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Year: 2022

Version: Published version

Please cite the original version:

Kari, T., Makkonen, M., Frank, L., & Kettunen, E. (2022). Does Physical Activity Application Use Promote Self-Efficacy for Exercise? A Study Among Aged People. In Proceedings of the 55th Hawaii International Conference on System Sciences (HICSS 2022) (pp. 1438-1447). University of Hawai'i at Manoa. Proceedings of the Annual Hawaii International Conference on System Sciences. https://doi.org/10.24251/HICSS.2022.179

Does Physical Activity Application Use Promote Self-Efficacy for Exercise? A Study Among Aged People

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Abstract

The importance of sustained physical activity in healthy aging is well established. To achieve sustained physical activity and exercise, related self-efficacy is important. Hence, solutions to promote self-efficacy for exercise among aged people are urgently needed. Digital wellness technologies provide a potential solution, but research on their potential to promote self-efficacy for exercise is scarce and more research is needed. To address this need, this study investigates how effective is the use of a physical activity application in promoting self-efficacy for exercise among aged people. Self-efficacy levels were compared between three different time points: before taking the application into use and after 4 and 12 months of use. The results suggest that physical activity application use can be effective in promoting self-efficacy for exercise among aged people as there was an improvement in most of the self-efficacy items as well as in total self-efficacy already after 4 months of use and this improvement was sustained after 12 months of use.

1. Introduction

The proliferation of *digital wellness technologies,* that is, “digital technologies that can be used to support different aspects of wellness” [1], has allowed various types of users with different physical activity levels to find suitable solutions for personal use [2, 3]. There exist a wide array of devices, applications, and services to support physical activity and exercise.

Supporting physical activity and exercise, either with technology or other means, is important because physical activity has significant health benefits and contributes to the prevention of non-communicable diseases in all age groups [4]. In addition, physical activity helps in maintaining the ability to function when a person gets older and is vital to ward off frailty and age-related illness [5]. The World Health Organization (WHO), as well as respective national health institutes, provide research-based physical activity guidelines for different age groups. Still, insufficient physical activity is a major global problem in all age groups [4]. For example, in Finland, where our study was conducted, only around one-fourth of the people aged 60 years and older meet the suggested minimum of physical activity set by the WHO guidelines [6].

Aged people form an important target group for physical activity supporting actions: the global population is ageing, and practically all countries are experiencing a growth in the proportion of their older population. The global number of people aged over 65 years is projected to double by the year 2050, and at the same time, the life expectancy at older ages is improving [7]. This, together with the insufficient physical activity levels, raises serious concerns among healthcare and policy providers, making it imperative to find more solutions to support physical activity and exercise among aged people.

For achieving sustained physical activity and exercise, related self-efficacy for exercise is important [8–10]. Self-efficacy refers to the individual’s “belief in one’s capabilities to organize and execute the courses of action required to produce given attainments” [11]. Thus, innovative solutions to promote not just short-term physical activity and exercise but also longer-term physical activity and exercise, as well as related self-efficacy among aged people, are urgently needed.

URI: https://hdl.handle.net/10125/79511
978-0-9981331-5-7

Digital wellness technologies provide a prospective solution. The potential of digital wellness technologies to promote physical activity and exercise among aged people has been suggested [e.g., 1, 12], but more detailed research on their potential to promote related self-efficacy among aged people is scarce, and more research is needed. To address this need, our study investigates the following research question: *How effective is the use of a physical activity application in promoting self-efficacy for exercise among aged people*? By addressing this need, we contribute to the information systems (IS) stream of research on the ability of information technology to influence non-IS related self-efficacy. Further, although the purpose of the study is not to investigate the influence of self-efficacy on human behavior, considering the extant evidence on this [e.g., 8–11], we also contribute to the stream of research on the ability of digital wellness technologies to support physical activity and exercise behavior. We also provide needed insights on how such technologies could support self-efficacy for exercise among aged people. The study is part of an ongoing DigitalWells research program in which aged people take a mobile physical activity application into use.

2. Theoretical background

2.1. Self-efficacy

Self-efficacy is a concept proposed by psychologist Albert Bandura [13]. It refers to the individual's "belief in one's capabilities to organize and execute the courses of action required to produce given attainments" [11], or in other words, "the belief that one can achieve what one sets out to do" [11].

