

# FitAware: Mediating Group Fitness Strategies with Smartwatch Glanceable Feedback

Andrey Esakia<sup>1</sup> D. Scott McCrickard<sup>1</sup>

<sup>1</sup>Department of Computer Science and  
Center for HCI  
Virginia Tech  
esakia|mccricks@cs.vt.edu

Samantha Harden<sup>2</sup>

<sup>2</sup>Department of Human  
Nutrition, Foods, and Exercise  
Virginia Tech  
harden.samantha@vt.edu

Michael Horning<sup>3</sup>

<sup>3</sup>Department of Communication  
and Center for HCI  
Virginia Tech  
mhorning@vt.edu

## ABSTRACT

Smartwatch fitness trackers seek to encourage healthy behavior through rich glanceable feedback that is easily accessible. This research examines how smartwatches can be used in existing group-based physical activity community interventions to provide group and individual feedback as the means to channel competitive and cooperative strategies. Seeking to avoid relying on in-person or web-based interventions that are known to have high drop-out rates, this paper presents a smartwatch-centered system that tracks steps and provides glanceable group dynamics-based feedback about personal and group performance. An 8-week deployment program with 27 participants shows successes and challenges with smartwatch-centered interventions. Most notably, the smartwatch was integral for groups with high levels of group cohesion to successfully mediate friendly competition, cooperation, and support, leading to better adherence to individually set physical activity goals and higher engagement levels with the smartwatch and the program.

## Author Keywords

Physical activity; health informatics; group dynamics; community intervention; persuasive technology.

## ACM Classification Keywords

H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous

## INTRODUCTION

Community-based physical activity behavior change interventions—targeting pre-existing groups in their natural environments—have been shown to be effective [27] and are recommended by the Task Force on Community Preventive Services as an effective approach to tackle the physical inactivity epidemic in the US [34]. Such interventions leverage the influence exerted from interpersonal factors in

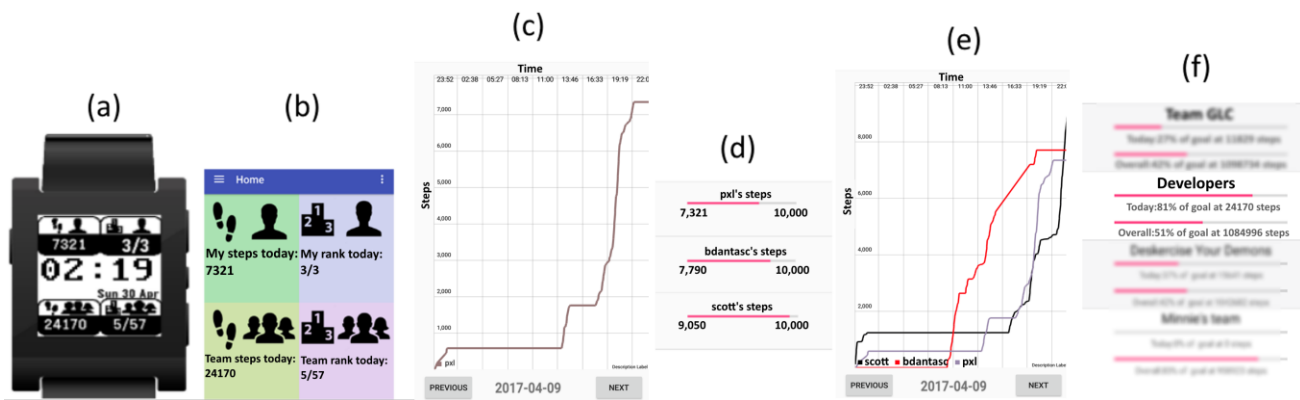
Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for components of this work owned by others than ACM must be honored. Abstracting with credit is permitted. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee. Request permissions from [Permissions@acm.org](mailto:Permissions@acm.org).

*PervasiveHealth '18*, May 21–24, 2018, New York, NY, USA © 2018 Association for Computing Machinery. ACM ISBN 978-1-4503-6450-8/18/05... \$15.00 <https://doi.org/10.1145/3240925.3240926>

small groups referred to as *group dynamics* to facilitate physical activity behavior change due to “a dynamic process that is reflected in the tendency for a group to stick together and remain united in pursuit of its instrumental objectives and/or for the satisfaction of member affective needs” [7]. Interventions that employ group dynamics principles complement the three core individually-based behavior change strategies of self-monitoring, feedback and goal setting, with group-specific strategies such as interaction and communication and/or group goal setting [6]. Such interventions have been shown to be effective in improving physical activity behaviors [18].

Group dynamics-based interventions have been shown to be effective in in-person settings where participant groups meet regularly to enable communication and interaction. Such interventions rely on facilitation of group interactions with help from health practitioners who provide feedback and encourage group member interactions, making interventions costly and difficult to scale. Current attempts to mitigate the reliance on staff and physical co-location of participants via browser and tablet alternatives have not shown the desired results as participants do not feel connected to their groups and experience interaction burden with the system [29].

