Are Older Adults Ready for Wireless Physical Activity Tracking Devices? A Usability Quality Improvement Project

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ABSTRACT

**Background:** Physical activity tracking devices (PA-TDs) are becoming increasingly popular but their use among older adults is unknown. **Objectives:** We present results of a quality improvement project on wearable physical activity tracking devices (PA-TDs) examining the acceptability of PA-TDs to remotely monitor activity. **Methods:** 30 of 63 participating Veterans, ages 65-91 had a smart phone; 7 compared 4 PA-TDs for 2-7 days. One in-person session was needed to introduce each device. **Results:** Average daily step counts were low for this group, ranging from 800-5,000 steps. Monitored activity revealed patterns of increased activity, from 4682 to 6159 steps, when using the device. **Conclusions:** Barriers and positive aspects to widespread use of PA-TDs are highlighted and need further investigation.

**Key Words:** Aging, physical activity, technology
ACKNOWLEDGEMENTS

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INTRODUCTION

Physical activity (PA) is a modifiable behavior that has immense importance to health and overall well-being. Decrease of PA generally comes as a result of increased sedentary behaviors, which have been linked to many negative health outcomes. High levels of sedentary behaviors were found to be inversely proportional to risk factors for metabolic syndrome, cardiovascular disease, type 2 diabetes, and an overall shortened and robust-depleted life. High levels of sedentary behaviors are most prominently seen in individuals 60 years and older, with over 50% of men and over 60% of women 65 years and older reporting no PA behaviors at all.

New technologies are increasingly available that facilitate simple methods to self-monitor daily activity. For the most part, these commercially available devices are developed for personal activity monitoring, but researchers and clinicians have embraced this technology as a potential tool to monitor and motivate behavioral change. Physical activity tracking devices (PA-TDs) may monitor activity more objectively and provide measures that more closely document actual PA levels compared to self-reports. Also, PA-TDs record activity in near real time, as opposed to research quality accelerometers that require transfer of data collected. PA-TDs have been used as increasingly reliable tools that pose substantial benefit when correctly implemented and integrated into health care. The ability of patients to wear such devices during daily activities while clinicians can access and monitor activity remotely and unobtrusively, expands the potential for PA-TDs as tools not
only to increase and promote positive PA behaviors, but also to highlight patients who may be at risk for certain diseases due to low levels of PA.\textsuperscript{12}

The ability of PA-TDs to remotely monitor activity, set daily step goals, and send motivational messages may increase effectiveness and efficiency of exercise counseling and overall exercise intervention implementation. Recent literature supports positive changes in overall physical activity and health outcomes, such as blood pressure and weight, when pedometers have been used in young and middle aged adults.\textsuperscript{13-16} Most robust changes occur when the devices are used in combination with other program components.\textsuperscript{16} While PA-TDs have become increasingly popular and hold many potential benefits to increase PA, their adoption by older adults is unknown. Therefore, the purpose of this study was to compare the usability and feasibility of 7 commercially available PA-TDs in older adults.
METHODS

Design

This study was initiated as part of a quality improvement project to enhance outreach of physical activity. The project sought to evaluate the usability and acceptability of PA-TDs in remotely monitoring PA in older adults. The study was conducted at Gerofit, a Durham VA outpatient exercise clinic in Durham, NC.

Subjects

A convenience sample of participants was recruited from an outpatient clinical exercise program, Gerofit, for older adults, ages 65 years and over, at the Durham VA Medical Center.\textsuperscript{17} All subjects were enrolled in Gerofit, and had been referred by their primary care providers. Since PA-TDs sync wirelessly to affiliated mobile phone applications (apps), patients were required to have a phone with Bluetooth capabilities to be included in testing the devices. Thirty of 63 Veterans surveyed had a smart phone. However, some veterans who reported not having a smartphone did not realize that their cellular phone contained features qualifying it as a smart phone. The age range of veterans surveyed was 65 to 91 years old, with a mean age of 75 years and mean education level of 14 years. Seven individuals participated in the study, based on willingness to wear a PA-TD for a trial period of two to seven days. All participants were male.

Instrumentation

We preliminarily selected a group of PA-TDs based on Internet reviews of the most popular PA-TDs on the market at the time.\textsuperscript{18} Criteria used to identify potential study devices included: data web transfer, physical display and structure, dashboard
appearance and capabilities, battery life, and consumer feedback of each PA-TD. As the targeted market for PA-TDs is geared towards younger, active individuals, devices were not solely selected on the basis of popularity. Our main objective in this phase was to analyze the syncing capabilities of the phone with the activity tracker and to obtain general feedback from patients about each device.

**Data Collection**

After obtaining permission from each patient to download the affiliated mobile phone application, the device was synced to the phone and then with a pre-existing generic account that was put in the affiliated mobile app that was downloaded. The generic account contained no personal identifying information, and was strictly used to remotely access activity data.

Which device each patient initially received was varied in a non-randomized fashion based on availability of the devices. Each subject participated in one in-person training session at the start of the usability trial phase, in which he was instructed on what each device measured and the aims of this phase of the study. Additionally, each participant was instructed on how to turn the device on, what the data screens signified, how to charge the device, and how to access the data on the mobile phone dashboard; each was also given a set of written directions. Verbal assurance that each patient understood all directions and device features was obtained, and all questions were addressed before the preliminary PA-TD counseling session was concluded.

A usability questionnaire was administered at the conclusion of each 2-7 day trial period, followed by a structured interview that collected opinions about the
devices, reflected in Table 2. In addition to the questionnaire, general feedback was collected on willingness to wear the device for an extended period of time with activity being monitored and the chance for telephone calls if a pre-established activity goal was not being met.
RESULTS

To establish the usability of the device for research or clinical purposes, two perspectives had to be considered when analyzing the most effective PA-TD for use with older adults. First, PA-TDs were analyzed as to the acceptability of their characteristics to older adults. Second, the preferred device also had to provide optimal means of data monitoring and remote access capabilities. Table 1 describes the characteristics of the participant sample and details of their smart phone devices. Neither the Misfit Shine nor the Nuband Activ+ has remote access to activity data, and as a result, these two devices were excluded from usability testing. Table 2 summarizes the PA-TD characteristics that were analyzed relating to device comfort, aesthetics, ease of use, frequency of data monitoring, and likelihood of daily life integration for each PA-TD usability trial period. Participants reported the in-person training session as an essential component to be able to understand and use the PA-TD.

