Preventive Medicine Reports 6 (2017) 210–213

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: http://ees.elsevier.com/pmedr

Piloting a mobile health intervention to increase physical activity for adolescents with ADHD

Erin Schoenfelder [a,b,c,*], Megan Moreno [a,c], Molly Wilner [d], Kathryn B. Whitlock [a], Jason A. Mendoza [a,c]

[a] Seattle Children's Research Institute, United States
[b] University of Washington School of Medicine, Department of Psychiatry and Behavioral Sciences, United States
[c] University of Washington School of Medicine, Department of Pediatrics, United States
[d] Touro College of Osteopathic Medicine, United States

ARTICLE INFO

Article history:
Received 20 October 2016
Received in revised form 9 March 2017
Accepted 13 March 2017
Available online 18 March 2017

Keywords:
Attention Deficit Hyperactivity Disorder
Physical activity
Adolescents

ABSTRACT

Physical activity (PA) reduces symptoms of Attention Deficit Hyperactivity Disorder (ADHD); interventions to increase PA may improve functioning and health for adolescents with ADHD. Mobile health (mHealth) technology and social media constitute promising interactive modalities for engaging adolescents—who are at highest risk for ADHD treatment drop-out—in interventions to increase PA. The current pilot study evaluated feasibility and acceptability of an innovative intervention incorporating an mHealth-linked wearable activity tracker (Fitbit Flex) and a Facebook group to increase PA among adolescents with ADHD. 11 adolescents diagnosed with ADHD (age 14–18, m = 15.5; 54% female) participated in a 4-week trial utilizing the Fitbit Flex in conjunction with (1) weekly personalized step count goals (2) social support through a Facebook group and (3) daily text messages about PA. The study took place in the greater Seattle, Washington area in the fall of 2015. Adolescents completed online surveys twice per week to rate their ADHD symptoms and positive and negative mood states, and parents rated adolescent ADHD symptoms weekly.

Participants were adherent to the study protocol and acceptability of the intervention was high. Linear mixed models indicated that participants significantly increased their average weekly steps over the course of the study and demonstrated improvements in both adolescent and parent-reported ADHD Inattentive symptoms. Results indicate that this mHealth intervention is engaging and promising for increasing PA among adolescents with ADHD, and warrant further study. Implications for improving ADHD symptoms and overall functioning for this undertreated population are discussed.

1. Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is the most common behavioral disorder, impacting many domains of functioning and contributing to health risks such as substance use and obesity (Schoenfelder and Kollins, 2015). Pharmacological treatments effectively mitigate symptoms, but acceptability of these treatments is often low and discontinuation ranges between 13.2% to 64% in children (Adler and Nierenberg, 2010) with over half discontinuing in the first year (Winterstein et al., 2007). Treatment drop-out is found to approach 90% in adolescence (McCarthy et al., 2009), leaving adolescents at heightened risk for functional impairments and unhealthy behaviors during a particularly risky developmental stage. Thus, alternative or adjunct treatments, as well as general health promotion strategies, are much needed for this population.

Physical activity (PA) improves cognitive performance, executive functions (i.e., working memory, behavioral inhibition), and ADHD symptoms in children and adults (Gapin et al., 2011; Medina et al., 2010). Children with ADHD who received brief PA at school (e.g., ~30 min of games designed to be within the moderate-to-vigorous intensity range) show improved ADHD symptoms and on-task behavior (Hoza et al., 2014). PA also influences positive and negative mood states (Byrne and Byrne, 1993), reduces symptoms of depression and fatigue, and improves motivation for individuals with ADHD (Fritz and O'Connor, 2016). However, little is known about the impact of increasing habitual daily PA such as walking (Ainsworth et al., 2011) for individuals with ADHD. Adolescents may benefit in particular from interventions to increase PA because PA typically declines with age, with only one quarter of adolescents meeting the recommended minimum of 1-hour of daily moderate-or higher intensity-PA (Nader et al., 2008).

