A case study on older adults' long-term use of an activity tracker

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A. Schlomann. A case study on older adults' long-term use of an activity tracker. Gerontechnology 2017;16(2):115-124; https://doi.org/10.4017/gt.2017.16.2.007.00 **Background** A lack of physical activity can jeopardise older adults' health whereas activity tracking by means of wearable technologies (activity trackers) can help to promote physical activity. It is, however, unanswered how older people use such technologies in non-experimental contexts. **Objectives** This paper aims at understanding older adults' long-term use of an activity tracker, at identifying reasons for continued or abandoned use and at evaluating possible effects of activity tracking on the level of physical activity. **Methods** Semi-structured telephone interviews were conducted with participants of a long-term follow-up study on the use of an activity tracker (*ViFit connect Activity Tracker*). They were asked about their experiences with an activity tracker during the last year. Interviews were analysed using qualitative content analysis and compared to the results of a group interview that had taken part immediately after the participants had started to use the devices. **Results** Statements were classified in five main categories: integration into everyday life, advancement of usage patterns, aspects relevant for long-term use, reasons for abandoned or reduced use, and effects on behaviour. The long-term comparison showed that criticisms expressed at the beginning of use also persisted in the long term. Users had established individual routines in the course of one year. **Conclusion** Objective information on activity level and the reminder function of the activity tracker contributed to long-term use. However, the reported everyday use of the activity tracker was mainly passive. Opportunities to improve older adults' user experience include individualized and age-sensitive incentive mechanisms for physical activity, the integration of activity tracking into broader contexts and the development of suitable platforms for interpersonal exchange.

Keywords: wearable technology; activity tracking; older adults; behaviour change

A sedentary lifestyle may pose a major health risk in general and especially for older adults. Yet many older people do not sufficiently engage in physical activity. There is a need for appropriate and innovative measures to increase the level of physical activity in this group. Physical activity tracking by means of wearable devices might be a possible approach. However, older adults' long-term use of tracking technologies and possible promoters and barriers for long-term use have not been investigated systematically yet.

Relevance and effects of physical activity

Physical inactivity is one of the major risk factors for non-communicable diseases such as type 2 diabetes mellitus or cardiovascular diseases worldwide[1,2]. For older people, positive effects of physical activity on health[3], well-being[4], and cognitive functioning[5] have been demonstrated.

The relevance of physical activity throughout the lifespan also becomes apparent in public guidelines for appropriate extents of physical activity. The World Health Organization recommends doing 10,000 steps per day[6] and the U.S. Department of Health and Human Services has defined specific physical activity guidelines for individuals of different age groups. According to these guidelines, adults should do at least 150 minutes a week of moderate-intensity or 75 minutes of vigorous-intensity physical activity for substantial health benefits[7]. These recommendations also apply to older adults provided that they do not suffer from chronic conditions or disabilities.

Despite the public debate about positive effects of physical activity on physical performance and health, every third adult worldwide does not meet physical activity recommendations and the level of physical activity decreases with age[8]. There is further evidence that a considerable number of people is not aware of their insufficient level of physical activity[9]. Especially older people overestimate their level of physical activity in subjective measurements[10,11]. As physical inactivity may cause major health risks in advanced age, innovative measures are needed to raise awareness for the importance of physical activity and to initiate behaviour changes within the group of older people.

Wearable devices for physical activity tracking

Wearable devices like smartwatches and other wristbands for physical activity tracking facilitate an individual and continuous documentation of physical activity using simple, cost-effective methods[12]. These technologies have become popular in recent years. A current trend is the use of so called activity trackers, wristbands providing information on the wearer's physical activity based on counting steps and often coupled with an application on the smartphone[13]. Given the constantly growing number of tools and devices for physical activity tracking[14] their use might be a novel approach to increase awareness for physical activity and to encourage people to remain physically active throughout their lifespan[15].

From a conceptual point of view, the continuous and regular feedback provided by activity-tracking technology is expected to change behavioural routines[16]. Behavioural change theories like goal setting theory[17] or self-regulation theory[18] stress the importance of goal-setting, self-regulation, and action planning in order to translate intentions into behaviour. Also, the Health Action Process Approach[19] considers self-efficacy and planning as important factors for explaining behaviour change in the context of health behaviour and physical activity.

