplot2” using a Generalized Additive Model (GAM) function. All statistical analyses were conducted using R Version 3.6.1. The code and data used for the present analyses are fully available at https://osf.io/6kfup/[28]. Two-tailed p-values with predefined cut-off for statistical significance was set at 0·05. Data was segmented out between the dates of November 1, 2019 and October 30th, 2020. Descriptive statistics (proportions, means, and standard deviations (SD)) defined key demographic characteristics. Generalized additive models were conducted on each outcome variable in relation to time.

Results

Data from a total of 315 participants were evaluated to determine inclusion in the present study. Among them, 8 participants were removed after filtering for valid days based on our wear time criteria (i.e., these 8 participants wore their devices for less 10 hours [600 minutes] per day). Then, 210 participants were removed for inconsistent wear time over the year (less than 250 days, roughly 70% of valid days over a year). This rather strict cut-off criteria (i.e., 250 days) was used in order to reflect an entire year of consistent wear time. A total of 97 participants had at least 250 valid days of monitoring from November 1st 2019 to October 30th 2020 and were included in the analyses (see the Figure 1).

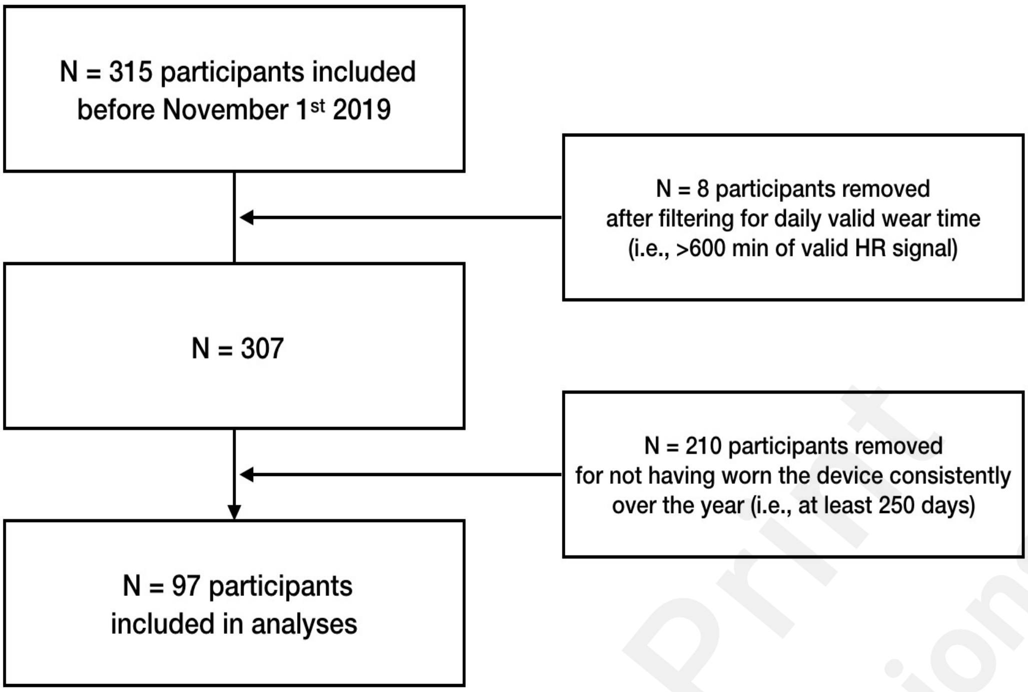

Figure 1: Flow diagram of participants in SMART 2.0 who were included in final analysis

Demographic Characteristics

Table 1 shows unadjusted study sample characteristics of the 97 participants included in the final analysis. The average age of the study population was 26·5 (SD 8·5) years, 41·2% identified as Latino or Hispanic, 44·3% identified as non-white, and 59·8% identified as female. On average, participants had 45 minutes (SD 15) of moderate-vigorous physical activity (MVPA), 6,200 steps (SD 2,000), 367 minutes (SD 67) of sleep, and 1,020 minutes (SD 108) of sedentary time a day throughout the analysis. The 97 participants included in the present analyses did not differ from the 210 participants who were excluded based on the key demographic characteristics reported above.

Table 1. Baseline characteristics of participants of SMART 2.0 who wore a Fitbit device for more than 250 days over the course of 1 year in California

	N (%) or Mean ± SD
Sex	
Male	39 (40·2%)
Female	58 (59·8%)
Hispanic or Latino origin	
Yes	40 (41·2%)
No	57 (58·8%)
Race	
White or Caucasian	54 (55·7%)
Black or African-American	4 (4·1%)
Asian	28 (28·9%)