To mitigate the reliance on face-to-face meetings and health practitioner interactions, this project seeks to leverage the widespread availability and rise in popularity of smart wearable devices (44 million adults in US have wearables [35]) and smartphones. Smartwatches are capable of automatically capturing physical activity and providing glanceable feedback with minimal interaction requirements. Research shows that the smartwatch users regularly look at the watchface, primarily to check the time[31].Such regular watchface observations provide opportune moments to peripherally present users with intervention-specific glanceable feedback. Feedback from wearables such as Fitbit and Jawbone, which provide glanceable access to data like steps and heart rate, have proven to be successful at improving physical activity behaviors[28]. This work seeks to leverage the capabilities of smartwatches in presenting continued glanceable feedback to channel group-related information to members in the groups. This supports the examination of user experience in receiving wrist-based glanceable feedback, constrained by its small screen size but



**Figure 1. From left to right: a) FitAware Pebble smartwatch watchface; b) companion app home screen; c) personal step view plotting steps vs time; d) team view individual rank with group member steps and goals; e) day view group member steps for steps vs time; f) team list with goals, daily, and total steps.**

empowered by its quick and easy availability, in the context of group health information.

This paper presents an 8-week deployment of FitAware as part of a statewide group dynamics-based physical activity community intervention, called FitEx[24]. A subset of teams volunteered to use the FitAware smartwatch-centered system paired with a companion smartphone app. FitAware seeks to channel evidence-based strategies via glanceable indicators on the smartwatch coupled with extended views on the companion app (See Figure 1). The watchface was set to display in quadrants: self-step count, self-rank, team step count, and team rank. The companion app expounds on smartwatch information to offer more details. This paper reports on participant experience, focusing on feedback from indicators of personal steps, team steps, personal rank, and team rank for physical activity behaviors, group behaviors, and FitAware engagement levels. A mixed-methods approach comprised of surveys, system usage data analysis and participant interviews capture different aspects of the field study.

**RELATED WORK**

Group dynamics-based physical activity interventions use strategies such as group member interaction, competition, cooperation, sense of collective efficacy and goal setting[8]. Although group dynamics approaches have been shown to be effective in increasing physical activity levels, these interventions rely on in-person program delivery—which is costly and may limit reach [18] [12,26]. Web and tablet based have been studied as part of an effort to reduce costs and increase reach, but such systems suffered from engagement decline and high dropout rates [29], due to factors like interaction burden [19].

Prior studies have explored the feasibility of smartphones to facilitate the physical activity of groups by channeling elements of group dynamics. It has been shown that smartphones encourage communication [10], progress sharing [2], and competition and collaboration [1,9] to

increase physical activity. Smartphones have been shown to be valuable tools for supporting social interactions among members of a community [25] and for providing awareness of the activities of friends [20,23]. These examples, while effective in certain ways, all require user interaction in order to receive information feedback. Even for smartphones, hardware ergonomics impose barriers on the user experience [3].

Smartwatches, however, enable faster information access, with lower cognitive demand than smartphones [22,31] through glanceable notifications [21]. There are few studies on the effectiveness of smartwatches for physical activity promotion in social groups. Gouveia et al., [22] considered the design space of smartwatch glanceable interfaces. The study explored four different types of smartwatch interfaces among twelve young male participants that already owned a specific smartwatch. One smartwatch interface provided step-count comparison information of an average user (normalized based on a large database of tracked steps) with the same goal. Thus, users were able to compare themselves to someone else with the same goal by simply glancing at the watchface. The study found that participants often noticed and reacted to small step-count differences (500 or under) by walking within five minutes of discovering the information. The authors conclude that participants were more motivated to walk when they knew that it would not take much time to overtake the opponent or stay ahead.

FitAware fills the gap of examining user experience through wrist-based glanceable feedback, to support channeling behavioral strategies prescribed by group-dynamics and in the context of small, socially connected groups.

**FITAWARE APPROACH AND PROTOTYPE DESIGN**

FitAware is a three-component system consisting of a Pebble smartwatch interface, companion Android app, and a website. The system digitizes and enhances components of FitEx, an 8-week community-based group dynamics



physical activity assessment survey. The website is most useful for in-depth examinations of participant and team rankings.

## METHOD

As per our elaboration in the previous sections, it is important to learn how the experience with the glanceable feedback from fitness smartwatches can influence user engagement and physical activity behaviors in a group setting. As stated in the introduction, this work seeks to determine how FitAware can channel underlying behavioral strategies via glanceable feedback about personal steps, personal rank, team steps, and team rank. This study explores FitAware impacts on physical activity behaviors, group behaviors, and system engagement.

### Recruitment

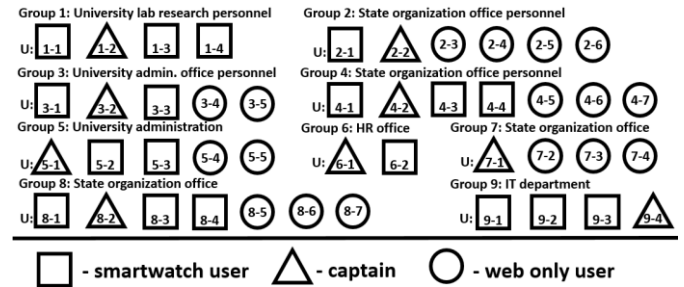
FitAware was advertised during the recruiting stage of a statewide community outreach organization for a web-mediated group dynamics-based physical activity intervention program. Interested participants (representing a small subset of the total program participant pool) completed a short survey allowing us to determine their eligibility based on their type of phone, willingness to wear a Pebble smartwatch, and the availability of friends, family, and coworkers who also met eligibility requirements. Eligible participants were contacted and individually assisted with the system installation and setup. This work asked participants to complete the program registration, which included demographics survey and physical activity goals. Participation in the study was voluntary with no compensation for completion.