Mobile health applications (mHealth apps) are a rapidly growing and promising approach for interactive and individualized interventions for disease prevention (Patrick et al., 2008; Atienza and Patrick,

* Corresponding author at: 4800 Sand Point Way NE, OA.5.161, Seattle, WA 98105, United States.
E-mail address: Erin.Schoenfelder@SeattleChildrens.org (E. Schoenfelder).

http://dx.doi.org/10.1016/j.pmedr.2017.03.003

2011), and may be a particularly effective platform for engaging adolescents due to the ubiquity of smartphone use in this population. Social media websites constitute an ideal platform both for engaging adolescents and for sharing mHealth application data and connecting with other users. Over 80% of adolescents reported using social networking sites in 2013, with the majority using Facebook (FB) (Madden et al., 2013), which has been used for multiple health promotion programs (Cavallo et al., 2012). A previous community-based study of 30 adolescents pairing an mHealth app, wearable activity tracker, and FB group and found that teens rated their participation and online interactions to be enjoyable and beneficial (Pumper et al., 2015).

The current study fills an important gap in the literature and evaluates the feasibility, acceptability, and preliminary estimates of effect of a behavioral intervention to increase daily habitual PA for adolescents with ADHD involving the Fitbit Flex, a wearable activity tracker, and a FB group to increase engagement.

2. Methods

2.1. Participants

Participants were 11 adolescents ages 14–18 diagnosed with ADHD, recruited using flyers through primary care and specialty clinics (i.e., Adolescent Medicine, Outpatient Psychiatry) affiliated with a children's hospital in Washington state. Inclusion criteria were: a) ages 14–18 years; b) diagnosis of ADHD by a medical or mental health professional (diagnostic documentation from past 3 years provided to the study), c) one parent or guardian willing to complete measures, d) able to complete forms in English, e) no restrictions by a health care provider on PA, f) own a smart phone or similar Fitbit compatible mobile device, and g) install and share Fitbit data with the investigators. Exclusion criteria include adolescents who have previously used a wearable PA tracker to reduce variability in regard to prior interest, engagement, and routines of use with this technology. Participants with co-morbid mental health diagnoses or taking psychoactive medications, including psychostimulants, were included.

Participant assent (or consent if 18 years old) and parent written informed consent were reviewed via telephone and signed digitally. Participants then received their Fitbit Flex device and instructions by mail, were asked to "friend" the study coordinator on FB and join the private FB study group, and completed study questionnaires online. Parents also competed baseline study questionnaires. Participants received incentives of $5/week for each online survey completed (two per week) and $20 for the post-study interview – totaling up to $60 for adolescents and $20 for parents.

2.2. Intervention

Similar to a previous pilot study (Pumper et al., 2015) participants were asked to wear a Fitbit for four weeks, sync the device twice weekly, join a FB group, receive daily text messages, and complete twice-weekly online questionnaires.

The Fitbit Flex wristband collects data through its built-in accelerometer to provide proxy estimates of PA including steps, energy expended, and distance traveled. The data synchronizes with the Fitbit mHealth app on a mobile device, called the "Dashboard," to provide graphs of the data and feedback toward personalized goal attainment. Adolescents received a standardized activity goal for Week 1 (10,000 steps/day), and thereafter an individualized goal based on their average week 1 steps plus 1% steps weekly.

Participants joined a private, invitation-only FB group created for the study to interact with other participants and receive study information and encouragement. A study staff facilitator profile posted to the group, interacted with participants, and monitored posts daily. Participants earned digital badges for meeting weekly activity goals, as well as for social interactions (e.g., liking other's posts) or making improvement toward goals (e.g., active minutes, exceed goal, etc.) to ensure that all participants received positive feedback. Participants were encouraged, but not required, to post in the group, encourage their fellow participants, and share their Fitbit data on FB.