American Indian or Alaska native	8 (8·2%)
Native Hawaiian or Pacific Islander	1 (1·0%)
Other	15 (15·5%)
Highest level of education	
Less than high school	0, 0·0%
High school graduate	8 (8·2%)
Some college or Associate degree	44 (45·4%)
College graduate or Baccalaureate degree	21 (21·6%)
Master's degree	24 (24.·7%)
Professional/Vocational degree	0 (0·0%)
Doctoral degree	0 (0·0%)
Current relationship status	
Single or casually dating	44 (45·4%)
In a committed relationship	33 (34·0%),
Living in a marriage like relationship	4 (4.·1%)
Married	15 (15.·5%)
Separated	0 (0·0%)
Divorced	1 (1·0%)
Income over the last 12 months	
Less than $5,000	28 (28·9%)
$5,000 through $11,999	8 (8·2%)
$12,000 through $15,999	6 (6·2%)
$16,000 through $24,999	10 (10·3%)
$25,000 through $34,999	13 (13·4%)
$35,000 through $49,999	11 (11·3%)
$50,000 through $74,999	12 (12·4%)
$75,000 through $99,999	5 (5·2%),
$100,000 or greater	4 (4·1%)
Children under 18 that live in your home	
0	75 (77·3%)
1	13 (13·4%)
2	6 (6·1%)
3	3 (3·1%)
Adults that live in your home including self	
1	15 (15·5%)
2	33 (34·0%)
3	19 (19·6%)
4	18 (18·6%)
5	4 (4·1%)
6	7 (7·2%)
10	1 (1·0%)
What university are you affiliated with?	
UCSD	77 (79·4%)
SDSU	6 (6·2%)
CSUSM	14 (14·4%)
What is your affiliation?	
Staff	32 (33·0%)
Student	72 (74·2)

Changes in physical activity and sedentary behavior

Many of the breaks in activity fall in line with the pandemic mitigation strategies in San Diego County, including the closing of schools, gyms, recreation spaces, parks, beaches and other businesses in mid-March, the reopening of outdoor space at the end of April 2020 and early June 2020, as well as the introduction of the tiered reopening strategy introduced at the end of August 2020 . As shown in Figure 2 there was a marked decrease in steps, light PA, and MVPA, as well as an increase in sedentary time in March 2020 comparing to the months before. For steps, the structural break detection algorithm indicated 3 breaks in the time series occurring between December 20th 2019 and January 20th 2020, between March 11th and March 13th 2020, and between June 8th and June 18th 2020. Three structural breaks were also detected for MVPA, occurring between January 1st and 14th 2020, between March 7th and 10th 2020, and between June 13th and 18th 2020. Two structural breaks were detected for light PA, occurring between March 14th and 16th and between June 9th and 14th 2020, as well as for sedentary behavior where two breaks occurred between March 7th and 14th and June 1st to June 16th. Taken together the results suggest a significant increase in steps and MVPA at the beginning of the year after the holiday season, a net decrease then in physical activity outcomes in mid-March, between the 10th and 16th, and a new increase in physical activity and decrease in sedentary behavior in the two first weeks of June (see supplemental material #1 for further information on these models).