### Study

During the initial in-person meeting the participants registered on the website to create their account, chose a role ('regular participant' or 'captain') form teams (a captain can invite members into team), set goals and to provide demographic information such as age, sex, weight, height, education level, race and health status. Upon signing the consent form, the participants were asked also to complete the Social Support for Exercise Survey (SSES) [33] which is used to capture an individual's perceived levels of social support for exercise during the past three months, via Likert scale responses to questions that inquire about occurrences of collective exercises, encouragement to exercise, instances of adjusting schedules to exercise together and others. This survey allowed us to determine the interpersonal factors of the members in the groups.

At the end of the study, the FitAware participants were offered the chance to complete a post-study survey and half hour interview for a \$20 compensation. The survey asked about user experiences with the smartwatch via questions inquiring about the reasons for looking at the watchface, priority of the indicators on the watchface, likelihood of noticing changes in the indicators and the perceived degree of awareness of the indicators. The survey also included questions to determine the levels of group cohesion of the

teams via an adapted version of the Physical Activity Group Environment-Questionnaire (PAGE-Q) [17] which is used to assess the levels of perceived group cohesion in the group via questions inquiring about competition, cooperation, interaction, and competition.



**Table 1. Recruited teams and their composition (all captains were smartwatch users).**

### Survey Design

To better understand the variables inherent to field studies, a three-pronged approach was used that included surveys (to help quantify user perceptions about the experience with the system and their groups), system usage data (to explore participant physical activity levels and engagement with the system) and interviews (transcribed verbatim and thematically coded to learn about participant experience and clarify the results from the surveys and system usage).

We used the SSES to measure the perceived levels of social support prior to the study. We followed the scoring approach prescribed by the authors of the instrument [31]. For the PAGE-Q, which was used to measure perceived levels of group cohesion, we modified its items to better match the context of the study. The PAGE-Q produces measures reflecting perceived *competition*, *interaction and communication*, and *cooperation* each consisting of multiple items. To ensure validity of the modified survey, we analyzed the reliabilities of each of the items in the measure. The *competition* measure consisted of three items (ex. "The experience with the Pebble smartwatch display made you want to be the healthiest person in this group"). All three items in this measure were reliable with Cronbach's Alpha at 0.89 ( $M = 5.17, SD = 1.32$ ). For the *cooperation* items consisting of six questions (ex. "The experience with the Pebble smartwatch display lead to many conversations about physical activity and exercise"), the alpha was 0.910 ( $M = 2.59, SD = 0.70$ ). And finally, for the two questions forming the *cooperation* measure we obtained an alpha of 0.938 ( $M = 4.48, SD = 1.69$ ).

As the primary focus of the analysis is to understand how the experience with the watchface indicators influences physical activity behaviors and engagement with the system in the context of groups, we resort to Pearson's correlation analyses to explore potential links between group/individual characteristics and physical activity levels as well as

engagement with the system. We use t-test to confirm the significance of observed correlations and identify categories.

## RESULTS

The FitEx program in 2017 recruited 275 individuals in total, of which 27 were interested and eligible to use FitAware. The 27 contributed to 9 groups in our study. Per eligibility criteria, groups were composed of individuals older than 18 that shared an existing social circle, with some or all of members equipped with an Android smartphone. Of the 9 groups (see Table 1 for the detailed breakdown), 4 groups had 4 FitAware users, 2 had 3, 2 had 2 and 1 had only 1 FitAware user (one of the eligible members opted out from signing up for the study leaving another one alone). Groups g1, g9 and g6 were composed of strictly FitAware users while the others had two or more web users who estimated and manually entered progress via our web interface.

All 27 participants were full-time coworkers and often worked in the same department or office (with the exception of g3, where all three members worked in different offices) the teams shared the same cubicle space (g1), floor (g9, g3, g5), or building (g2, g4, g6, g7 and g8). The occupations of the participants differed, including front desk receptionists, government clerks, and university lab technicians. Program participants varied in age (23 to 61), gender (20 female/7 male), race (20 Caucasian/5 African-American/1 Native-American/1 Asian), BMI (21 to 46) and education level (12 post college/9 college/5 some college/1 high school).

### Participation

Of the 27 participants that were set up to use the smartwatch three dropped out in the first three days, leaving 24 participants that completed the 8-week long study (see Table 1). Of the 24 participants that finished the study, 23 yielded usable system tracking data (u1-4 had a smartphone with faulty Bluetooth, preventing data from being received from the smartwatch), 21 responded to the survey and 20 participated in the post-survey debriefing interviews.

### Connected versus mixed groups

Upon investigating the survey responses for the SSES we detected a strong correlation between the group size and the degree of perceived social support ( $r = 0.496, p = 0.022$ ). Bigger groups reported higher levels of perceived social support. Further analysis revealed that there is a significant difference in terms of the degree of perceived social support between the groups with four smartwatch users (g1, g8 and g9) and other groups with fewer smartwatch users, ( $t(16) = 2.636, p = 0.018$ ). We will refer to g1, g8 and g9 as *connected* groups and the other groups as *mixed*.

Interviews reveal that the more connected groups namely g1, g8 and g9 had members that asked each other to go on walks (u1-3: “*We would we often ask each other to go on walks... like in the afternoon if I'm going out of work which I tend to do anyway I'll stop by that office where they 'all live' and ask if they wanna come with me*”) which lead to lunchtime walks (u9-1: “*I walk with them sometimes I walked with <u9-4> at*

*lunchtime frequently*”) or regular walks at designated place (u8-2: “*So I would try once a week hey team, hey let's go walk the track and I would get me and u8-1 and u8-4 would all be the ones who would go consistently*”).