Of the four devices, the majority of the participants rated the Garmin Vivosmart as the best PA-TD overall. The Vivosmart has a clear display from which activity data could easily be obtained and understood. Participants rated the physical appearance of the Vivosmart as best, with some claiming it as “the sleekest, most unobtrusive device that [they] would love to wear everyday.” Ninety percent of participants were able to put the Vivosmart on and off without any assistance, and all unanimously rated this device as the most comfortable. The battery life of the Vivosmart reported by participants was roughly seven to ten days, and required 1.5 hours to completely re-charge. This was the longest reported battery life and
shortest amount of time to recharge the battery of all PA-TDs analyzed in this study. Participants checked their levels of activity most frequently on both their smart phones and the device itself during their Vivosmart usability trial. From a remote monitoring standpoint, the Vivosmart’s dashboard was the easiest to use for collecting and analyzing data. However, twice during the usability trial, Garmin updated both the device and the mobile app software, resulting in syncing and data transfer problems. Once the software was updated on the device and smart phone, respectively, the problems resolved and data web transfer resumed.

From a remotely monitoring perspective, the FitBit Flex’s web-based dashboard was very straightforward and data could be easily extracted. However, this PA-TD posed many problems for participants, leading to overall negative ratings. One of the main problems was the device’s main display, which was a narrow slit vertical on the band that displayed Light-emitting Diode (LED) dots, each representing 20% achievement toward a daily step goal. Participants had a very hard time seeing the display and did not like the Flex’s inability to double as a watch. All participants were unable to put the device on themselves and needed assistance during the initial in-person counseling session. During one usability trial, the FitBit Flex fell off a participant’s wrist without his knowledge. As a result, other participants were not able to test the device and provide feedback.

The Microsoft Band was rated as the second best PA-TD of the six devices used in this study. The Microsoft Band had a very clear display with many smart watch features. The dashboards on both the web-based site and smart phone application were user friendly for this sample, as step counts could easily be
extracted. The heart rate monitor feature on the Microsoft band was one feature that favorably stood out to participants. No participants reported any use of this metric, as many had no knowledge of the measurement’s accuracy or what it might mean from a health standpoint. The overall physical appearance of the Microsoft Band was reported as too bulky, with an uncomfortable rubber strap that chaffed the skin when worn. Additionally, the Microsoft Band’s battery life was reportedly very short. The battery lasted roughly 48 hours, and was shortened with the increased use of the heart rate and other smart watch features of the device. We experienced many problems trying to sync the device to participants’ smart phones. These findings are in agreement with the Microsoft Band website’s report of low energy for Bluetooth connection and 48 hours of battery life.\(^1^9\) While the Microsoft Band did connect to some participants’ phones, the Bluetooth connection was frequently lost, preventing data from being synced. This inability to initially sync the device and phone, with frequent loss in connection, hinders the ability for data web transfer and is an important drawback when considering this PA-TD for remotely monitoring activity.

The Basis Peak was found to have a clear, easy to read display. However, the mobile dashboard contained information beyond direct measurements of activity that participants found superfluous and confusing. This was in part because the feature measuring number of steps was not the main focus of the dashboard. As a result, repeated, specific instruction was necessary to make participants aware of where they could see their daily step count. Similarly, the data feature, while displayed in a clear manner, was not the main screen of the web-based dashboard.
The chief complaint of the Basis Peak was the short three-day battery life. Participants reported feelings of frustration from frequently having to charge the Basis Peak at the expense of being able to track their activity. Three participants became so frustrated with the device that they each refused to wear it after only one out of three days of their usability trial.
DISCUSSION

To our knowledge, this is the first study to compare and examine usability of PA-TDs in an older sample. Previous reports have focused on the use of PA-TD and pedometers in younger, healthy samples. PA-TDs were found to provide accurate measurements of step count, with significant improvements in overall physical activity and health outcomes.\textsuperscript{13-16, 20-22} PA-TDs have been found useful as objective measures of PA in adults, especially more sedentary adults. While previous studies have focused on healthy, middle-aged individuals (30-65 years old), the use of accelerometers with remotely monitoring capabilities has been shown to improve overall PA, engagement in more moderate to vigorous activity, weight loss, and metabolic syndrome.\textsuperscript{23-27} The results of this study support the utility and acceptability of PA-TDs in the tested sample of older adults. Overwhelmingly, participants expressed an interest in the Garmin Vivosmart, and secondarily the Microsoft Band.

The in-person sessions and frequent personal monitoring during this usability trial provided important information for the utility of PA-TDs in this older population. This result is consistent with previous studies, in which providing an in person session that delineates the device features and capabilities was found to increase the number of participants wearing the device.\textsuperscript{24} In a previous study, participants reported significantly higher frustration and lower overall satisfaction with the device when a device was administered without an in person training session.\textsuperscript{28} Making sure participants are comfortable with the device and expectations are clear about the device’s features and purpose are important in
order to analyze the usability of PA-TDs in this population and determine which
device is the best. This in-person counseling session was also beneficial in that it
addressed any concerns regarding the new technology, which have been previously
mentioned as factors contributing to recruitment difficulties.  

One unique focus of this study was examining the ability of older adults to
integrate a PA-TD into their daily lives. A previous study documented poor study
adherence when using an accelerometer in health care due to the inability of
participants to integrate the device into their daily lives. PA-TDs worn on the wrist
may be more acceptable for assimilation into daily life, as they most closely
resemble a watch and can be left on at all times compared to hip-worn PA-TDs
which constantly have to be put on and off whenever an individual changes clothes.