Bandura [13] also presents central factors that influence self-efficacy. An individual's beliefs in personal efficacy are based on four main sources of influence: performance accomplishments, vicarious experience, verbal persuasion, and emotional arousal, all of which can have either a positive or a negative influence on self-efficacy [13]. *Performance accomplishments* are exceptionally influential, as they are based on personal mastery experiences, that is, experiences an individual gains when taking on a new task and being successful at mastering it. *Vicarious experience* refers to an experience of observing other individuals complete a task successfully without adverse outcomes. Observing peers succeed in a task increases the observer's belief in being able to succeed in a similar task as well. *Verbal persuasion* refers to external positive verbal feedback concerning an individual's ability to succeed in a given task, and it can persuade an individual to believe in being able to succeed in the task. *Emotional arousal* refers to an individual's current state of arousal and how it influences the perceptions of being able to succeed in a task. Whereas positive arousal can have a positive influence, aversive arousal tends to decrease an individual's belief of succeeding in a task [13]. Out of these four sources, performance accomplishments have consistently been shown to be the most influential [8]. It is important to note that all these main sources of influence can also decrease the level of self-efficacy if they are associated negatively. For example, if an individual fails in a task and does not gain a mastery experience, it can decrease self-efficacy [13].

In the specific context of physical activity and exercise, [51] studied the key sources of self-efficacy for physical activity among older adults. They found that mastery experiences, self-persuasion, and reduction in negative affective state are the most important predictors of self-efficacy for physical activity among older adults. However, contrary to [13], they found vicarious experiences to have no association with subsequent self-efficacy beliefs among older adults. This could be due to older adults' lack of social models for physical activity and exercise [51].

The impact that self-efficacy has on human behavior and its influence on an individual's actions is significant. An individual with high self-efficacy is more likely to undertake tasks that he/she perceives as difficult or challenging, whereas an individual with low self-efficacy is more likely inclined to avoid difficult tasks [13, 14]. Self-efficacy can also have a positive role on motivation towards an activity or a task and eventually on performance, though this is not always straightforward [15]. With suitably challenging tasks, an individual may experience the satisfaction of success and subsequently increased motivation, whereas with too easy or too difficult tasks, an individual may experience boredom or frustration and subsequently decreased motivation [16]. Individuals with high self-efficacy are likely to be generally more successful than individuals with low self-efficacy [11]. This also applies in the case of physical activity and exercise [8].

Self-efficacy is also one of the most important determinants of physical activity and exercise [17, 18, 51]. It is important in both the adoption and the maintenance phases of exercise [51], although some research suggest that the role could be lesser during the maintenance phase [8, 19]. Nevertheless, after initial mastery experiences, self-efficacy helps to maintain and resume health-related behaviors, even in the face of challenges [51]. Moreover, self-efficacy has been demonstrated to be a significant predictor of long-term exercise adherence [8, 10, 51]. This is the case also among aged people [9, 20, 45]. For example, in a study by [45], self-efficacy significantly predicted exercise behavior among older adults while controlling for biological and behavioral influences.

2.2. Digital wellness technologies

Previous research has shown that digital wellness technologies, in general, can potentially support physical activity and exercise in various ways. For example, digital wellness technologies can support increasing physical activity levels [e.g., 1, 21] and goal-setting [e.g., 22, 23]. They can add to the enjoyment of exercise by using gamification [49, 50] or exergames [e.g., 41–43]. They can support by providing social support features [e.g., 24], and certain novel solutions also include digital coaching features [see, e.g., 25, 26]. Furthermore, feedback provided by digital wellness technologies can increase the user's awareness of personal physical activity [e.g., 27], which subsequently can foster motivation and self-efficacy for exercise [28]. Digital wellness technology use can also increase confidence in having control to perform exercise, which too can foster self-efficacy [28]. Besides these favorable outcomes, it should also be noted that occasionally users face negative and harmful experiences with these technologies [29]. Aged people have also been shown to face different challenges when implementing such technologies into use and during the use [46].