Conversely, for mixed groups, the interviews revealed a situation where participants felt disconnected from their group (u5-1: “*I didn't care and I didn't feel like I was part of the team and we weren't getting out and walking*”) and pointed out that not engaging in group activities demotivated them (u2-1: “*You know we really didn't we do things together and we rode in my opinion for whatever reason we never really came together as a team is not that really didn't get it, I think if we had done more things together maybe and really kind of encouraged each other maybe I would have been more interested*”).

Glanceable feedback from the watchface, survey responses to a question about encouragement to engage in physical activity based on watchface feedback (“*The information from the indicators encouraged me to engage in physical activity*”) indicated that the average for the groups using only smartwatches ( $M = 6.0$ ) was significantly higher than for other groups ( $M = 4.33, t(20) = 2.352, p = 0.029$ ).

### Physical activity levels

To assess the physical activity levels, we measured the number of weeks for each participant during which the average daily steps for the week met or exceeded the individual goal. Results show that, on average, participants exceeded or met daily individual goals for most weeks ( $M = 4.82, SD = 2.85$ , see Figure 2a). The result is significantly higher for the connected groups ( $M = 6.3$  weeks) than mixed groups ( $M = 3.33$  weeks), ( $t(20) = 3.16, p = 0.005$ ). All members from connected groups met their goals for at least 5 weeks (with the exception of u9-1 who suffered a serious illness during the study).

### Smartwatch wear consistency

Since the system relies on users regularly receiving glanceable feedback we measured user adherence to wearing the watch and counted active days of wearing for each user. Active days are defined as days with accumulated steps for at least 8 hours during the day with periods of inactivity shorter than one hour. On average, the 23 participants had 5.22 ( $SD = 0.29$ ) active days of smartwatch use per week (see Figure 2b). Debriefing interviews revealed some of the reasons for not wearing the watches which included leaving it charging (“*Forgot it was charging*”) and forgetting to put it on (“*Simply because I would forget to put it on.*”).

Connected and mixed groups differed in the consistency of wearing the smartwatch ( $t(16) = 2.375, p = 0.03$ ). The average number of active days per week for the two groups did not differ throughout the 8 weeks (see Figure 2b). Further investigation into the differences to adherence of smartwatch between the two types of groups revealed that user's active days significantly correlated with perceived social support ( $r = 0.502, p = 0.028$ ) from the smartwatch app as well as the

interaction and communication dimension from PAGE-Q ( $r = 0.49$ ,  $p = 0.025$ ).

### Reasons for and frequency of glancing

As FitAware relies on glanceable feedback being frequently received we investigated the reasons for glancing as well as frequency. In terms of the primary and secondary reasons for looking at the FitAware watchface, the survey results reveal that users typically looked at the watchface because of the personal steps and time indicators as well as incoming notifications (see Figure 2c). User response to survey questions about frequency of glancing at the watchface show that 7 users do so between 4 and 5 times per hour, 4 users more than 10 times per hour and the rest 2-3 times per hour or less (see Figure 2d). One participant that responded with “10+ times/hour” explained that, as a captain, she wanted to ensure that the group members were contributing steps (u8-2: “Well I’m the team captain so I was checking that everybody was remembering and syncing properly”).

### Awareness from watchface indicators

It is critical for user users to be aware of the indicators and notice changes in order to enable the underlying behavioral strategies via feedback awareness. Our analysis of survey and interview data – detailed in another paper [14] -- reveals strong overall awareness levels with a significant dependence on group characteristics.

## MIXED-METHODS ANALYSIS OF USER PERCEPTION AND EXPERIENCES

### Personal steps

The personal steps indicator provides continuously updated feedback of daily steps. Responses to questions about noticing changes and being aware with regards to the indicator both reveal significant correlations with the number of active days of wearing the watch ( $r = 0.527$ ,  $p = 0.023$  and  $r = 0.602$ ,  $p = 0.005$  respectively). There were no correlations with other measures that we captured in the study including group cohesiveness and social support for exercise. The results suggest that users have a higher awareness of personal steps and are likely to notice changes as they wear the watch regardless of group size, support, or cohesiveness.

The interviews reveal that, regardless of group, users learned about how many steps their routines contribute (u1-2: “I couldn’t get out of the house in the morning and into my office without 3000 steps, so I knew that that is how much it would show up and start the day with”, u2-1: “To put a load of clothes in the washer I’m taking 35 steps going from upstairs to downstairs into the washer”), spotted situations of prolonged physical inactivity leading to initiation physical activity (u1-4: “I was just thinking about it so I’ve been sitting here for a little while, oh well yeah you have 2000 steps, probably should get up and walk around the building”), and monitored success towards achieving the daily goal (u8-2: “I’m very competitive but when I looked at my watch and saw that I only had 4000 steps and it was almost noon I almost had a heart attack so you have to have

*5000 step by noon if you want to have 10000 back by the end of your work day so you can get 15000 steps by the end of the day all together”).*

The companion app view for the personal steps (see Figure 1b) allows users to see a cumulative chart for any given day. In terms of the frequency of opening that view the connected groups opened it significantly more times than the mixed groups (t-test for the sample means is significant at  $P=0.03$ ). Interviews did not reveal utility of this view, suggesting that it was opened in tandem with other views.

### Personal Rank

The indicator for the personal ranking shows a numerical value based on user’s current daily step count in comparison with other members’. Survey results show that the responses to the question about competitiveness (“*The experience with the Pebble smartwatch display helped you do the same things the healthiest people of this group were doing*”) correlate with the survey responses about noticing changes ( $r = 0.49$ ,  $p = 0.024$ ) and being aware ( $r = 0.460$ ,  $p = 0.036$ ). These correlations suggest that competitive users tended to notice rank changes more.