Online questionnaires were administered through online secure, encrypted survey program. Digital prompts (emails and FB group messages) were sent to adolescents mid-day on Tuesdays and to adolescents and parents on Saturdays requesting them to complete the ADHD symptom and mood surveys within 12 h. Saturdays were chosen for parent assessments based on the assumption that parents would be home with their adolescent and able to observe their symptoms. A second group FB reminder was sent after 4 h if the scales were not completed, and a final text message and a private FB message were sent after 10 h.

2.3. Measures and data collection

2.3.1. Demographics

Baseline demographics included age, gender, and ethnicity, height, and weight.

2.3.2. ADHD symptoms

ADHD symptoms were measured at baseline through parent and adolescent reports, and then throughout the study period; twice weekly for adolescents and once weekly for parents. Parents completed the Vanderbilt ADHD Diagnostic Parent Rating Scale (VADPRS) (Wolraich et al., 2003), on which they rated severity of their adolescents' symptoms on a 0–3 scale over the previous 24 hour period. Adolescents completed the 18 items of the VADPRS with wording adjusted to apply to the adolescent; this format has been found to have good internal consistency (Cronbach's alpha = 0.90) and correspondence with parent reports on the VADPRS (ICC = 0.78; $p < 0.001$) (Yen et al., 2007).

2.3.3. Mood valence

Adolescents rated their mood using the 10-item Positive and Negative Affect Schedule for Children (PANAS-C) (Ebesutani et al., 2012) at baseline and twice-weekly during the study period. Using a 1–5 Likert scale (1 = Very Slightly; 5 = Extremely), they rated the extent to which they experienced 5 positive and 5 negative mood state in the past 24 h, yielding an average positive and negative score.

2.3.4. Step counts

Participants' daily step counts were collected by downloading data from their Fitbit Dashboards to the study database. Fitbit devices, including the Flex, have acceptable reliability and validity for step counts (Evenson et al., 2015).

2.3.5. Study participation

Percentage of days wearing the Fitbit, syncing the device, and digital questionnaires completed were compiled. FB engagement data included "likes," comments, and adolescents' posts to the FB group page and their own page.

2.3.6. Acceptability

Post-intervention, adolescents and parents rated the program on 8 dimensions using a 1–4 scale using the Client Satisfaction Questionnaire (CSQ-8) (Larsen et al., 1979).

2.3.7. Qualitative interviews

Participants completed one-on-one, semi-structured phone interviews after study completion consisting of 16 scripted questions with several optional follow-up prompts. Questions asked what did and did not work well about the Fitbit Flex, Dashboard, FB page, text communications, digital questionnaires, and overall program. They were also asked whether they would recommend the program and ideas to improve it.

2.4. Data analysis

Feasibility was evaluated using rates of enrollment/retention and previously described aspects of study participation. Qualitative interview audio files were transcribed verbatim and analyzed for themes using an iterative process by two coders, with discrepancies resolved through discussion. We examined activity, mood, and symptom changes over time in separate linear mixed models, with random effect of participant and autoregressive within subject correlation. Linear mixed models accommodate unbalanced data, and estimate over missing observations at each time point (Cnaan et al., 1997; Gueorguieva and Krystal, 2004). Estimates of 30-day change were calculated. Associations of step counts with mood and symptoms on the same day were examined in similar linear mixed models with step counts predicting mood and symptoms. Additionally, associations of 4-day and 7-day cumulative step counts with mood and symptoms were also analyzed. All analyses were conducted at the alpha = 0.05 significance level.

3. Results

Participant characteristics are provided in Table 1. The facilitator made a total of 35 FB posts consisting of 28.6% study information, 17.1% discussion prompts, 31.4% badges, 28.6% reminders, and 8.6% page updates. Participants received an average of 48.8 (SD = 16.6; range 29–78) text messages from study staff; 36.9% were standard fitness messages, 27.9% (SD = 9.4; range 4–21) were reminders (surveys, Fitbit charging, etc.), and the remainder were personal reminders or troubleshooting participant questions.