Currently available devices for physical activity tracking like activity trackers already incorporate gamification elements like challenges, badges or rank lists that might facilitate goal-setting and increase self-efficacy[20,21]. Physical activity tracking might help individuals to review and plan their everyday behaviour and to set goals for a specific level of physical activity. As a result, it might help to overcome the *intention-behaviour gap*[22]. Empirical research shows that that using wearable devices for physical activity tracking can actually support goal-setting and is related to greater self-efficacy and action control[23]. Setting goals for physical activity was an important factor contributing to higher levels of physical activity in a sample of older women[24]. However, research on gamification also suggests that ease of use of gamification decreases with age and novelty effects of gamification elements are stronger for younger people[25]. This may be an indication that using wearable devices that make use of gamification elements might be more effective in younger age groups.

Older adults' use of wearable devices for physical activity tracking

A number of studies showed that using wearable devices for physical activity tracking positively affected the level of physical activity[26,27]. In a small, experimental study, this has also been shown for the group of older people[28]. The general acceptance of activity trackers by older adults has also been examined[29].

But the sustainability and long-term impact of these findings is uncertain. Only a few studies have investigated the long-term use of wearable devices for physical activity tracking so far[30]. A systematic review on the effectiveness and feasibility of using activity trackers in adolescents concludes that the devices are generally evaluated positively by younger people but more research is needed to examine these topics over longer periods of time; attitudes are barely studied so far[31]. The majority of studies examining activity-tracking devices focuses on factors leading to initial usage. But it is also necessary to consider the sustainability of using intentions. A study by Ledger and McCaffrey[32] showed that about half of the users of an activity tracker quit using it after six months. Also for mobile fitness apps, usage rates have been shown to decrease significantly after five months[33]. This study also stressed the importance of attitudes relating to app use for exercising in the long-term. Identified reasons for abandoning the use of wearable devices in other research were a misfit with the conception of the self, lacking interest in the gathered information or additional burdens while using[34]. Research focusing on the use of smart devices concluded that continued use or abandonment are complex and multi-dimensional processes not only caused by users' satisfaction or dissatisfaction[35].

Beyond this, a second focus must be on the specific demands of older people relating to the use of new technologies. Usability evaluations have revealed that physical and cognitive limitations in higher age need to be taken into account when studying technology usage behaviour[36]. Also problems in sensory perception are of high relevance[37]. As a consequence, it is important to consider older people as a special group since older people are in many ways less accustomed to new technologies than younger people and feel less confident in using[38]. It has furthermore been shown that determinants of technology acceptance differ between younger and older people[39]. Cognitive functioning and socio-demographic variables were identified as factors that have an impact on attitudes towards new technologies in higher age[40]. Empirical results derived from research in younger age groups are, therefore, not easily transferrable to older people.

To sum up, older adults' long-term use of wearable devices for physical activity tracking has not been examined systematically yet. Therefore, this paper aims at exploring older adults' long-term use of a specific activity tracking technology (i.e., an activity tracker) by identifying reasons for con-

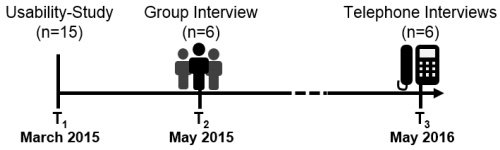

Figure 1. Graphical overview of study design

tinued or abandoned use and evaluating possible effects of using on the level of physical activity.

Methods

This paper reports the final results of a case study exploring older adults' use of an activity tracker. The project was composed of three parts as a whole (*Figure 1*). The first part (T_1) was an in-depth study of usability. Participants were then asked to participate in a first follow-up interview (T_2) one month after the usability study and a second follow-up interview one year after the start of the study (T_3). The results of the usability study (T_1) and the first follow-up interview (T_2) have already been published elsewhere[41,42]. The analyses in this paper, therefore, focus on the second follow-up interviews (T_3).

After presenting the main results, findings are compared to the first follow-up interview (T_2) to sketch relevant developments over the duration of one year. A qualitative research design including a long-term component was applied that allows to explore underlying motivational mechanisms over time.