Interviews with connected groups participants reveal that they reacted to personal rank changes even when the step count was high (u1-4: “*Yeah so if I had like 10,000 steps and I’m still ranked third then it made me want to get more and because I had already done a lot and it is still as third*”) and tried to maintain higher ranking through more walks (u1-3: “*I would always try to be number one as much as I could so I would like to go on longer walks and you know also the weather was changing it was kind of timed nicely to spring so you could do more and more activity*”). Some admitted to just shaking their hand in an attempt to improve their personal rank (u12-3: “*I remember one time I went to bed and I had gone to the bathroom and I was 1 and I went back into the room then I was 2, so lying in bed I was like this [shakes her hand] [laughs] and husband was like ‘what is going on??’ So I would modify my behavior to be #1 again.*”) leading to a friendly banter with the group captain (u1-3: “*And I told u1-2 about it and she got annoyed -- ‘You are cheating!’*”). Others remembered surprising situations where their rank was low despite high personal step count (u1-4: “*I played the volleyball tournament all day and I was tired I was very tired and I still like 4th out of 4, I took a picture of mine with the camera (Figure 2e). I was supposed to go, I had almost 16,000 steps and I was tired and sore and I was still only 4<sup>th</sup>.*”).

The observations of the personal rank also lead to friendly banter between group members (u9-3: “*<u9-4> would come in start complaining about it [not being #1] ‘how did you beat me last night?’ that sort of thing [and] I would just smile at her usually ‘<u9-4>, you know I walk more than you do’*”) However, for another group, noticing personal rank did not result in any reactions (“u5-3: “*I saw it, but it would be like ok cool, but it wouldn’t register in terms of ‘oh I have to be*

number 1'. I would see it I would recognize it but that wasn't going to motivate me to be number one in the group").

The companion app's personal rank view extends the watchface indicator by including information about specific user steps as well as the progress towards daily goals (see Figure 1c). Participants from the connected groups opened the 'my rank' view significantly ( $t(16) = 2.393, p = 0.029$ ) more times than the participants from the mixed groups (see Figure 2e). Interviews show that "my rank" was used to get detailed step-count information about their group members (u1-2: "I know what my rank is but I don't actually know an absolute number of steps for each person unless I go to my app and really look that up."). The detailed information from the app provided more specific context for competition (u8-1: "I would access the app on my phone to see who was where and then, of course, I would try to compete with them"). Team captains also used it as a way to make sure their group members were tracking steps (u8-2: "I would check and make sure that the other people were syncing correctly because I can see that on there, you know if it's 2 in the afternoon and <u8-1> has had 800 steps I know that something is wrong so I can check that on there and text her to the make sure it is working out correctly")

It is also notable that the members of the connected groups demonstrated awareness of the who is at what rank (u1-2: "Yeah like I'm usually I'm always number one in the morning because I'm the one that's up in the morning and then <u1-3> would sometimes overtake me cuz she gardens a lot in the evening and <u1-4> overtake me because she walks to and from work and also walks her dog a lot she hikes on weekend") and had a general tendency to be curious about their members' rank (u1-1: "We would kind of jokingly between the four of us and our group at times talk about how was like a friendly competition you know we were trying to figure out who was who was going to get the first place that day") which is suggestive of strong group cohesion.

### Team Steps

In order to determine team steps, the system calculates the sum of group member steps and provides an awareness of collective daily progress. A survey item asked participants how often they noticed team steps. Survey responses for noticing changes in the team steps significantly correlated with the *cooperation* ( $r = 0.511, p = 0.018$ ) as well *competition* ( $r = 0.683, p = 0.001$ ) dimensions of the PAGE-Q. These correlations suggest that the teams with members that report a stronger sense of cooperation and competition are more attentive to changes in the team steps.

Interviews reveal that the team steps indicator helped members of the connected groups put their personal steps in the context of the collective steps (u1-3: "Basically I would be subtracting my steps from the team steps to figure out how much of my steps was the percentage. I just wanted to see how much ass I was kicking") and use that information as a motivating factor (u1-4: "If I noticed that my steps were

pretty far behind everybody else, I would try to have more steps or if I had a lot of steps and I wanted to stay high ranking I would try to do more steps").

From the perspective of engagement with the smartphone companion app's team steps view, members from the connected groups opened it significantly more times than members from the mixed groups ( $t(16) = 2.469, p = 0.025$ ).

The interviews show that the captains from the connected groups looked at the team steps to check on their group members' progress to make sure they were active (u1-2: "If I thought our cumulative step count was low for the day I would go and check to see if someone wasn't updating.", u8-2: "Sometimes I would check and make sure that the other people were syncing correctly because I can see that on there if it's 2 in the afternoon and u8-1 has had 800 steps I know that something is wrong so I can check that on there[companion app]", u9-4: "If they were really low on steps I would go and definitely check with them to see if they are actually not active or like they have like other issues that we can help with") and for knowing who is contributing the most (u1-3: "At least at least a few people would use the app to see like who is pulling the group up so high that was also a topic of conversation"). Some users checked the team steps chart and felt motivated to walk more if they were close to the leader (u9-3: "If I saw I am number 2 there[watchface] then I looked the chart [companion app] ... I usually like to look at the chart... and saw that I was close enough to maybe be number one, that would encourage me to walk more") also the chart served as a way to learn about group members' physical activity habits leading to adoption of novel behaviors (u9-1: "It[team steps chart] made me aware of how long I sit without moving and so then I was aware of 'oh hell I sit still for 3 hours at a time' and you know other people are moving around all morning and so that was a health change for me").