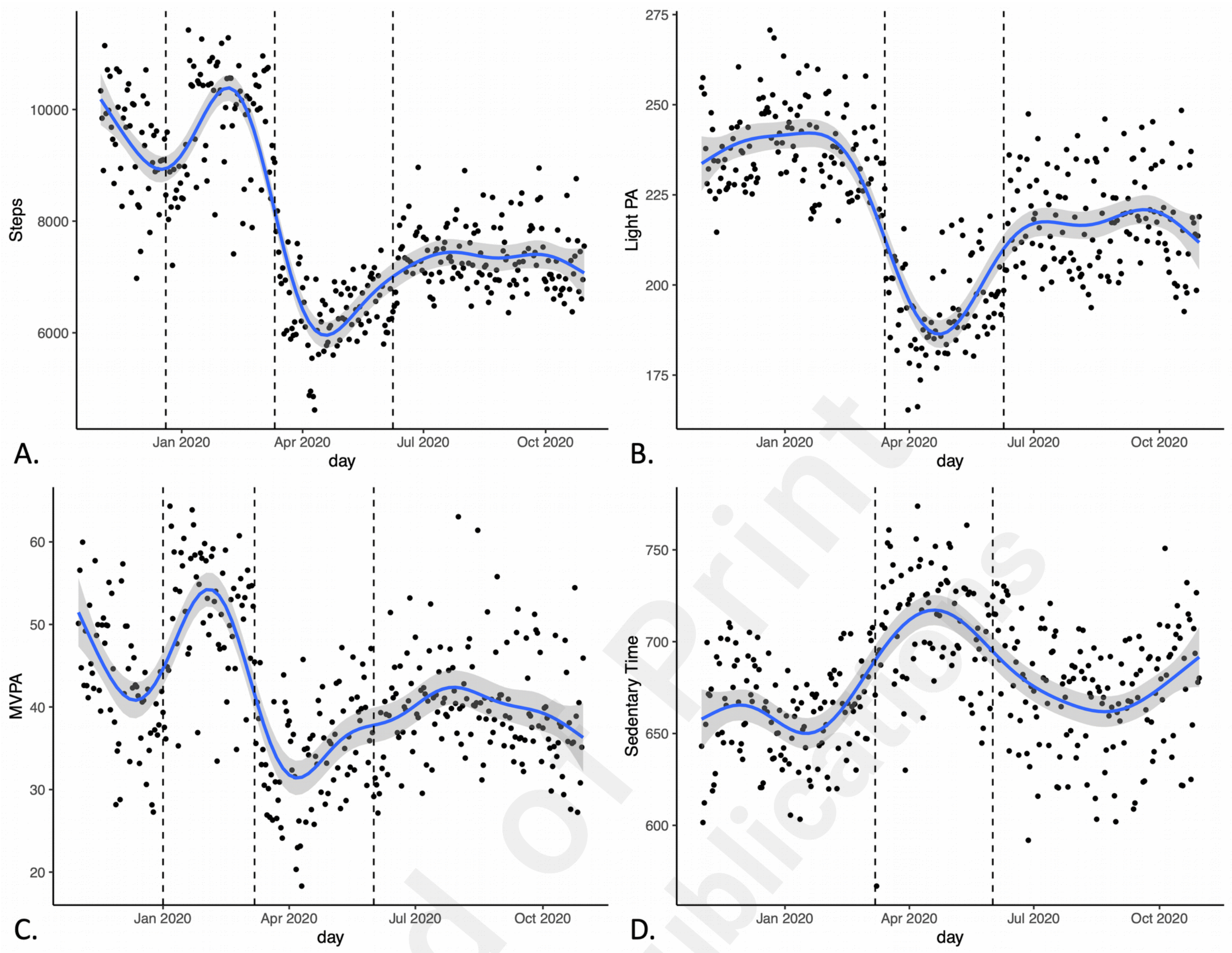

Figure 2: Changes in mean a A. steps, B. MVPA, C. light physical activity, and D. Sedentary with 3 breaks in the time series highlighted at end of December 2019, mid-March 2020, and July 2020 among participants of SMART 2.0 who wore a Fitbit device for more than 250 days over the course of 1 year in California

Results from linear mixed effect models confirmed significant differences in each outcome between the three periods: from (*i*) November 2019 to end of February 2020, (*ii*) the beginning of March to the end of May, and (*iii*) the beginning of June to October 2020 (see Figure 3).

The average daily number of steps were respectively 9641 (SE = 251), 6769 (SE = 253) and 7299 (SE = 251) steps per day in the three time periods. A significant drop of 2872 steps per day was observed between period 1 and 2, 95%CI [2734; 3010]; a significant increase occurred between period 2 and 3 (+529 steps per day, 95%CI [396, 663]); the average number of steps in period 3 was still significantly lower than period 1 (-2343 steps per day, 95%CI [2223, 2463]).

Similar patterns of results were observed for the other outcomes. Average minutes of MVPA per day was 47.6 (SE = 2) minutes per day in period 1, 35.4 (SE = 2) minutes per day in period 2 (-12.2 minutes, 95%CI [10.6, 13·8]), and 39.9 (SE = 2) minutes per day in period 3 (+4.5 minutes comparing to period 2, 95%CI [2.9, 6]).

Average minutes of light PA per day was to 239 (SE = 5) minutes per day in period 1, 197 (SE = 5) minutes per day in period 2 (-41.9 minutes, 95%CI [39·5, 44.3]), and 216 (SE = 5) minutes per day in period 3 (+19.1 minutes comparing to period 2, 95%CI [16.7, 21.4]).

Average minutes of sedentary behavior per day was 659 (SE = 10) minutes per day in period 1, 712 (SE = 10) minutes per day in period 2 (+52.8 minutes, 95%CI [47, 58.5]), and 678 (SE = 10) minutes per day in period 3 (-34 minutes comparing to period 2, 95%CI [28.4, 39.6]).

