



Published in final edited form as:

Circ Cardiovasc Qual Outcomes. 2022 November ; 15(11): e009328. doi:10.1161/
CIRCOUTCOMES.122.009328.

Customizing place-tailored messaging using a multi-level approach: Pilot study of the Step It Up physical activity mobile app tailored to neighborhood environment

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Disclosures

None.

Clinical Trial Registration: [NCT03288207](https://clinicaltrials.gov/ct2/show/study/NCT03288207)

List of Supplemental Materials:

Supplemental Methods

Supplemental Figures Figure S1 and Figure S2

Supplemental Tables Table S1- S3

Keywords

physical activity intervention; physical activity; Social Determinants of Health; neighborhood adversity; obesity; cardiovascular disease

1. Goals and Vision of the Program

As outlined by the 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease, strong evidence suggests that regular physical activity (PA), specifically aerobic exercise like walking, has clear benefits on cardiovascular disease (CVD) risk and outcomes.¹ PA engagement is significantly determined by intra- and inter-personal factors, along with objective and perceived measures of neighborhood environment.² Due to structural and social factors, African American (AA) women are more likely to live in resource-limited neighborhoods, exhibit lower PA rates, and are disproportionately affected by CVD.^{2,3} Previous work has elucidated the importance of incorporating social determinants of health (SDoH) into multilevel CVD interventions.³ Digital health technology can be used to address multiple socio-ecological factors that influence PA promotion within diverse communities. However, there is a need to specifically focus on the feasibility of digital health technology in populations highly impacted by SDoH.⁴

We created Step It Up, a digital health app, to address barriers to increased PA engagement among AA women in lower-resourced neighborhoods. Place-tailored messaging is a method of improving PA resource awareness and utilization by providing information about nearby PA resources. Our prior work has determined elements important to PA in the community of focus, identifying links between neighborhood perception, PA and sedentary behaviors, as well as the acceptability and feasibility of utilizing the digital health technology described.⁴ Through a community-based pilot feasibility intervention, we sought to assess the impact of place-tailored messaging on PA and CVD outcomes. We also aimed to elucidate the multi-level environmental and psychosocial factors that associate with PA app engagement. Ultimately, study findings will be used to maximize user engagement in a six-month, community-based PA intervention using the Step It Up app among AA women in the Washington, D.C. area.

2. Local Challenges in Implementation

Given the community-centered nature of this pilot intervention, it was crucial to interact directly with community members and seek their input during intervention development and implementation. While facilitating opportunities for sufficient community engagement can be challenging, we worked with the DC Cardiovascular Health and Obesity Collaborative (DC CHOC). DC CHOC is an established community advisory board consisting of leaders from faith-based and community organizations with expertise and/or interest in cardiovascular health (Supplemental Material). Through DC CHOC involvement, we were able to successfully incorporate the feedback of AA community members to design this intervention.

Additionally, initiative implementation was impacted by neighborhood- and individual-level social factors relating to PA resources and perceptions. Generally, neighborhood-level socioeconomic disadvantage (NSD) is directly attributed to discriminatory housing and urban planning policies that promote increased racial/ethnic segregation and decreased resource allocation to communities comprised predominantly of people of color.³ As a result of this adverse built and social neighborhood environment, residents are less able to engage in PA. Furthermore, PA may be influenced by perceived neighborhood social environment (PNSE) as a SDoH³, which includes resident perceptions of neighborhood violence, physical/social environment, and social cohesion. Greater perceived crime and lack of neighborhood safety associate with low PA levels, especially women.² At the individual-level among AA women, intra- and inter-personal factors determine an individual's PA engagement. Anxiety and depression associate with decreased PA, as do other intrapersonal barriers such as time constraints, lack of motivation, and costs of exercise facilities. Interpersonal PA barriers include caregiving/family responsibilities, limited social support, and limited social accountability.² The Step It Up app thus targets PA barriers using a multi-level approach.

3. Design of the Initiative

This intervention designed from a multi-level framework (Supplemental Methods/Figure S1) focused on AA women living in lower-resourced neighborhoods within the Washington, D.C. metropolitan area (Wards 5, 7, 8, and the contiguous Prince George's County, MD). These neighborhoods have a population that is mostly AA, lower PA resources and median household income, and the highest CVD burden compared to other neighborhoods in the metropolitan area.⁴ Participants, recruited through engagement with DC CHOC, were 24 AA women with overweight/obesity (BMI $\geq 25\text{kg/m}^2$) aged 21–75years. Participants had access to an Apple iOS smartphone compatible with the Step It Up app, which was designed in partnership with the DC CHOC and CHAI Core: Interventions (University of North Carolina, Chapel Hill) using an initial health and needs assessment, focus groups, and iterative end-user testing⁴ (Supplemental Methods, Table S1).