### Team Rank

Team rank indicator provides feedback about group's rank in comparison to other groups and is based daily steps. Survey results show that responses to the question about noticing changes in the team rank ("I noticed changes in the team rank") indicator changes significantly correlate with PAGE-Q's measure of *competitiveness* ( $r = 0.494$  and  $p = 0.023$ ). This result suggests that user competitiveness correlates with them noticing changes in the team rank indicator.

Interviews show that captains of connected groups were attentive to team rank changes (u1-2: "I mean yeah I would notice that, I'd especially notice if we were usually we were about number 3 out of 57 that I would notice if we, like we were 2 or 3 out of 57 so then I would notice") and acknowledged success to group members (u1-1: "u1-2 would send 'Guys, we are 1st out of all 57 groups!'") as well as enjoyed seeing it (u8-2: "Every single day it says we were team member 1 out of 57 and I really liked seeing that!").

Regular participants, including those from the connected groups, did not pay as much attention to the team rank (u1-4: “I noticed it but it wasn't it wasn't like my primary focus”) as they paid more attention to their own progress (u1-1: “The team ranking was not one of the things that really stuck out in my mind most of the time. I was more concentrating on my steps.”). In some cases participants were discouraged by the overly frequent changes in the team rank (u7-1: “I would see it fluctuate and I wouldn't get much of a reaction out of me because of that”, u2-1: “To me they changed so much it just started not being very motivating” ) as well as by lack of knowledge about the groups against which the ranks were computed (u9-3: “It was unlikely for me to look at the team rank and I think I said this later on, I didn't have a good feel for how many teams were actually actively participating. who are all these 57 teams maybe if I knew more about them or ... where they all active?”).

The companion app's view for the team rank provided a comprehensive list of teams and allowed users to check current day's and overall ranks and progress towards group's daily and overall goals (see Figure 1d). Interviews reveal that captains of the connected groups checked the overall rank (u8-2: “Towards the end sometime it would be team number 4 out of 7 for a little while and then I had to check to make sure we weren't overall team 4 out of 57 cuz I would have been horrible”) and then motivated their groups to be active (u9-4: “Towards the end we were like the top one or two so and then were almost losing it so then we would I would almost like nudge them every day and go to them and say you know the program and say ‘we are almost there, we should be winning’”) as well as to ensure group member's connectivity with the smartphone (u8-2: “Usually I was checking my overall team rank I always wanted to know if we gone up sometimes I would check and make sure that the other people were syncing correctly”).

## DISCUSSION

This work argues that smartwatches have potential to affect behavior change through continued glanceable feedback in a way that requires minimal user input or cognitively taxing interactions. In the context of a group dynamics-based physical activity behavior change intervention, FitAware conveyed behavioral strategies to the users via the glanceable feedback, channeling underlying strategies via indicators that allow users to track personal steps, group steps, personal rank, and group ranking.

*Smartwatch use and glanceable feedback.* Quantitative results show that most users were willing to wear the smartwatch consistently during a fitness program. Survey and interview results show that users regularly look at the watchface at rates similar to prior research [11]. Surveys and interviews show that users peripherally notice the information presented on the smartwatch watchface.

*Personal steps.* Qualitative results show that participants developed self-awareness of their daily step count progression and reacted to low step count values with

increased physical activity. This finding is also supported by the survey responses to a question about the reasons for checking the watchface which state that the participants' generally checked the watchface to see their personal steps. However, the feedback from the indicators involve group members' progress (personal rank, team steps, team rank) showed that the groups with stronger social support, as measured via Social Support for Exercise survey [33], were different from the other groups with relation to the experience with FitAware as well as the adherence to the personal daily step goals.

*Personal rank.* The members from the connected groups were more attentive to the personal rank changes and reacted to them by engaging in physical activity, by seeking more information on the companion smartphone app and by interacting with their group members.

*Team steps.* For the team steps indicator, the members of connected groups thought in terms what share their personal steps represent of the collective steps, resorted to the companion app to seek more details about their group member steps and to explain personal rank changes as well as to help group captain ensure that their groups were active and connected. In contrast, the members from the groups that were less socially connected, their engagement with the companion app was significantly lower and lacked enthusiasm with the group related feedback on the smartwatch watchface.

*Team rank.* The team rank indicator, as well as the team rank companion app, were primarily appreciated by the captains of the connected groups as a way to ensure their progress, as a reason to reach out and communicate with their group members to encourage more physical activity. However, outside of captains, the regular participants, including those from the connected groups, were less attentive to the team rank indicator, citing overly frequent changes and lack of knowledge about other groups as the justification for low interest. This raises a question of how the group information should be presented, specifically, to what degree the users should know about what is ‘behind’ the displayed indicator.

*Physical activity.* Adherence to individual physical activity goals was higher for people in connected groups, suggesting that not only did FitAware mediate the intended group dynamics-based behavioral strategies, but also it led to measurably better physical activity behaviors. However, the connected groups were all of size 4 while the mixed groups were of size 3 or less (excluding web-only users), perhaps a crucial factor as more group members provide more opportunity to experience rank changes. Another important factor is that all three captains from connected groups were younger, active, and with healthy BMI. Yet another potential factor relates to the digital divide, as infrequent or non-tech people were excluded from the study.

The results, particularly for socially connected groups, suggests that FitAware successfully channels the intended

behavioral strategies in the context of a community physical activity intervention. We hope that this paper can encourage other researchers to further explore the utility and applicability of glanceable smartwatch-based feedback to convey group related information in the context of tight small tight-knit groups of individuals.

