Strive Pilot Study with Front Porch and OASIS

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1. Aim:

The aim of this study was to determine the feasibility of using smartphone-based technologies to promote physical activity among older adults, specifically in the 60-80 year category. A secondary goal was to collect normative data about physical activity for this population to inform better design decisions for smartphone applications.
The project was originally conceived as a competition between two teams of older adults. Adults would use activity data collected passively as points to boost their team's score. The goal behind the competition was to determine if social competition could be a motivator in encouraging physical activity. The study would also allow participants to gain insight into their everyday lifestyle habits for the study duration.

2. System Design:

Overview:

The idea behind the system was that each participant would use a cellphone to collect their daily activities. The cellphone would run an application that would passively collect movement intensity information 24x7. Each person would need to carry the phone on their person to record their physical activity. The app used "Motion Intensity" calculated on a per-minute basis as a movement descriptor. These were calculated using accelerometers and gyroscope. Each time the person moved for at least two minutes, the app would record the movement. No GPS data were collected.
Every week, data from the participants would be synced to a central repository. Initially, a live-sync approach was considered but this had to be replaced with manual, cable-based syncing because of the lack of Internet penetration in this community. These data would then be processed to display visualizations of daily activity that would be relevant to the individual and the group. Participants would learn about their lifestyle habits.

App Design:

Various process went to the design of the app, the main considerations were:
Navigation: We designed a single home screen with only the most relevant information. There were no menus within the app to avoid navigation hierarchies and all settings were hard-coded. The app itself could be directly accessed through the phone home screen through a large icon. The design was minimalist to prevent cognitive overload. The data that was shown included "Total Active minutes in a day", a daily goal (which was set to a default of 30 min per day based on CDC recommendations) and weekly progress. We chose a large, circular display with the total number of active minutes per day and a circular progress bar to indicate progress towards goals. For weekly progress, we used a two-level bar chart that would reset every week.

Color and Font Choices: We picked few, high contrast colors with a flat texture and no skeuomorphism. We also picked blue and green as base colors to stay in the middle of the visible color spectrum. Blue was used as a base color, green was used to indicate progress. A third color, yellow was used to indicate achievement of goals beyond progress. The app had two color modes, prior to goal completion, the daily activity circle would be blue with a green progress bar. Upon completion of goals, the activity circle would be green (to indicate goal achievement) with a yellow completed ring to indicate that all future activity is beyond the goal. This allowed a user to quickly estimate how far they are from their goals. Font-sizes were specifically chosen to be large and easily visible and sans-serif.

Figure 1: Accessing the App

Figure 2: App screenshot

3. Study Details:

Demographics:

Participants volunteered from OASIS, a non-profit organization dedicated to help older adults lead productive lives. Prior to recruitment, study coordinators described the study in physical activity classes held at two OASIS community centers – WS and BH. 16 participants (all female) volunteered of which 8 were selected for the study. Participants were chosen so that they had prior experience with phones. Participants were enrolled so that there were four participants from each center. The average age of the participants was 74+/-11 years (Min: 61, Max: 88). The average weight was 68+/-15 kg (Min: 52, Max: 99). The average height was 160+/-7 cm (Min: 150, Max: 170) and average BMI was 26 +/- 6 (Min: 22, Max: 40).

Orientation Session:

Prior to deployment, participants attended an orientation session at each center. Each participant was given a Google Nexus 4 smartphone. This smartphone was chosen because allowed background collection of activity information with low battery overhead. During the session, participants were introduced to the project and given training on how to use the phone, charge the phone, how to use the app. Each participant was also given an instruction document on appropriate phone usage. Each participant was told that the phone would passively collect their physical activity information. In order to log their physical activity, they needed to carry their phone on their person for as long as possible. Participants then conducted a "demo" walk where they walked around the center environment with the phone on their person and observed that the app tracked their data. Participants were instructed to carry the phone with them as much as possible to count all activities during day.

4. Results:

a. Pre-Study Survey

Participants also completed a pre-study survey designed to understand their cellphone usage habits. The results of the survey are summarized below.

Lessons Learned:

Phone Usage: 3 participants used smartphones (all of them were iPhones). The main use cases of their smartphones were phone calls, entertainment, shopping, banking, paying bills, accessing government services, and navigation (e.g., looking up a location or route). One participant wanted to use phones for accessibility apps, cameras and emergency calling. The remaining 5 participants used feature phones. Top reasons for using feature phones were phone calls and text messaging.

Location preference of phones: This population wants their phone to be convenient and accessible. Based on this, their most preferred location is either in the shoulder purse or hand purse, with a third option being the pocket, bra or fanny pack. Any tracking algorithm has to be robust to those locations.

Motivation to stay physically active: The main motivation for people in this age group to stay physical active is to fight aging and maintain overall health. They prefer low impact activities like walking or swimming. Thus in terms of devising intervention techniques, one recommendation would be to create low-impact exercise programs. The way to motivate people to stay in those programs is to emphasize how exercising helps them stay young. It is also important to emphasize small increments such as 5-10 min bouts and remind them that all those minutes add up.

b. Mid-Study Check-in Sessions:

The study ran for a duration of three weeks. As part of the study, participants were required to carry the cellphone at all times. Each week, the study coordinator met the participants to manually download the information collected by the phones. Once downloaded, each participant was showed a summary of their data. The summary data included their daily activity over the last week, their weekly summarized activity information and an activity "heat map" indicating their active times throughout the week. Each participant was also told their individual position in their community and across all participants. The coordinator also collected feedback about the application during the mid-study sessions.