Procedure

In-depth study of usability (T_1)

In total, n = 15 older people aged 60 to 78 years (mean age = 68.0 years, SD = 5.29) participated in the initial study on usability at T_1. They were recruited in a convenience sample in the local area of Aachen (Germany). A prerequisite for participation was that the individuals owned a smartphone and used it regularly. The *ViFit connect Activity Tracker* by Medisana was chosen for the study due to higher compliance with German privacy policy regulations as compared to other activity trackers. Privacy of users was protected since all data was stored and processed in accordance with the German Federal Data Protection Act, i.e., all personal data was processed on servers in Germany. The *ViFit connect Activity Tracker* employs accelerometer technology linked with an algorithm that translates measured steps into further values (e.g. distances, energy consumption, and movement during sleep). An overview of daily activity can be displayed on a small liquid crystal display that is integrated into the activity tracker. The activity tracker itself needs to be plugged into a silicon wristband to strap it around the wrist. It can by synchronised with a smartphone or tablet using the Vitadock+ app. It is also possible to connect and synchronize the activity tracker to a PC.

At a first appointment, every participant was equipped with a *ViFit connect Activity Tracker*. Participants received no individual training or instructions on using and were only given the standard manual included with the activity tracker. During this appointment, all participants answered questions on technical affinity using a questionnaire containing 15 questions measured on four-point scales[43]. Higher values indicate higher technical affinity. The perceived usability of the activity tracker was measured by applying the Post-Study System Usability Questionnaire[44]. Seven-point Likert scales were used with lower values indicating better usability. All participants furthermore estimated their level of physical activity (hours per week) and provided demographic information. At the end of this appointment, participants were asked to use the activity tracker during the following four weeks according to their individual interests. The only direction they were given was the 10,000 steps-guideline by the World Health Organization[6]. During the following four weeks, the number of steps was objectively measured by the activity trackers.

There was a second appointment at the end of the four weeks. Participants answered the same questions on technical affinity and general usability a second time and again estimated their level of physical activity. Subsequently, they were given the opportunity to keep the activity tracker and were asked to take part in a long-term follow-up study. This provided the opportunity to contact them at later points in time (i.e., at T_2 and T_3). The study has obtained approval from the responsible ethics committee.

Group interview (T_2)

Participants who agreed to take part in the long-term follow-up study were asked to participate in a group interview one month after the usability study. From the initial sample of 15 people, n = 6 participants (mean age = 71.7 years, SD = 4.41) agreed to participate. In this part of the study, issues relating to acceptance and individual experiences with the activity tracker at the beginning of use were discussed. Applying a group interview allowed to analyse individual as well as collective opinions and group processes[45]. The interview was structured by guiding questions, audio recorded, and transcribed for analysis. Prior to their participation, all individuals had signed a written informed consent.

Telephone interviews (T_3)

One year after the usability study, participants were contacted again. N = 6 people (mean age = 69.0 years, SD = 6.00) agreed to participate in

the second follow-up. Three of them participated in the group interview (T_2) and all of them were participants in the initial study on usability (T_1).

At the second follow-up contact (T_3) semi-structured telephone interviews were conducted. The telephone interviews were structured by guiding questions. Following an introduction, interviewees were asked whether they still used the activity tracker. If they did so, questions relating to the everyday usage of the activity tracker and changes during the last year followed. If a person did not use the activity tracker anymore, possible reasons were discussed. Mainly general questions were asked to allow participants to talk about the topics that were important to them. The interviews were audio recorded and transcribed. Prior to their participation, all individuals had signed a written informed consent.

Method of analysis

The open answers given in the telephone interviews were analysed by applying qualitative content analysis. This method implies the analysis of text data by systematically classifying comments and remarks in categories. In this way themes and patterns in the open statements can be identified[46,47]. A combination of an inductive and deductive approach was applied. Some main categories were deduced from the interview guideline. Most categories were worked out in an inductive manner. The same method of analysis was applied at T_2. This procedure allows to compare the statements over time.