### CONCLUSION AND FUTURE WORK

Smartwatches are a convenient way to present health and wellness related data in a non-disruptive way as users check entire watchface regardless of the reason for looking at the smartwatch. In case of group dynamics-based interventions where both individual and group progress feedback is critical for the behavior change, the use of glanceable watchface is very promising. Our results of deploying FitAware as part of a statewide community intervention, show that users tend to show high levels of consistency of wearing and thus exposing their attention to the information from the watchface. In the case of groups that were distinctively more socially supportive FitAware can demonstrably better channel group dynamics-based strategies such as competition, cooperation, interaction and communication leading to positive effects on physical activity behaviors and higher engagement levels with the system. We recommend the use of smartwatch watchface for physical activity interventions that seek to provide groups of participants with individual as well as group related feedback and rely on users noticing and reacting to the group related feedback.

### REFERENCES

1. Aino Ahtinen, Pertti Huuskonen, and Jonna Häkikä. 2010. Let's all get up and walk to the North Pole: design and evaluation of a mobile wellness application. In *Proceedings of the 6th Nordic conference on human-computer interaction: Extending boundaries*, 3–12. Retrieved January 6, 2017 from <http://dl.acm.org/citation.cfm?id=1868920>
2. Ian Anderson, Julie Maitland, Scott Sherwood, Louise Barkhuus, Matthew Chalmers, Malcolm Hall, Barry Brown, and Henk Muller. 2007. Shakra: tracking and sharing daily activity levels with unaugmented mobile phones. *Mobile Networks and Applications* 12, 2–3: 185–199.
3. Daniel Lee Ashbrook. 2010. Enabling mobile microinteractions. Georgia Institute of Technology. Retrieved May 7, 2017 from <https://smartech.gatech.edu/handle/1853/33986>
4. Joseph B. Bayer, Scott W. Campbell, and Rich Ling. 2015. Connection Cues: Activating the Norms and Habits of Social Connectedness. *Communication Theory*. Retrieved January 6, 2017 from <http://onlinelibrary.wiley.com/doi/10.1111/comt.12090/pdf>
5. Frank Bentley and Konrad Tollmar. 2013. The power of mobile notifications to increase wellbeing logging behavior. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 1095–1098. Retrieved January 6, 2017 from <http://dl.acm.org/citation.cfm?id=2466140>
6. Lawrence R. Brawley, W. Jack Rejeski, and Lesley Lutes. 2000. A Group-Mediated Cognitive-Behavioral intervention for Increasing Adherence to Physical Activity in Older Adults<sup>1</sup>. *Journal of Applied Biobehavioral Research* 5, 1: 47–65.
7. Albert V. Carron and Lawrence R. Brawley. 2000. Cohesion conceptual and measurement issues. *Small Group Research* 31, 1: 89–106.
8. Albert V. Carron and Kevin S. Spink. 1993. Team building in an exercise setting. *Sport Psychologist* 7, 1. Retrieved January 6, 2017 from <http://search.ebscohost.com/login.aspx?direct=true&profile=ehost&scope=site&authtype=crawler&jrnl=08884781&AN=20735419&h=R6x1x8ocUsYPW016x7C40%2FEiTd8skrgbuS52QihsyXm6mYwxjz8k0Gh0JFgSvBxd69%2BX5iFoi%2BKT0cdHYXGs9w%3D%3D&crl=c>
9. Yu Chen and Pearl Pu. 2014. HealthyTogether: exploring social incentives for mobile fitness applications. In *Proceedings of the Second International Symposium of Chinese CHI*, 25–34. Retrieved January 6, 2017 from <http://dl.acm.org/citation.cfm?id=2592240>
10. Sunny Consolvo, Katherine Everitt, Ian Smith, and James A. Landay. 2006. Design requirements for technologies that encourage physical activity. In *Proceedings of the SIGCHI conference on Human Factors in computing systems*, 457–466. Retrieved January 6, 2017 from <http://dl.acm.org/citation.cfm?id=1124840>
11. Bernard Desarnauts. 2015. Seconds at a time. Retrieved November 3, 2016 from <https://medium.com/wristly-thoughts/seconds-at-a-time-e8762b223476#.5s634umn7>
12. Diane K. Ehlers, Jennifer L. Huberty, and Gert-Jan de Vreede. 2015. Can an evidence-based book club intervention delivered via a tablet computer improve physical activity in middle-aged women? *Telemedicine and e-Health* 21, 2: 125–131.
13. Andrey Esakia, Samantha M. Harden, D. Scott McCrickard, and Michael Horning. 2017. FitAware: Channeling Group Dynamics Strategies with Smartwatches in a Physical Activity Intervention. In *Proceedings of the 2017 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, 2551–2559. Retrieved May 7, 2017 from <http://dl.acm.org/citation.cfm?id=3053249>
14. Andrey Esakia, D. Scott McCrickard, Samantha Harden, and Michael Horning. 2018. FitAware: Promoting Group Fitness Awareness Through Glanceable Smartwatches. In *Proceedings of the 2018 ACM Conference on Supporting Groupwork*, 178–183.
15. Andrey Esakia, Shuo Niu, and D. Scott McCrickard. 2015. Augmenting Undergraduate Computer Science Education With Programmable Smartwatches. In *Proceedings of the 46th ACM Technical Symposium on Computer Science Education*, 66–71. Retrieved January 6, 2017 from <http://dl.acm.org/citation.cfm?id=2677285>