Lessons Learned:

Social Support: In the WS center, 3 participants chose the same time to sync their data. Unprompted by the facilitator, the participants started talking about their activity information and how they are doing. They also started providing peer support ("You're doing fine for someone in their 70s") and used the data as a topic to discuss their daily lives. This suggests that a future program should have an in-person component where participants can meet and discuss their information. This brings about a spirit of camaraderie and personal investment which could serve as additional motivation.

Contextual Coaching: During the session, the facilitator guided the participants through their data. This included indicating at what times during the week the participants had been more active. A common behavior that was observed was that

the participants would try and recall what they were doing during that time period. For example, one participant indicated that she had a birthday for her grandchild and was preparing for that. Another mentioned that she went for walks with her dog. This context allowed participants to understand the overall picture behind their activity. For example, the participant that was preparing for her grandchild's birthday understood why she was not as active the next day (because of knee pain). This suggests an approach where data collected could be paired with inputs from a health professional to provide coaching. One example would be, the professional would advise the participant to slow down if they are walking too much and this could be encoded in the application.

Summary of Participants' Activity Data:

Figure 3 illustrates the progress of participants over the duration of the study. All participants in this study logged a cumulative of 323 hours, 19 minutes over 3 weeks. Participants from the BH center logged a total of 193 hours, 35 minutes and from the WS center logged a total of 131 hours, 44 minutes. In both teams, a single participant accounted for a third of the minutes (107 hours, 51 minutes for BH and 78 hours, 49 minutes for WS). One participant fell ill during the first week and had several issues with remembering the carry the phone. This participant had the lowest minutes in the population. The participant had the impression that the study was meant to be just passive data collection and not to get people to stay active.

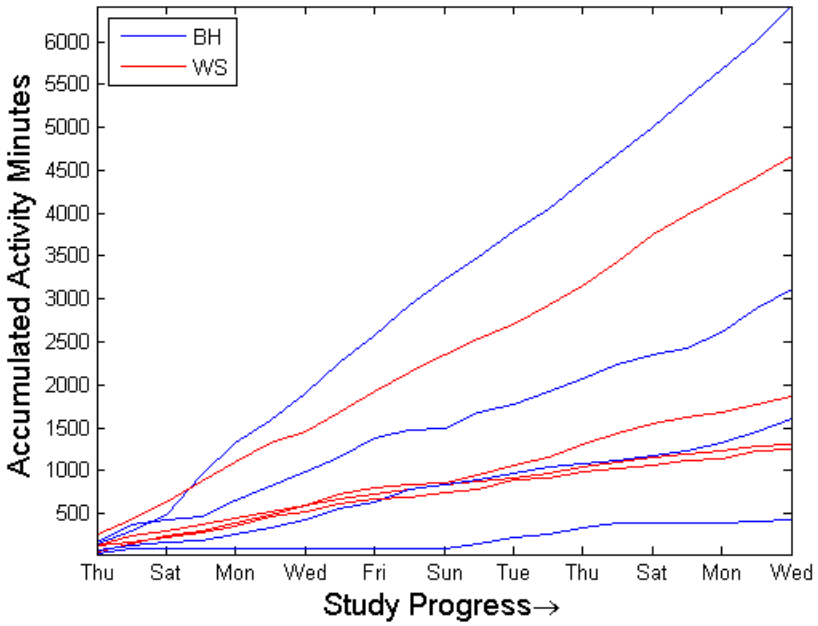

Figure 3: Accumulated activity minutes per participant, color coded by center

Figure 4 illustrates the performance of participants overall through each day of the study. The cyan and green represent weekends. The days start from Thursday because that was the first day of the study. It can be seen that overall, the participants' data follows a weekly pattern where there is a weekend lull followed by increasing intense activity levels in the middle of the week.