3.1. Feasibility

The 11 participants were referred from specialty clinics and all completed the study. Adherence and participation data are summarized in Table 1. All participants (parent and adolescent) completed questionnaires at 2 or more time points, with 84.1% of both adolescent and parent surveys completed overall. The facilitator averaged 10–30 min per day managing the FB group and texts, and an additional 1 h weekly calculating new fitness goals for participants, for a total of 22 min per participant per week.

Table 1
Participant characteristics and participation in study protocol.

Participant characteristics (n = 11)					
Age		$M = 15.5$			$SD = 1.4$
Body mass index		$M = 22.1$			$SD = 4.5$
Female		54%			
Ethnicity					
Caucasian		80%			
Asian American		10%			
Multi-racial		10%			
Taking daily medication for ADHD		60%			
ADHD med plus SSRI		40%			
ADHD med plus acid reflux med		10%			
Average participation	**Week 1**	**Week 2**	**Week 3**	**Week 4**	**Overall**
Days Fitbit worn	91.2	84.4	88.6	76.8	85.2
Males	95.0	88.6	85.7	82.2	87.9
Females	88.1	80.9	90.5	72.2.	82.9
Synced Fitbit device	81.2	98.5	90.9	90.0	90.1
Adolescent questionnaires completed	86.4	68.2	90.9	90.9	84.1
Before text reminder	36.4	40.9	36.4	22.7	34.1
After text reminder	50	27.3	54.5	68.2	50.0
Parent questionnaires completed	100	54.5	90.9	90.9	84.1
Viewed FB posts and updates	38.2	*	21.8	29.9	30.0
Posted in group FB page	18.2	*	9.1	9.1	12.1
Posted on own FB page	27.3	66.7	18.2	36.4	37.1

*Due to a technical error, the group moderator was not able to post in the FB group for several days, skewing the data for this week. Study took place in Seattle, WA in 2015.

3.2. Acceptability

Total CSQ score averaged 1.4 for adolescents and 1.4 for parents (1 = definitely, 4 = not at all). All respondents responded in the affirmative when asked if they received the kind of service they wanted, would recommend the program, and would participate again.

3.3. Preliminary intervention outcomes

PA (daily step counts) and symptom data are found in Table 2. Daily steps averaged 8014 (SD = 5728). Across 30 days, there were significant increases in steps (3218 total, 107 steps/day, 95% CI: 931 to 5291) and significant decreases in teen- and parent-reported Inattentive and Hyperactive/Impulsive symptoms (30-day change ranging from −0.4 to −0.8). There was no significant change in mood valence. The association of either same day or prior cumulative 4 or 7 day active steps with mood or ADHD symptoms was nonsignificant (p range 0.15 to 0.86).

3.4. Qualitative interviews

Qualitative interviews universally indicated positive experiences with the overall study and all components of the study. The most common unprompted themes identified included increased awareness of activity level and of ADHD symptoms. The most frequent suggestions for improvement included increasing reminders, adding additional activity challenges or goals, and using additional social media sites.

4. Conclusions

The Fitbit and Facebook mHealth intervention was feasible and had high acceptability among adolescents with ADHD. Although the study size was limited, adolescents in this study exhibited an average increase in steps and an average decrease in ADHD symptoms over the 30 day intervention. The intervention appears to be a promising approach to help adolescents with ADHD increase PA and potentially improve their health and functioning, which warrants further testing (e.g., a randomized controlled trial).

Adherence with wearing the Fitbit was high. Adolescents and parents completed the majority of the digital questionnaires, indicating that it is feasible for both teens and parents to digitally track symptoms in real time from their phones. However, multiple reminders were needed to prompt survey completion, even with a financial incentive. The majority of participants did not appear to be frequent FB users and some reported preferring other social media platforms (i.e., Instagram).

Study limitations include the small sample size, short duration of the intervention, and lack of comparison group and post-intervention follow-up. Thus, findings must be interpreted cautiously. Additionally, we do not know whether medication doses may have changed during the intervention period. The intervention should be evaluated in a randomized controlled trial to determine program effects. Based on this 4-week trial, it is unclear whether engagement can be maintained over a longer period and this should be evaluated in a longer trial. Further, it will be important to determine whether costs of technology and interventionist time to facilitate this interactive program outweigh costs resulting from functional and health problems related to untreated ADHD. Future adaptations include using multiple social media platforms, a longer intervention period and follow-up, evaluating ADHD medication as a moderator of program response, and recruiting in an accessible primary care setting.

Table 2
Steps, ADHD symptoms, and mood ratings: means (standard deviations) and 30 day change.

	Pretest	Week 1	Week 2	Week 3	Week 4	Average	B (slope)	SE	*p*	30 day change
Daily steps	n/a	6223 (3897)	8370 (5901)	8365 (5123)	8864 (5532)	8013 (5271)	107.27	38.17	0.005	3218
ADHD-inattentive symptoms										
Adolescents	13.2 (6.3)	9.7 (6.5)	6.9 (5.7)	7.0 (6.1)	9.2 (6.6)	8.2 (6.2)	−0.02	0.004	<0.0001	−0.59
Parents	15.9 (2.8)	14.5 (5.9)	12.4 (4.9)	11.2 (2.9)	8.6 (4.7)	12.5 (4.3)	−0.03	0.004	<0.0001	−0.84
ADHD-hyperactive/impulsive symptoms										
Adolescents	8.5 (7.3)	8.2 (8.2)	2.9 (2.9)	5.5 (8.3)	5.7 (6.6)	6.2 (6.6)	−0.01	0.004	0.0003	−0.41
Parents	7 (5.2)	4.0 (4.0)	2.2 (1.5)	6.3 (2.2)	3.0 (3.5)	4.5 (3.3)	−0.02	0.004	0.0003	−0.47
Mood valence										
Negative mood	10.7 (5.0)	9.5 (3.9)	7.5 (2.3)	8.5 (3.6)	9.0 (4.4)	8.8 (3.3)	−0.010	0.007	0.16	−0.31
Positive mood	17.3 (3.7)	18.1 (2.4)	18.8 (3.2)	17.0 (2.5)	17.3 (4.8)	17.6 (2.7)	−0.006	0.006	0.33	−0.18

Study took place in Seattle, WA in 2015.

In sum, this pilot indicated that it is feasible and acceptable to implement a wearable mHealth and social media-based intervention with adolescents with ADHD, and it may benefit their activity level and health.

Funding

Funding was provided by the Center for Child Health, Behavior and Development at Seattle Children's Research Institute, 2015.

Conflicts of interest

None.

Transparency document

The Transparency document associated with this article can be found, in the online version.