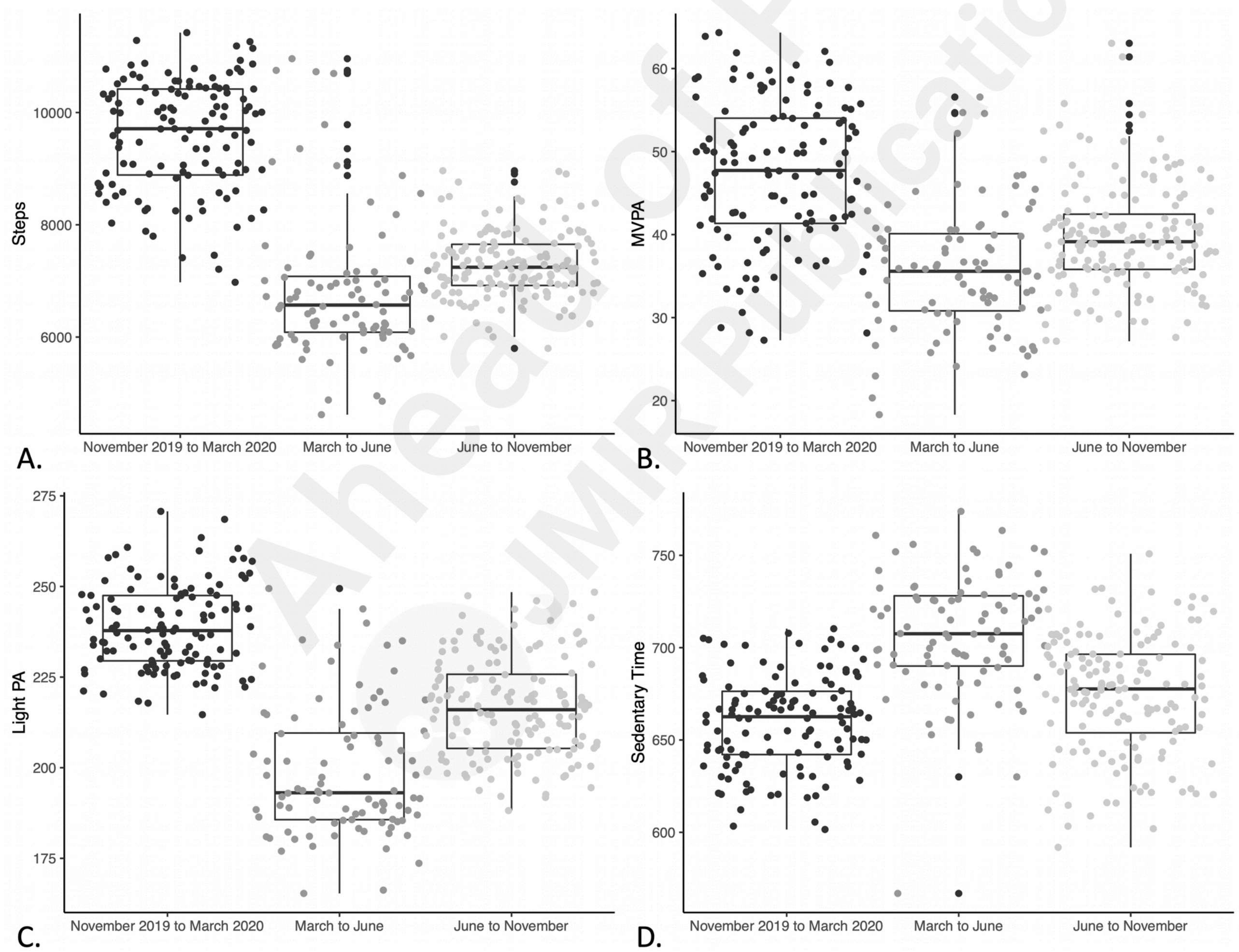

Figure 3: Results from linear mixed effect models confirmed significant differences in A. steps, B. MVPA, C. light physical activity, and D. Sedentary time between the three periods: from (i) November 2019 to end of February 2020, (ii) the beginning of March to the end of May, and (iii) the beginning of June to October 2020 among participants of SMART 2.0 who wore

a Fitbit device for more than 250 days over the course of 1 year in California

The times series highlighted that these patterns of changes were relatively similar across sub-groups comparisons, including between males and females, single or committed participants, participants with incomes below or above 25k annual or participants with and without children (see supplemental material #2), with one exception. Participants with children (N = 22) showed a reduced decline in light physical activity comparing to participants without children (N = 73; see Figure 4). Light physical activity was significantly different during the period 2 between these two groups (-45.4 minutes for the participants without children, 95%CI [-79.98, -10.90]), as well as during the period 3 (-43.63 minutes for the participants without children, 95%CI [-78.01, -9.25]).