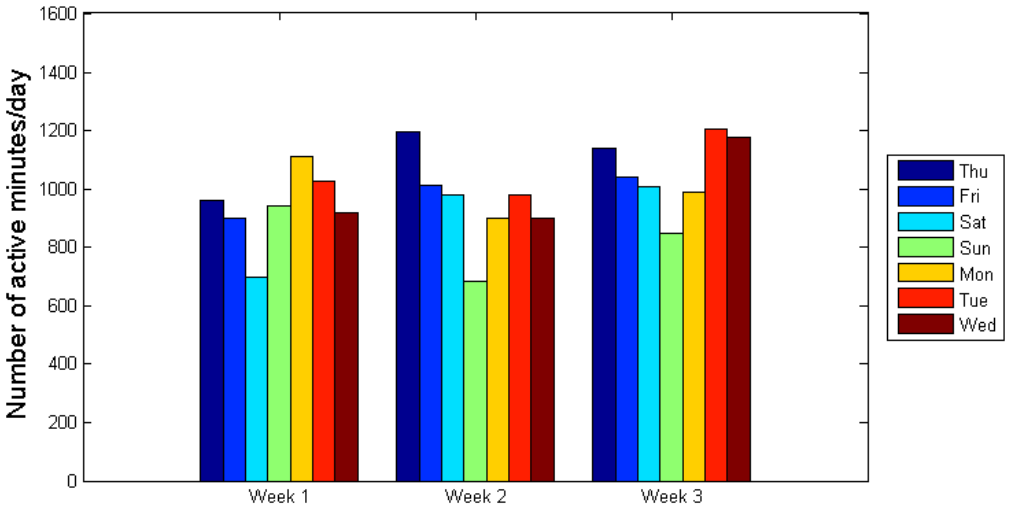

Figure 4: Day-to-day active minutes across all participants

Figure 5 illustrates the performance of participants overall summed over each week. It can be seen that the activity of participants increased slightly in the second week and more in the third week. This is could be because most participants started experimenting with new ways to capture additional activity and because the least active participant started carrying the phone more often.

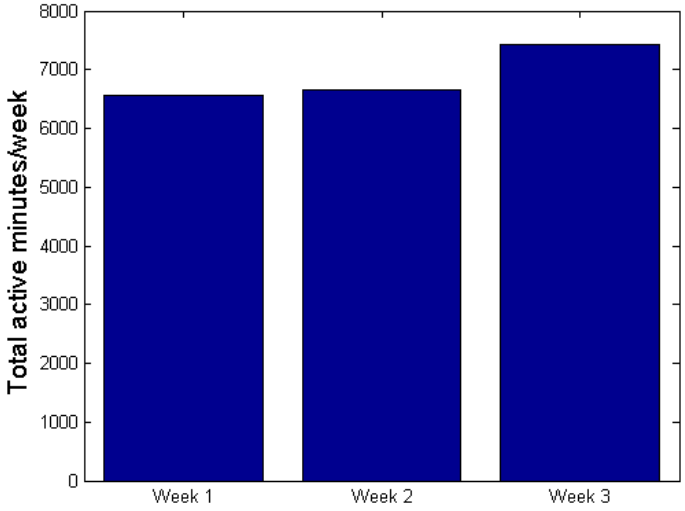

Figure 5: Total active minutes across all participants per week

Figure 6 illustrates the performance of participants by site summed over each week. Participants in the BH site constantly kept increasing their activity through the study period. This was not the case for WS participants.

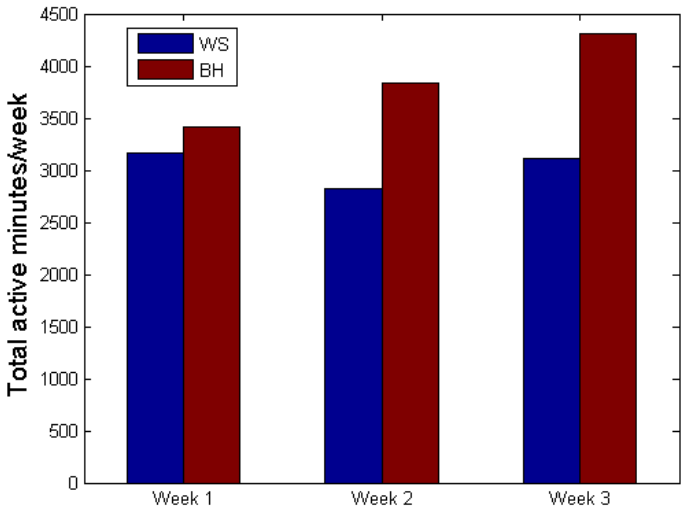

Figure 6: Total active minutes by site

In addition to summarized weekly information, participants also received individual versions of their activity information in the form of a report. An example report is shown in Appendix B.

The availability of large scale data also allows the determination of activity patterns to provide further context about an individual's lifestyle. Figures 7 to 9 illustrate such heat maps for inactive, moderately active and very active participants. The darker the color, the higher the activity in that hour. This kind of fine-grained information allows one to introduce activity routines in a daily lifestyle to bring an inactive person to an active state and measure progress.

