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DEMOGRAPHIC DIFFERENCES IN THE EFFECTIVENESS OF A PHYSICAL ACTIVITY APPLICATION TO PROMOTE PHYSICAL ACTIVITY: STUDY AMONG AGED PEOPLE

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Abstract The global population is ageing and simultaneously the life expectancy at older ages is improving. To support healthy and active aging, it is imperative to find solutions to support physical activity (PA) in older age. Digital wellness technologies are a potential solution, but in order for such technologies to be successful, research is needed to gain a better understanding on their use and effectiveness among aged people. To address this need, this study investigated the effectiveness of a physical activity application to promote PA behavior among aged people of different demographics (gender, age, education, marital status). PA levels were measured before taking the application into use and after 12 months of use. The results suggest that a physical activity application can be effective in promoting PA behavior among aged people as there was a notable and a statistically significant increase in walking and total PA levels between baseline and 12-month follow-up. Regarding the demographic differences, there were very few differences in the changes in PA levels between different demographics, suggesting the effectiveness is not subject to the demographic background of the user.

Keywords: digital wellness, wellness technology, mobile wellness application, mobile application, physical activity, aged people, young elderly, IPAQ-E, follow-up study, physical activity application

1 Introduction

The global population is ageing and practically all countries are experiencing growth in the proportion of their older population. Globally, the number of people aged over 65 years is projected to double by 2050, and at the same time, the life expectancy at older ages is improving (United Nations 2019). This makes healthcare and policy makers concerned, and it is imperative to find more solutions to support PA in older age. PA has significant health benefits and contributes to the prevention of non-communicable diseases across all age groups, but also aids in upkeeping the ability to function when a person gets older and is vital to ward off frailty and age-related illness (Hoogendijk et al. 2019). The World Health Organization (WHO) as well as several national health institutes provide research-based PA guidelines. Yet, insufficient PA is a major global problem across all age groups (WHO 2020). For example, the WHO (2020) recommends that people aged 65 years and older should do at least 150–300 minutes of moderate PA or at least 75–150 minutes of vigorous PA per week, or an equivalent combination. Balance and muscle-strength exercises should also be conducted regularly. Additional health benefits can be reached with more PA. In Finland, where our study was conducted, only around one fourth of the people aged 60 years and older meet these guidelines (THL 2019). Thus, innovative solutions to promote PA among aged people are urgently needed.

Digital wellness technologies, that is, “digital technologies that can be used to support different aspects of wellness” (Kari et al. 2021), represent a potential solution. There are various PA devices, applications, and services, the use of which has become increasingly common for diverse types of users with different PA levels (Kettunen et al. 2017; Moilanen et al. 2014). Their potential to promote PA behaviors among aged people has been suggested, but more research on their effectiveness is called for (e.g., Carlsson & Walden 2017; Larsen et al. 2019; Seifert et al. 2018). To address this, our study investigates the following research question: *How effectively can a physical activity application promote PA behavior among aged people of different demographics?* For PA, we follow the definitions by WHO (2020). The investigated demographics are gender, age, education, and marital status. By addressing this, we contribute to the IS stream of research on the ability of digital wellness technologies to influence behavior change and also provide insights on how they could support changes in PA behavior among aged people. The study is part of an ongoing research program in which aged people participants take into use a mobile physical activity application.

2 Digital Wellness Technologies Among Aged People

A key reason for using digital wellness technologies and physical activity applications is often the expected positive effects on PA behavior and health. When using digital wellness technologies, the users are receptive to potential changes in their PA behavior. As Oinas-Kukkonen (2013, p. 1225) notes, “information technology always influences people’s attitudes and behaviors in one way or another”, either intendedly or unintendedly. There is a plethora of information systems that can be used to persuade (either positive or negative) behavior changes (Oinas-Kukkonen 2013). Such systems are often discussed in the literature using the terms persuasive systems (e.g., Oduor & Oinas-Kukkonen 2021) or persuasive technology (e.g., Fogg 2003). On this line, Oinas-Kukkonen (2013) presented the concept of behavior change support system (BCSS), defined as “a socio-technical information system with psychological and behavioral outcomes designed to form, alter or reinforce attitudes, behaviors or an act of complying without using coercion or deception”.