Sample description and analysis of drop-outs

Sample composition changed from T_1 to T_2 and T_3. *Table 1* provides an overview on the samples over the three time points. In this way, it is possible to gain insights into differences between the groups and potential reasons for drop-outs.

Participants at T_3 on average did 8,799 (*SD* = 3,732) steps per day during the first four weeks of the study. This number of steps does not largely differ from the whole sample at T_1 (mean number of steps = 8,849, *SD* = 3,065) and the sub-sample at T_2 (mean number of steps = 8,389, *SD* = 2,349). Participants at T_3 estimated to be approximately 5 hours physically active within one week (5.3 hours at the start and 5.5 hours at the end of T_1). This value varies only slightly between the three samples. Also technical affinity is quite stable across time points and samples with average values of about 3 in all groups indicating a rather high level of technical affinity in all samples. Perceived usability varies between values of 2.0 and 2.6 which suggests a fairly good usability of the device. In conclusion, no major differences across the samples at T_1, T_2, and T_3 can be stated. Participants and non-participants at T_2 and T_3, therefore, do not differ notably relating to the reported characteristics from the initial sample at T_1.

Results

The following presentation of results is structured by five main themes identified in the open statements at T_3. *Table 2* provides an overview of categories and codes. The quoted statements were translated from German into English by the author. The individual interviewees are denoted as A to F. After presenting the main results of T_3, attitudes and experiences are compared over time.

Integration into everyday life

Half of participants (*n* = 3) reported a passive use of the activity tracker. They used the device only at the end of the day to check the total number of steps and wore it only at daytime although there was also a function to monitor sleep. In general, they reported to spend only little time on the provided information.

Only two interviewees used the device more actively to review the intraday progress. One of them estimated to *"[…] look at the number of steps about ten times a day" (D).* Both synchronized the data with the smartphone app or with a computer albeit one of them only irregularly: *"When I have some time or when I'm in the mood I synchronise it with the app. […]. But that is not really my primary concern" (A).*

All participants who used the activity tracker regularly (n = 5) reported to use it not only for its 'smart' functions but also benefited from additional features. They described the activity tracker as an adequate replacement for a watch and referred to the integrated time display as a main advantage.

Table 1. Sample description and analysis of drop-outs

Sample Characteristics		T_1 (n = 15)	T_2 (n = 6)	T_3 (n = 6)
Mean age (*SD*)		68.0 (4.74)	71.7 (4.41)	69.0 (6.00)
Average number of steps during T_1 (*SD*)		8,849 (3,065)	8,389 (2,349)	8,799 (3,732)
Mean hours of physical activity per week (*SD*)	At start	5.2 (2.96)	5.3 (3.14)	5.3 (3.67)
	End of T_1	5.7 (2.92)	5.5 (3.02)	5.5 (3.56)
Average technical affinity (*SD*)	At start	3.0 (0.47)	2.9 (0.42)	3.1 (0.47)
	End of T_1	2.9 (0.41)	2.9 (0.23)	3.0 (0.20)
Average perceived usability (*SD*)	At start	2.2 (1.10)	2.6 (1.40)	2.5 (1.30)
	End of T_1	2.1 (0.61)	2.1 (0.71)	2.0 (0.40)

Table 2. Overview of categories and codes (T_3)

Category	Codes (n)	Participants (n)
Integration into everyday life	**24**	**6**
Passive use	6	3
Active use	3	2
Benefit from additional features	5	5
Exchange with others	10	6
Advancement of usage patterns	**13**	**6**
Daily habits	5	3
Irregular use	2	2
Effects of external conditions on intensity of use	6	4
Aspects relevant for long-term use	**16**	**5**
Objective information on activity level	5	4
Reminder function of the activity tracker	7	4
Perception as device related to health behaviour	4	4
Reasons for abandoned or reduced use	**27**	**6**
Lack of customization	10	4
Declining interest	6	4
Difficult manageability	9	6
Incompatibility with other technology	2	2
Effects on behaviour	**12**	**6**
No changes in physical activity	3	3
Adjustment of behaviour according to feedback	6	4
No negative pressure caused by feedback	3	3

When explicitly asked whether they talked about the feedback with other people, all participants (n = 6) reported that an exchange with others solely occurred unplanned and spontaneously mainly by *"pure coincidence" (E)*. None of the interviewees shared data in online communities. There was some exchange with family members. However, in most cases this did not provide added value for the users as fitness levels and using purposes were too different: *"My sister also has such a device. But her [activity] level is much higher than mine, [she takes] many more steps than I do" (A)*. Two interviewees shared their results in groups (i.e., sports group, Weight Watchers group).