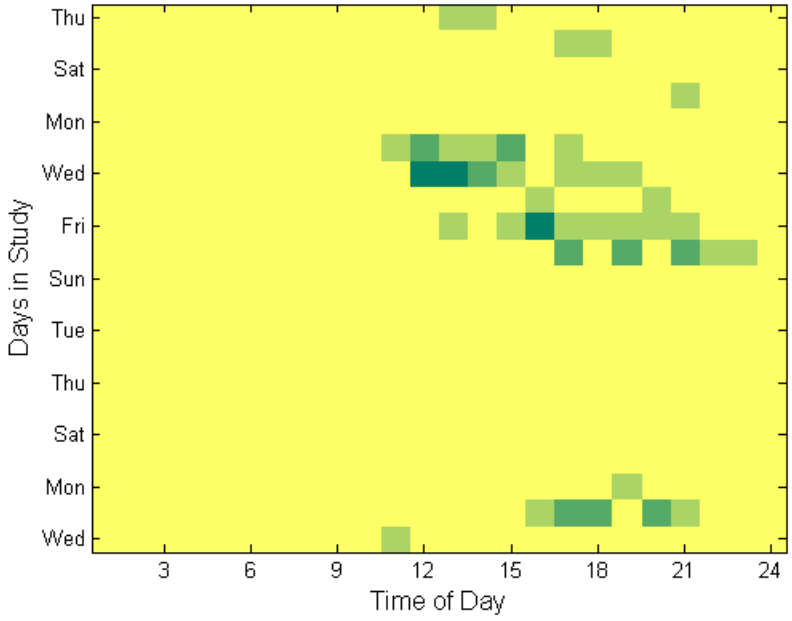

Figure 7 Heat map for an inactive participant

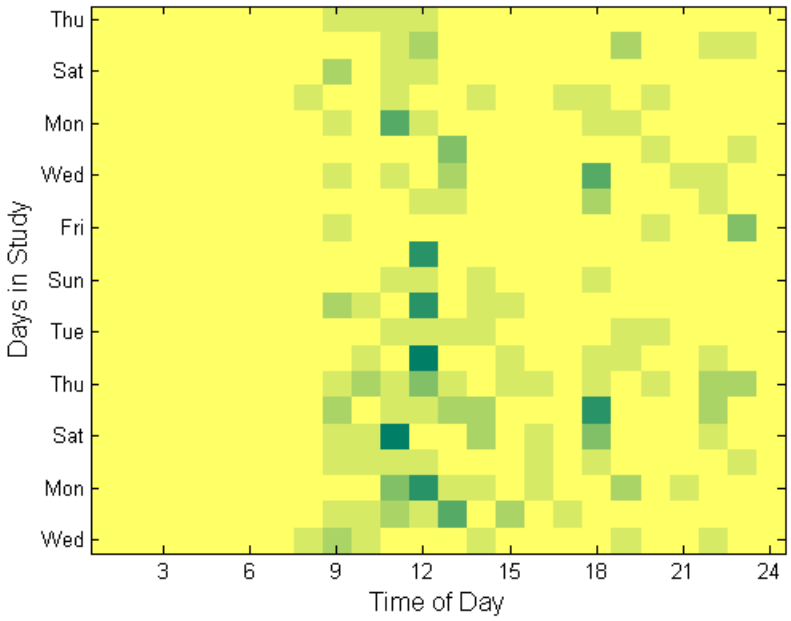

Figure 8 Heat map for a moderately active participant

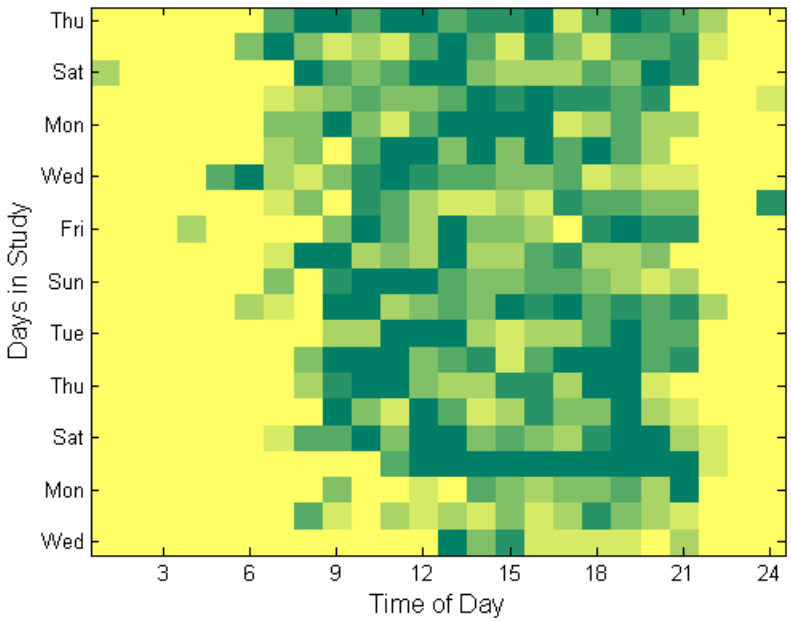

Figure 9 Heat map for a very active participant

Figure 10 illustrates the relationship between accumulated activity minutes and age along with a curve of best fit (quadratic). It can be seen that there exists a negative correlation between age and accumulated activity minutes. The higher the age, the lower the activity minutes. A person who is 50 years old accumulates almost 6 times the number of minutes (4 hours per day) as someone who is 75 (45 minutes per day). This effect tapers with age. This could be due to reduced activity capacity with age and also issues related to smartphone adoption with age. This suggests the usage of age related goals that are contextual.