Digital wellness technologies have been found to possess potential in promoting physical activity and exercise also among aged people, although often with certain limitations. For example, in studies focusing on aged people, [30] found that interventions utilizing a mobile health application are potential in promoting physical activity and in reducing sedentary time in the short term. Similarly, [31] found that interventions utilizing eHealth solutions can be effective in promoting physical activity, at least in the short term. [21] found low-quality evidence for a moderate effect on physical activity in interventions utilizing physical activity monitors. [1] found in a 12-month follow-up study that physical activity application use leads to a modest increase in physical activity levels. [32] found that mHealth technology can, among several other outcomes, improve physical activity and self-efficacy.

In the light of the previous related research [e.g., 28], it seems that physical activity applications can be effective in promoting self-efficacy for exercise – also among aged people [32]. Moreover, [33] found that self-tracking, an activity that such applications often support, could increase older adults' self-efficacy for exercise. [34] found that self-efficacy can be influenced by technology-supported feedback. More precisely, they found that the graphical inspection of data, which is another activity often supported by physical activity applications, had a positive effect on experiencing success in a task, and experiencing success increased self-efficacy regarding the task [34]. On a similar note, [44] in their review on general intervention techniques to promote self-efficacy for physical activity, found that feedback on past or others' performance produced the highest levels of self-efficacy.

Whilst the existing evidence suggests that solutions like physical activity applications may indeed promote self-efficacy for exercise, research and evidence on the matter among aged people are limited. This study investigates the topic further with focus on aged people.

3. Methodology

The main purpose of this study was to investigate how effective is the use of a physical activity application in promoting self-efficacy for exercise among aged people. This was done by examining the changes in self-efficacy between three different time points: before taking the application into use (t0 – as the baseline level), after 4 months of use (t1), and after 12 months of use (t2). Thus, the participants of this study consist of those partaking in the DigitalWells research program and using the application for at least 12 months.

3.1. The physical activity application used in the study

The application was developed for the target group in the ongoing DigitalWells research program. The application operates on the Wellmo application platform [48], where the application features constitute their own entity. Wellmo supports iOS and Android operating systems. The central features are related to tracking everyday physical activity and exercise. This includes, for example, features for tracking and following the conducted physical activities and exercises, as well as weekly, monthly, and annual reports on the conducted physical activity and exercise. It is also possible to import data from external services supported by the Wellmo platform, such as Google Fit, Apple Health, and Polar Flow.

3.2. Research setting, data collection, and data analysis

The first field groups in the research program started in June 2019, after which new groups have started continuously. The study was conducted in Finland, and the field groups (i.e., the participants) were recruited via the Finnish pensioners' associations. No limits beyond age and owning a smartphone were set for partaking, meaning that the physical activity level of the participants could range from very low to very high.

Each field group was assigned a field researcher who guided the participants in taking the physical activity application into use and using it. The participants used the application in their everyday life and conducted physical activity and exercise according to their own preferences: they were not provided with any specific exercise programs to follow or goals to reach out for, but instead could freely conduct physical activity and exercise how and when they preferred. The application and its use were free of charge for the participants, but they were required to have their own smartphone. During the research program, the participants were presented with general facts about the benefits of physical activity and encouraged to envision themselves some weekly plan for conducting physical activity.

The local ethical committee was contacted before the start of the research program deeming that no separate approval was needed for this study. All participants gave a written informed consent.

For data collection and analysis, this study follows a quantitative approach. The data on self-efficacy was collected with online surveys at three different time points (t0, t1, and t2). Self-efficacy was measured as a self-report by using the Self-Efficacy for Exercise (SEE) Scale [35], which assesses an individual's beliefs in his/her ability to exercise three times per week for 20 minutes. The SEE scale includes nine statements (items) concerning personal confidence related to conducting exercise (presented in Table 1), measured on a scale of 0-10, where 0 presents *not confident* and 10 *very confident*. The SEE scale also includes a self-efficacy total score value (0-90), presenting the overall self-efficacy, which is calculated by summing the responses to each item. A higher score indicates higher self-efficacy for exercise [35]. The SEE scale is widely used in measuring self-efficacy for exercise, and it has been tested to provide reliability and validity also when used with older adults [35].

Table 1. SEE scale statements [35]

How confident are you right now that you could exercise three times per week for 20 minutes if:
1. The weather was bothering you
2. You were bored by the program or activity
3. You felt pain when exercising
4. You had to exercise alone
5. You did not enjoy it
6. You were too busy with other activities
7. You felt tired
8. You felt stressed
9. You felt depressed

For this study, the SEE scale questionnaire was translated from English to Finnish and Swedish, as there were both Finnish and Swedish (both are official languages in Finland) speaking participants. The data was collected with an online questionnaire, each participant receiving a survey invitation link via email. They were also given instructions on answering. Any interim results of the questionnaire analysis were not presented to the participants during the study period.