Advancement of usage patterns

Some participants (n = 3) had developed daily habits, including individual goal setting, in the course of one year. These routines sometimes seemed to be independent of the device itself. By wearing the activity tracker as a wristband, it had become a daily companion. They could not imagine to ever stop using it without giving exact reasons: *"[…] there are things that just enter everyday life and then, it remains as it is. […]. Then, it becomes a habit. And this is precisely what happened to me with my watch [reference to the activity tracker]" (B)*.

Others (n = 2) reported an irregular use of the activity tracker. One participant used the device exclusively during hiking tours *"to measure walked distances" (F)*. Another one stated that the activity tracker was beneficial for monitoring the level of physical activity on specific days only, not permanently.

There were diverse effects of external conditions on intensity of use. Those included constant characteristics of the environment (e.g., self-perceived walkability of the neighbourhood) and effects of changing weather conditions: *"There have been fluctuations during the year. It's much more difficult in winter […]. When it's snowing and freezing the motivation is likely to flag" (D)*. A more intense use was sometimes impeded by constraints of everyday life like other obligations and sedentary work.

Aspects relevant for long-term use

Participants (n = 4) stressed that they were more aware of personal achievements when using the activity tracker because they received objective information on activity level. In this way, the device sensitized for physical activity: *"[…] it helps […] to achieve one's own goals. Because you can control it directly. It is not vague anymore and you can check it objectively" (D)*.

Another factor relevant for long-term use was the reminder function of the activity tracker. The device helped to *"overcome one's lack of will power" (E)*. Colour marking and pictorial representations of the activity level in the smartphone app were rated positive.

The activity tracker was perceived as a device related to health behaviour. Participants stressed the beneficial effect of physical activity on health. One priority of using the activity tracker was to remain mobile. However, the permanent reminder of health issues led to reduced use in one participant: *"The more often you think about diseases and all those things the more likely you will fall ill. […] I lead a healthy life and I feel well. Why should I deal with those things every day? I think there are more lovely topics (laughing)" (C)*.

Reasons for abandoned or reduced use

A more intense use of the activity tracker may have been impeded by their lacking customization. Participants complained that the device was not waterproof and they asked for more functions e.g. for managing drug intake or measuring pulse and blood pressure. Other statements indicated that some of the currently available functions such as information on energy consumption, were mainly deemed superfluous.

The general interest to use partly declined in the course of the year; sometimes caused by a lack of perceived need. Participants also referred to specific features which they were not interested in. Those included, e.g., success messages: *"I think they [note: the success messages] are ridiculous. In terms of: now I got this or that badge.*

This rather prevented me from using it instead of offering an incentive" (F).

A more frequent use was also inhibited by difficult manageability. All participants (n = 6) reported such problems. Interviewees explicitly asked for easy-to-use devices: *"When it's too complicated […] then you say 'I don't want this'" (F)*. Several participants used the labels 'young' and 'old' to mark differences in technology competences. They described having problems with the activity tracker and assumed that younger people would be capable of handling those: *"Future generations grow up with those things. They can all handle it. But for us oldies, it is not that simple" (E).*

When the activity tracker was not compatible with the smartphone this was reported as another reason for abandoned use (n = 2).

Effects on behaviour

Half of participants (n = 3) reported that the general lifestyle and the level of physical activity were not changed by using the activity tracker. Most of the participants perceived themselves as physically active before participating in the study: *"That is not because of the device, I am living an active life. I still play tennis regularly" (B).*

However, some participants (n = 4) also reported about certain situations in which they had adjusted their behaviour according to the feedback of the activity tracker relating to the goal of 10,000 steps or any individually aspired goal. But this did not apply to all participants: *"But I don't say 'Oh I only did 1,000 steps today, now I have to walk around or anything' – No, I don't do that" (E).*

Independent of whether changes in physical activity were reported, no participant felt negative pressure caused by the feedback of the activity tracker which was explicitly stated by three participants.