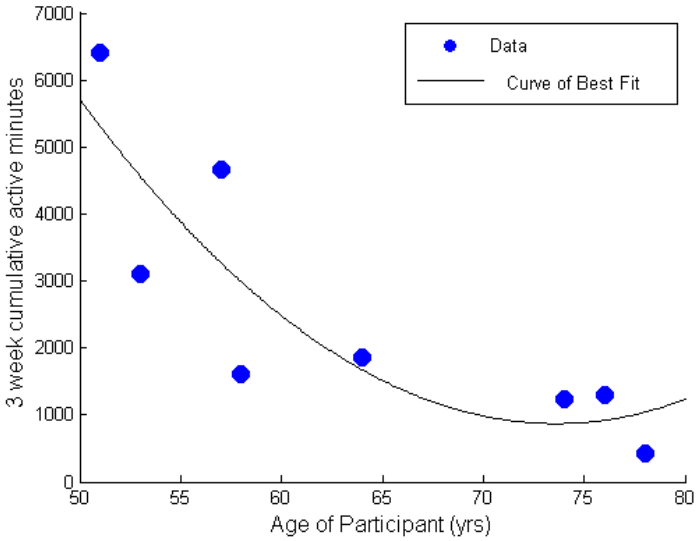

Figure 10 Relationship between age and accumulated activity

c. Post-study Survey and Focus Group:

5 out of 8 participants participated in the post-study focus groups. The main aim of the focus group was to determine the attitudes and responses of the participants to the app, to smartphone usage and technical feasibility of using one's phone for 24 hour activity monitoring. Participants filled out a post-study survey and then engaged in a group interview with the study facilitator. The following summarizes the results of the post-study focus group.

Lessons Learned:

Motivation for participation in the study: The main motivation for the participants was to understand and increase their daily physical activity. The reasons for increasing physical activity included the need to maintain weight or manage conditions such as osteoporosis and arthritis. One participant saw how not being physically active adversely affected people later in their lives. This made her conscious enough to stay active. Other motivations included the need to be active outside of their regular classes and for self-awareness (to understand how busy or not busy they were all day).

App Utility: The most important utility that participants found from the app was using the app data to gain awareness about their lifestyles. This was also reflected in their surveys: the second most useful feature was talking about the app data with the study coordinator to understand their information. Participants used the app to set goals given their awareness. Interestingly, while their most important feature was using the app data to gain awareness, the least important feature was looking at the app data alone. This suggests that it is not simply the data that is important but the app plus coaching to gain awareness about their lifestyles.

Goal Setting: Goal setting was considered a very important feature of the app. Even though the app assumed a standard goal of 30 minutes per day, all participants set customized goals mentally and tried to meet them. Three participants felt they were more in competition with themselves. Participants were disappointed if they did not meet their goals.

Competition and Sharing: Participants were ambivalent towards the competition aspect of the program. Most were not that interested in sharing data with peers. Most participants did not know other participants prior to the study. During each data sync, participants chose times that were convenient to themselves and this meant that not all participants got to interact with each other. One participant felt that if there were a real-time component, she would check comparative statistics more often to see how well she was doing. The other participants agreed with this assessment.

Participants were ambivalent towards sharing the data from the app with their family but were more likely to share their data with other members of their community. This suggests that a social feature, if implemented, should include peers first.

One participant felt that if she was not doing well, she might not share her information. On the other hand, participants also felt that competition could help motivate the people who are lower ranked, by providing encouraging messages from their teammates. The idea that even if they contribute a little bit their team will move ahead faster could be a motivator.

Usability: Strive was considered more usable than pedometers because no calibration was necessary. The usage of number of active minutes as a unit was considered more intuitive by all participants. Participant felt that with a traditional pedometer, one has to align steps and that calibration was painful. The use of active minutes seemed to simplify the cognitive load required since almost any kind of movement they did could count as activity.
With respect to the app design, the use of one big button that was easy to press (they felt this was superior to other apps) and a single interface greatly simplified their experience and allowed them to focus on increasing the number of activities. Participants felt that the app was something they could always check, since it was with them all the time and monitoring in the background. This kept them motivated and reminded.

Whether doctors would like it: One participant felt that her doctor would like a copy of her activity information. She felt that the utility would be to provide a moving baseline for one's physical activity, it would almost act like a diagnostic test. The participant felt that the utility would be in comparing week to week data and providing support or advice based on the data.

Phone carrying habits: Typically, participants placed their phones in a purse or in their innerwear. Other locations included waist band and fanny packs. An important observation was that sometimes participants designed custom harnesses or improvised on where they placed their phones (the knee, pant legs or in socks) so that they may capture physical activity. The main motivation behind the improvisations was to count certain activities that the app was not designed for. Participants wanted to count every single activity towards their total active minutes for the day and were disappointed if the phone didn't give them credit for those movements. To compensate for this, they carried their phones with them all the time. Despite the fact that such improvisations were needed, participants didn't consider it inconvenient to do so. This suggests that their motivation to count physical activity superseded the inconvenience of carrying a phone in a non-traditional location.
For the participants who already owned phones and had to carry an extra phone, they did not perceive any changes in their regular phone carrying behavior despite the fact that they modified their daily behavior of phone usage to record more activities. All participants felt that it would be more convenient if they could use their existing phones.

Phone attitudes: 2 of the interviewed participants felt that their attitude to smartphones had changed from prior to the study. Prior to the study, these participants did not understand the utility of smartphones. During the study, they explored many of the other features of the smartphones on their own and felt that there were many relevant features that would be useful in their personal lives. The most common things they felt were useful included calling, texting, emailing, web browsing, photos and music.