References

Adler, L.D., Nierenberg, A.A., 2010. Review of medication adherence in children and adults with ADHD. Postgrad. Med. 122 (1), 184–191.
Ainsworth, B.E., Haskell, W.L., Herrmann, S.D., et al., 2011. 2011 Compendium of Physical Activities: a second update of codes and MET values. Med. Sci. Sports Exerc. 43 (8), 1575–1581.
Atienza, A.A., Patrick, K., 2011. Mobile health: the killer app for cyberinfrastructure and consumer health. Am. J. Prev. Med. 40 (5 Suppl 2), S151–S153.
Byrne, A., Byrne, D.G., 1993. The effect of exercise on depression, anxiety and other mood states: a review. J. Psychosom. Res. 37 (6), 565–574.
Cavallo, D.N., Tate, D.F., Ries, A.V., Brown, J.D., DeVellis, R.F., Ammerman, A.S., 2012. A social media-based physical activity intervention: a randomized controlled trial. Am. J. Prev. Med. 43 (5), 527–532.
Cnaan, A., Laird, N., Slasor, P., 1997. Tutorial in biostatistics: using the general linear mixed model to analyse unbalanced repeated measures and longitudinal data. Stat. Med. 16, 2349–2380.
Ebesutani, C., Regan, J., Smith, A., Reise, S., Higa-McMillan, C., Chorpita, B.F., 2012. The 10-item positive and negative affect schedule for children, child and parent shortened versions: application of item response theory for more efficient assessment. J. Psychopathol. Behav. Assess. 34 (2), 191–203.
Evenson, K.R., Goto, M.M., Furberg, R.D., 2015. Systematic review of the validity and reliability of consumer-wearable activity trackers. Int. J. Behav. Nutr. Phys. Act. 12 (1), 1.
Fritz, K.M., O'Connor, P.J., 2016. Acute exercise improves mood and motivation in young men with ADHD symptoms. Med. Sci. Sports Exerc.
Gapin, J.I., Labban, J.D., Etnier, J.L., 2011. The effects of physical activity on attention deficit hyperactivity disorder symptoms: the evidence. Prev. Med. 52 (Suppl. 1), S70–S74 Journal Article.
Gueorguieva, R., Krystal, J.H., 2004. Move over anova: progress in analyzing repeated-measures data andits reflection in papers published in the archives of general psychiatry. Arch. Gen. Psychiatry 61 (3), 310–317.
Hoza, B., Smith, A.L., Shoulberg, E.K., et al., 2014. A randomized trial examining the effects of aerobic physical activity on attention-deficit/hyperactivity disorder symptoms in young children. J. Abnorm. Child Psychol. (Journal Article).
Larsen, D.L., Attkisson, C.C., Hargreaves, W.A., Nguyen, T.D., 1979. Assessment of client/patient satisfaction: development of a general scale. Eval. Program Plann. 2 (3), 197–207.
Madden, M., Lenhart, A., Duggan, M., Cortesi, S., Gasser, U., 2013. Teens and Technology 2013. Pew Internet & American Life Project.
McCarthy, S., Asherson, P., Coghill, D., et al., 2009. Attention-deficit hyperactivity disorder: treatment discontinuation in adolescents and young adults. Br. J. Psychiatry J. Ment. Sci. 194 (3), 273–277.
Medina, J.A., Netto, T.L., Muszkat, M., et al., 2010. Exercise impact on sustained attention of ADHD children, methylphenidate effects. Atten. Defic. Hyperact. Disord. 2 (1), 49–58.
Nader, P.R., Bradley, R.H., Houts, R.M., McRitchie, S.L., O'Brien, M., 2008. Moderate-to-vigorous physical activity from ages 9 to 15 years. JAMA 300 (3), 295–305.
Patrick, K., Griswold, W.G., Raab, F., Intille, S.S., 2008. Health and the mobile phone. Am. J. Prev. Med. 35 (2), 177–181.
Pumper, M.A., Mendoza, J.A., Arseniev-Koehler, A., Holm, M., Waite, A., Moreno, M.A., 2015. Using a Facebook group as an adjunct to a pilot mHealth physical activity intervention: a mixed methods approach. Stud. Health Technol. Inform. 219, 97–101.
Schoenfelder, E.N., Kollins, S.H., 2015. Topical review: ADHD and health-risk behaviors: toward prevention and health promotion. J. Pediatr. Psychol.
Winterstein, A.G., Gerhard, T., Shuster, J., Johnson, M., Zito, J.M., Saidi, A., 2007. Cardiac safety of central nervous system stimulants in children and adolescents with attention-deficit/hyperactivity disorder. Pediatrics 120 (6), e1494–e1501.
Wolraich, M.L., Lambert, W., Doffing, M.A., Bickman, L., Simmons, T., Worley, K., 2003. Psychometric properties of the Vanderbilt ADHD diagnostic parent rating scale in a referred population. J. Pediatr. Psychol. 28 (8), 559–567.
Yen, J.Y., Ko, C.H., Yen, C.F., Wu, H.Y., Yang, M.J., 2007. The comorbid psychiatric symptoms of Internet addiction: attention deficit and hyperactivity disorder (ADHD), depression, social phobia, and hostility. J. Adolesc. Health 41 (1), 93–98.