Comparison of T_2 and T_3

Table 3 indicates which themes were relevant at T_2, which emerged only at T_3, and which endured over time. Comparing the two follow-up points of data collection it becomes obvious that criticisms relating to technical features and functionality from the very beginning of use also persisted in the long term. One year after starting to use an activity tracker, the users still asked for customization and complained about lacking functions. Participants considered the activity tracker as a device related to health behaviour and were interested in measuring further information beyond the mere counting of steps. The specific information differed between the single participants and also seemed to be dependent on individual health status, e.g., the presence of chronic diseases such as type 2 diabetes mellitus. Also problems in manageability reported during the group interview were still relevant one year later. All participants reported on this topic which is a rather strong indication for its importance.

Objective information on the activity level (i.e., the number of steps) were considered the most relevant information at both points in time. At T_3 interviewees furthermore reported to benefit from additional features of the activity trackers. They for example mentioned the integrated time display. In combination with the reported daily habits and routines that had emerged during one year, the activity tracker had become a daily companion. Relating to the general utilization of the activity tracker, 'trial & error' utilization strategies and pragmatic use were prominent at T_2 while at T_3 users had established active or passive usage routines.

There was also some shift for the importance of different motivational elements over the course of one year. A general interest in tracking one's own physical activity which was observed at the beginning of use was mainly individualized one year later. In some cases, the aim of 10,000 steps per day was adapted to personal interests. In the long term, the reminder function of the device and links to health issues became relevant for continued use. An active exchange with other users relating to the level of activity and technical features that could be observed during the group interview did not show up in the long term. Although some specific environments for exchanging data were mentioned (i.e., sports group, Weight Watchers group) these possible resources for motivation were not used regularly. Relating to possible effects on behaviour, the feedback provided by the activity tracker was judged as relevant at both time points. Users reported heightened sensitivity towards physical activity in the short- and the long-term. While participants partly reported to feel overstrained at T_2, this was not relevant in the follow-up. No major changes in physical activity were reported at T_3.

Discussion

The aim of the study was to obtain insights into older adults' long-term use of an activity tracker. Objective information on activity level and the reminder function of the device were identified as important factors contributing to a long-term use. Most of the participants integrated the activity tracker into their everyday life in a rather passive way and individuals sometimes benefited strongly from the 'non-smart' functions of the devices. Usage patterns had advanced in the course of one year due to external conditions and the development of daily habits. Participants stressed a higher degree of sensitivity towards physical activity and its positive effects

Table 3. Comparison of salient themes at T_2 and T_3

Themes	T_2 "first impressions"	T_3 "relevant in the long term"
Technical features/ functionality	Lacking functions (desire for customization) Difficult manageability	
Most relevant information	Counting steps (objective information on activity level)	
		Benefit from additional features
Utilization	Pragmatism Trial & error	Passive vs. active usage routines
Motivational elements	General interest Aim: 10,000 steps	Individualized use Aims partly adapted to personal goals Reminder function Device related to health behaviour
Exchange with others	Active comparisons (level of activity, technical features)	Irregular and spontaneous exchange
Effects on behaviour	Relevance of feedback for behaviour	
	Feelings of being overstrained	No negative pressure caused by feedback No changes in activity level

on health and well-being as a consequence of using the activity tracker.

The reported importance of objective information fits well with the assumptions of psychological theories examining the role of goal-setting for behaviour changes[17,18]. Having the possibility to control the level of physical activity by means of wearable technology seems to be a relevant source of information also for older people. On average, participant estimated to spend about 5 hours a week physically active which is well above the guideline of 150 minutes[7]. However, referring to the objective measurement of physical activity, participants did not reach the recommended activity level of 10,000 steps[6] on average and the activity level did not generally change during the study period. This might have several reasons.