Suggested further improvements: Most of the suggested improvements centered on increasing the range of activities counted and wearability. One participant wanted a smaller wearable monitor that can be clipped and also worked for swimming. She wanted clips or lanyards to extend the range of places where she could wear the phone. One participant expressed disappointment that the phone didn't always pick up her minutes. This was echoed by another participant. This participant noted that when using her stationary bike, she did 45 minutes of activity that didn't count. She also attended a chair exercise class, during the class, for one hour of work, she only got 6 or 7 minutes. This disappointed her. She tried modifying the phone by putting it in her shoe, strapping it to her knee or calves but it made no difference. Once she tried hanging the phone on her neck and she got higher minutes even though she did not change my activity level. She wanted the ability to be able to count certain activities. It must be remembered, that some of the higher numbers for this participant and lack of minutes being counted could be artifacts of the sensing algorithm on the phones. This suggests that better sensing algorithms will definitely help the app because they expand the scope of activities that can be counted.
With respect to additional data, participants wanted to know how many calories they were burning or calories burned translated into a unit they could relate to (such as cookies).

Two participants liked the idea of a reminder buzz to encourage them to move but they felt it should remind them only when they are doing well or that they aren't meeting their goals fast enough, in effect it should trust their intentions and try to help them get to their goals faster.

General Conclusions:

This study provided a proof-of-concept validation in the use of smartphone-based sensors to encourage physical activity among older adults, in particular, those between 60 and 75. During the study, results indicated that wearability of phones is not the main issue and neither is technology familiarity. Technology familiarity could be achieved with a basic training program and user interface design that is simple, designed for this population and easy to use. The main motivations for participants in this age group to stay active are loss of personal health due ageing, the need to stay young and the need to manage chronic conditions. This has important implications in tailoring interventions and providing motivational messages to encourage them to stay active.

The value that 24x7 smartphone-based technologies can provide to them is that they would provide an easy-to-use and always available companion to check their daily lifestyles and allows them to maintain live awareness about their physical activity without having to remember what they did. Participants had internal goals that naturally arose from tracking and felt it was important to set personal goals and then have the means to track those goals. If this platform could be coupled with a coaching element from an expert to help participants interpret their data over the long term, the value of the system would be even higher. We did not see any major problems with respect to carrying of phones. Participants were willing to bear the inconvenience of physical activity tracking due a phone if it meant that they would obtain a better report of their daily physical activities. Younger participants were more comfortable with handling smartphones. Participants must be explicitly told that their goal is to keep their phone on them as much as possible in order to track all possible activities.

Future Work for the Platform:

The main limitations of this study are that it focused on a small population of adults over a short period of time (3 weeks). While it shows a satisfactory initial validation of such a system, it does not supply enough data to make conclusions about appropriate long-term interventions. Additionally, the study chose adults who were already motivated to stay active and had prior cellphone usage experience. The real-challenge will lie in working with adults who are less motivated and have problems coping with active lifestyles. Current work suggests that the population might not have major problems working with smartphones but the real challenge could be in getting them to stay active.

The other limitation in this study is the lack of social support features. This study was initially billed as a social competition but technological limitations prevented full scale deployment of social features. As a result, the potential of social competition and peer support to encourage individuals to stay more active was not fully explored.

Based on the results of the study, we think the following should be immediate priorities for app development.

App Features:

- Provide a self-report feature for people to count activities that can't be recorded or can be recorded with great difficulty with the phone. This is a critical feature to add.
- Improve the wearability of the app by providing more options to carry the phone (including lanyards, belt clips or arm bands)
- Provide age appropriate goals that are dependent on the population. Allow for custom goal setting using the age appropriate goal as a starting point.
- Add a monthly progress statistic that would show summaries of goal progress in the last 30 days for longer term statistics. Make this progress easy to read.
- Add an "upper limit" on activity, if a user exceeds the upper limit, then the app will encouragement to slow down. This also suggests the usage of an "activity sweet spot" where users have to meet a goal with some tolerance (between 30 and 40 minutes of activity per day).

- Incorporate a reminder nudge feature that encourages them to stay more active and keeps them moving. In the nudge feature, emphasize how physical activity will make them feel younger with age. Whenever a user does something good, reinforce it with a nudge and a sound.

Technical Enhancements:

- Provide a web dashboard that participants could use to look at their most recent synced-data and their group's information and higher frequency paper reports. In each paper report, provide an informational article that teaches them healthy living. Provide motivational messages reminding them about how healthy lifestyles can prevent premature ageing. Simplify data collection with manual syncing within the app.
- Improve algorithms so that they are more robust across purse usage and also support a wider array of activities.
- Augment kinematic data with coarse-GPS information to provide geographic context to where people are most active.
- Develop and iPhone version to be able to install on more phones

Social:

- Provide a community support option for people to discuss their lifestyles and provide peer support, this could be online or in-person with paper reports. This could also be via text message to team members who are lagging behind.