Wearing a PA-TD provides real-time activity monitoring and associated
feedback that may be very important in altering lifestyle behaviors to increase PA.
While our study did not analyze changes in PA, participants reported frequently
checking the device, and altering their behavior according to their total step count
and necessary steps to reach the set goal. Previous studies have documented that
individuals who frequently monitor their activity see weight loss improvements.
Since PA-TDs are reflections of how much activity a participant is engaging in terms
of quantified step counts, individuals are able to pair these measurements with their
perceptions of how much activity they are engaging in. For people who may
overestimate their activity levels, pedometers have been found to be useful in
providing insightful feedback on actual PA levels, and serve as motivational tools to
help an individual reach an activity goal. The capability of continuous self-
monitoring in conjunction with our in-person training session when administering a PA-TD to older adults may provide important tools to increase adherence and maximize benefits of exercise interventions.

There are a few limitations to this project. This sample size was small and is likely a biased sample in that it included only men who were participating in an exercise program and would be more likely to view these devices in a positive light. We also did not test the accuracy of the PA-TDs in this sample, nor with individuals with cognitive impairments. However, we sought volunteers with multiple chronic diseases, mobility impairment, and wide range of socioeconomic statuses. Participants in this group had low daily step count averages, which may make them at greater risk for negative health outcomes associated with decreased PA and more sedentary behaviors. Therefore, these participants may benefit greatly from the use of PA-TDs.

All participants greatly enjoyed using the PA-TDs and reported a willingness to spend between $50-$100 to purchase a device. While “younger” older adults (i.e., baby boomers) are relatively technologically savvy, other older adults are largely unfamiliar with smart devices and the affiliated technology. With proper instruction and instrumentation, the potential for these activity trackers to help monitor activity and motivate behavior remotely is great. As many interventions provide benefits only when the patient is physically present, an intervention that can be more generally administered is not only necessary for inclusion of a broader range of patients, but also crucial in garnering all possible benefits. Therefore, future studies are needed to analyze the feasibility of PA-TDs in conjunction with
counseling to increase PA to national step averages. In conclusion, older adults highly favored the usability of PA-TDs, and would be willing to wear the devices for remote activity monitoring. For these devices to be feasible in this cohort, a one-on-one in-person instruction and set-up session for the PA-TD is necessary.
## Table 1. Baseline Characteristics of Participants

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Table 2. PA-TD Characteristics

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<th>Nuband Activ+</th>
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Case Study One
**Setting the Stage**

For our purpose, the potential for these activity trackers to help monitor activity remotely, is great. These devices would serve as a means to see participants’ daily activity without having to be in the same physical location. As many interventions provide benefits only when the patient is physically present, an intervention that can be more generally administered is not only necessary for inclusion of a broader range of patients, but also crucial in garnering maximum benefits. However, one major factor is the feasibility and acceptability of these devices in older populations. Would older adults be able to use activity trackers? How would they react to such a device? Are older adults capable of learning to incorporate the use of activity trackers into their daily routine? We first began an instrument testing and selection phase in order to address such questions, and determine which activity tracker is the most beneficial for the target population and intervention of interest.

During the initial testing and selection phase, the Garmin Vivosmart pulled ahead. With other PA-TDs circulating through other participants for the usability trial and the Vivosmart sitting idly, we decided to give the Vivosmart to Joe for a trial period of one week. Joe is a 70-year-old male, who has completed 16 years of education, and has had a smart phone for roughly 18 months. Joe had already completed usability testing of all six PA-TDs at that time. From the very beginning, Joe was extremely excited and eager to be included in the usability of different PA-TDs. Our objective in this next step was to begin assessing the feasibility of a PA-TD in conjunction with counseling to increase PA.
Joe’s Experience

As we had done for every usability trial, I conducted one in-person counseling session before we began this new trial phase of the study with Joe. After each person tried a device, I made a document of his activity filled with graphs, charts, and numbers highlighting number of steps and overall activity for each day the participant had a device. As he had previously used the Vivosmart for three days, Joe was already familiar with how the device worked and all it had to offer. I had calculated his baseline daily step count of 6831 from his initial trial with the Vivosmart.

Since the usability trial phase is a short two-day period, this baseline measurement is just a rough estimate of average steps. Nonetheless, I found that this measurement carried a lot of weight and importance to Joe. This number was a way to quantify his daily activity. In other words, Joe had never known how many steps he took throughout a day. Since he had neither owned nor worn any type of PA-TD before this usability trial in our study, he had never put much thought into how many steps he took a day. Instead he “focused on doing [his] exercises in Gerofit, and trying to get out of the house to do chores or anything really so that [he] was not being lazy all day.” When he was wearing the PA-TD, he found himself frequently checking to see how many steps he had taken, often adding up to over four times an hour.

During the in-person counseling session, I showed Joe his activity in graph form and clearly highlighted how I came to 6831 steps as his baseline daily average. One unique feature of the Vivosmart is its ability to automatically generate a step
goal according to one’s activity trends. While this is a potentially very useful feature, Joe and I decided to manually set a goal of 7000 steps for this initial counseling session. Based on his baseline step count measurement, we both agreed this goal to be realistic, yet challenging him to be more active. We discussed how I would be monitoring his activity daily and agreed I would check in with brief telephone calls after three days of inactivity or if he was very far off his daily goal. After refreshing his memory on how the device works and where he could check his activity on the device band and smart phone app, he went off to complete his Gerofit exercise regimen.

The first few days went smoothly; I was able to remotely monitor Joe’s activity, and he reported no problems with the device. Unfortunately, it was not even three days after the initial in-person counseling session that Durham experienced a severe snowstorm and treacherous black ice warnings. Consequently, Joe was stuck in his house for nearly two weeks and his activity levels plummeted drastically, falling far off the course of the daily goal we had established. To further compound the issue, Gerofit was canceled for five consecutive sessions. Joe lucked out in a sense that he got to keep the device for nearly two weeks; on the other hand, he was unable to exercise as normal, with his daily step count suffering as a result.