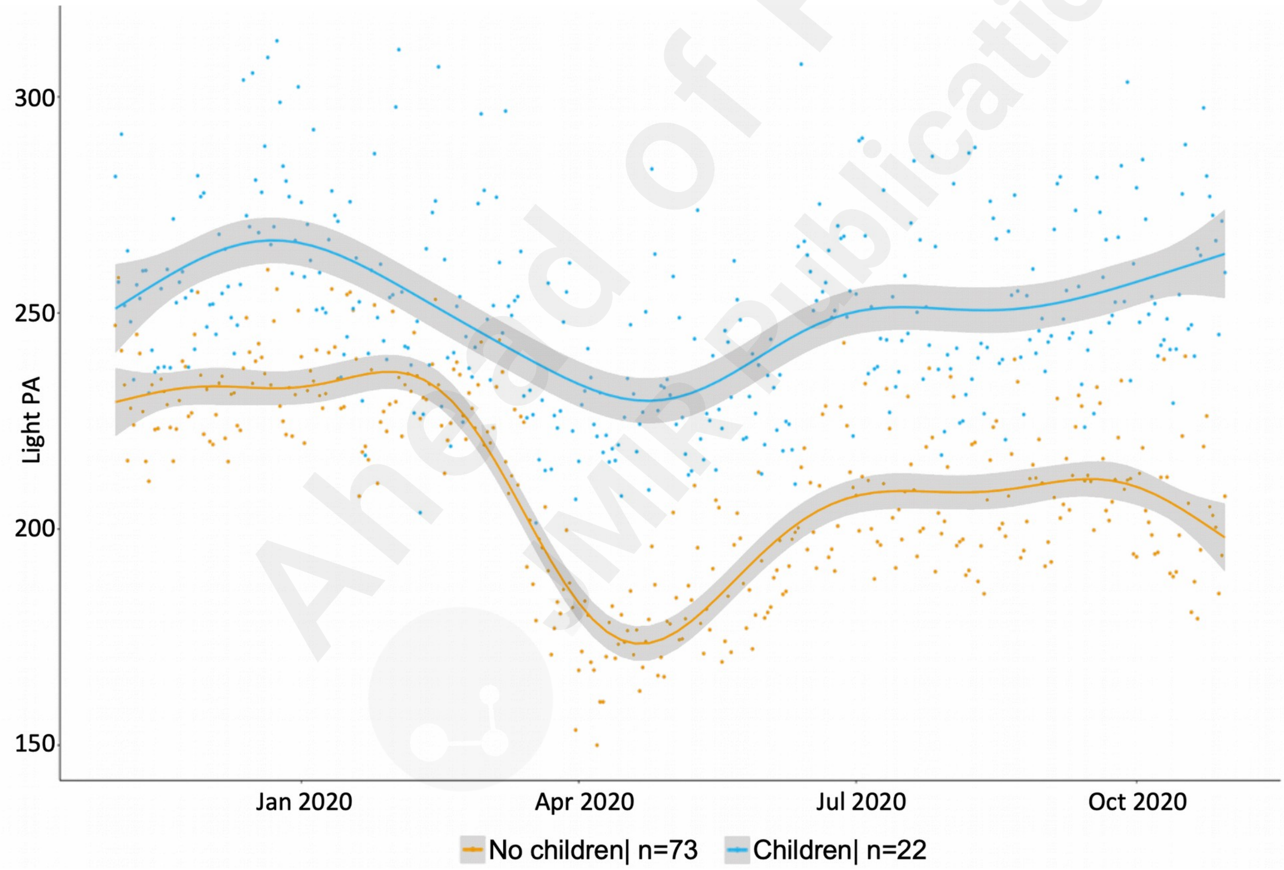

Figure 4 – Changes in mean light physical activity of participants of SMART 2.0 who wore a Fitbit device for more than 250 days over the course of 1 year in California with children (N = 22) showed a reduced decline in light physical activity compared to participants without children (N = 73)

Discussion

Our study leverages a complete year of objective, high-resolution data to assess the impact of mitigation strategies associated with the COVID-19 pandemic on physical activity and sedentary behavior in young adults. We observed that after initiation of the shelter-in-place order in CA, there were significant decreases in step counts, light physical activity, and moderate-to-vigorous physical activity, as well as significant increases in sedentary behavior. Decreases were greater than the expected declines observed during winter holidays, and they had not returned to levels observed prior to shelter-in-place orders. The length of the time series used in the present study provides valuable insight into the effects of the COVID-19 mitigation strategies. Specifically, strategies that include reducing access to recreation spaces and gyms, shifting to remote, online work rather than commuting to work or school, are likely causes of the reductions in physical activity and increases in sedentary behavior observed within our study population.[2], [3],[4],[29]. These mitigation strategies, while important for reducing the spread of infectious disease, may further exacerbate an ongoing and separate health crisis of low physical activity and high sedentary behavior present in a young adult population.

The current findings are compatible with the findings from the existing literature to date, which has relied on self-report surveys, and vary in length from 24-hour recalls[30], to 6-month self-recall physical activity reports[2],[31]. Decreases in steps, MVPA, light PA, and increases in sedentary behavior have been reported[17],[19],[30]. There have been reports of increased activity in populations, however these patterns are inequal depending on access as well as whether or not they were meeting recommended physical activity prior to the pandemic mitigation strategies [32] [33]. Most data have found that over 30% of adults reported declines in physical activity in response to strict lockdown ordinances [34][35]. Our results expand the research in this area by revealing the magnitude of the declines in activity and increases in sedentary behavior throughout key moments within the pandemic. This analysis captures the scope of predicted declines in activity (November 2019 through the end of February 2020) due to holidays impacting work, family, education, and social routines and daily behaviors associated with them. This is in contrast to the initial mitigation strategies at the beginning of March through May 2020, including the March 19th, 2020 'Stay-at-home' order closing gyms, beaches, parks, recreation spaces, etc., followed by the opening of beaches and parks on April 27th 2020, as well as period of increased activity, which includes June 2020 through October 2020 including the June 12th, 2020 reopening of some gyms and businesses and the tiered reopening system that took effect on August 31st, 2020, although still falling short of pre-pandemic levels.

Our results showed that these trends were consistent across gender, partner status, income, and whether or not participants had children, underscoring the strong effect of COVID-19 mitigation strategies across all subgroups. The pronounced decreases in physical activity highlights a need for further investigation into reasons for the decline; while many local restrictions led to the closures of gyms and other recreational areas, even the strictest stay-at-home orders all allowed for outdoor physical activity, and many gyms continued operations and classes outdoors. Additionally, significant reductions in commuting time due to work and school being conducted remotely provided many individuals with increased leisure time. It is likely, then, that reductions in activity were due to changes in lifestyle activity associated with occupational and transportation physical activity, and to individuals being unable or unwilling to adapt routines to accommodate COVID-19-related restrictions, though more research on this is needed.