Participants received one of two types of motivational messaging through push notifications three times a day at regular intervals via the Step It Up app. Participants randomized to standard messaging received motivational messages focused on intra- and interpersonal-level factors for PA, such as goal-setting, personal efficacy, and social support. Participants randomized to tailored-to-place messaging received additional messages addressing both individual- and neighborhood- level factors affecting PA, including available PA resources nearby (Supplemental Methods). Using a database of PA resources of parks, trails, fitness centers, and PA locations identified through community engagement⁴ within study areas, geofences were created with a 0.75-mile radius (approximately representing a 10–15 minute walk) around each PA location.⁴ Users randomized to place-tailored messaging received messages informing participants of nearby PA locations during the appropriate time frame and encouraged PA. Among those randomized to place-tailored messaging, there were two variations. The first group (objective) received messaging that included only locations from the registry compiled by the research team. The second group (personalized) added five

of their own preferred PA locations, including informal resources like schools, homes, and workplaces.

All participants received a wearable PA monitor (Fitbit Charge 2, Fitbit, San Francisco, CA), which synced with the Step It Up app, allowing users to monitor daily step count. Users were encouraged to wear the Fitbit daily, and track sleep, minutes of vigorous activity, total activity, and daily steps through the Step It Up app because all Fitbit app and tracker notifications were disabled during the study. The Fitbit was chosen for its comfort, features, and ease-of-use, and has been validated to reliably measure outcome variables (steps per day) of this study⁴.

4. Implementation of the Initiative

This Step It Up pilot intervention was conducted with 24 participants between October 2019 and February 2020. Each participant was for three weeks, and randomized into 1 of 3 messaging types, which were standard messaging, standard messaging with objective place-tailored messaging, or standard with personalized place-tailored messaging. Upon enrollment, all participants completed surveys assessing socio-demographics, health history, and behavioral, psychosocial, and environmental factors that may influence PA. A Fitbit Charge 2 was configured for PA monitoring and the Step It Up app was installed on their mobile phones. Participants had access to the Fitbit, but the Step It Up app was not active during the first week. After collecting baseline data for the first week, participants had access to all features of the app for the second and third weeks, including ecological momentary stress assessments (EMA), educational PA modules, a community forum, and personalized goal-setting tools, the details of which have been previously published.⁴

Key outcomes for this pilot included PA, computed for each participant based on available Fitbit data as mean number of steps per day for each week of the intervention. In addition, we examined engagement with the Step It Up app as determined by a cumulative score ranging from 0 to 18 based on user interactions with various features of the app [number of educational modules completed (max=2 points), number of weeks utilizing the goal-setting tools (max=2 points), and number of days completing an EMA (max=14 points)]. We conducted statistical analyses to determine associations between a) place-tailored messaging with PA change over time using linear mixed models and b) environmental and psychosocial factors with app engagement using linear regression models.

5. Success of the Initiative

Place-tailored messaging was associated with PA increases of up to 1,588 steps (SE=894, p=0.08) per day during Week 2 and 1,344 steps per day (SE=894, p=0.14) during Week 3 in our fully adjusted model (Table 1). We adjusted for age and body mass index (BMI) because higher values for these variables may increase the difficulty of walking and thereby affect steps per day. The observed change in steps during weeks 2 and 3 for participants who received place-tailored messaging was between 1,000 and 2,000 steps a day compared to either baseline or to the standard messaging group, trending towards clinical significance.⁵

On average, participants wore the Fitbit 20.96hours/day over the 21-day study period, with all participants wearing the Fitbit for 21days (Table S2).

With regards to app engagement patterns, mean app engagement score was 9.8 (SD±6.3) out of 18 points. 37.5% of participants completed all 14 EMA and 62.5% completed at least half of the EMA. 62.5% of participants additionally completed all modules, but only 12.5% of participants utilized the personal goal-setting tools. At the neighborhood level, greater perceived neighborhood social cohesion and greater neighborhood safety were associated with greater app engagement (B=3.48, SE=1.43, p=0.02 and B=3.05, SE=1.30, and p=0.03, respectively). On the individual level, greater social isolation was associated with greater app engagement (B=5.24, SE=2.38, p=0.04) (Table S3).

The multi-level approach to analyzing PA app engagement focused on both neighborhood- and individual-level factors allows for a more nuanced understanding of the barriers and incentives to increased PA and utilization of tools within the Step It Up app. We observed the effects of individual experiences and neighborhood environment perceptions on PA app engagement. Some participants expressed that the app was useful to discover PA resources in suburban environments, which were consequentially associated with more favorable neighborhood perceptions. Users reporting greater social isolation were also more likely to engage with the app. This association is corroborated by informal feedback from participants, who wanted to see even more robust features within the community forum on the app.