The analysis was conducted with the IBM SPSS Statistics 26 software. The changes in self-efficacy were analyzed by comparing the means in the self-efficacy scores between t0 and t1, between t0 and t2, as well as between t1 and t2. This was done to examine if there was a change in self-efficacy between t0 and t1 as well as between t0 and t2; if the potential changes occurred already at t1 or not until at t2; and if the potential changes at t1 would be sustained at t2. The changes in self-efficacy were measured at both item and construct (i.e., the overall self-efficacy measured by the self-efficacy total score) level. When interpreting the results of the analysis, the statistical significances of the changes were analyzed with the Wilcoxon signed-rank test [36] because of the non-normal distributions of some of the items. The threshold of statistical significance was set to $p < .05$. However, because multiple comparisons were conducted (more specifically, three comparisons – t0 vs t1, t0 vs t2, and t1 vs t2), this threshold was adjusted with the Bonferroni correction [37], thus resulting in $p < .017$ (.05 / 3) to be used as the adjusted threshold of statistical significance.

4. Results

4.1. Sample

At the time of conducting the study, 264 participants of the research program had been partaking in the program for 12 months or more and had responded to all the three self-efficacy questionnaires, forming the sample of this study. Out of them, around 40% were male and 60% female. The respondents' age varied between 60 and 85 years, the mean age being 70.3 years (standard deviation 4.3 years). The perceived physical activity level (at t0) of the participants was mostly moderate, as was stated by 73.5 % of the participants. In addition, there were more than twice the number of more active (very high or high, 19.1 %) than less active (low or very low, 7.4 %) participants. As a methodological consideration, it should be noted that this was measured as a subjective perception and can vary from objective measurements due to the general limitations of assessing physical activity by self-report [e.g., 40]. A majority of the participants seemed to be rather familiar with smart phone apps, as almost 78 %

had been using them for 3–5 years or more. More detailed descriptive statistics of the sample are reported in Table 2.

Table 2. Descriptive statistics of the sample (n = 264)

	n	%
Gender		
Male	104	39.8
Female	157	60.2
Other	0	0.0
N/A	3	–
Age		
Under 65 years	18	6.9
65–69 years	93	35.8
70–74 years	112	43.1
75 years or over	37	14.2
N/A	4	–
Marital status		
Married	169	65.5
Common-law marriage	23	8.9
Single	11	4.3
Divorced	36	14.0
Widow(er)	19	7.4
N/A	12	–
Highest level of education		
Primary education	22	8.6
Vocational education	198	77.0
Uni of applied sciences	10	3.9
University	27	10.5
N/A	7	–
Perceived physical activity level		
Very high	5	1.9
High	44	17.1
Moderate	189	73.5
Low	15	5.8
Very Low	4	1.6
N/A	7	–
Years using smartphone applications		
<1 year	16	6.3
1–2 years	40	15.9
3–5 years	79	31.3
6–10 years	73	29.0
>10 years	44	17.5
N/A	12	–
Language		
Finnish	251	95.1
Swedish	13	4.9

4.2. Changes in self-efficacy

Of the sample, not everyone responded to the self-efficacy questionnaire at all the three time points (t0, t1, and t2). A respondent might also have a missing response in one or more of the items in the questionnaire. Thus, if a participant did not answer a particular item in all the three surveys, all responses from that participant for that particular item were excluded. For calculating the total self-efficacy score, only responses from those participants who had responded to all the items in all the three surveys were included. Thus, the exact number of respondents (N) varies slightly between the items.

The SEE scale used for measuring self-efficacy for exercise [35] included nine statements concerning personal confidence related to conducting exercise. The statements, as well as the results, are depicted in Table 3: from left to right, the columns report the statement code, number of respondents (N), the mean and standard deviations of the scores at the three time-points, and the p-values. The p-values are from the Wilcoxon signed-rank tests, and the first p-value is for the test comparing the statistical significance of the change in the mean scores between t0 and t1, whereas the second p-value is for the test comparing the statistical significance of the change in the mean scores between t0 and t2. Rows S1-S9 present the item level changes, whereas the row TS (total score) presents the construct level change, i.e., the overall change in self-efficacy.