Our findings highlight a vast need for interventions focused on increased physical activity and decreased sedentary behavior in young adults, and for these interventions to highlight problem solving and adaptation to changing conditions. Importantly, increasing evidence suggests that these physical activity can reduce risk of infection from SARS-Cov-2 and the development of serious COVID-19 illness [2],[4],[5]. Given these risks, the increases in screen time associated with remote work and school, and significant deleterious effects of the COVID-19 pandemic on mental health, maintaining and increasing physical activity is a key strategy for reducing some of the greatest mental and physical health risks associated with the COVID-19 pandemic. The World Health Organization (WHO) has predicted more global health emergencies in the future[36]; the success of future health behavior interventions may depend on their ability to adapt to changing conditions on a global and individual level.

Strengths of this study include the use of objective data from an existing cohort that has been longitudinally observed over the course of an entire year. This provides the ability to segment and examine expected declines in physical activity due to holidays compared to those unexpected declines resulting from COVID-19 mitigation efforts. Limitations include the use of a sample recruited entirely in San Diego, CA, making findings potentially less generalizable to all young adults in other regions. Participants were also a part of an ongoing weight loss study and seeking to lose weight, which may further limit the generalizability of results to those attempting to lose weight and those motivated to use a Fitbit to support weight loss. Additionally, due to the conservative cut-off criteria used for valid days and consistent wear time, our analysis includes a smaller sample size compared to the original study's larger sample size.

Conclusion

In summary, the current findings support the observation that health behaviors in young adults have been significantly impacted by COVID-19 mitigation strategies. The strategies used to mitigate the spread of the virus, while important to control the spread of SARS-CoV-2, have unintended consequences that may continue to become increasingly apparent in the young adult population following the COVID-19 pandemic. As the pandemic continues, they will be faced with a different lifestyle compared to before the pandemic, one in which the need for improved health behaviors should be emphasized beyond the pre-pandemic levels, and as pandemic fatigue[27] continues to exacerbate lifestyle decisions. Future interventions aimed at young-adults should include varied options for physical activity, including at home and in the community, as well as strategies for decreasing sedentary behavior when most activities of daily living now occur in a home environment.

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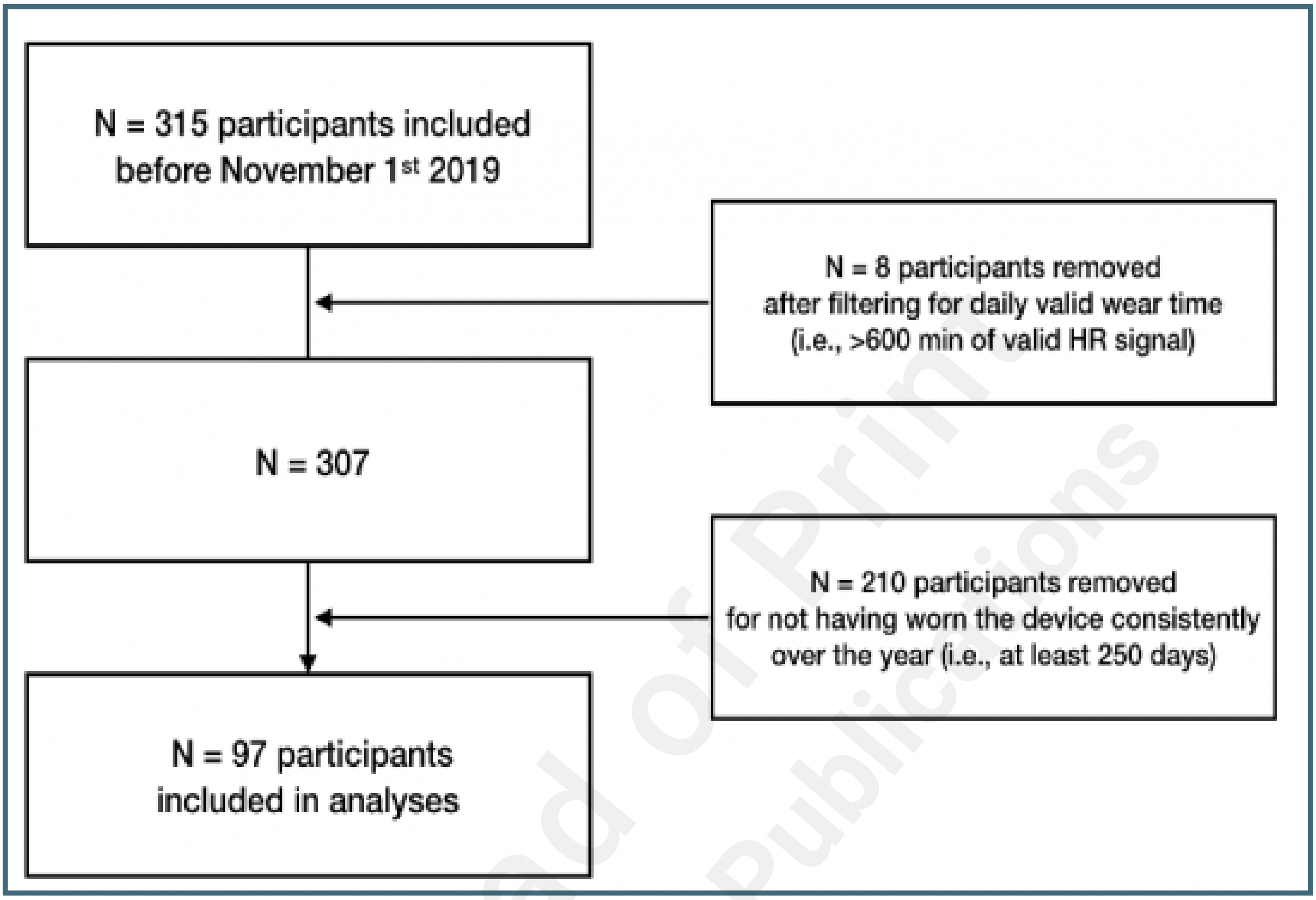
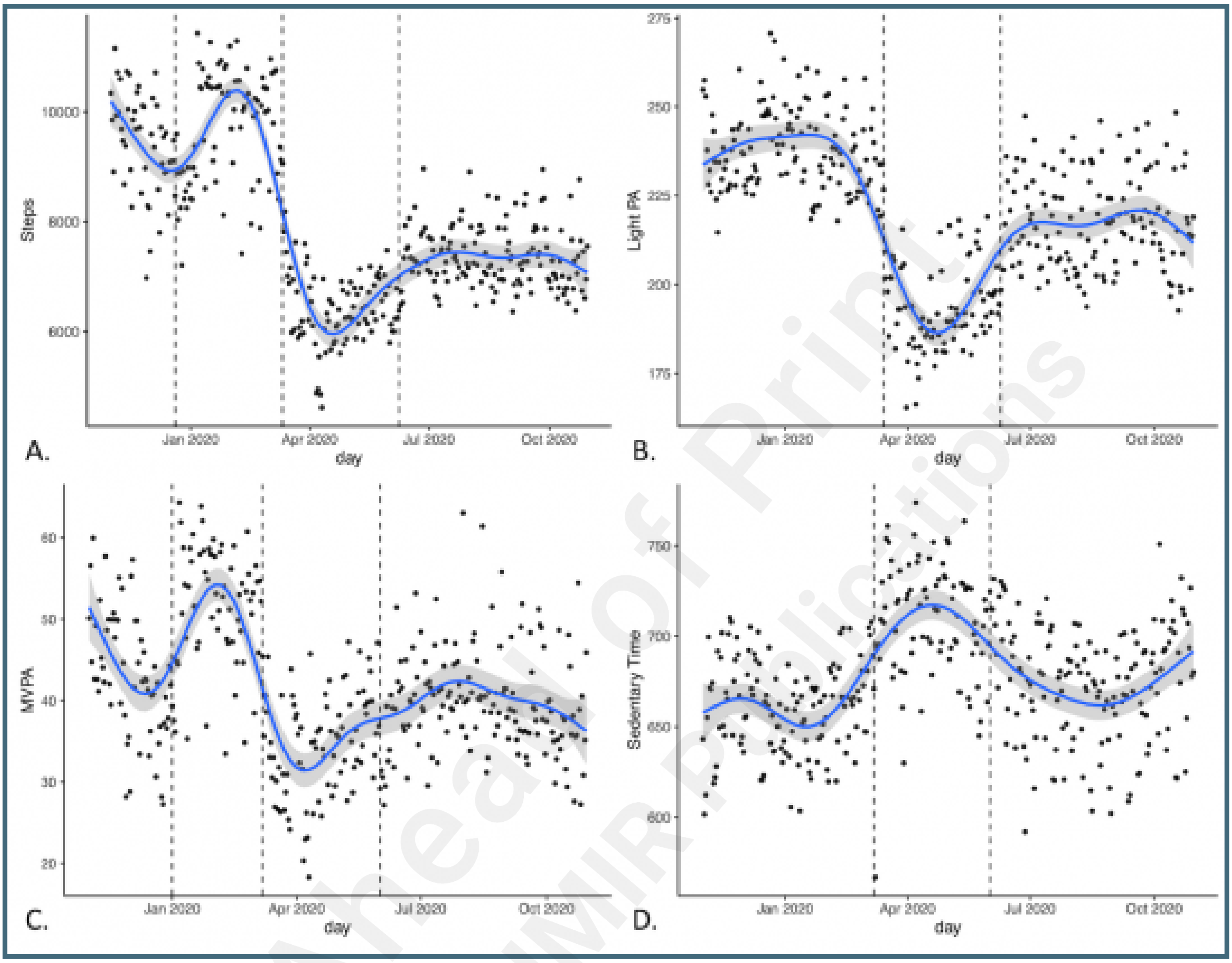
Supplementary Files

