ORIGINAL RESEARCH

American Heart Association | American Stroke Association

An Initial Evaluation of the Impact of Pokémon GO on Physical Activity

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***Background*—**Pokémon GO is a location-based augmented reality game. Using GPS and the camera on a smartphone, the game requires players to travel in real world to capture animated creatures, called Pokémon. We examined the impact of Pokémon GO on physical activity (PA).

***Methods and Results*—**A pre-post observational study of 167 Pokémon GO players who were self-enrolled through recruitment flyers or online social media was performed. Participants were instructed to provide screenshots of their step counts recorded by the iPhone Health app between June 15 and July 31, 2016, which was 3 weeks before and 3 weeks after the Pokémon GO release date. Of 167 participants, the median age was 25 years (interquartile range, 21–29 years). The daily average steps of participants at baseline was 5678 (SD, 2833; median, 5718 [interquartile range, 3675–7279]). After initiation of Pokémon GO, daily activity rose to 7654 steps (SD, 3616; median, 7232 [interquartile range, 5041–9744], pre-post change: 1976; 95% CI, 1494–2458, or a 34.8% relative increase [$P<0.001$]). On average, 10 000 "XP" points (a measure of game progression) was associated with 2134 additional steps per day (95% CI, 1673–2595), suggesting a potential dose-response relationship. The number of participants achieving a goal of 10 000+ steps per day increased from 15.3% before to 27.5% after (odds ratio, 2.06; 95% CI, 1.70–2.50). Increased PA was also observed in subgroups, with the largest increases seen in participants who spent more time playing Pokémon GO, those who were overweight/obese, or those with a lower baseline PA level.

***Conclusions*—**Pokémon GO participation was associated with a significant increase in PA among young adults. Incorporating PA into gameplay may provide an alternative way to promote PA in persons who are attracted to the game.

***Clinical Trial Registration*—**URL: http://www.clinicaltrials.gov. Unique identifier: NCT02888314. **(*J Am Heart Assoc*. 2017;6: e005341. DOI: 10.1161/JAHA.116.005341.)**

Key Words: exercise • mobile games • physical exercise

Insufficient physical activity (PA) has been identified as the fourth leading cause of mortality, accounting for 6% of death globally.[1] Despite well-documented health benefits of regular exercise, PA levels remain low in many countries.[2] As a result, the World Health Organization recommends regular and adequate levels of PA among all age groups.[1] However, nearly 50% of Americans are not regularly active at the recommended levels.[3] While lack of enjoyment and time are commonly cited reasons for not adopting an active lifestyle, playing mobile games has become an increasingly popular leisure pastime. It is estimated that more than 50% of mobile phone users in the United States play mobile games.[4,5]

While mobile gaming is often considered a sedentary behavior, a new trend is to incorporate PA into gameplay. Pokémon GO is a location-based augmented reality game developed by Niantic, Inc, for iOS and Android devices.[6] Making use of the GPS and camera functions in the smartphone, Pokémon GO players are encouraged to ambulate (eg, walk, bike, or drive) to various physical locations in the real world to capture virtual creatures called Pokémon. Since its release on July 6, 2016, Pokémon GO has been downloaded more than 500 million times worldwide.

Despite the incentive for being active in this game, there are limited data examining the potential impact of Pokémon GO on PA.[7,8] An online survey of Pokémon GO players demonstrated a significant increase in self-reported PA.[9] Two more recent studies found 1000 to 1500 additional steps per day counted by iPhone or Microsoft Band after playing Pokémon GO.[10,11] However, the gaming experience may vary

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considerably among players. Persons who are attracted to the game may behave differently than occasional players. As players are encouraged to ambulate and are rewarded by capturing free-roaming Pokémon, a dose-response relationship between Pokémon GO engagement and PA might be expected. Therefore, we conducted a retrospective observational study among Pokémon GO players in September 2016 and analyzed their level of PA in terms of step count as reported on the iPhone Health app 3 weeks before and 3 weeks after initiation of Pokémon GO play. Specifically, we sought to compare changes in PA level before and after playing Pokémon GO and whether such changes differ by age, sex, baseline PA level, body mass index, and level of engagement in the game. The latter included a subjective measure of self-reported playing time as well as an objective measure of game progression indicating players' level of engagement.