6. Translation to Other Settings

This pilot study is representative of the process of developing a digital health intervention for communities with high CVD risk burden who are traditionally underrepresented in biomedical research, specifically in dense, urban areas with PA resources in proximity. Through engagement with a community advisory board, future initiatives could develop tailored digital health interventions that directly target barriers to PA as identified by community members themselves. Furthermore, this pilot study provides evidence for the value of incorporating targeted interventions for app engagement and neighborhood perceptions when addressing PA, which are factors often overlooked in digital health studies. This intervention can broadly serve as a model for other CVD interventions that are community-centered and SDoH-informed.

7. Summary of the Experience, Future Directions and Challenges

In this pilot study, we identified several neighborhood- and individual-level influences on engagement with a PA app in a population with a high CVD risk. We successfully achieved our goals of testing place-tailored messaging to be implemented in a six-month, community-engaged PA intervention.⁴ Findings from this study will be used to further tailor the six-month intervention utilizing the Step It Up app, which aims to address PA levels among AA women in the Washington, D.C. area, targeting those who live in urban areas with more unfavorable perceptions of the neighborhood environment. At the neighborhood-level, we will add PA resources in DC that fit user preference and accordingly modify place-tailored

messaging in the full study. Utilizing what we have learned about app engagement, we are incorporating additional features such as messaging specifically encouraging interaction with the community forum, individualized goal-setting tools to plan PA types over the course of the week, and options to flag unsafe locations to address the relationship between perceived neighborhood safety and app engagement (Figure S2).

We also aim to study the impact of community-building measures on social isolation outcomes at the individual level, as increased interaction with fellow participants could possibly lead to improved app engagement. In addition, based on our findings suggesting that positive neighborhood perceptions were associated with greater engagement, we will further clarify the role of the built environment on PA and engagement in the full study and observe whether participants flag unsafe PA resources while in the study. As a limitation of this pilot study, we were only able to recruit participants with access to an Apple iOS smartphone. However, for the future intervention⁴, the Step It Up app was designed to also be used with Android phones. Lastly, we will need to evaluate the effects of the COVID-19 pandemic as a potential barrier to participants' willingness to engage in the Step It Up PA intervention. Ultimately, we hope the full intervention will successfully address the SDoH that influence PA and app engagement to make a meaningful reduction in CVD risk and improve outcomes with future efforts to integrate similar tailored, digital-health interventions into cardiovascular care.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

We would like to acknowledge our partners in the Washington DC Cardiovascular Health and Obesity Collaborative community advisory board, study participants, and former students and fellows, without whom none of our work would have been possible. We would also like to thank the NIH staff and clinical teams and our collaborators for their continuous support.

Sources of Funding

The statements and contents expressed in this perspective are those of the authors and do not reflect the official position of the NIH, DHHS, and/or the US Government. The Social Determinants of Obesity and Cardiovascular Risk Laboratory is funded by the Division of Intramural Research of the National Heart, Lung, and Blood Institute and Intramural Research Program of the National Institute on Minority Health and Health Disparities. The Translational, Biobehavioral and Health Disparities Branch is funded by the Intramural Research Program of the National Institutes of Health, Clinical Center. The Socio-Spatial Determinants of Health Laboratory is supported by the Intramural Research Program, National Institute on Minority Health and Health Disparities, National Institutes of Health and by the NIH Distinguished Scholars Programs. This research was made possible through the NIH Medical Research Scholars Program, a public-private partnership supported jointly by the NIH and generous contributions to the Foundation for the NIH from the Doris Duke Charitable Foundation, Genentech, the American Association for Dental Research, the Colgate-Palmolive Company, Elsevier, alumni of student research programs, and other individual supporters via contributions to the Foundation for the National Institutes of Health.

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Table 1.

Linear Mixed Modeling of change in average steps/day by week and message type (n=72 person-weeks, 24 participants). Referent group for the TPM group were those that received standard messaging (without any location-specific information).

Effect	Adjusted (Age, BMI [*])		Adjusted (TPM [†])		Fully Adjusted (TPM [†] , Age, BMI [*])	
	Estimate (SE [‡])	P	Estimate (SE [‡])	P	Estimate (SE [‡])	P
Intercept	6096 (7084)	0.40	7840 (869)	<.0001	8034 (7108)	0.27
Week 2	685 (429)	0.12	-361 (720)	0.62	-373 (727)	0.61
Week 3	1180 (429)	0.01	295 (720)	0.68	284 (727)	0.70
Place-tailored Messaging (TPM [†])			-221 (1505)	0.88	-154 (1515)	0.92
Week 2 *TPM [†]			1571 (882)	0.08	1588 (894)	0.08
Week 3 *TPM [†]			1327 (882)	0.14	1344 (894)	0.14
Age	17 (67)	0.81			9 (66)	0.89
BMI [*]	25 (120)	0.84			-16 (119)	0.89

* BMI: Body Mass Index;

[†]TPM: Place-tailored messaging;

[‡]SE: Standard error.