Operational:

We would like to expand the scope of this pilot to a larger, paid pilot involving 20-30 individuals. The length of the study will be over a period of 6 weeks to study longer term trends in daily activity when using the Strive platform and to test various intervention measures to boost daily activity. The phones provided would also support data plans to be used in syncing information. Some suggestions on the goals of the study include:

- Incorporate an activity coach in the relationship. We strongly see the opportunity for providing a service where individuals use the phones to measure their daily activities and a coach provides guidance about their lifestyles. We would want to see if using a system like what we provide and a coach to provide contextual coaching would further enhance the relationship and improve outcomes.
- Implement real-time social support. We feel that the social section of this study was not given its due. We want to incorporate a social component where participants can see other participants' data in real-time and Examine whether using such a monitoring system in addition to social support can improve physical activity.

The outcomes measured would be participant satisfaction, increased physical activity (as measured by the app) over six weeks and better health measures. In order to achieve this, we would need to raise money either in the form of grants or support from an organization.

Acknowledgements:

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Appendix A: Pre-study Survey Results

Cellphone wearing habits:

1. Where is your personal mobile phone now?
   7 people answered in purse. 1 answered in pocket

2. In how many of these locations have you ever put your phone?
   All 8 said trousers, all 8 said shoulder purse, 7 said hand purse, 6 said close to bed, 6 said car, 6 said jacket, 5 said hand, 4 said table at home. Other locations included office table, bra/fannypack.

3. In what locations have you put your phone in the last 24 hours?
   6 said shoulder purse, 4 said table at home, 4 said close to bed, 3 said Trousers, 3 said hand purse, 2 said out in car. Other locations included shelf, bra/fanny pack.

4. Where do you normally keep your mobile phone at home?
   5 said shoulder purse, 4 said table at home, 2 said trousers, 3 said close to bed. Other responses included all over and in car.

5. Where do you normally keep your mobile phone in the car?
   6 said shoulder purse, 2 said trousers, 2 said hand purse. Other responses included out in car

6. Where do you normally keep your mobile phone when walking?
   6 said shoulder purse, 2 said trousers. Other responses included in jacket and in hand.

7. Where do you normally keep your mobile phone when you sleep?
   Everyone placed it on a table or nightstand. Other responses included shoulder purse and office shelf

8. How do you decide where to keep your phone at home?
   Top 2 reasons were: Convenience and Accessibility. No one cared about safety of phone, personal comfort and the need to minimize distractions. Other reasons included charging and where I am least likely to forget.

9. How do you decide where to keep your phone in the car?
   Top 2 reasons were: Convenience and Accessibility. Other responses included safety of phone.

10. How do you decide where to keep your phone when you walk?
    Top 2 reasons were: Convenience and Accessibility. Other responses included safety of phone.

Physical Activity and Lifestyle:

Most participants woke up between 7 am and 8 am and went to sleep between 10 pm and 11 pm.

1. Self-rating of activity levels (1= lowest, 5 = highest): Average 3. Most responses were in the 2-3 range (6/8 people)

2. When asked “What are your top reasons for being physical active and exercising”, the main reasons given were: Fighting aging (7 people), Feel good about themselves (6 people), Improving overall health (6 people), Socializing with others (4 people), Reduce Stress (4 people), Weight control (4 people), Fun (3 people), the challenge of being active (2).

3. Top reasons why they think they are not physically active:
   Not enough time (2 people), No sidewalks or streets nearby (2 people), lack energy (2 people)

4. What is your favorite exercise?

Walking (5 people), Swimming (2 people), Biking (2 people), Video games (2 people). Others included exercise classes and dancing.

5. Where do you usually exercise?
   At home (6 people), Outside (5 people). No one exercises in the gym.

6. Please estimate how much physical activity you accumulate in one week?
   Most responses were between 2 and 4 hours (5/8). 2 people reported greater than 4 hours, 1 person reported less than 1 hour

7. For how many hours a day do you estimate you walk?

Most responses were 2 hours. Two participants reported 6 hours.

Appendix B: Post-study Survey Results

App Feedback:

How would you rate the easy or difficulty in using Strive (1 = easiest, 5 = hardest)
Average = 1.2

How many times a day did you look at the app screen?
Greater than 5 times (3), 1-5 times (2)

How useful did you find looking at your weekly data?
Very useful (3), No opinion (2)

The app correctly estimated my daily physical activity due to walking
Somewhat Agree (3), Strongly Agree (2)

The app has overall helped me increase my physical exercise activity
Strongly Agree (3), Somewhat Agree (2)

I feel physically fit as a result of tracking my activities with the app
Strongly Agree (2), Somewhat Agree (2), No opinion (1)

I was able to use the app to calculate my total daily physical activity.
Strongly Agree (4), No opinion (1)

Most useful app features:

1. Using app data to gain awareness
2. Talking about the app data with the study coordinator
3. Using app data to set personal goals
4. Competition
5. Just looking at the App data

Would you recommend others in your community to use such an app?
Strongly Agree (4), No opinion (1)

Would you recommend your family members to use such an app so you can share each other's data?
Strongly Agree (2), Somewhat Agree (1), Somewhat Disagree (1), No opinion (1),

If the mobile app and a leaderboard will be available in my community, I will continue to use the app.
Strongly Agree (3), Somewhat Agree (2)

Physical Activity:

I feel more mentally alert as I walked more.
Somewhat Agree (3), Strongly Agree (1), No opinion (1)