Methods

Study Design and Participants

We launched an online survey in September 2016 to leverage existing PA data recorded by the iPhone Health app. iPhone users who were 18 years or older and had played Pokémon GO in July 2016 were eligible for the study. Study participants were instructed to upload screenshots of the "Pokémon GO Trainer Profile" and all recorded daily steps displayed on the iPhone Health dashboard between June 15, 2016, and July 31, 2016, which were 3 weeks before and ≈3 weeks after the Pokémon GO release date (Figure 1). The number of steps were automatically recorded by the iPhone Health app without the requirement of a third-party app or device. The Trainer Profile indicates when the player started playing Pokémon GO and his/her XP, a measure of progression in Pokémon GO that can be used to quantify the level of engagement in the game. On average, a player is rewarded a minimum of 100 XP points for each Pokémon captured. The survey also included questions that characterized each player's demographics and attitude toward the game, such as self-reported number of hours playing Pokémon GO and self-reported PA level after playing Pokémon GO.

To attract Pokémon players, recruitment flyers were placed at "PokéStops" around Duke University campus, Durham, North Carolina. PokéStops are locations where players can collect items such as Poké Balls, Potions, and Eggs to capture more Pokémon. The recruitment flyers contained a link and a quick response code. Clicking on the link or scanning the quick response code using the iPhone would automatically direct to the survey website by Qualtrics, an online survey software program. Similar flyers were also posted on Facebook, Twitter, Reddit, and WeChat to maximize global representation of the study. The first 100 participants were compensated monetarily ($5 Amazon gift card) for completing the survey. All participants were automatically entered into a prize drawing for a $100 Amazon gift card.

Measures and Statistical Analysis

The average steps per day and percentage of days >10 000 steps per day were calculated based on the number of steps counted by the iPhone Health app for each participant. Paired *t* test and Wilcoxon signed-rank test were used to compare the changes in average steps per day and percentage of days >10 000 steps per day before and after playing Pokémon GO. The more an individual plays Pokémon GO, the more likely he/she will capture Pokémon and gain higher XP points. We used average XP points gained per day as a proxy for the level of engagement. The average XP value was calculated as the total XP points displayed on the Pokémon GO Trainer Profile (Figure 1), divided by the number of days from the date of game download to the date of survey. Ordinal least squares regression was used to evaluate the relationship between XP value and changes in daily step count after Pokémon GO.

Because individuals' PA may vary during holidays and exam weeks, sensitivity analysis was performed by excluding dates when a participant was taking a vacation or final exam. A separate sensitivity analysis was performed by excluding individuals who did not carry their phones when not playing the game, because the number of steps could be underestimated in these participants. In addition, exploratory post hoc subgroup analyses were performed by age, sex, body mass index, baseline PA level before Pokémon GO, self-reported hours playing Pokémon GO per day as a subjective measure of level of engagement in the game, use of wearable devices, and how often playing Pokémon GO when cycling or in a moving vehicle.

The study was approved by the institutional review board at Duke University. All study participants gave informed consent. The study team had no association or financial interest with Niantic, Inc; Nintendo; or Apple. A prespecified sample size calculation indicated 73 participants would be required to detect a 2000-step difference (SD, 6000) after playing Pokémon GO. All tests were evaluated at a 2-sided significance level of $P<0.05$. The analyses were performed using SAS 9.4 software (SAS Institute Inc).

Results

A total of 167 volunteers from North America, South America, Europe, Australia, and Asia completed the online survey between August 31 and September 30, 2016. Baseline

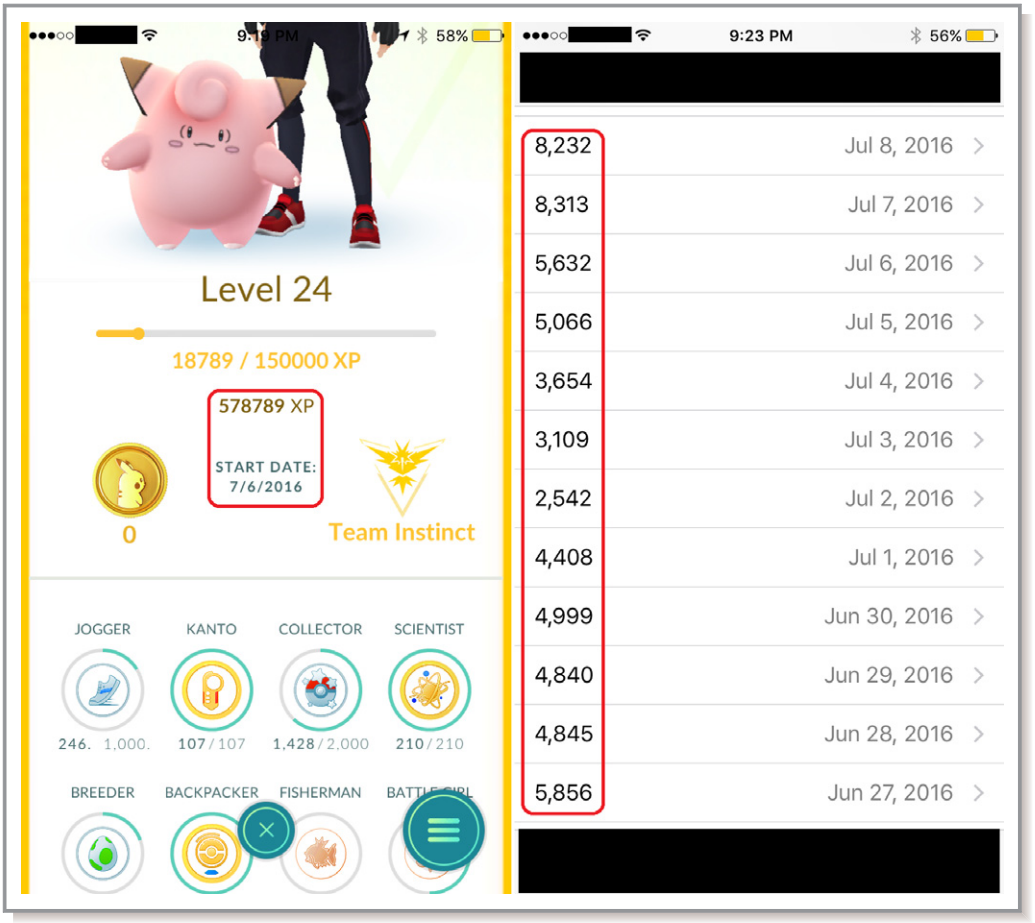

Figure 1. Examples of Pokémon GO trainer profile and step count automatically recorded by the iPhone Health app. Image from Pokémon GO used with permission from Niantic, Inc.

characteristics are shown in the Table. The median age was 25 years (interquartile range [IQR], 21–29), with a median body mass index of 23.4 kg/m^2 (IQR, 20.5–25.6). Nearly half of the study participants (80 of 167) were women. The majority (84.4%) downloaded Pokémon GO within 1 week of the initial release date of July 6, 2016. The median self-reported time playing Pokémon GO was 2.0 h/d (IQR, 1.0–2.5). Although only a few participants reported always played Pokémon GO in a moving vehicle (4.2%), >90% participants self-reported ever playing Pokémon GO in a car. Nonetheless, >85% participants self-reported an increase in their PA level since playing Pokémon GO.