Relating to the incentive mechanisms it is important to notice that not everyone was motivated by the given goal of 10,000 steps in the long term. Therefore, possible alternatives should be contemplated. Other research in this field showed for example that women were more motivated by the 10,000 steps-message than men[48]. Also the deployment of gamification-elements, such as success messages cannot be entirely judged positively. As shown by the results, not everyone benefitted from those features, they might even impede use. The individualization of motivational elements and personalization of feedback is, therefore, worth thinking about, in particular whether motivation can be better targeted by the purpose (doing a certain number of steps) or rather by the activity itself (having fun while being physically active). A customization is needed to guarantee long-term use and long-term effects on behaviour. Individualized usage patterns for the usage of activity trackers have also been identified in recent research on human-computer interaction. In this context, it was mentioned that users frequently pause using an activity tracker but continue at a later point in time and sometimes use the device only for special occasions. It was proposed that these natural patterns of use should be considered to assure long-term adherence and prevent abandonment[49]. This also seems valid for the findings in the present study. Age-related questions need to be taken into account. Older people place for example more trust in those wearable fitness devices that they rate more usable[50]. Possible starting points might, therefore, include individualized and age-sensitive incentive mechanisms for physical activity and personalized feedback relating to achievements.

Secondly, behaviour changes are complex and caused by more than one single factor. Ecological models are one possibility to describe and forecast behavioural change processes. Technology can be regarded as part of the individual environment[51] but it also encompasses the immediate surroundings of a person, circumstances in life, and social networks. The effect of external conditions on the level of physical activity has already been shown in previous studies using pedometers[52]. The participants in this study also stressed effects of external conditions. The use of activity-tracking technology should be integrated into broader everyday settings and larger contexts to enhance motivation and help trigger behavioural changes.

Thirdly, it is important to underline that there was no active exchange with others relating to the feedback provided by the device in the long term. But exchanging with others might be an additional source of motivation and should be promoted accordingly. Especially in early states of use, reinforcement by family or peers seems to be important[53]. Suitable platforms and opportunities for interpersonal exchange should, there-

fore, be established and provided for older people who are using activity-tracking technologies. The reported problems in manageability, which were relevant in a first impression and still salient in the long term, might partly be solved by the availability of support, which has also been shown as an important factor for acceptance in other studies[36]. New platforms for interpersonal exchange need to be developed which, amongst others, provide sufficient coaching and support.

If those aspects are taken into account, the use of activity trackers might be a promising approach to increase awareness for health-conscious behaviours into old age and contribute to increases in physical activity.

Limitations

It must be considered that the sample was small and not representative. Participants were selected using convenience sampling and they owned a smartphone. Participants in this study may be more favourable towards new technologies than people who do not use smartphones. The analysis of drop-outs showed that the three samples did not differ according to the characteristics analysed. Nevertheless, they might probably differ relating to other characteristics like personality or other socio-demographic variables. The findings of this study, therefore, cannot be generalized to older adults in general and must be replicated in other groups to infer reliable statements.

Interrelations between individual predispositions and technology use like, e.g., the role of socio-economic status or experiences with other technologies for the use of activity-tracking technologies, might be studied in future works.

Also, the proposed integration of age-sensitive incentive mechanisms into activity-tracking devices needs further investigation since such approach might also imply negative age-stereotypes which might in turn, negatively affect using intentions.

Another limitation of this case study is that participants' experiences are limited to the *ViFit connect Activity Tracker* only. Other activity trackers might display the gathered information differently or make use of other motivational strategies. Further studies are needed to compare the findings of this study with findings for other activity trackers.

Conclusion

For a small sample of older adults, the study showed that an activity tracker was still used after one year and that it continued to provide benefit for the users. Activity trackers could not turn couch potatoes into star athletes and activity tracking cannot be considered a universal remedy for the high prevalence of inactivity. Nevertheless, the present study shows some important aspects which should be addressed to further improve older people's user experiences when using activity-tracking technology.

Adherence to ethical principles

The usability-study has obtained approval from the responsible ethics committee (Faculty of Medicine, Independent Ethics Committee RWTH AACHEN, EK038/15, February 2015). Prior to their participation in the group interview and the telephone interviews, a written informed consent was obtained from all individuals included in the study. Data is presented in a form which does not allow for personal identification.

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