Digital wellness technologies (e.g., physical activity applications) can act as BCSSs in several ways, as by using such technologies, the users are exposed to different user experiences that can act as drivers for future PA behaviors (e.g., Kari et al. 2016a; Karppinen et al. 2016). Hence, using such technologies can potentially change and support PA behaviors in various ways. For example, digital wellness technologies can be used to increase PA levels (e.g., Larsen et al. 2019; Romeo et al. 2019), and to reduce sedentary behaviors (e.g., Stephenson et al. 2017). They can support goal-setting (e.g., Gordon et al. 2019; Kirwan et al. 2013), and some advanced products also include digital coaching features (e.g., Kari & Rinne 2018; Kettunen et al. 2020; Schmidt et al. 2015). Features for social support are another benefit (e.g., Sullivan & Lachman 2017). They can also make PA more compelling via gamification (Kari et al. 2016b; Koivisto & Hamari 2019) or exergaming (e.g., Kari 2014; Kari et al. 2019; Loos & Zonneweld 2016). Moreover, digital wellness technologies can provide different feedback, which can increase the user’s awareness of PA and motivate to improve related behavior (e.g., Wang et al. 2016). However, the “learning-effect” resulting from the increased awareness may also lead to use discontinuance (Kari et al. 2017, p. 285). One should also note that sometimes users face negative and harmful experiences with these technologies (Rockmann 2019). The perceived compatibility is also important (Makkonen et al. 2012).

Digital wellness technologies have been found promising in terms of promoting wellness and PA behavior among aged people, however, questions have been posed regarding their effectiveness. In studies focusing on aged people, Changizi and Kaveh (2017) found that mobile health solutions can improve PA, self-management, and self-efficacy among other things. Muellmann et al. (2018) found interventions utilizing eHealth solutions to be effective in promoting PA at least on short-term. Similarly, Yerrakalva et al. (2019) found that mobile health application-based interventions are potential in promoting PA and reducing sedentary time on short term. Larsen et al. (2019) found low-quality evidence for a moderate effect of physical activity monitor-based interventions on PA. Stockwell et al. (2019) found that digital behavior change interventions may increase PA and ability to function. A common conclusion in these studies is that more high-quality studies are required.

3 Methodology

To investigate how effectively can a physical activity application promote PA behavior among aged people of different demographics (gender, age, education, marital status), we examined the changes in PA levels between baseline (before taking the application into use) and follow-up (after 12 months of use). Thus, the participants of this study consist of those partaking in the research program and using the application for a whole 12 months or longer.

3.1 The Physical Activity Application Used in the Study

The application was developed for the target group in the ongoing research program. The application operates on the Wellmo application platform (Wellmo 2019), where its features constitute their own entity. Wellmo supports iOS and Android operating systems. The central features are related to tracking PA, including for example, logging conducted PA and following it through weekly, monthly, and yearly reports. User can also import data from external PA services supported by Wellmo platform.

3.2 Research Setting, Data Collection, and 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., participants) were recruited via the Finnish pensioners' associations. No limits beyond age were set for partaking, meaning that the baseline PA level could be anything from very low to very high. Each field group was assigned a field researcher who guided the participants in taking the application into use and using it. The participants used the application in daily life and conducted PA according to their own preferences, meaning they were not provided with any specific PA programs to follow or goals to reach out for, but instead could freely conduct PA 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.

The data on PA levels were collected with surveys and measured as a self-report by using the IPAQ-E (Hurtig-Wennlöf et al. 2010). The IPAQ-E is a modified version of the short-format IPAQ (Craig et al. 2003; Ekelund et al. 2006), and it has been culturally adapted and validated for the elderly (Hurtig-Wennlöf et al. 2010). The IPAQ and IPAQ-E are designed to provide a set of well-developed instruments that can be used to obtain comparable estimates of PA (IPAQ group 2005a). The IPAQ is the most widely used and validated PA questionnaire (Lee et al. 2011; van Poppel et al. 2010). The IPAQ-E focuses on collecting self-reported PA data on sitting time, walking, moderate PA, and vigorous PA from the period of last seven days. For this study, the IPAQ-E questionnaire was translated from Swedish to Finnish following the wording of the Finnish short-format IPAQ. As there were Finnish and Swedish (both are official languages in Finland) speaking participants, both language versions were used. The baseline data was collected with printed questionnaires in organized meetings. The participants were given oral and written instructions on answering. The follow-up data was collected with an online questionnaire, each participant receiving a survey invitation link via email. 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.