The distribution of daily steps for each individual is shown in Figure 2. The average number of steps per day was 5678 (SD, 2833; median, 5718 [IQR, 3675–7279]) before Pokémon GO and 7654 (SD, 3616; median, 7232 [IQR, 5041–9744]) after the initiation of Pokémon GO. On average, study participants walked 1976 additional steps per day (95% CI, 1494–2458, or a 34.8% relative increase; P<0.001) after playing Pokémon GO. The percentage of days with >10 000 steps per day increased from 15.3% before to 27.5% after playing Pokémon GO (a 12.2% increase; 95% CI, 8.7–15.6% [P<0.001]). A generalized linear model with generalized estimating equations accounting for within-subject correlation of measurements at multiple time points found a similar increase in step count (1948 per day; 95% CI, 1489–2408 [P<0.001]) and a greater likelihood of reaching the goal of 10 000+ steps per day (odds ratio, 2.06; 95% CI, 1.70–2.50 [P<0.001]) after playing Pokémon GO.

The mean Pokémon GO XP points gained per day was 10 293 points (SD, 8651; median, 8295 [95% CI, 3706–14 183]), suggesting study participants captured as many as 100 Pokémon per day if the player did not gain XP points through other ways such as hatching an Egg, winning a Gym Battle, or receiving a bonus. Figure 3 shows a potential linear relationship between Pokémon GO XP value and changes in steps per day after Pokémon GO. On average, every 10 000 XP points gained in Pokémon GO were associated with 2134 additional steps per day (95% CI, 1673–2595; P<0.001 [R^2=0.33]), suggesting a potential dose-response relationship, in which the more an individual played, the higher level of PA could be achieved.

Table. Baseline Characteristics of Study Participants

Characteristics	Total (N=167)
Age, median (IQR), y	25 (21–29)
Women, No. (%)	80 (47.9)
Body mass index, median (IQR), kg/m^2	23.4 (20.5–25.6)
Student, No. (%)	90 (53.9)
Location, No. (%)	
North America	146 (87.4)
Europe	15 (9.0)
Australia	4 (2.4)
Asia	1 (0.6)
South America	1 (0.6)
Took a vacation during the study period, No. (%)	57 (34.1)
Took exams during the study period, No. (%)	6 (7.2)
Carry iPhone when not playing Pokémon GO,* No. (%)	
In hand	28 (16.7)
On a belt holster	1 (0.6)
In pocket	115 (68.9)
On the table	29 (17.4)
Other	17 (10.2)
Used wearable devices, No. (%)	34 (20.4)
Self-reported time playing Pokémon GO per day, median (IQR), h	2.0 (1.0–2.5)
Self-reported changes in physical activity after playing Pokémon GO, No. (%)	
Much higher	20 (20.0)
Moderately higher	52 (31.1)
Slightly higher	71 (42.5)
About the same	24 (14.4)
Slightly lower	0 (0)
Moderately lower	0 (0)
Much lower	0 (0)
Played Pokémon GO in a moving vehicle	
Always	7 (4.2)
Most of the time	29 (17.4)
About half the time	32 (19.2)
Sometimes	85 (50.9)
Never	14 (8.4)
Played Pokémon GO when cycling	
Always	7 (4.2)
Most of the time	12 (7.2)
About half the time	7 (4.2)
Sometimes	19 (11.4)
Never	122 (73.1)

IQR indicates interquartile range.
*Individual could choose more than one option.

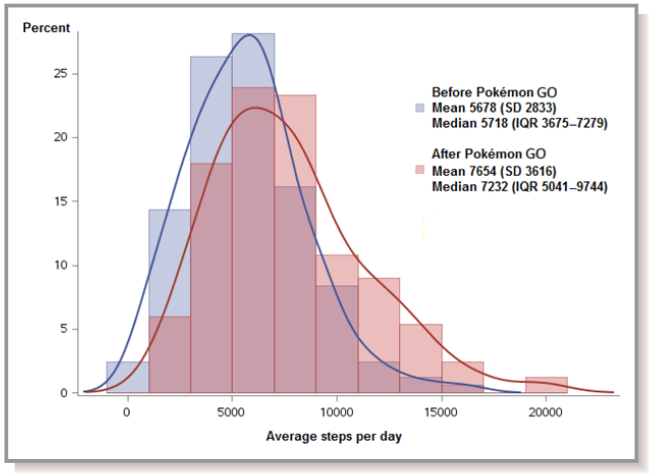

Figure 2. Average steps per day before and after playing Pokémon GO. IQR indicates interquartile range.

Except for participants who played Pokémon GO for <1 h/d, those younger than 20 years, and those with the highest baseline PA level, post hoc subgroup analyses found a consistent pattern of higher PA level after the initiation of Pokémon GO (Figure 4). Among all exploratory subgroups, the largest differences were seen in participants 30 years or older (3320 additional steps per day; 95% CI, 2118–4523), individuals with the lowest PA at baseline (2899 additional steps; 95% CI, 2030–3767), overweight/obese (3031 additional steps; 95% CI, 2132–3929), or individuals who spent more time playing Pokémon GO (2–2.5 h/d: 2861 additional steps [95% CI, 1884–3837]; >2.5 h/d: 2238 additional steps [95% CI, 1008–3467]). Increased level of PA was also observed after excluding data from dates of vacations or

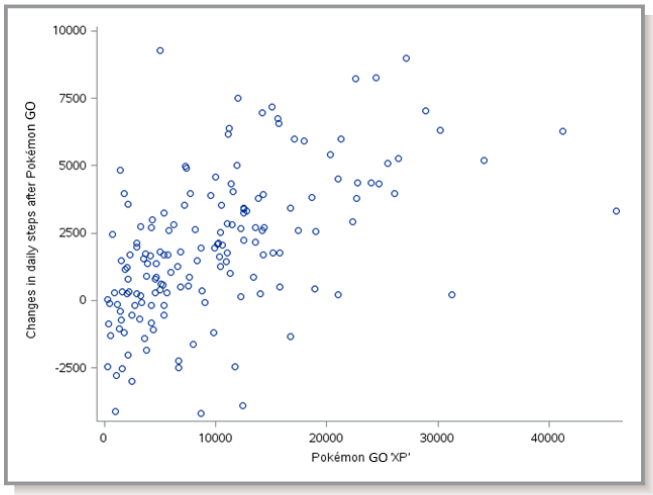

Figure 3. Relationship between Pokémon GO "XP" (a measure of game progression) and changes in step count per day after playing Pokémon GO.* *The figure excluded 2 observations ≤1st percentiles and 2 observations ≥99th percentiles.

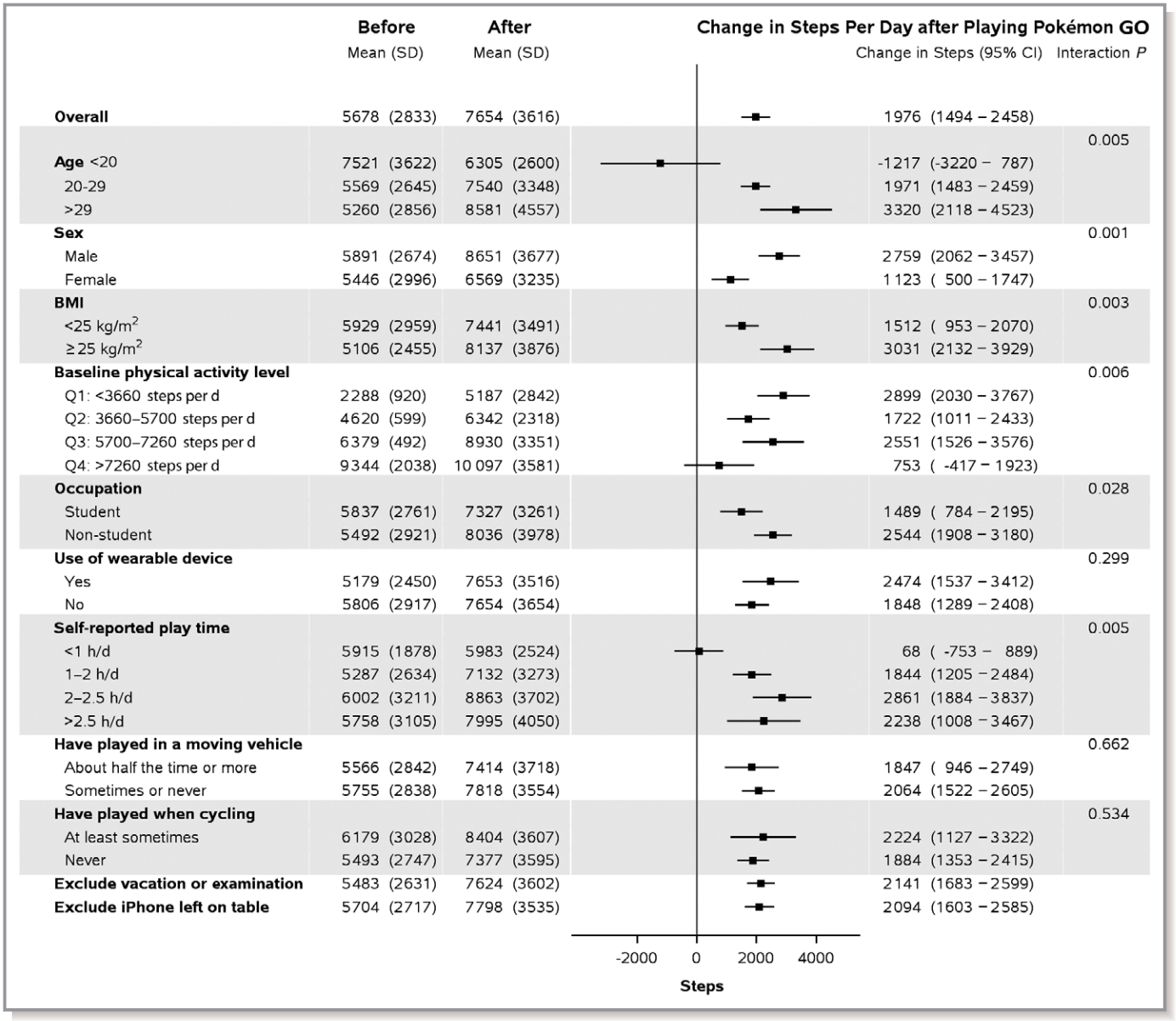

Figure 4. Sensitivity and subgroup analyses.

examinations (2141 additional steps per day; 95% CI, 1683–2599) or excluding individuals who did not usually carry their phones (2094 additional steps; 95% CI, 1603–2585).

Discussion

Regular PA is one of the most important things people can do to improve their health, yet achieving regular PA is often challenging. By encouraging players to ambulate in the real world to locations that would permit capture of Pokémon in the virtual world, Pokémon GO provides an enjoyable way to engage people in PA. Our analysis is among the first rigorously designed studies to evaluate the effect of Pokémon GO on PA.[10,11] While players subjectively reported an increase in PA, automatically recorded step count objectively corroborated an increase in PA level associated with Pokémon GO playing. On average, an individual can walk nearly 2000 additional steps per day and is more likely to achieve 10 000+ steps per day after playing Pokémon GO. While the differences appear modest, doing some PA is better than doing none.[1] Previous study findings indicate that an increase of 2000 steps per day decreases the risk of cardiovascular events by 8% in high-risk individuals.[12] Considering the higher prevalence of physical inactivity worldwide,[13] games such as Pokémon GO may provide an enjoyable alternative to engage people who would otherwise never exercise.

Consistent with anecdotal reports on the Internet,[13–15] we observed that Pokémon GO players spent a significant portion of their day playing the game. The median self-reported playtime was 2.0 h/d among our study volunteers. However,

the attraction of the game had effects in that the more an individual plays, the higher level of PA can be achieved. Participants who reported spending 2 to 2.5 hours playing Pokémon GO can walk 2861 additional steps per day. In contrast, there was no significant increase in step count among occasional gamers who played <1 h/d. While self-reported playtime is subject to recall bias, we used Pokémon GO XP points as a proxy of level of engagement and found a potential dose-response relationship with PA level. On average, 10 000 more XP points gained in the game would translate into 2134 additional steps per day, suggesting that Pokémon GO can help increase PA level for those who play it regularly.