Figures

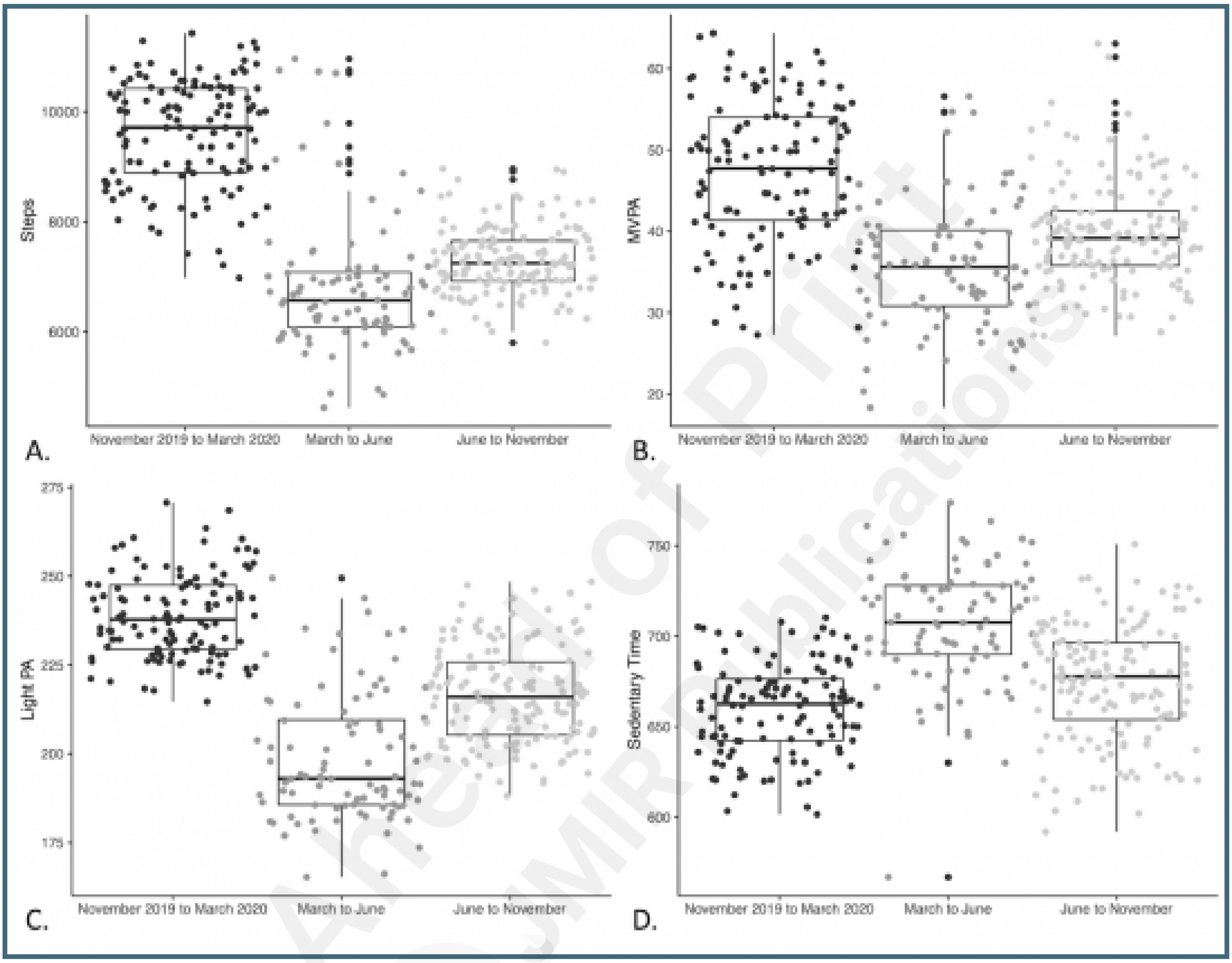
Flow diagram of participants in SMART 2.0 who were included in final analysis.



Changes in mean a A. steps, B. MVPA, C. light physical activity, and D. Sedentary with 3 breaks in the time series highlighted at end of December 2019, mid-March 2020, and July 2020 among participants of SMART 2.0 who wore a Fitbit device for more than 250 days over the course of 1 year in California.



Results from linear mixed effect models confirmed significant differences in A. steps, B. MVPA, C. light physical activity, and D. Sedentary time between the three periods: from (i) November 2019 to end of February 2020, (ii) the beginning of March to the end of May, and (iii) the beginning of June to October 2020 among participants of SMART 2.0 who wore a Fitbit device for more than 250 days over the course of 1 year in California.



Changes in mean light physical activity of participants of SMART 2.0 who wore a Fitbit device for more than 250 days over the course of 1 year in California with children (N = 22) showed a reduced decline in light physical activity compared to participants without children (N = 73).