16. Paul A. Estabrooks, Michael Bradshaw, David A. Dziewaltowski, and Renae L. Smith-Ray. 2008. Determining the impact of Walk Kansas: applying a team-building approach to community physical activity promotion. *Annals of Behavioral medicine* 36, 1: 1–12.
17. Paul A. Estabrooks and Albert V. Carron. 2000. The Physical Activity Group Environment Questionnaire: An instrument for the assessment of cohesion in exercise classes. *Group Dynamics: Theory, Research, and Practice* 4, 3: 230.
18. Paul A. Estabrooks, Samantha M. Harden, and Shauna M. Burke. 2012. Group dynamics in physical activity promotion: what works? *Social and Personality Psychology Compass* 6, 1: 18–40.
19. Gunther Eysenbach. 2005. The law of attrition. *Journal of medical Internet research* 7, 1: e11.
20. Craig H. Ganoë, Harold R. Robinson, Michael A. Horning, Xiaoyan Xie, and John M. Carroll. 2010. Mobile awareness and participation in community-oriented activities. In *Proceedings of the 1st International Conference and Exhibition on Computing for Geospatial Research & Application*, 10. Retrieved January 11, 2017 from <http://dl.acm.org/citation.cfm?id=1823868>
21. Wayne CW Giang, Liberty Hoekstra-Atwood, and Birsan Donmez. 2014. Driver engagement in notifications a comparison of visual-manual interaction between smartwatches and smartphones. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 2161–2165. Retrieved January 6, 2017 from <http://pro.sagepub.com/content/58/1/2161.short>
22. Rúben Gouveia, Fábio Pereira, Evangelos Karapanos, Sean A. Munson, and Marc Hassenzahl. 2016. Exploring the design space of glanceable feedback for physical activity trackers. In *Proceedings of the 2016 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, 144–155. Retrieved January 6, 2017 from <http://dl.acm.org/citation.cfm?id=2971754>
23. Xinning Gui, Yu Chen, Clara Caldeira, Dan Xiao, and Yunan Chen. 2017. When Fitness Meets Social Networks: Investigating Fitness Tracking and Social Practices on WeRun. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, 1647–1659. Retrieved from <http://dl.acm.org/citation.cfm?id=3025654>
24. Samantha M. Harden, Sallie Beth Johnson, Fabio A. Almeida, and Paul A. Estabrooks. Improving physical activity program adoption using integrated research-practice partnerships: an effectiveness-implementation trial. *Translational Behavioral Medicine*: 1–11.
25. Michael A. Horning, Harold R. Robinson, and John M. Carroll. 2014. A scenario-based approach for projecting user requirements for wireless proximal community networks. *Computers in Human Behavior* 35: 413–422.
26. Brandon Irwin, Daniel Kurz, Patrice Chalin, and Nicholas Thompson. 2016. Testing the Efficacy of OurSpace, a Brief, Group Dynamics-Based Physical Activity Intervention: A Randomized Controlled Trial. *Journal of medical Internet research* 18, 4. Retrieved January 10, 2017 from <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC4875491/>
27. Emily B. Kahn, Leigh T. Ramsey, Ross C. Brownson, Gregory W. Heath, Elizabeth H. Howze, Kenneth E. Powell, Elaine J. Stone, Mummy W. Rajab, and Phaedra Corso. 2002. The effectiveness of interventions to increase physical activity: A systematic review. *American journal of preventive medicine* 22, 4: 73–107.
28. Elizabeth J. Lyons, Zakkoyya H. Lewis, Brian G. Mayrsohn, and Jennifer L. Rowland. 2014. Behavior change techniques implemented in electronic lifestyle activity monitors: a systematic content analysis. *Journal of medical Internet research* 16, 8. Retrieved September 19, 2017 from <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4147713/>
29. Emily L. Mailey, Jennifer Huberty, and Brandon C. Irwin. 2016. Feasibility and Effectiveness of a Web-Based Physical Activity Intervention for Working Mothers. *Journal of physical activity & health*. Retrieved January 10, 2017 from <http://europepmc.org/abstract/med/26999823>
30. D. Scott McCrickard, Christa M. Chewar, Jacob P. Somervell, and Ali Ndiwalana. 2003. A model for notification systems evaluation—assessing user goals for multitasking activity. *ACM Transactions on Computer-Human Interaction (TOCHI)* 10, 4: 312–338.
31. Stefania Pizza, Barry Brown, Donald McMillan, and Airi Lampinen. 2016. Smartwatch in Vivo. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16)*, 5456–5469. <https://doi.org/10.1145/2858036.2858522>
32. Alireza Sahami Shirazi, Niels Henze, Tilman Dingler, Martin Pielot, Dominik Weber, and Albrecht Schmidt. 2014. Large-scale assessment of mobile notifications. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 3055–3064. Retrieved January 6, 2017 from <http://dl.acm.org/citation.cfm?id=2557189>
33. James F. Sallis, Robin M. Grossman, Robin B. Pinski, Thomas L. Patterson, and Philip R. Nader. 1987. The development of scales to measure social support for diet and exercise behaviors. *Preventive medicine* 16, 6: 825–836.
34. 2015. Products - NHIS Early Release - 2015. Retrieved October 17, 2016 from <http://www.cdc.gov/nchs/nhis/released201509.htm>
35. 2017. Wearables 2017: The Wrist-Worn Revolution. Retrieved August 8, 2017 from <https://www.emarketer.com/Report/Wearables-2017-Wrist-Worn-Revolution-Fails-Materialize/2001929>