For a more active older adult like Joe, this period of time was extremely frustrating. Not only was he restless, but his very realistic fear of falling outside due to the severe weather conditions kept him sedentary for two weeks. Just as the snow forced school to be canceled, so too did it force us to cancel our initial aims of
this longer-term trial phase. By the time Gerofit reopened and Joe and I were able to meet in person to discuss the events from when he had the Vivosmart, his irritation from being housebound was high, yet his excitement for finally being able to exercise was extremely high.

**What I Learned from Joe’s Experience**

The weather was an unfortunate, uncontrollable variable that changed our plans for this phase of our trial. While this longer-term trial period of the Vivosmart did not shine light on the feasibility of PA-TDs in conjunction with counseling to increase PA as we had hoped, it did provide useful information. Right before the ice and snowstorm, I saw an increase in Joe’s activity. He frequently said, “The device doesn’t lie. If I thought I was being active and then checked the device and saw I was not anywhere near the goal number of steps that I should be, I would get up and move around so that I could reach my goal. I always wanted to make sure I reached my goal, and knowing that I was wearing the band and you were monitoring my activity, it made me more motivated to be more active.” While Joe is more active than many of his peers, his experience of increased motivation to exercise just from wearing the device and knowing I was closely monitoring his activity is promising. If such a device can increase PA and motivation in already active individuals, who is to say the benefit for sedentary older adults would not be even greater or less?

Even though this event cannot be used as evidence toward the feasibility of using PA-TDs with counseling to increase PA in older adults, it is a small hint for future studies. Joe is an example that older adults can be taught how to use new technology such as PA-TDs as long as at least one in-person counseling session is
conducted to instruct the participant on how the device works. Joe’s enthusiasm for the Vivosmart was unwavering even when he was stuck in his house unable to exercise at all. Unfortunately, nothing can be concluded from this single trial because there were extraordinary weather patterns that threw the whole state of North Carolina into a bit of a frenzy, shutting down everything from schools to convenience stores. This was also only one trial with one subject. But the potential for such a small tool to increase activity in a more active older adult from the little information gathered even under such strange circumstances is exciting.
Case Study Two
**Misleading First Impressions**

Throughout my time in Gerofit, I greatly enjoyed working with older adults. They were all very kind, welcoming, and receptive to any information I provided about our study and the new pieces of technology I had. Dr. Morey introduced Barry to me as a gentleman eager to participate in our study. Barry is a 69-year-old man who has had a smart phone for approximately eight months. He came to me stating that while he may not know everything about his device, he prided himself on knowing the majority of the iPhone features, and had previously used an earlier iteration of a FitBit. My initial impression was that he would be an easy individual to work with, understand how to use the devices, and be able to absorb maximum information from the data collected.

Unfortunately, my initial impression was very wrong. The first day of Barry’s initial usability trial could not have gotten off to a worse start. For one, his phone would not download the app associated with the first device he was to try. While I had explained that the terrible Wi-Fi connection in Gerofit hindered the downloading speed of the device’s app on his phone, Barry was extremely irritated that it was not instantaneous. Once the app finally downloaded onto his phone and I was able to input the generic account information we had created, we hit yet another series of problems that put Barry further on edge. To name a few, the device and smart phone were not connecting through Bluetooth and his phone kept stalling, once randomly restarting itself. It was during this time that Barry’s frustration with technology became evident and spilled over to his tone and attitude towards me. He said he had no patience for such flaws in technology like the
connection problems we were having; it was this technology that boasted making life easier, yet he thought made things more complicated. I had asked him if he regretted investing in a smartphone, to which he replied that he had no regrets buying it, but used his phone less and less as a result of these sorts of problems.

After a turbulent start and countless attempts, I finally got the device to sync with Barry’s phone. We then moved on to how the device works, all the different screens and features, how to charge the device, how to check activity on the device and mobile app, and the overall aims of the project. I then handed Barry a set of written instructions emphasizing in print everything we had just discussed and asked if he had any questions that I did not cover. Lastly, I asked him to try and turn the device on, swipe through the different screens, and get to his step counts on the device and his phone. This was just a precautionary measure to make sure the directions were administered in a clear, concise manner and he understood all directions received.

**From a Turbulent Start to More Turbulent Feedback**

Two days after our initial meeting and device counseling session, Barry was back with plenty of feedback. During our debriefing of his opinions on the device, his frustration with the directions clouded his perception of the device itself. Instead of being able to analyze the usability of such a device in his everyday life to monitor activity, Barry was unable to get past his belief that I had incorrectly explained how to turn on the PA-TD’s screen. Even though I had made sure to go over the directions on how to turn on the device and swipe through the different screens a few times during our initial meeting, I realized that it had not been enough for the information
to actually stick with Barry once he left our session. My perception of what was enough had clearly been misguided. This was a learning point for me, as I realized the presentation of directions I had been giving to all participants was not the most effective for everyone. Especially for someone like Barry, I had failed to reach a point in my instruction where he was able to internalize and remember all the information I had thrown his way. I learned that I needed to cater my delivery method more specifically to each person.

For the rest of Barry’s usability trials, I made sure to go over directions more than twice, with the intent of making the information more tangible for him to absorb so he could focus on the features of the device. The rest of the devices proved extremely difficult to pair with all participants’ smart phones, with Barry’s phone being no exception. Each time he came back to try a new device, his frustration was palpable even before I attempted to pair the device with his phone. Every time we met, I assured him he did not have to try any additional devices, as this should be an enjoyable event, not a stressful one. With his frustration in check, he still expressed great interest in trying out his devices, as he had “many opinions about technology” that he “wanted to be heard.”

**When Impressions and Reality Collide**

Barry is one example of a gentleman who boasted an active lifestyle, yet was surprised at the actual activity data collected during his usability trials of the PA-TDs. After the first device Barry tried, I showed him his activity over the course of those two and a half days. He exceeded 5000 steps only once by 26 steps. As explained previously, 5000 steps a day is the minimum step count for classification
as “Low Active.” However, based on all step count measurements collected throughout Barry’s usability trials, he would be classified as “Sedentary,” with this day of 5026 steps being an exceptionally active day. While he was surprised and somewhat unbelieving of his low activity, we eventually hit on the fact that after Gerofit, and on the days he did not come to Gerofit, he barely engaged in any PA. He explained to me that since he was not being held accountable to exercise, PA generally was not on his list of priorities because he believed he was being “active enough.”

Barry’s concluding remarks at the focus group at the end of the usability trial phase of this study provided encouraging information moving forward, even with all the trouble we had along the way. Barry said, “The concept of the devices is great. While the directions and mechanics of the device connecting to the phone are faulty, I believe the PA-TD would be a beneficial tool in motivating me to be more active, especially on the days I do not come in to Gerofit.” Hearing this first statement of optimism from Barry was like the light at the end of a long, dark tunnel after his negativity throughout the entire usability trial phase. There were many lessons I learned from working with Barry, such as the need to change my instruction presentation in ways that would emphasize the same underlying information, yet be more tangible and acceptable for each individual I worked with.

**Lasting Impressions**

After gathering baseline information on Barry’s opinions about the PA-TDs and his average daily step counts, I believe Barry is an individual who could greatly benefit from having a PA-TD to help increase motivation and PA behaviors.
However, throughout his usability trials, I was not optimistic that a PA-TD could be feasibly integrated into his daily life. To be frank, I thought he would reject the devices all together, especially after two occasions where he reported taking off the device due to frustration and lack of interest or desire to wear the device at all. However, hearing his final comments about the devices laced with a general optimism about PA-TDs changed my own opinions, and reaffirmed my belief of the usability and overall acceptance of PA-TDs by older adults.
Case Study Three
Initial Impressions

Each step was a process, visibly labored and exhausting. Yet even with a slight limp and slow gait, Luke was a man with incredible presence. It was not because he was a solid few inches over six feet with a strong build; he was a man whose confidence radiated from his core with every step he took. Luke was extremely friendly and enthusiastic from the very first time we met. It was his bubbly personality that surprised me, as it was not what I had expected based on his intense, focused walk over. From our initial meeting, I saw him as an individual who would be able to provide incredible insight into the usability of PA-TDs, and the feasibility for such devices to increase activity in someone with slower gait and more mobility impairments.

The First Usability Trial

After explaining our primary aims of the usability trial, Luke was happy to participate and do whatever he could to help. As an honest and up front guy, Luke made two important statements regarding his participation in this trial. The first was that he felt he did enough activity. Second, he said that since we were not requiring him to check activity on the PA-TD or his cell phone, he was not going to look at either for as long as he had the devices. He simply was not interested. Rather than take these comments as negative, I found them to be insightful. Here was an individual who was willing to participate in our study, attentively listened to all directions regarding the device and affiliated mobile app, was able to replicate how to turn the device on, switch through different screens and understand what each screen meant, yet had no interest in checking his activity. To me, this seemed like a
contradiction, but I was extremely eager to hear how his attitude might or might not change after he wore the devices.

After wearing the first device for only three days, Luke returned with the same labored, intensive walk, but with an entirely different attitude. We went through the standard procedure of filling out the written questionnaire and discussing his opinions about the device. It was when I asked him if he checked his activity at any point that I hit the source of his changed perspective. He explained that while he was bragging about to some of his friends as to how the device worked, what it did, and why he was wearing it, he discovered a sense of pride that made him want to see how much activity he actually engaged in on a daily basis. It was from that point on that Luke reported checking his step count at least once every hour of each day during the usability trial phase.

Reflecting on the Usability Trials

His feedback was a mix of frustration and concern, yet somehow laced with optimism. He repeatedly said that wearing the device “made you aware of how much you walk, or if you are just sitting around doing nothing. I was surprised to see how little steps I had every day. I thought I was pretty active, but the device doesn’t make things up just to make you feel good about yourself. The device doesn’t care about your ego, it just tells you the facts of your activity.” This clash of perception with reality was an important learning experience for both of us. By wearing the device, Luke was able to quantify his daily activity in terms of steps per day. His overestimation of personal PA behaviors became evident with the PA-TD’s objective measurement of his activity. While initially discouraged at the extremely low
number of daily steps, we discussed how much room for improvement he had now that he was able to put his PA behaviors in perspective.

From just having a device on his wrist, he said he was “more motivated to get the step count higher, as I found myself frequently checking the amount of activity I had. I have never before had anything like this device, and I think it has definitely held me more accountable to get up and move more in the short time I have had it.” This was reflected in his step count data in the following usability trials, as I noticed an increase in his daily step counts after his first experience with a PA-TD.

During one of his usability trials, the FitBit Flex fell off his wrist without his knowledge. After searching for quite an extended period of time, Luke unfortunately could not find the device, preventing further data collection and use of this device by other participants in the usability phase of this project. He was extremely discouraged and apologetic about losing the device, and became hesitant about trying others. Putting his feelings aside, he agreed to try the other devices in order to complete the usability phase and evaluate all of the PA-TDs. However, the Microsoft Band and Nuband Activ+ were both too small to fit on Luke’s wrist. We had bought the largest of each device, with the idea that large bands can be tightened smaller, but small bands cannot be made larger. This meant that these PA-TDs physically excluded someone like Luke from using them at all. This is an unfortunate, yet important, drawback of the Microsoft Band and Nuband Activ+, as Luke is a sedentary individual who could benefit greatly from a device that could help improve his PA and overall health.

**What I Learned from Luke’s Usability Trial**
Luke is an example of an individual with mobility impairments that may prohibit him from reaching the number of steps in the “Low Active” category. Being active carries a different meaning for someone like Luke who has a significantly low average daily step count of 942. As a result, improvements in increasing activity may look significantly different for Luke than his peers or national averages of recommended activity levels.

His slower gait also shed light on which devices were better in recording activity. By putting a PA-TD on someone like Luke, his slower gait weeded out devices unable to detect subtle changes in activity. I preliminarily started analyzing differences in daily step counts between the PA-TDs throughout Luke’s usability trials. I gave Luke the Basis Peak at the very beginning of Gerofit and was able to closely monitor and observe Luke’s activity throughout Gerofit that morning. Roughly 45 minutes after I had given him the device and he was in the thick of his exercise regimen, he abruptly stopped exercising and came over to me with a look of serious concern. He described how he had been frequently checking the device to see his step count, but the Basis Peak was barely registering any improvements in activity.

In fact, if I had only gone according to the Basis Peak’s recorded data, I would have thought that Luke had been sitting down all day. To check my assumptions that the Basis Peak was unable to pick up such subtle changes in activity due to slow gait speed, I compared Luke’s activity data from this Gerofit session wearing the Basis Peak to a Gerofit session when he wore the Garmin Vivosmart. I made sure that I was present for the entire Gerofit session when Luke wore the Vivosmart, just as I
had been when he wore the Basis Peak. The differences in step count were drastically different: on the same day of the week, doing the same exercises, the Vivosmart recorded nearly 800 steps, four times the amount recorded by the Basis Peak (200). This was true for the other days I compared the Vivosmart step count total to the Basis Peak step count, in and out of Gerofit.

While this is a very primitive analysis that carries no statistical significance, I believe it to be an important finding. Especially for someone as sedentary as Luke, a PA-TD will not be usable if it is unable to track the slight changes in ambulatory activity that comprise the majority of such individuals’ movement and exercise. If the PA-TD cannot detect low gait speed, there is no point for an individual like Luke to wear the device at all. Additionally, Luke was continuously frustrated by the Basis Peak’s lack of activity monitoring, as it was not a true reflection of the amount of exercise he had done. This increased frustration and overall negative experience with the device would prevent such individuals from using the PA-TD and incorporating it into their everyday lives. Therefore, this PA-TD would neither be feasible for remotely monitoring activity nor in future exercise interventions to increase PA.
REFERENCES


APPENDIX A:
Physical Activity in Older Adults
The Effects of a Sedentary Lifestyle

Physical activity (PA) is a modifiable behavior that has immense importance to health and overall well-being. Decrease in PA generally comes as a result of increased sedentary behaviors, which have been linked to many negative health outcomes. Defined as “human endeavors that result in an energy expenditure of no more than 1.5 times’ resting energy expenditure,” sedentary behaviors include sitting, lying down, and other behaviors that require very little energy. High levels of sedentary behaviors were found to be inversely proportional to risk factors for metabolic syndrome, cardiovascular disease, type 2 diabetes, and an overall shortened and robust-depleted life.2-6

The greatest sedentary behaviors are most prominently seen in individuals 60 years and older.3,7 Accordingly, these individuals are also at greatest risk for the associated negative health outcomes. Lack of motivation, fears of falling or injury, inadequate time, or physical limitations are examples of barriers preventing individuals from engaging in physical activity and exercise, which contribute to a more sedentary lifestyle and higher levels of disability.31,32 These barriers have also been associated with increased muscle weakness in the elderly population with increasing age.33,34 While age is an uncontrollable variable, exercise is a malleable behavior that can be employed as a powerful tool to increase quality of life, reduce dependency in later years of life, and improve certain health risk factors at any age.35-38 Because sedentary behaviors are most prominent in older adults, they have the greatest area for improvement in PA levels and tendencies.
In many cases, when individuals engage in sedentary behaviors, their muscles require less fuel due to lack of contraction, causing excess energy (glucose) to remain in the bloodstream. This increased blood glucose resulting from muscles being in a relaxed state is one of the reasons why sedentary behaviors may lead to increased risk of type 2 diabetes. Additionally, declined engagement in physical activity has been shown to increase the progression of frailty and deteriorating cognitive functioning with increasing age. Underlying processes of mental acuity, such as attention and concentration, may be positively affected by engaging in aerobic activity, as the brain has been surmised to be in a mild state of hypoxia when individuals are not consistently physically active.

Among older adults, veterans may be at greater risk for disorders related to functional limitations than the general population. Veterans using the Veterans Affairs Health Care System (VA) were found to have overall worse health than both the general population and non-VA veterans. Sociodemographic factors such as health status, education level, income, and resource access and subsequent use have been linked to the differences in health between VA veterans and the general patient population. VA patients were found to have lower average income and to lack health care insurance, and were older with more chronic conditions, which were factors contributing to their eligibility for VA healthcare services. VA veterans were also found to have activity levels well below the Surgeon General (SG) recommended guidelines and national exercise averages.

What exactly constitutes a healthy level of PA?
According to the SG, the baseline recommended amount of physical activity is 30 minutes, five times a week. There is a gap of knowledge in how engagement in physical activity in relation to the SG-endorsed guidelines affects physical functioning in older adults. Physical activity levels at or above the SG guidelines were found to have positive effects on physical functioning, with levels of physical activity below guidelines having a damaging effect on physical functioning with age.\textsuperscript{43} The average adult in the United States was found to take an average $9676 \pm 107$ steps a day.\textsuperscript{9} In healthy older adults, the recommended 150 minutes of activity each week was found to convert to approximately 7100 steps each day.\textsuperscript{44} Delving deeper, a previous study created a spectrum defining levels of activity in older adults. “Sedentary” was lower than 5000 steps; “Low Active” was 5000-7499 steps; “Somewhat Active” was 7500-9999 steps; “Active” was 10,000 steps and above; and 12,500 steps and above was classified as “Highly Active.”\textsuperscript{44}

**The Tense Relationship between Exercise and Older Adults**

One major gap in the field to date is the prescription of exercise from physicians when dealing with older adults. With exercise having been long accepted as having positive effects on health, these benefits may be especially true and important for the elderly population, VA veterans in particular. Physicians and exercise advocates can help patients reinterpret diseases, diagnoses, and physical limitations as motivators to improve health, rather than excuses from shying away from physical activity.\textsuperscript{32,33,45}

Many older adults have expressed great interest in physical activity and increasing associated behaviors, yet lack the necessary guidance and structure to
effectively adopt them.\textsuperscript{31, 32, 46, 47} The number of patients who receive exercise counseling from their physicians declines with increasing age of the patient; only 14\% of patients over the age of 85 receive information or guidance on how engaging in exercise behaviors can improve health outcomes and overall well being.\textsuperscript{32} In older patients with chronic conditions, greater, longer term adherence to exercise programs has been associated with decreased risk of mortality over a ten year period.\textsuperscript{48} Observational studies have found older adults to have a reduced risk of 30\% for functional limitation development with consistent engagement in exercise behaviors.\textsuperscript{6} Exercise interventions based on participants’ homes have suggested improvements in lifestyle behaviors that may lead to lowered risk of functional decline later in life.\textsuperscript{49} Improving attitudes toward exercise is a key component in adherence to different exercise programs, leading to increased PA behaviors overall.
APPENDIX B:
Why I Care
Ever since I can remember I have had an incredible love for the water. Bribed to swim my first lap at the young age of three, my passion and love for the sport have only increased. Competing at the national level during high school, I knew that I wanted to further my swimming career at the collegiate level. The challenge to push past any limitations and exceed expectations comes with higher demands in practice and during competition. The increased pressures and stresses that come with collegiate level participation only fueled my desire further.

Freshman year, I felt invincible. Even a battle with Lyme disease my sophomore year did not begin to put a dent in my passion for swimming. It did, however, leave my abilities to train and my immune system compromised during the season. With an altered training regimen, I made sure that I was able to compete when it really mattered at the end of the season. Pushing myself to overcome physical weaknesses, I was training as hard as I could to get back into my best possible physical conditioning.

Increased desire to get in shape came with higher levels of intensity in the weight room and in the pool. There was no question my self-identity revolved around being a swimmer, now more than ever. Swimming was my life; everything I did revolved around practice times and meet competition. Along with my highly competitive nature, there was no question I wanted to do everything in my power to be the best athlete I could be. I lived for those high-pressure situations where a race comes down to the final lap, and you have to muster any strength you have left not only to finish, but also to touch the wall first. Nothing was going to stand in my way. That is, at least, until I started experiencing pain localized in my elbow. Believing it
was just part of increasing my weights and intensity during workouts in and out of the pool, I ignored it. What was a little pain anyway? I associated pain as something that comes with the territory of being a collegiate level athlete. At that point in my career, I didn’t even question this mentality, as it was something I believed was close to universally believed. But the sheer pain I started to experience down my arm when pushing off the blocks at the start of each race confirmed all my biggest fears: I was injured.

Time went by, orthopedic elbow specialists were seen, and surgery was not merely an option, but a necessity if I ever wanted to continue swimming competitively. On top of my anger, I fell victim to many depressed and angry emotions, as I was watching my teammates train and compete, getting closer to championships, while I was stuck waiting for my surgery date to finally arrive. Feelings of helplessness became extremely common. All the negative emotions I experienced and ruminated upon finally got me to the point where I felt isolated from my team, coaches, and even my family. I had completely shut myself off from all forms of exercise, and found myself increasingly lethargic and negative. It was at this point that I realized the power of exercise and positivity. I started seeking outside support, as I realized that I could not cope with my injury on my own. I began to admit that I was not as strong as I had pretended to be, but still was going to do whatever it took to get back to competition again. I found that reaching into different areas of my life for support catered to different needs I had. For instance, I could turn to other injured athletes for advice on physical therapy, and how they stayed in shape when they were no longer able to train with their teams. I could also
turn to my family for support beyond the pool, helping my mental well-being overall.

Lying in a pre-op bed before surgery, I asked my surgeon to document the procedure with photos. Understanding my passion for medicine, interest in the procedure, and desire to capitalize on any learning opportunity, he quickly agreed and became excited to share his work. Awakening from anesthesia, I asked him not only if he took the pictures but how soon I could get them. He laughed at my enthusiasm and assured me they had already been sent. I was wheeled out of the hospital, arm in a sling, surgery pictures saved on my phone and a grin from ear to ear.

Many people think I’m crazy when I show off my pictures and scar as proud parents do their children. To me, these signify the magic that is medicine. They are examples of how surgeons restructure muscles and nerves to create more effective pathways in the body. Both my scar and pictures are symbols of how far I have come mentally and physically after being broken down by different events. The scar was not a sad reminder of my setbacks, but a symbol of inner strength and insight I gained throughout the process, further enhancing my belief in the magic.

My elbow injury was one of the biggest turning points in my life. While I was forced to sit out that year’s season, my scar and pictures made me ask personal questions about identity, leadership, how to contribute to my team outside of the water, and what impression I wanted to leave on others. Why be upset and focus on what went wrong when I could choose to control what I can and find a silver lining? The jagged, smile-like scar on the inside of my elbow is a reminder that barriers can
be overcome with hard work and positivity. With a recent fourth surgery, I know firsthand that sometimes medicine cannot offer a quick fix. It isn’t the number of procedures, but the number of doctors I have met and experiences I have gone through that have strengthened my belief in medicine and desire to become a doctor.

During my time at Duke, I have had the extreme fortune of sharing other “scar stories” with patients in the Duke Hospital through The Collegiate Athlete Premedical Experience (CAPE). I shadowed doctors, performed neurological exams, and interacted with patients in the Robert Tisch Brain Tumor Clinic (BTC). Throughout my two years in clinic, I made sure to engage patients in small talk while collecting patient histories and conducting neurological exams. Asking patients about their hobbies and sharing stories about our scars in follow up visits were some of the most positive and memorable aspects for me.

After administering one neurological exam and patient history, one older patient and I fervently got onto the topic of sports and exercise. I animatedly discussed how I believed in the healing powers of exercise and being active in any way you can, especially after a surgical procedure. A look of utter confusion flooded the patient’s face; she was actually able to exercise after her surgery? No one had ever mentioned when engaging in physical activity would be acceptable following surgery. This question hit me in the face like a ton of bricks. I was utterly shocked that no one had ever mentioned all the beneficial aspects of exercise during recovery, especially following cancer treatments. This is when I realized that I had to do something to help.
I developed the idea to create a pre-surgical exercise intervention for brain tumor patients. I met with countless physicians, patients, and other medical staff to discuss the nuances of creating a project such as the one in my mind. I was two weeks from starting the project when I got word that a physician had adapted my study into a version of her own, and I was no longer needed. I was crushed. Not only had I invested a lot of time and energy into this novel project, but I was genuinely excited to share my knowledge and passion of exercise and recovery to help other patients in any way that I could.

Rather than letting all of my excitement and hard work go to waste, I presented my idea to Dr. George, who had been my professor the semester before and had inspired me with all of her knowledge in medicine and sociology. I felt of all people, she would give me the best advice and challenge me to think at a higher level to create a project that would be feasible yet rewarding and beneficial. It was through Dr. George that I was connected with Dr. Morey, and exercise physiologist who is in charge of Gerofit on top of doing significant research in the Perioperative Optimization of Senior Health Clinic (POSH) at Duke University Medical Center.

During my meeting with Dr. Morey, we both realized we had been thinking along the same lines, as she had wanted to do a similar project to my own. By streamlining my ideas with her insight as to realistic steps to making my project a reality, we were able to create a proposal and get the ball rolling. Their infrastructure has provided me with ample leeway and opportunity to conduct this study in the most effective and beneficial way possible with two awarded grants. I soon learned that the path to research and conducting the study I had in mind was
interlaced with many potholes, cracks, and pitfalls that made the journey anything but smooth.

With my main objective to create an exercise intervention for pre-surgical geriatric patients using activity trackers in mind, the first phase needed was to investigate the usability of such devices in older adults. The first issue we ran into was the physical purchasing of the devices to be used in our study. After countless hours pouring over Internet sites, previous literature, and going to retail stores to discuss different PA-TD features, I finally presented a list of which devices I thought would be the best for older adults. Sharing my enthusiasm to get the project started, Dr. Morey placed the order in almost immediately after we collaborated on the different features of the devices and any others she thought were beneficial that I may have missed.

Due to the infrastructure of the VA, we had to wait over two months to receive only two out of the six devices we had originally ordered. Rather than waiting for the other devices to trickle in, we decided to get a jump-start to the usability trial of the Garmin Vivosmart and FitBit Flex by beginning our instruction session. This was right before winter break, so we were only able to have one participant try out the new devices. Following winter break, we had still yet to receive any additional devices, and were not optimistic about when they would come in. We continued the usability trial with different participants using the two PA-TDs we had up until one was lost. One participant (see the Case Study Three below) did not realize the FitBit Flex had fallen off his wrist until it was far beyond the point of finding it. Even though every individual who had worn the FitBit had
overwhelmingly negative reviews of the device, its loss meant the inability to have other participants try it out for themselves.

The end of February came with the severe snow and ice event that shut down Durham public schools for almost two full weeks. Since Gerofit is canceled whenever the public schools are canceled or delayed, I was unable to redistribute the Vivosmart to other participants. Joe (see the Case Study One below) had the device for the entirety of the snowstorm, but was largely unable to benefit from the device due to being landlocked by the icy external conditions.

Finally March rolled around with the promise of the remaining four devices to be delivered any day. As soon as they were delivered, I picked them up and set them up for immediate use by participants in Gerofit to continue our usability trial. Trying to set up these devices in Gerofit while other people constantly asked if they could participate (some did not have a smart phone and we did not have enough devices to give to everyone who did have a smartphone at Gerofit) only added to the chaos that already permeated the environment. Trying to maintain a quick turn-around in terms of switching devices between participants for the usability phase, while also maintaining a sense of integrity in assuring all participants received the same amount of instruction with room to discuss any questions or concerns they may have, was very stressful. The connection problems between some devices and the smart phones only made it more so.

The connection problems did not affect participants’ opinions about the usability of the device; rather, it affected my opinion about the usability of the device from a data web transfer and remote monitoring standpoint. Luckily, the
devices that were most challenging to sync to the smart phones were also the devices that were least favored among participants. Overall, I am extremely excited about our results that PA-TDs are usable and acceptable in this population for remotely monitoring PA. Nine out of ten participants ultimately rated the Vivosmart as the best, with the other favoring the Microsoft Band, directly in line with our conclusion that the Vivosmart is the most useful device in terms of accessing activity data remotely.

There have been many hills and valleys that I have traversed throughout the course of my study. While my initial idea has changed from brain tumor patients, to pre-surgical exercise interventions with PA-TDs in geriatric patients, to analyzing the usability and feasibility of PA-TDs in older adult populations and remotely monitoring activity, I have learned more than I ever expected possible. Not only was I also exposed to the world of research, but I was able to work with an entirely different population than I have before. I was still able to spread my love and passion for exercise and couple it with a novel project analyzing new technology that has potential to be a very important, useful tool in relation to physical activity.

With all my past experiences, I have learned the value of any victory regardless of how large or small. While not what I expected, I believe this project has far exceeded my expectations, filled with many victories. I am excited that my journey with this project does not end with this final paper; instead, I will be continuing on towards my initial goal of the use of PA-TDs in a pre-surgical exercise intervention. However, before I can reach that objective, the next mountain to climb is the use of the best PA-TD from this study in a longer-term trial that analyzes the
feasibility of the Garmin Vivosmart in conjunction with counseling to increase PA in older adults. I have immensely enjoyed working with this cohort and my first real exposure to conducting my own research study. From my personal experiences, to everything I have been taught while working on this project and the many faces it has displayed, I have learned that perseverance during adversity creates opportunity and fuels passions. While I know there will be many more challenges to face and obstacles to overcome in my life and throughout my career, now more than ever I feel as though I am better prepared to be a physician of positive change.