Do games like Pokémon GO help people who live a sedentary lifestyle? Interestingly, we found a low level of PA at baseline in our study participants, suggesting that people who are attracted to the game might be more sedentary. Importantly, participants with the lowest baseline activity level and who were overweight or obese appear to be those who benefit most from the game. Individuals with the lowest PA level at baseline (≤3659 steps per day) walked nearly 3000 additional steps per day after playing Pokémon GO. Individuals with a body mass index ≥25 kg/m^2 walked 3031 additional steps per day, which almost doubled the changes from lower-weight players (1512 additional steps). While they are not intentionally designed or marketed as PA or exercise apps, games such as Pokémon GO have the potential to promote PA and decrease sedentary behaviors.[9,16] Nonetheless, it should be noted that there has been no study evaluating energy expenditure when playing Pokémon GO. Although it is likely lower than more intense exercise modalities such as running and swimming, the best form of PA is the one that people will do, not necessarily the ones with the highest energy expenditure. It is unlikely that marathon runners or regular joggers would benefit from Pokémon GO. However, Pokémon GO may provide an alternative way to engage people who live a sedentary lifestyle and otherwise would never participate in any traditional form of exercise.

Despite the potential health benefits of playing Pokémon GO, we did observe risky behavior among Pokémon GO players. More than 90% of players in our study reported ever playing the game in a moving vehicle. Although we could not determine whether it was the driver or the passenger playing Pokémon GO, a systemic review of Twitter postings found that Pokémon GO creates a distraction for drivers, passengers, and pedestrians.[17] A recent update of the Pokémon GO app includes a speed limit warning. However, the efficacy of such safety messages remains to be seen.

Study Limitations

Our study should be interpreted in the context of the following limitations. First, our study participants were self-selected. Those who participated in the study were more likely to be avid Pokémon GO fans. Their gaming experience may not be representative of the general population. In addition, Pokémon GO was first released in the United States. Therefore, there were fewer participants outside of North America. Second, the majority of the study participants were young adults. Although we found increased levels of PA overall and in many subgroups, further evaluation is needed to determine the extent to which these findings can be generalized to targeted populations such as children, adolescents, the elderly, and persons with more vulnerable health profiles. Third, we used step count recorded by the iPhone Health app to measure PA level. The accuracy of the iPhone Health app has not been well validated in the literature. Inaccuracies notwithstanding, our study utilized a pre-post design and each individual was treated as his/her own control. In addition, we excluded conditions that may influence PA level in sensitivity analyses. Therefore, the degree of change in steps occurring before and after Pokémon GO should be less subject to measurement errors. Fourth, although the primary end point of change in step count was prespecified, all post hoc subgroup analyses were exploratory and might be subject to type I error. Finally, this study is retrospective, using 6 weeks of PA data. While we found a significant increase in PA level after playing Pokémon GO, the initial interest in the game may decline over time. Unfortunately, Apple released the new operation system iOS 10 at the end of September, and the iPhone Health app is now turned off by default. We are unable to evaluate the sustainability of Pokémon GO over time because of the lack of follow-up data. Indeed, 2 recent studies found an initial increase in daily number of steps after Pokémon GO but it gradually attenuated over time.[10,11] google Trends analysis also indicates that search interests related to Pokémon GO are nearly back to prerelease volumes.[18] A constant stream of new functionality in Pokémon GO or other apps is needed to promote participation and maintain sustained PA.

Conclusions

By playing Pokémon GO, an individual could walk nearly 2000 additional steps per day and is more likely to achieve a goal of 10 000+ steps per day, especially among those who spend more time playing Pokémon GO and those who are overweight/obese or have a lower baseline PA level. Games such as Pokémon GO may provide an alternative way to adopt an active lifestyle for persons who play them regularly.

Author Contributions

All authors were involved in the study design, analysis, and manuscript revision. All authors read and approved the final manuscript. Dr Xian is the guarantor who accepts full

responsibility for the work and the conduct of the study, had access to the data, and controlled the decision to publish.

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Disclosures

The study team had no association or financial interest with Niantic, Inc; Nintendo; or Apple.

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