Table 3. Changes in self-efficacy for exercise

S	N	Time 0		Time 1		Time 2		p 0 vs 1	p 0 vs 2
		M	SD	M	SD	M	SD		
S1	165	6.7	2.9	6.8	2.5	7.0	2.3	0.140	0.146
S2	163	6.1	2.5	6.6	2.3	6.4	2.7	**0.005**	0.097
S3	164	4.4	2.6	5.4	2.6	5.4	2.8	**<0.001**	**<0.001**
S4	159	8.3	2.0	8.5	2.2	8.5	2.2	0.060	0.069
S5	159	5.5	2.4	6.1	2.5	6.0	2.8	**0.006**	0.032
S6	162	5.6	2.5	6.5	2.5	6.5	2.5	**<0.001**	**<0.001**
S7	162	5.8	2.4	6.6	2.2	6.5	2.5	**<0.001**	**0.001**
S8	157	6.6	2.5	7.4	2.4	7.1	2.6	**<0.001**	0.021
S9	158	6.4	2.5	6.9	2.5	6.8	2.6	**0.013**	0.031
TS	138	56.0	16.3	62.0	15.0	61.5	16.8	**<0.001**	**<0.001**

S = Statement; M = Mean; SD = Standard deviation

How confident are you right now that you could exercise three times per week for 20 minutes if:

S1 = The weather was bothering you

S2 = You were bored by the program or activity

S3 = You felt pain when exercising

S4 = You had to exercise alone

S5 = You did not enjoy it

S6 = You were too busy with other activities

S7 = You felt tired

S8 = You felt stressed

S9 = You felt depressed

TS = Total score

At the item level, three out of the nine items (S3, S6, and S7) had a statistically significant change at both t1 and t2 when compared to t0. In turn, four items (S2, S5, S8, and S9) had a statistically significant change at t1 but not at t2. All the aforementioned changes were positive, meaning that the mean score had increased. The two items (S1 and S4) in which there were no statistically significant changes at neither t1 nor t2 were the two items with the highest mean score at t0 (i.e., had the least room for improvement).

At the construct level, the total score (TS) had a statistically significant change at both t1 and t2 when compared to t0. The mean total score had increased from 56.0 at t0 to 62.0 at t1 and to 61.5 at t2.

In addition to the total score, five items (S2, S5, S7, S8, and S9) had a slightly lower mean score at t2 than at t1, whereas only one item (S1) had a higher mean score at t2 than at t1. However, none of the changes between t1 and t2 were statistically significant. This means that the changes at t1 were sustained at t2. In other words, the (positive) changes in self-efficacy were observable already after 4 months of use and were generally sustained close to the same level after 12 months of use.

5. Discussion and conclusions

The main purpose of this study was to investigate the following research question: How effective is the use of a physical activity application in promoting self-efficacy for exercise among aged people? The study participants took into use a physical activity application to track their everyday physical activity and exercise. Self-efficacy was measured by using the SEE scale [35] at three different time points: before taking the application into use (t0), after 4 months of use (t1), and after 12 months of use (t2). The changes in self-efficacy were measured at both item and construct level.

As a response to the research question, the results suggest that the use of a physical activity application can be effective in promoting self-efficacy for exercise among aged people. There was a notable and statistically significant improvement in several self-efficacy items as well as in total self-efficacy after 4 months of use and after 12 months of use when compared to the baseline level. Such increase in self-efficacy for exercise is, of course, very welcomed, as it has been found important for sustained physical activity and exercise [e.g., 8–10]. These results complement and are in line with previous literature [e.g., 28, 32] on the ability of physical activity applications and similar digital wellness technologies to support self-efficacy for exercise. The results complement previous research by demonstrating that the improvement in self-efficacy for exercise occurs already during the first four months of use, which in the cases of digital wellness technology use and physical exercise is still a relatively short period. Furthermore, this improvement is not just a short-term occurrence but is also sustained for longer-term, as implied by the sustained improvement in self-efficacy after 12 months of use. Such sustained improvement also supports the longevity of exercise, which is important for acquiring related health benefits.

However, it should be noted that the observed increase in self-efficacy was not any higher after 12 months of use than after 4 months of use, that is, the longer use period did not result in a higher increase in self-efficacy. This is interesting and might be due to the used physical activity application, as it was designed for tracking everyday physical activity and exercise. Perhaps such features that guide in conducting the physical activity and exercise in more detail (e.g., digital coaching [25, 26]) or certain gamification features (see e.g., [49, 50]) would keep the self-efficacy in an upward trend for a longer time. This warrants further investigation. Another potential explanation, which would also require more specific research, could be that self-efficacy may not be increased infinitely without additional actions or interventions, and the application use becoming habitual could influence its potential to change non-IS related self-efficacy over time. Naturally, users' self-efficacy towards using the application itself would likely continue to increase with habitual use [47], whereas the influence on non-IS related self-efficacy, in this case self-efficacy for exercise, is probably less likely to continue as strong after a certain time point. Overall, our results demonstrate the ability of information technology to influence non-IS related self-efficacy, as the studied information technology artefact (i.e., the application) use was found to be potential in promoting non-IS related self-efficacy (i.e., self-efficacy for exercise).

When contemplating the results from the perspective of the self-efficacy theory [13], we speculate that from the four main sources of influence, performance accomplishments were the main source behind increased self-efficacy. The physical activity application enabled self-tracking of physical activity and exercise as well as graphical inspection of the related data, both of which have been found as distinct determinants to support the increase in self-efficacy [33, 34]. The self-tracking and inspection of the data have enabled users to verify that they had been successful at mastering a task.

The results also indicate that the use of a physical activity application can be effective in promoting self-efficacy for exercise among aged people under free-living physical activity conditions, that is, in regular everyday life without accompanied active exercise counseling that would focus on increasing exercise skills, for example. This is an important finding, as for most of the potential users, taking an application or another digital wellness technology into personal use is a much more accessible and cheaper option than signing up for an exercise program with exercise-related counseling.

From a practical point of view, this means that the actors working in physical activity and exercise promotion could utilize physical activity applications to support self-efficacy for exercise among aged people. Such applications can also be utilized to support self-efficacy for exercise and physical activity during exceptional times, such as those when there are exercise-related restrictions or home confinements in force. One example of this is the ongoing coronavirus disease 2019 (COVID-19) pandemic caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which has limited the possibilities for physical activity and exercise especially among aged people and has had detrimental effects on their physical activity levels [38, 39]. And as previous literature has shown, supporting self-efficacy for exercise can subsequently promote physical activity and exercise behavior as well.

6. Limitation and future research

This study has some limitations that should be acknowledged. First, due to the lack of a control group, it is not certain whether the changes in self-efficacy for exercise resulted mainly from using the application or because of taking part in the study or research program. However, as no exercise counseling was provided to the participants and they conducted physical activity and exercise in free-living conditions, we have a strong reason to believe that the physical activity application use had a significant role in promoting self-efficacy for exercise. Second, on average, the participants seemed to represent a rather physically active segment of the aged population, meaning that they could have had a higher self-efficacy (at t0) compared to the aged population in general. This might have limited the size of the changes in self-efficacy. For future research, it would be valuable to acquire more participants with also lower physical activity levels in order to minimize this non-participation bias. Third, we cannot rule out the possible influence of the COVID-19 pandemic and the resulting restrictions, such as the temporal closures of different exercise facilities and pauses in many of the group activities, which may have had a negative influence on some participants' self-efficacy for exercise around t1 and t2.

For future research, it would also be interesting to collect qualitative data (e.g., by user interviews) to further analyze the individual differences among people in measuring the parameters related to self-efficacy. Another aspect that scholars should look into is how to improve the self-efficacy scale/s to better fit the research context of digital application use for physical activity. Studies focusing on the interface and design of the applications (e.g., usability study), as well as mediations to peoples' daily life beyond physical activity, would also be valuable. Future research could also focus on a longitudinal investigation on the relationship between self-efficacy for exercise and physical activity levels in order to verify whether the changes in self-efficacy also lead to changes in physical activity levels. This is actually in our future plans. Further, as longitudinal research on related topics is much called for, our plan is also to continue the follow-up surveys in order to complement earlier study findings [e.g., 52–54].

7. Acknowledgements

We are thankful to The Social Insurance Institution of Finland for funding the DigitalWells program and research project.

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