Before the analysis, the *Guidelines for the data processing and analysis of the International Physical Activity Questionnaire* (IPAQ group, 2005b) and the guidelines presented by Hurtig-Wennlöf et al. (2010) were followed. First, before the analysis, the standard methods for the cleaning and treatment of IPAQ datasets were conducted (IPAQ group 2005b, p. 10-11). Second, the results are presented in *median minutes per week* rather than means, together with the interquartile ranges (25th–75th percentile) (IPAQ group 2005b); and as advised by Hurtig-Wennlöf et al. (2010, p. 1853), the results are presented in *time in minutes spent in different intensities* instead of converting into metabolic equivalent of task values (MET) and MET-minutes, except for the *total PA* which is presented in MET-min per week. Total PA was calculated using the formula: $3.3 * \text{walking min} + 4.0 * \text{moderate min} + 8.0 * \text{vigorous min}$ (IPAQ group 2005b). However, as Hurtig-Wennlöf et al. (2010) note, the used weighting factors correspond to activity-specific MET values in adults and might not be appropriate for older people (e.g., moderate intensity level in the elderly is likely lower than the same intensity level in younger adults). Yet, they assumedly “can still reflect the proportions of PA intensities and are therefore useful for ranking participants with regard to PA” (Hurtig-Wennlöf et al. 2010, p. 1853).

The analysis was conducted with the IBM SPSS Statistics 26 software. The changes in sitting and different types of PA behavior (walking, moderate, vigorous) as well as total PA were analyzed by comparing the PA levels between the baseline and the follow-up. The statistical significance of the overall changes in PA levels were analyzed with the Wilcoxon signed-rank test (Wilcoxon, 1945) as the focus was on medians. For our particular interest in the differences in changes between different demographics, we conducted two different analyses: 1) we compared the differences in changes between the sub-groups of each demographic variable separately by using the Mood’s median tests with statistical significance level set to 0.05, and 2) we analyzed the changes in PA levels by using quantile (median) regression with the aforementioned demographic variables as explanatory variables and the baseline PA levels as a control variable. Missing values were handled by excluding the responses of a certain participant to a certain item if s/he had not responded it in both data collection rounds (a participant could have missed the follow-up for some reason or dropped out from the program entirely). Thus, the exact number of respondents slightly varies between the items. For the analysis, we formed broader sub-groups. For example, the different sub-groups of marital status were combined into broader “In a relationship” and “Not in a relationship” sub-groups.

Results

442 research program participants had been partaking for 12 months or more¹. Of them, 294 responded to the IPAQ-E at both baseline and 12-month follow-up and formed the sample of this study (descriptive statistics reported in Table 1).

Table 1: Descriptive statistics of the sample of this study (N=294)

	n	%
Gender		
Male	109	37.1
Female	185	62.9
Other	0	0.0
Age (mean 69.7 years – standard deviation 4.2 years)		
–64 years	26	8.8
65–69 years	110	37.4
70–74 years	127	43.2
75 years or over	31	10.5
Marital Status		
Married	202	69.2
Common-law marriage	25	8.6
Single	9	3.1
Divorced	36	12.3
Widow(er)	20	6.8
N/A	2	–
Highest level of education		
Primary education	16	5.6
Vocational education	200	69.9
University of applied sciences	20	7.0
University	50	17.5
N/A	8	–
Language		
Finnish	227	77.2
Swedish	67	22.8

¹ At the time of conducting the study.

3.3 Overall Changes in the PA Levels

The statistical significance of the overall changes (all participants as one group) in the PA levels were analyzed with the Wilcoxon signed-rank test (Wilcoxon, 1945), the results of which are presented in Table 2. Regarding the overall changes in the *median minutes per week spent in different intensities*, there was a notable and statistically significant increase in walking. The median minutes per week for sitting and vigorous PA remained unchanged, whereas moderate PA had a very small but statistically not significant decrease. As for total PA MET-min, there was a notable and statistically significant increase.

Table 2: Overall changes in the PA levels (N=294)

Overall	n	Baseline (min/week)		Follow-up (min/week)		Change	p
		Median	25th–75th	Median	25th–75th	Median	
Sitting	283	2100	1680–2940	2100	1680–2730	0	0.661
Walking	276	540	273–840	840	405–1260	75	< 0.001
Moderate	284	240	120–450	233	90–420	0	0.529
Vigorous	286	60	0–240	60	0–240	0	0.603
Total PA	264	4098	2251–6435	4518	2326–6753	213	0.037

3.4 Differences in the Changes in PA Levels

When comparing the differences in changes in PA levels between the sub-groups of each demographic variable separately by using the Mood's median tests (Table 3), there was a statistically significant difference between marital statuses in sitting and walking (those *not in a relationship* increased walking time more than those *in a relationship*, but *they* also increased sitting time, whereas those *in a relationship* did not) and between age groups in walking (those aged *70 years or older* increased walking time, whereas those aged *under 70 years* did not). When explaining the changes in PA levels by using quantile (median) regression with the aforementioned demographic variables as explanatory variables and the baseline PA levels as a control variable (Table 4), there was a statistically significant difference between genders in walking (*females* having a more positive (or less negative) change than *males*) and between marital statuses in sitting (those *not in a relationship* having a more positive (or less negative) change than those *in a relationship*, which in the case of sitting is of course an undesirable change). These results also show that, in general, the higher the

baseline level the less positive (or more negative) change there has been in sitting, walking, moderate PA, vigorous PA, and total PA.

Table 3: Changes in median PA levels between the sub-groups (N=294)

	Change (min/week)			n	Change (min/week)		p
	n	Median	25th–75th		Median	25th–75th	
Gender		Male			Female		
Sitting	107	-105	-840–420	176	0	-420–420	0.305
Walking	105	20	-180–313	171	150	0–600	0.173
Moderate	104	0	-180–180	180	0	-180–131	0.520
Vigorous	109	0	-140–65	177	0	-60–90	0.987
Total PA	100	-86	-1544–2018	164	501	-1308–2667	0.205
Marital status		In a relationship			Not in a relationship		
Sitting	218	0	-630–420	63	420	-420–840	0.001
Walking	212	25	-140–420	62	240	0–630	0.021
Moderate	219	0	-180–180	63	20	-140–180	0.111
Vigorous	221	0	-120–83	63	0	-60–100	0.785
Total PA	203	107	-1581–2376	59	948	-740–2838	0.183
Highest education		Vocational/Primary			Academic		
Sitting	210	0	-534–420	65	0	-420–420	0.879
Walking	200	65	-55–420	68	93	-136–360	0.779
Moderate	206	0	-180–158	70	0	-120–158	0.903
Vigorous	209	0	-145–90	70	0	-53–101	0.910
Total PA	189	129	-1682–2419	68	806	-977–2541	0.083
Age		–69			70–		
Sitting	130	0	-630–420	153	0	-420–525	0.565
Walking	131	0	-125–420	145	150	0–520	0.011
Moderate	134	0	-180–180	150	0	-180–150	0.403
Vigorous	131	0	-60–90	155	0	-135–90	0.763
Total PA	125	44	-1467–2527	139	530	-1480–2462	0.109

Table 4: Results from the quantile regression (N=294)

	Sitting	Walking	Moderate	Vigorous	Total PA
Gender: Female Ref: Male	38.182	191.45**	-47.14	-19.34	523.44
Age: -69 Ref: 70-	-190.91	-80.13	-12.86	5.13	-529.79
Marital status: Not in a Ref: In a relationship	343.64*	55.66	4.29	-2.76	43.521
Highest education: V/P Ref: Academic	0	-37.11	-8.57	-1.97	-191.20
Intercept	1145.46*	259.74**	158.57**	31.97	1996.48**
Baseline PA level	-0.545***	-0.309***	-0.643***	-0.566***	-0.389***
Pseudo R²	0.178	0.098	0.148	0.148	0.102
The cells present the sizes and the statistical significances of the effects of the demographic variables on changes in PA levels after controlling the baseline PA levels; *p<0.05, **p<0.01, ***p<0.001; Ref = Reference group; Highest education: V/P = Vocational/Primary.					

4 Discussion and Conclusions

The main purpose of this study was to investigate the following research question: How effectively can a physical activity application promote PA behavior among aged people of different demographics? The study participants took into use a physical activity application to track their everyday PA. The self-reported PA was measured by using the IPAQ-E at two time points: before taking the application into use and after 12 months of use. The changes in four types of PA behavior (sitting, walking, moderate, vigorous) and total PA as well as demographic differences were analyzed.

As a response to the research question, in general, the results suggest that a physical activity application could be effective in promoting PA behavior among aged people as there was a notable and statistically significant increase in walking and total PA between baseline and 12-month follow-up. There was no statistically significant change in sitting, moderate PA, nor vigorous PA. These results are mostly in line with a recent systematic review on the ability of physical activity monitors to promote PA behaviors among older adults (Larsen et al. 2019). Moreover, for the vast majority of the participants in the present study the baseline measurement took place before the COVID-19 related restrictions, whereas for all the participants the follow-up measurement took place during the restrictions, which in Finland led to temporal closure or restricted access to different exercise facilities and also paused

many of the group activities. Considering this, another positive observation is that the participating aged people were able to upkeep or even increase their PA levels during these restrictions. The results also indicate that physical activity applications can be effective among aged people under free-living PA without accompanied active PA counseling or specific PA programs to follow. This is an important finding, as for most of the potential users, taking an application or another digital wellness technology into personal use just by themselves is a much more accessible option than signing up for a PA intervention or program with PA counselors.

Regarding the demographic differences, the analyses show little differences in the changes in PA behavior between the sub-groups. Although the results give a cautious indication that the effectiveness might be better among those not in a relationship, people aged 70 years or older, and females, in general, the effectiveness of a physical activity application to promote PA behavior change among aged people does not seem to considerably depend on the demographic background (gender, age, education, marital status) of the user. For the designers and developers this indicates that modifying the physical activity applications for different demographics of aged people may not be worthwhile, but we speculate that application modifications could be more in place for users of different PA backgrounds, as this likely has more effect on the user's needs towards PA solutions. Further research on this is warranted.

In terms of BCSSs and behavior change, the results indicate that physical activity applications can be utilized as BCSSs to support or persuade PA behavior change across different demographics; also for longer-term, as implied by the change in the PA levels after 12 months of use. Hence, from a more practical standpoint, such technologies could be used in different PA promotion programs and interventions or be taken into use by (aged) people looking for solutions to support their PA or PA behavior change. They could also be utilized to support PA during exceptional times, such as those when there are restrictions or home confinements in force.

5 Limitations & Future Research

This study has some limitations that should be acknowledged. First, those participants not tracking their PA before taking the application into use could have had a less accurate view on their baseline PA, whereas by using the application this view might have gotten more accurate. Hence, the latter measurement of PA could have been more accurate. Second, on average, the participants seemed to represent a rather physically active share of the aged population, which limits the generalization. For future research, it would be valuable to acquire more participants with lower PA levels to minimize non-participation bias. Third, due to the lack of control group, it is not certain whether the changes in PA resulted mainly from using the application or because of taking part in the study. We also cannot rule out the possible influence of some other uncontrolled factors, such as the COVID-19 pandemic and the resulting restrictions, which have potentially influenced some participants' PA levels around the follow-up. Hence, further related research is warranted. Future research with different digital wellness technologies and focus on other changes besides behavior would be valuable. As long-term research on related topics is much called for, we plan to continue the follow-ups to complement earlier study findings (e.g., Carlsson et al. 2020; Kari et al. 2021; Makkonen et al. 2020).

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