I feel that walking as part of a team helped motivate me to exercise harder
Strongly Agree (3), Somewhat Agree (2)

Which of these helped motivate you to walk more?
Improving my personal best (3), improving personal best and helping team (2)

Smartphone Adoption:

I was comfortable using a smartphone during the study
Strongly Agree (4), Somewhat Agree (1)

After this study, I feel more comfortable with smartphones
Strongly Agree (3), No opinion (2)

After this study, I am considering buying a smartphone for myself
Strongly Agree (2/2)

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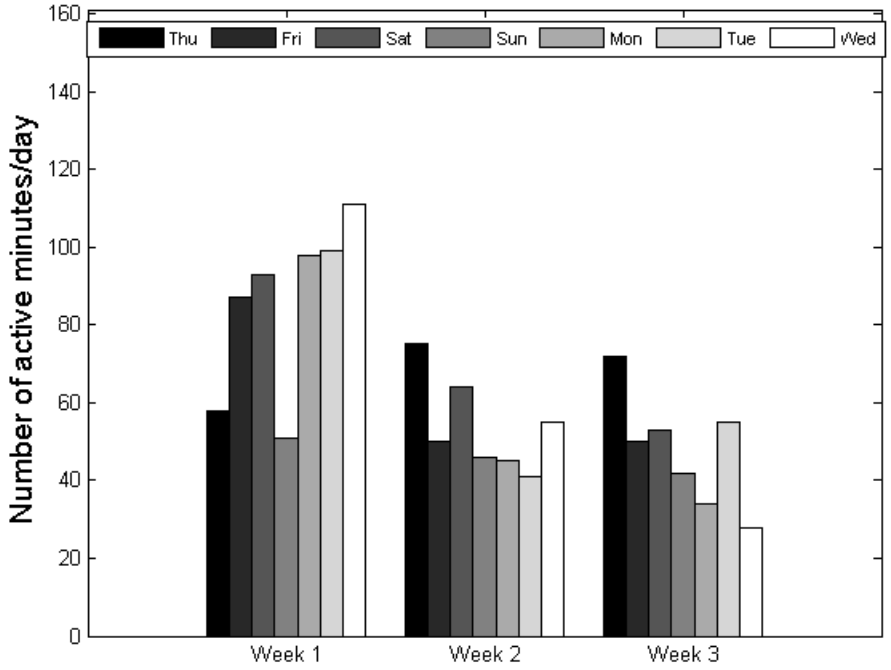
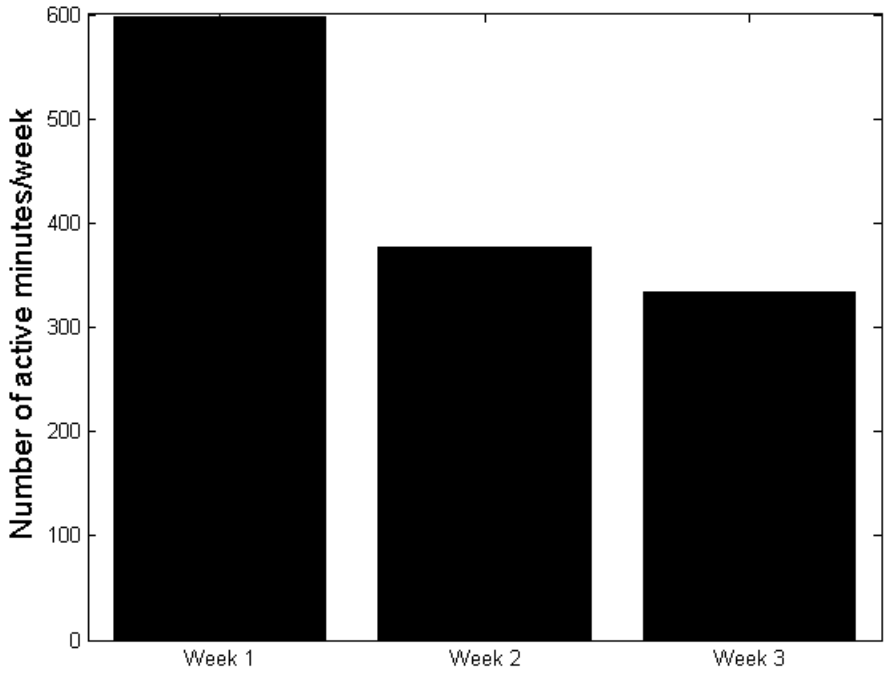
You were active for a total of 22 hours, 47 minutes over the last 3 weeks.
You averaged 1 hours, 2 minutes per day.
You were in position 8 among all participants.
Your most active day was Sat.
Your least active day was Sun.
Your team was active for a total of 131 hours, 44 minutes over the last 3 weeks.
Everyone in this study logged 323 hours, 19 minutes over the last 3 weeks.

Your weekly activity history, each group is one week, within a week, a day is colored differently:



Your weekly activity summary, each bar is the sum total of active minutes for that week:



Your performance on a daily basis compared across week. This graph lets you see how you did on each day across 3 weeks. Each group is a day. For each day, each week is colored differently: