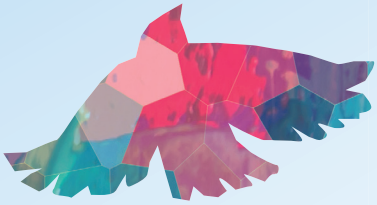
Physical activity and loneliness

Physical activity and loneliness

a healthy ageing intervention for single older adults with physical impairments



Janet Boekhout

Physical activity and loneliness

a healthy ageing intervention for single older adults with physical impairments

Janet Boekhout

Cover Design: Mercedes Benjaminse
Lay-out: Lieve Stiers
Printing: ProefschriftMaken – www.proefschriftmaken.nl
ISBN: 978-94-6380-516-2

The studies in this thesis were funded by “Meer Veerkracht, Langer Thuis”, a program of FNO (reference number 100698).

Physical activity and loneliness

a healthy ageing intervention for single older adults with physical impairments

PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Open Universiteit
op gezag van de rector magnificus
prof. dr. Th.J. Bastiaens
ten overstaan van een door het
College voor promoties ingestelde commissie
in het openbaar te verdedigen

op donderdag 7 november 2019 te Heerlen
om 13:30 uur precies

door

Janet Maria Boekhout-Oppeneer
geboren op 15 februari 1970 te Terneuzen

Promotores
Prof. dr. L. Lechner, Open Universiteit
Prof. dr. C.A.W. Bolman, Open Universiteit

Co-promotor
Dr. D.A. Peels, Open Universiteit

Leden beoordelingscommissie
Prof. dr. G. Cardon, Universiteit Gent
Prof. dr. R.A.C. Ruiter, Maastricht University
Prof. dr. I.H.M. Steenhuis, Vrije Universiteit Amsterdam
Prof. dr. A.E.R. Bos, Open Universiteit

Contents

Chapter 1

General introduction

General introduction

This dissertation describes the Active Plus65 project. The Active Plus65 project entails the development, implementation and evaluation of a healthy ageing intervention for single older adults with physical impairments. The primary aim of the intervention is to stimulate physical activity (PA); the secondary aim is to stimulate social contacts while being physically active in order to decrease loneliness. In this introduction, the rationale behind the Active Plus65 project will be described. This will be done by first describing what healthy ageing entails, and why sufficient PA and loneliness are relevant in that context. Next it is analyzed which groups are specifically at risk for insufficient PA and loneliness, and why this PhD-dissertation focusses on single older adults with physical impairments. Then the determinants of PA and loneliness will be described, as well as what is known so far about interventions addressing these determinants. Furthermore, this introduction will provide insights in the content of Active Plus65 and the research questions that will be answered in this dissertation.

Healthy ageing

Prognoses are that in the next 2 decades the number of older adults (aged 65 years and over) will double worldwide (World Health Organisation, 2015). Also in the Netherlands, society is ageing in an accelerating pace. It is expected that between 2018 and 2040 the proportion of older adults will increase from 14% to 27% (Dutch Central Bureau of Statistics, 2018d). At older age, the majority of people will develop one or more (non-communicable) chronic diseases, such as arthritis, cardiovascular disease, respiratory disease, and type 2 diabetes. This (multi)morbidity increases with age. In the age-category of 65 to 74 years, 82% of people in the Netherlands have one or more chronic diseases; from the age of 75 years this increases to over 90% (Dutch Department of Health Wellbeing and Sports, 2016b). As societies are ageing, the prevalence of chronic diseases is expected to increase in the next decades (Dutch Department of Health Wellbeing and Sports, 2018c). In ageing societies not only physical health is at risk but also social and mental health. Although human beings are social by nature, the present way of life in high income societies has brought along changes that threaten social relations for older adults. Younger generations now often leave their home-town for education and careers, resulting in family members often living far apart (World Health Organisation, 2018). As societies are ageing, and as older adults nowadays live at home longer instead of moving into retirement-homes, an increase in the percentage of older adults living alone is expected: at present 31% of all those living alone are over 65 years, but in 2050 50% of those living alone will be over 65 years (Dutch Department of Health Wellbeing and Sports, 2018c). Living alone is often accompanied with loneliness (Dutch Central Bureau of Statistics, 2016b): it is estimated that 51% of those living alone feel lonely, compared to 29% of those living with a spouse (Dutch Department of Health Wellbeing and Sports, 2018c).

The increased prevalence of health problems related to ageing comes with a huge burden on society: health care expenditure rises with age, showing a sharp rise in the oldest age groups (Organisation for Economic Cooperation and Development, 2016). In the Netherlands in 2017, the health care expenditure in the age group between 80 and 85 years was more than 3 times higher than in the age group between 60 and 64 years. Not only will the burden on formal care increase but also the burden on informal care. With more and more older adults living alone, higher demands will be put on informal caregivers while at the same time fewer informal caregivers will be available (Dutch Department of Health Wellbeing and Sports, 2018c).

These developments have triggered an increased societal and academic attention for healthy aging, with, for example, the World Health Organisation (WHO) declaring healthy ageing as the focus of their work on ageing between 2015 and 2030 (World Health Organisation, 2018). Healthy ageing can be defined as "the process of developing and maintaining the functional ability that enables well-being in older age" (World Health Organisation, 2015). In this definition functional ability refers to "all health related attributes that enable people to be and to do what they have reason to value". Well-being in this definition is considered in the broadest sense by the WHO and includes domains such as physical health, happiness, satisfaction and fulfilment (Beard et al., 2016). This definition of healthy ageing thus reflects the necessity to focus on physical, mental and social components.

Physical activity. Stimulating a sufficient level of PA is one of the core components of the WHO action plans for healthy ageing (World Health Organisation, 2013). Sufficient PA has demonstrated to be highly beneficial to health: it decreases the risk of developing many serious health conditions, such as coronary heart disease, stroke, type 2 diabetes, hypertension, obesity, and some types of cancer (World Health Organisation, 2010a). Especially for older adults the beneficial effects of sufficient PA are not limited to physical health, but also include a better quality of life, reduced stress, better mental health and stronger social integration (Chekroud et al., 2018; Das & Horton, 2012; Zubala et al., 2017).

Considering these beneficial effects of sufficient PA, guidelines have been formulated. Until 2017, the guidelines in the Netherlands recommended that adults (of all ages) should be physically active with moderate to vigorous intensity for at least 30 minutes per day, upon at least 5 days per week. For older adults, in 2018 these guidelines were changed to at least 150 minutes per week of moderate intensity, spread over several days, with muscle and bone strengthening activities on at least 2 days per week (Weggemans et al., 2018), which is in line with the international guidelines (World Health Organisation, 2010a). Despite the well-known positive health outcomes of sufficient PA for older adults, a large percentage of older adults does not comply with this new guideline: in the age group of 65 to 75 years, 45% comply with the guidelines, which decreases to 25% for those over 75 years (Dutch Department of Health Wellbeing and Sports, 2017). There is a myriad of reasons why older adults are less physically active, such as the progressive decline in physiological functioning resulting in physical and mobility limitations, or a fear of falling,

injury or pain (Dutch Department of Health Wellbeing and Sports, 2016a; McPhee et al., 2016). In addition, older adults have grown up in a time when being physically active purely for leisure purposes was less common than nowadays, making it less obvious for them to integrate leisure-PA into daily life (Olanrewaju, Kelly, Cowan, Brayne, & Lafortune, 2016). Also technological and economic developments (such as increase in possession of cars and electronic domestic appliances) may negatively affect PA in daily life. Additionally, environmental situations that may barely hinder younger adults, such as poor walkability of neighborhoods, may keep older adults from being sufficiently active (Thornton et al., 2017).

Loneliness. The prevention and alleviation of older adults' loneliness is a substantial part of global public health policies (World Health Organisation, 2015). Loneliness can be defined as "the unpleasant experience or feelings associated with a lack of close relationships" (De Jong-Gierveld, 1998). Loneliness affects the social, physical and mental health (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015). Social health is at risk as those who are lonely tend to be less strong in social interaction and less prone to make contacts with others quickly, possibly resulting in social disconnectedness (Cohen-Mansfield & Perach, 2015). Physically, loneliness can increase the risk of developing, and deteriorating the course of, chronic diseases such as heart conditions and arthritis (Courtin & Knapp, 2017; Leigh-Hunt et al., 2017; Luo, Hawkley, Waite, & Cacioppo, 2012; Ong, Uchino, & Wethington, 2016). As underlying mechanisms for this relation it has been suggested that among lonely individuals health behaviors are poorer and that cortisol regulation, cardiovascular activation and sleep functioning are more decreased, but findings are not conclusive (Cacioppo et al., 2002). Also, loneliness has often been found to be a risk factor for mental health problems, such as anxiety and depression (Heinrich & Gullone, 2006). In all, the detrimental effects of loneliness on health are such that loneliness negatively affects healthy ageing and it is considered to be an independent risk factor for mortality with a magnitude just under smoking, obesity and physical inactivity (Holt-Lunstad et al., 2015).

Loneliness increases with age. In the age group between 65 and 74 years, 44% report feeling lonely which increases steadily to 63% of people over the age of 85 (Dutch Department of Health Wellbeing and Sports, 2016c). This increase in loneliness can be explained by multiple major life changes that people are confronted with at older age, such as retirement, widowhood, friends and family in the same age-category passing away and the relocation of children (Cohen-Mansfield, Hazan, Lerman, & Shalom, 2016). Other more physiological life changes, such as the deterioration of mobility or independence caused by a decline in both physical and cognitive abilities, can also result in loneliness (World Health Organisation, 2015).

The above demonstrates why PA and loneliness in itself are both core-components of the WHO action plans for healthy ageing (World Health Organisation, 2018). There are also some associations between PA and loneliness that need to be taken into account, as these associations can influence how PA and loneliness should be addressed in healthy ageing interventions. Therefore, the next section provides more insight into the associations between these determinants and possible explanations.

Associations between physical activity, social activity and loneliness. Research has often demonstrated a negative association between PA and loneliness (Lindsay Smith, Banting, Eime, O'Sullivan, & Van Uffelen, 2017; Pels & Kleinert, 2016; Robins, Hill, Finch, Clemson, & Haines, 2016). Literature provides no leading theoretical framework for this association but several explanations can be found. The Loneliness Model of Hawkley and Cacioppo (2010) states that feelings of loneliness are accompanied with a decreased capacity for self-regulation: not being able to sufficiently regulate one's feelings, emotions and behavior can result in a diminished likelihood of performing health enhancing behavior, such as PA. Another explanation can be found in physiological processes, as PA stimulates the production of 'feel good' hormones such as serotonin (Lubans et al., 2016). Another approach focusses on the compensating effects of having social contacts while being physically active, which may partially replace lost contacts with meaningful others (Ferraro & Farmer, 1995; Lemon, Bengtson, & Peterson, 1972). For older adults, these lost social contacts with meaningful others are often the result of the previously discussed major life changes older adults are confronted with.

Stimulating social activity in order to increase the amount of social contacts is an often used approach in interventions aiming to alleviate loneliness (Masi, Chen, Hawkley, & Cacioppo, 2011). The definition of loneliness ("the unpleasant experience or feelings associated with a lack of close relationships") entails that social contacts are a prerequisite for developing close relationships. However, the definition also implies that these social contacts need to be meaningful: a lack of social contacts can be considered as an objective state (i.e., the number of contacts or relationships), which can result in loneliness (i.e., a subjective feeling) when the quantity and quality of the desired and the actually present social contacts are out of balance (Bruggencate, Luijkx, & Sturm, 2018; Cohen-Mansfield & Perach, 2015; Gardiner, Geldenhuys, & Gott, 2018). A sufficient level of social contacts, which can be achieved with social activity, can thus contribute to alleviating loneliness.

Although social activity is a wide concept, PA offers an interesting potential to increase social activity, and through that also loneliness, as a lot of physical activities can be done together with others or in the presence of others. Stimulating PA, preferably done in a social context, can thus be seen as a way to target the core components of healthy ageing, i.e., physical, social and mental health.

Risk groups for insufficient physical activity and loneliness

In addition to the fact that insufficient PA and loneliness are more prevalent among older adults than in younger age groups, there are some sub-populations within the population of older adults where insufficient PA and loneliness are even more prevalent. Among older adults with chronic diseases insufficient PA is more common than among healthy older adults, which can be contributed to the presence of some form of physical impairment regarding PA that is caused by these chronic diseases (Cook, Brawer, & Vowles, 2006; Ekvall-Hansson, Sundquist, Jakobsson, & Larsson, 2016; Goodman, Posner, Huang, Parekh, & Koh,

2013). In the Netherlands, 50% of older adults indicate that their chronic disease impairs them in their potential for PA (Dutch Department of Health Wellbeing and Sports, 2018c), which is reflected in differences in the amount of older adults that meet the guidelines for PA: in 2018, 44% of older adults without chronic diseases met the guidelines for PA against 30% of those with one or more chronic diseases (Dutch Central Bureau of Statistics, 2018a).

Apart from having a chronic disease, being single (i.e., being widowed, divorced or otherwise not having a life-partner) is another feature of older adults who are less physically active (Masi et al., 2011; Toepoel, 2013). In the Netherlands in 2016, 77% of older adults living with a partner complied with the (former) PA–norm, in contrast to 61% of the single older adults (Dutch Central Bureau of Statistics, 2017).

Having physical impairments and being single is not only associated with lower levels of PA, but also with loneliness among older adults. Loneliness is more prevalent among older adults with physical impairments caused by chronic diseases than among those without (Richard et al., 2017). Also for people with chronic diseases, feelings of loneliness are higher and increase stronger over the years (Barlow, Liu, & Wrosch, 2015; Dutch Department of Health Wellbeing and Sports, 2018b; Sundström, Fransson, Malmberg, & Davey, 2009; Vlaming, Haveman-Nies, Groeniger, De Groot, & Van't Veer, 2014). Being single has also demonstrated to be associated with feelings of loneliness (De Jong-Gierveld, 1998). In the Netherlands, 51% of those living alone report feeling lonely, in contrast to 29% of those living with a partner (Dutch Department of Health Wellbeing and Sports, 2018b).

The above demonstrates that single older adults with physical impairments are in high risk for health problems, caused by insufficient PA and loneliness. Moreover, this group is growing steadily. Stimulating physical and social activity in order to decrease loneliness, especially in single older adults with physical impairments, is thus essential when striving for healthy ageing within a society (Beard et al., 2016). Identifying the factors that determine physical and social activity in this target population is essential in order to change these factors.

Determinants of behavior change

Behavior change theories offer explanations for why people do or do not change their behavior by describing determinants of behavior and behavior change. Determinants are defined as "modifiable influential factors that are specific to behavior, population and context" (Kok et al., 2016). Behavior change theories connect determinants and describe by which processes the determinants can influence behavior. It is essential to know which determinants are changeable and strongly associated with physical and social activity behavior in single older adults with physical impairments, as these are the determinants that can be targeted in intervention programs.

The literature review of Van Stralen, De Vries, Mudde, Bolman, and Lechner (2009), which formed the foundation for the original Active Plus50 intervention, revealed the most relevant determinants for PA in the general population of adults aged over fifty. The review showed

that determinants that play a leading role in the influential theories for behavior and behavior change, such as Social Cognitive Theory (Bandura, 1986) and the Reasoned Action Approach (Ajzen, 1991), are also relevant determinants for changing PA in older adults: among these are self-efficacy, social influence, outcome expectations, goals, impediments and facilitators, intention, attitude, social norm and perceived behavioral control. More recent studies have corroborated the relevance of these determinants (Anderson-Bill, Winett, & Wojcik, 2011; White, Wójcicki, & McAuley, 2012). Moreover, they were also found important among older adults with chronic pain (Brooks et al., 2017; Stolte, Hopman-Rock, Aartsen, Van Tilburg, & Chorus, 2017), which is relevant for our target population of single older adults with physical impairments, as these impairments are often accompanied with pain.

Several theories, such as the Health Action Process Approach (HAPA) (Schwarzer & Luszczynska, 2008) and the Trans Theoretical Model (Prochaska, Redding, & Evers, 2008) emphasize the importance of distinguishing stages in health behavior change. Depending on the stage of change, it may be necessary to target different determinants. HAPA for example comprises a motivational stage and a volitional stage: in the first one self-efficacy, risk awareness and positive outcome expectancy are relevant determinants, and in the volitional stage self-efficacy, action planning, and action control are relevant determinants for behavior change. Studies have shown the usefulness of distinguishing pre-motivational, motivational and post-motivational determinants in predicting PA in older adults (Barg et al., 2012; Bierbauer et al., 2017; Parschau et al., 2014). The study of Van Stralen et al. (2009) also demonstrated the importance of distinguishing stages in behavior change: dissimilarities as well as similarities in determinants regarding the initiation-phase and maintenance-phase of PA were found. Determinants that were similar for these 2 phases were physical health, baseline PA, experience of life events, self-efficacy, perceived benefits, enjoyment, intention and mood status (Van Stralen et al., 2009). For single older adults with physical impairments, some of these determinants are especially relevant: their physical health is generally poorer than their peers which could affect the potential for (baseline) PA (Dutch Department of Health Wellbeing and Sports, 2016a; McPhee et al., 2016); as loneliness is more common in this target population, enjoyment and mood status may also be lower than their peers (Courtin & Knapp, 2017). In PA-interventions for single older adults with physical impairments, these determinants would thus require an additional focus.

The determinants for PA among single older adults with physical impairments as described above, of which self-efficacy, intention, and social influence appear to be the most prevalent, can mainly be classified as psycho-social determinants (Kosteli, Williams, & Cumming, 2016). Psycho-social determinants have been found to explain 30 to 50% of the variance in PA behavior (Schuster, Petosa, & Petosa, 1995; White et al., 2012), indicating that other determinants that explain behavior also need to be taken in to account. The importance of environmental determinants was found in the review of Van Stralen et al. (2009). Especially for single older adults with physical impairments, environmental determinants can play a large role: poor walkability of the streets, vandalism and limited access to public

transportation may be more hindering for them than for older adults who have a partner and are in good health (Barnett, Zhang, Johnston, & Cerin, 2018; Moran et al., 2014; Van Cauwenberg, Nathan, Barnett, Barnett, & Cerin, 2018).

Apart from the overview of the main determinants of PA in older adults that can provide direction for stimulating PA in this group, in the current dissertation the determinants to become socially active for single older adults with physical impairments are also important. The study of Anaby, Miller, Eng, Jarus, and Noreau (2009) shows that balance confidence and mobility capacity are predictors of higher social activity. Wilkie, Peat, Thomas, and Croft (2007) demonstrated that the presence and degree of pain and the number of (chronic) diseases are also relevant. In addition to these more physical determinants, mental determinants such as emotional distress, depression and subjective memory complaints have been negatively associated with social activity (Cardol et al., 2002; Kuiper et al., 2017; Pritchard et al., 2015). Identical to PA, environmental determinants also influence social activity: especially the quality of public transportation and neighborhood security play a vital role (Levasseur et al., 2015).

The above demonstrates that interventions that aim to change behavior in single older adults with physical impairments, such as interventions stimulating physical and social activity, should thus focus on pre-motivational, motivational and post-motivational psycho-social determinants as well as on physical, mental and environmental determinants. The next section provides more insight in such interventions.

Healthy ageing interventions for older adults

The prevalence of insufficient levels of PA as well as the prevalence of loneliness among single older adults with physical impairments call for interventions. Interventions can help to motivate individuals throughout their change process. In the past decades many interventions targeting PA among older adults have been developed. Also many interventions that target social activity by stimulating PA together with others have been developed, as an increase in social activity is expected to decrease loneliness. The rising interest in healthy ageing is reflected in the increasing popularity of multidimensional healthy ageing interventions, i.e., interventions targeting both physical, social and mental health. A recent review (Seah et al., 2019) found that the content of healthy ageing interventions varies widely and targets outcomes such as quality of life, health-related outcomes and health behavior. Most of the studies included in that review underwrite an ecological approach to healthy ageing, including both individual-focused as well as environment-focused content; however, not many interventions actually include topics such as community life, social capital, and availability of local facilities for activity participation. According to this review not only individual-focused, but also an environment-focused approach is essential when addressing the physical, mental and social health of older adults.

Computer-tailoring has become a leading method to provide participants of health promotion interventions with individualized advice. In computer-tailoring the advice is tailored to the needs and requirements of each specific individual participant based on

characteristics that are assessed with a questionnaire. The effectiveness of computer-tailored interventions on health behavior change is well documented (Krebs, Prochaska, & Rossi, 2010; Muellmann et al., 2017). However, effect sizes for the short term are rather modest (with effect sizes ranging between 0.06 and 0.35), and evidence for effectiveness in the long term is limited. Moreover, the limited effects are not only applicable for computer-tailored interventions, but for a wide range of PA interventions: the review of Chase (2015) shows an average effect sizes of 0.23 among the analyzed interventions. However, most interventions that were assessed in the studies mentioned above focused on older adults in general: for single older adults with physical impairments, there may be additional barriers: the presence of physical impairments has been demonstrated to affect the effectiveness of PA interventions negatively (Chase, 2015).

Many interventions have been developed that stimulate PA together with others in order to alleviate loneliness. By stimulating PA in such a social context it is expected that both the actual amount or intensity of social contacts can be increased, as well as the imbalance between desired and present social contacts, thus alleviating loneliness (Cohen-Mansfield & Perach, 2015; Masi et al., 2011; Poscia et al., 2018). The reported average effect size on loneliness in reviews for multidimensional healthy ageing interventions ranges between 0.11 and 0.49 (Gardiner et al., 2018; Robins, Jansons, & Haines, 2016; Shvedko, Whittaker, Thompson, & Greig, 2017).

Besides being effective, to have an impact on public health, interventions should also be able to reach the target population and to maintain their participation. To reach the target population, internet delivery modes are gaining popularity due to their potential for a great reach. However, for older adults online participation may be challenging: although internet use among older adults has increased in the last decades, older adults still lack behind in digital skills (Gualtieri, Phillips, Rosenbluth, & Synoracki, 2018; Kantar Public, 2018). For this group a printed delivery mode may still be relevant in order to optimize reach and minimize attrition, thus enhancing the public health impact of interventions (Golsteijn et al., 2017; Short, Vandelanotte, & Duncan, 2014). In addition, a printed delivery mode is also easy to implement at a large scale and puts less pressure on health care providers than face-to-face interventions would. A systematic review into PA interventions for older adults was inconclusive whether internet delivered interventions are more effective than non-internet interventions (such as printed or telephone delivered interventions) (Muellmann et al., 2017).

The above demonstrates promising developments of healthy ageing interventions for older adults. However, insights are not conclusive, specifically for the target-population of single older adults with physical impairments, and custom-made interventions appear to be rather limited. As single older adults with physical impairments are a growing and vulnerable target population, it was considered important to develop and evaluate a healthy ageing intervention specifically for this target population.

The Active Plus65 intervention

Active Plus65 was developed in 2016 (Boekhout, Peels, Berendsen, Bolman, & Lechner, 2017) and is based on influential health behavior change theories, such as the I-Change Model (De Vries et al., 2003), Trans Theoretical Model (Prochaska et al., 2008), and Health Action Process Approach (Schwarzer & Luszczynska, 2008). Active Plus65 is an elaboration of the Active Plus50 intervention, which was previously developed to stimulate the initiation and maintenance of PA for people over the age of 50 (Peels, Van Stralen, et al., 2012; Van Stralen et al., 2008). Active Plus50 was demonstrated to be effective in increasing PA in the short and long term, as well as cost-effective, in a large scale Randomized Controlled Trial (RCT) (Golsteijn et al., 2014; Peels, Bolman, et al., 2013; Peels et al., 2014). Program evaluations of Active Plus50 showed that for certain sub-populations additional tailoring would be in place: the subgroup of single older adults with physical impairments caused by a chronic disease expressed that they preferred more information about the type of PA that fitted their individual physical impairment. This group also expressed the wish to increase their social network whilst being physically active (Peels, Bolman, et al., 2013; Peels et al., 2014). Based on these program evaluations, Active Plus65 was developed. To accommodate this large and growing sub-population, the goal of the original intervention was extended (from stimulating only PA to also stimulating social activity) and the target population was more specified (from the general population of adults aged over 50 to single adults aged over 65 with physical impairments). Thus, Active Plus65 aims primarily to increase the amount of PA, preferably to the level of the PA guideline. Secondarily it aims to decrease loneliness by stimulating social contacts while being physically active.

The computer-tailored advice can be delivered in either an online or printed delivery mode. The advice is predominantly text-based, supplemented with graphs, short videos (online version) or pictures (printed version). The content of both delivery modes is almost identical. Tailoring is based upon the participant's demographic and psychosocial characteristics (such as age, gender, attitude, self-efficacy and intention regarding PA), their present PA-level and stage of behavioral change. Depending on the assessed characteristics, the advice consists of 7 to 12 pages (A4 format). Additionally, each advice contains activating elements such as planning sheets, formats to formulate implementation intentions and to define and deal with difficult situations, brochures from local PA-exercise groups and (medical-related) information on being physically active with physical impairments. During the intervention period of 4 months, participants receive their tailored advice on 3 occasions, based on 2 self-report questionnaires. The first advice mainly aims to raise consciousness of the current PA-level by targeting pre-motivational psychosocial constructs, such as awareness and knowledge. The second advice aims to motivate participants to increase PA by targeting motivational psychosocial constructs such as attitude, self-efficacy, social influence, intrinsic motivation and intention. Moreover, participants are stimulated to plan their PA and to prepare for difficult situations. In both the second and third advice participants are motivated to overcome barriers and to transfer motivation into sustainable behavior by targeting post-

motivational determinants such as strategic, action and coping planning. Additionally, in the third advice, feedback on their progress in PA behavior and their perceptions on PA is given. In all 3 advices, attention to environmental determinants is given.

The Active Plus65 project: studies and research questions

The Active Plus65 project entails the development, implementation and evaluation of the Active Plus65 intervention, the previously described computer-tailored healthy ageing intervention. The current dissertation comprises the reports of the scientific studies that were performed in the context of the Active Plus65 project and can be categorized in intervention development ***(Chapter 2)*** and intervention implementation and evaluation ***(Chapters 3, 4 and 5)***.

Part I: Intervention development. When amendments are made to an existing evidence-based intervention (in this case Active Plus50) they may unintentionally lead to the intervention losing its effectiveness. It is therefore crucial that the adaptations are performed systematically and are based on theory, evidence and relevant determinants. Therefore, when adapting Active Plus50 into Active Plus65, the Intervention Mapping Protocol (IM) was applied, which is a systematic protocol, that is both theory and empirically based (Bartholomew et al., 2016).

The IM Protocol for adapting existing interventions consists of 6 steps, which are a) needs assessment and determination of fit with the problem, b) defining a logic model of change and matrices of change objectives, c) selecting theoretical methods and practical applications, d) producing programs, e) developing an adaptation and implementation plan, and f) developing an evaluation design. ***Chapter 2*** provides a description of how Active Plus65 was systematically developed from the foundation of Active Plus50 according to the 6 steps as described above. This chapter first describes how any potential discrepancies between the problems as found in the existing intervention and the problems for the target population of Active Plus65 were determined. Secondly, an overview is given of how the performance objectives, determinants and change objectives were established. Thirdly, the use of theoretical methods and practical applications is motivated. Fourthly, a description is given of how the materials, time schedule and delivery modes were analyzed. Finally, the plans for adaptation, implementation and evaluation are described.

Part II: Intervention evaluation. In the intervention evaluation part it is described what the effectiveness is regarding PA and loneliness among participants of Active Plus65. It is also described what characteristics predict a preference for either the internet delivery mode or the printed delivery mode, and which characteristics or delivery mode predicts attrition.

Active Plus65 is available in an internet and printed delivery mode. The content of both delivery modes is almost identical with only some practical differences (such as a modeling video in the internet delivery mode and a modeling text with pictures in the printed delivery mode). The printed delivery mode is more cost- and labor-intensive than the internet delivery mode, which could make it less attractive for intermediaries. However, as older

populations, such as the participants of Active Plus65, are known to be less familiar with internet, the internet delivery mode may be less desirable for them. ***Chapter 3*** describes an evaluation of differences in characteristics among those participants of Active Plus65 who participated by internet and those who participated by print. It also describes which characteristics or delivery mode predict attrition.

The effectiveness of Active Plus65 on PA ***(Chapter 4)*** was tested in a quasi-experimental pretest-posttest study. Six months after baseline it was analyzed what the differences were in effects on PA between participants of Active Plus65 (single, over 65 years of age and physically impaired) and between selected participants of Active Plus50 who formed the reference group. For this reference group those participants of the RCT studies into Active Plus50 (Peels et al., 2014) who were single, over the age of 65 and who had physical impairments were selected.

Chapter 5 describes how PA is associated with loneliness among all Active Plus65 participants. This was assessed in a pretest-posttest implementation study without reference group. Measurements were taken at baseline and at 3 and 6 months after baseline. It was also assessed how the presence of physical impairments influences the association between PA and loneliness.

Chapter 6 provides a discussion of all findings. An overview of the studies in this dissertation is displayed in Table 1.1.

Table 1.1 Overview of the studies conducted in this dissertation

Chapter	Study objective	Design and follow-up period	Sample-size
2	To describe the systematic development of Active Plus65	Not applicable	Not applicable
3	To investigate whether user characteristics predict delivery mode preference	Cross-sectional; baseline	N = 409 (single community-dwelling older adults with physical impairments)
	To investigate which user characteristics and delivery mode predict attrition	Single group pretest-posttest; 3 months	
4	To evaluate the longitudinal effectiveness of Active Plus65 on PA	Quasi experimental pretest-posttest with reference group; 6 months	N = 416 (intervention group); N = 87 (reference group) (single community- dwelling older adults with physical impairments)
5	To evaluate the association between PA and loneliness and the influence of physical impairments on this association	Single group pretest posttest; 6 months	N = 575 (single community-dwelling older adults)

PART I

Intervention development

Chapter 2

An eHealth intervention to promote physical activity and social network of single, chronically impaired older adults: adaptation of an existing intervention using Intervention Mapping

Janet M. Boekhout
Denise A. Peels
Brenda A.J. Berendsen
Catherine A.W. Bolman
Lilian Lechner

JMIR Research Protocols; ***2017****: 6(11): e230*
DOI: 10.2196/resprot.8093

Abstract

Introduction

Especially for single older adults with chronic diseases, physical inactivity and a poor social network are regarded as serious threats to their health and independence. The Active Plus intervention is an automated computer-tailored eHealth intervention that has been proven effective to promote physical activity (PA) in the general population of adults older than 50 years. The aim of this study was to report on the methods and results of the systematic adaptation of Active Plus to the wishes and needs of the subgroup of single people older than 65 years who have one or more chronic diseases, as this specific target population may encounter specific challenges regarding PA and social network.

Methods

The Intervention Mapping (IM) protocol was used to systematically adapt the existing intervention to optimally suit this specific target population. A literature study was performed, and quantitative as well as qualitative data were derived from health care professionals (by questionnaires, n = 10)) and the target population (by focus group interviews, n = 14), which were then systematically integrated into the adapted intervention.

Results

As the health problems and the targeted behavior are largely the same in the original and adapted intervention, the outcome of the needs assessment was that the performance objectives remained the same. As found in the literature study and in data derived from health professionals and focus groups, the relative importance and operationalization of the relevant psychosocial determinants related to these objectives are different from the original intervention, resulting in a refinement of the change objectives to optimally fit the specific target population. This refinement also resulted in changes in the practical applications, program components, intervention materials, and in the evaluation and implementation strategy for the subgroup of single, chronically impaired older adults.

Discussion

This study demonstrates that the adaptation of an existing intervention is an intensive process in which adopting the IM protocol is an invaluable tool. The study provides a broad insight in adapting interventions aimed at single older adults with a chronic disease. It is concluded that even when the new target population is a sizable segment of the original target population, the adapted intervention still needs considerable changes to optimally fit the needs and situational differences of the narrower target population.

Introduction

The international guideline for physical activity (PA) recommends that one should be physically active with moderate to vigorous intensity for at least 5 days a week with a minimum of 30 minutes a day (World Health Organisation, 2010a). Regular PA reduces the risks of multiple health problems, such as chronic diseases. For individuals with pre-existing health problems, being sufficiently physically active may be accompanied with more barriers, but can still result in an improved health and in a reduced risk of developing comorbidities (Matheson et al., 2013; World Health Organisation, 2010a). Especially for older adults (people older than 65 years) the health benefits of sufficient PA are relevant as PA also prevents cognitive decline (Gomez-Pinilla & Hillman, 2013) and improves balance, thus decreasing the risk of fall-related injuries (Haskell et al., 2007; Nelson et al., 2007). Moreover, PA is beneficial for mental health, as it reduces stress and depression, and has positive outcomes on general well-being, such as an increased social connectedness (Matheson et al., 2013; Toepoel, 2013).

Despite these benefits, PA decreases with age. In the Western world, 19% of the younger adults do not meet the recommended level of PA, compared with 55% of the older adults (World Health Organisation, 2010c). In certain subpopulations, a lack of sufficient PA is even more prevalent. In general, people with a chronic disease are less physically active than healthy people of their age group. In the Netherlands, 42% to 71% of the chronically ill people who are older than 55 years meet the recommended level of PA, whereas 84% of the healthy people in this age group meet the recommended level (Dutch Department of Health Wellbeing and Sports, 2015a). Western society in general shows a similar image (World Health Organisation, 2011). Chronic diseases often come with impairments to PA (Newsom et al., 2012; Öztürk, Şimşek, Yümin, Sertel, & Yümin, 2011). The lack of PA causes the physical condition to increasingly deteriorate and daily activities to cost more energy, ultimately resulting in a downward spiral (Izawa et al., 2011; Park, Meldrum, & Larson, 2013; Pedersen & Saltin, 2015). Another significant feature of older adults who are less physically active, is not having a life partner (Izawa et al., 2011; Masi et al., 2011; Park et al., 2013; Pedersen & Saltin, 2015; Toepoel, 2013). In addition to their lower level of PA, older people who do not have a life partner are at risk for becoming socially isolated, which often results in feelings of loneliness. Loneliness is considered to be a significant risk factor for negatively affecting the physical and mental health of single older adults (Das & Horton, 2012; Hildebrandt, Bernaards, & Stubbe, 2013). Promotion of PA, preferably done with others, in single older adults with a chronic disease is not only important from a physical and mental health perspective but also to stimulate participation in social life and society (Acree et al., 2006; Robins, Hill, et al., 2016; Vagetti et al., 2014). Several studies have shown reciprocal relations between PA and quality of life (Eime, Young, Harvey, Charity, & Payne, 2013; Phillips, Wójcicki, & McAuley, 2013; Pucci, Reis, Rech, & Hallal, 2012). No international data are available on what part of the population is single, as well as older than 65 years and

has a chronic disease. Available data in the Netherlands suggest that this group is a large proportion of the total population: in the age group of 65 to 84 years, the percentage of people with a chronic disease (with or without physical impairments) ranges between 78% and 93%; of the people older than 65 years, 39% are single (Dutch Department of Health Wellbeing and Sports, 2016a). It is assumed that the distribution of these characteristics is not very divergent from other Western countries. Stimulating PA is, therefore, of major relevance in this group, not only because of the benefits PA has for this group but also because of its proportion.

Previously, the computer-tailored Active Plus intervention (hereafter named Active Plus50) was developed to increase PA among people older than 50 years (Peels, Van Stralen, et al., 2012; Van Stralen et al., 2008). The intervention is available with a printed or a Web-based delivery mode. Active Plus50 provides tailored advice 3 times (after the first questionnaire at baseline, after 2 months and after the second questionnaire (3 months after baseline)). Although Active Plus50 was effective in stimulating PA in its target population (i.e., people older than 50 years) (Peels, Bolman, et al., 2013; Peels et al., 2014), as well as in its subpopulation of single older adults (older than 65 years) with a chronic disease that impaired them in their PA behavior, this particular subpopulation often felt the intervention was not sufficiently adapted to their specific needs and expectations with regard to PA (Peels, Van Stralen, et al., 2012). Furthermore, this subpopulation also indicated that even when they are stimulated to be more physically active, they often lack knowledge about their possibilities to be physically active in their own surroundings, given their impairment. Moreover, results of the qualitative evaluation results showed that this subpopulation would like more opportunities for personal and social contacts in the program. With these findings, it became apparent that the intervention could remain as is was for the general target population of people older than 50 years, but that it needed adaptation for the specific subpopulation of single older adults with a chronic impairment in PA. This study describes how the proven effective, evidence-based Active Plus50 intervention, aimed at raising and maintaining the amount of PA for people older than 50 years, was systematically adapted to better fit the needs and characteristics of older adults who are single and have one or multiple chronic physical impairments. To increase the chance that the adapted intervention (hereafter named Active Plus65) will remain effective, the Intervention Mapping (IM) protocol was used (Bartholomew et al., 2016). This study adds to the current knowledge on adaptation processes for existing interventions: a broad insight in adapting existing interventions was established by combining theory, previous research, and input from the target population and health care professionals.

Methods

Intervention Mapping steps for modifying an intervention

When an evidence-based intervention is modified, it may lose its effectiveness. Therefore, it is essential to carefully consider which components of the intervention are crucial to its effectiveness and, therefore, cannot be modified, and which elements can be modified without changing the effectiveness substantially. To develop new interventions and modify existing ones, several models and protocols have been developed. A well-studied and often used protocol is the IM protocol (Bartholomew et al., 2016). Compared with other models and protocols, IM enables the developer of the intervention to take all the necessary steps to develop or modify an intervention. The IM protocol for modifying an existing intervention differs from the IM protocol for developing new interventions. There are also 6 consecutive steps, but the content of the steps is different from that of the development model. The basic content of these steps, and how they are executed specifically in this study, are stated below.

Step 1: Needs assessment and determination of fit with the problem

In this step, a logic model for the problem is constructed, that is the problems for the target group regarding health, quality of life, related behavior and environment are assessed. Step 1 should result in a description of discrepancies between the problems as they are seen in the existing intervention and in the adapted intervention for the new (or in this study, a specific part of the original) high-risk target population. A literature study was conducted to achieve this goal in adapting Active Plus50. Furthermore, input from process evaluations from previous studies on Active Plus50 was used.

Step 2: Defining a logic model of change and matrices

This step aims to determine whether performance objectives, behavioral determinants and change objectives of the original intervention need to be modified to better fit the new target population. The original performance objectives resulting from the development of Active Plus50 (Van Stralen et al., 2008) are shown in Table 2.1.

Performance objectives consist of behavior that the target population has to perform to reach the program objective. The performance objectives can be regarded as specifications of the program objective, that is, the ultimate goal of the intervention; in Active Plus50 this is enhancing and maintaining the amount of PA.

Active Plus50 focusses on influencing behavioral determinants as well as the perception of environmental determinants (Van Stralen et al., 2008): these are shown in Textbox 2.1.

Crossing the performance objectives with determinants results in change objectives. Change objectives are the intervention objectives that are specific for this intervention. The result of step 2 according to IM should be a description of the change objectives that

have to be added to, altered, or removed from the original program. To optimize the change objectives to the target population, focus group interviews with the target population as well as a survey among health care professionals were conducted.

Table 2.1 Performance objectives (PO) of Active Plus50

Number	Description
PO [a] 1	Target population monitors their PA [b] level
PO 2	Target population indicates reasons to be physically active
PO 3	Target population identifies solutions to remove barriers to being physically active
PO 4	Target population decides to become more physically active
PO 5	Target population makes specific plans to become more physically active
PO 6	Target population increases their PA
PO 7	Target population makes specific plans to cope with difficult situations occurring while being physically active
PO 8	Target population maintains their PA by enhancing their routine and preventing relapses

[a] PO: performance objectives
[b] PA: physical activity

Textbox 2.1 Determinants of physical activity (PA), operationalized by the performance objectives, among people older than 50 years

Awareness
Knowledge
Commitment
Attitude
Self-efficacy
Intrinsic motivation
Intention
Action planning
Coping planning
Relapse prevention skills
Habit
Social Influence
Perceived social environment or having an exercise partner
Perceived physical environment

One of the theoretical frameworks that was applied in the original intervention (Van Stralen et al., 2008) is the Theory of Planned Behavior (TPB) (Fishbein & Ajzen, 2010). TPB stipulates that behavior is the result of a person's intention which is influenced by the following 3 psychological factors: attitude, subjective norm, and perceived behavioral control. Many proven effective interventions to stimulate PA were based on TPB (McEachan, Conner, Taylor, & Lawton, 2011). The I-Change Model (De Vries et al., 2003) is an adaptation of the TPB-model. Compared with TPB, the I-Change model considers more social influences than just subjective norm, such as social support. As Active Plus65 also has a focus on the social network of participants, the I-Change model with its broader definition of social influence has been applied in this adaptation of Active Plus instead of TPB. Perceived behavioral control is called self-efficacy in I-Change but to a large degree remains the same construct. To test the opinions of the target group, the focus group questions were based on the I-Change model. Two focus group interviews with participants were conducted in January 2016. Each focus group session lasted 2 hours and 3 researchers had the role of mediator (2 PhDs in Health Psychology, and 1 MSc student). The participants were recruited via local organizations for older adults, patient support groups for people with a chronic disease, a gymnastics club for older adults, and by distributing flyers in local supermarkets. A semi-structured focus group interview guide was made, which contained a list of topics and open ended questions to be discussed, based on previous evaluations of the Active Plus intervention (Peels, Van Stralen, et al., 2012), literature on behavior change strategies (Ajzen, 1985; De Vries et al., 2003) and literature on the diffusion of innovations theory (Rogers, 2003). The focus group started with a broad opening question per topic (e.g., perceived barriers) and a priori defined follow-up questions. Examples of questions that were presented to the focus group participants are as follows: "what barriers does a person as yourself with a chronic disease face, that a healthy person does not face, when being physically active?" or "what is your opinion on exercising together with other people?". Discussions were stimulated with the posing of new open questions until no new input was attained. Of both focus group interviews, audio-recordings were made and transcribed verbatim. The transcripts were thematically analyzed by the first and second author, according to guidelines for content analysis of focus groups (Braun & Clarke, 2006). These guidelines entail (1) getting familiarized with the data, (2) generating initial codes, (3) searching for themes, (4) reviewing themes, and (5) defining and naming themes. Examples of themes were as follows: *barriers for PA when being single* and *motivation to participate in the intervention*. The findings of the first and second researcher were independently reviewed by the third researcher. After reaching agreement on the analyses, conclusions were drawn.

Furthermore, to optimize the match of the change objectives to the new high-risk target population, a survey among physiotherapists was conducted. It was conducted in the same municipality where the evaluation of use, appreciation, and effectiveness of the altered intervention was to be studied. By incorporating the opinion of physiotherapists,

the knowledge and experience of health care experts concerning PA for older people with a chronic disease was added. Health care professionals have practical experience with the target population and may provide additional, more qualitative information than a literature study alone. This provided insights into which chronic disease needs special attention regarding PA, what type of PA is not recommendable, and how to communicate the content of advice messages. The survey was performed using a questionnaire that was sent by email. The questionnaire was sent to all 35 physiotherapists who were registered in the municipality of Heerlen, The Netherlands. The first question was to rate the necessity of a tailored PA advice for each of the most prevalent chronic diseases in the Netherlands, such as arthritis, cardiovascular pathology, lung disease, rheumatism, diabetes, cerebrovascular incidents, severe backaches, osteoporosis, and overweight (Dutch Department of Health Wellbeing and Sports, 2014). The importance was rated on a scale of 1 (*not important*) to 10 (*very important*). Per the chronic disease, the physiotherapists were asked to state the 3 most recommendable types of PA, and the 3 types of PA that are not advisable.

Step 3: Selection of theoretical methods and practical applications

In this step, it is necessary to make sure that there are appropriate and sufficient methods for all the change objectives. For all the essential methods, it needs to be ascertained that they are properly addressed with appropriate practical applications. One of those essentials upon which Active Plus50 is based is computer tailoring. Computer-tailoring is a method that assesses features, beliefs, behavior, etc., of the individual participant by using questionnaires upon which a computer-program independently produces feedback. The computer-program is based on if-then algorithms and deducts the appropriate advice messages from a message library. These messages are subsequently combined in a tailored advice letter. In computer-tailoring, the feedback is optimally tailored to the personal characteristics of the participant. The advice messages that single older adults with a chronic disease receive, therefore, need adaptation. The effectiveness of computer-tailoring in Active Plus50 has been demonstrated (Peels, Bolman, et al., 2013). Apart from computer-tailoring, various other theoretical methods and practical applications are used in Active Plus50. As they form the constructional base of the intervention, these have been maintained (Peels, De Vries, et al., 2013). Examples of the applied theoretical methods and applications are shown in Table 2.2.

When the core of the change objectives remain the same, no new theoretical methods and practical applications need to be added in this step. The result of this step should be a description of the theoretical methods and practical applications that need to be added, that needed to be deleted or that must be retained.

Table 2.2 Examples of theoretical methods and practical strategies in Active Plus50

Determinant	**Theoretical method**	**Practical strategy**	**Intervention components**	
			Print-delivered	**Web-based**
Motivation	Social modelling	Provide role model stories about intrinsic motives to be physically active	Picture of similar individuals (same age group and gender) with quotes about their (intrinsic) motivation to be physically active	Short video of similar individuals (same age group and gender) who tell about their (intrinsic) motivation to be physically active
Awareness	Self-monitoring	Encourage monitoring of own behavior	Logbook scheme to write down their own behavior. An example was included in the advice. An empty form was attached to the advice	Logbook scheme to write down their own behavior. An example was included in the advice. An empty form (PDF format) could be downloaded from the website
Perceived social environment or having a sports partner	Linking members to networks of people	Provide opportunity to contact others	Post cards to invite someone to be physically active together, attached to the advice	E-cards on the website to invite someone to be physically active together
Action planning	Active learning	Invite participants to formulate action plans	Weekly scheme to write down plans to be physically active (when, what, where, with whom). An example was included in the advice. An empty form was attached to the advice	Weekly scheme to write down plans to be physically active (when, what, where, with whom). An example was included in the advice. An empty form (PDF format) could be downloaded from the website

Step 4: Producing programs

In the fourth step, all the information gathered from step 1 to 3 is combined. At this moment of the intervention modification, it has been established that the program objectives and methods are appropriate. In Step 4 the materials, timeframe, and preferred delivery channels are analyzed. This should result in the modified intervention program.

To achieve this goal, the existing program materials were discussed in the focus groups with the target population. Their opinions and suggestions regarding the intervention materials of Active Plus50 were identified. The first focus group was presented with the original program materials from Active Plus50; their remarks were used to adapt the program materials. The adapted materials were then presented to the second focus group, after which final adaptations were made. The materials that were presented in both focus groups were as follows: (1) the part of the questionnaire that focuses on physical impairments. As the intervention targets people with chronic diseases, it is important to get a good insight into which chronic diseases are present, and into the related impairments; (2) a bar graph showing the PA of the participant and the daily recommended PA of the Dutch population in the relevant age category. The target population, however, only consists of single people with a chronic disease, who have a lower level of PA than the general population. It was studied whether comparing the PA behavior of the new target population with the PA behavior of the general population within a bar graph was possibly perceived as unfair because chronic disease impairs PA; and (3) a modelling-text. A method that is frequently used in Active Plus50 is modelling, for example, a video of a role model performing the targeted behavior. A parameter for the effectiveness of modeling is that the participant is able to identify himself with the role model. Therefore, we examined whether this identification still matched with the specific target population.

Step 5: Development of an adaption and implementation plan

The main focus of step 5 is to plan the adoption and actual implementation of the intervention. One of the actions in this step was to ask the participants of the focus groups about their opinion on the recruitment materials of the Active Plus program. Discussed materials included a personalized letter in which people are invited to join the program, and a flyer containing information about the program. The questions for the focus groups were based on the diffusion of innovations theory of Rogers (Rogers, 2003).

According to this theory there are a several features of innovations that indicate decisively whether the innovation will actually be used. These features are relative advantage, trialability, observability, compatibility, and complexity. The relative advantage of the intervention, for example, was addressed by asking participants whether the invitation letter and flyer explained the benefits of Active Plus65 compared with existing PA programs clearly. One way in which trialability was addressed was by assessing whether the participants understood that they could participate in the program for free and could stop at any time. Whether observability was addressed properly was, among other questions,

checked by asking whether the members of the focus groups expected that the results of the program would be visible among participants who had already joined the program. By asking whether there are elements in the letter or flyer that made the program sound too difficult, and that might deter them from joining the program, the perceived complexity was checked. One way in which compatibility was investigated was by asking whether the participants thought, based on the information they read in the implementation materials, that they could easily fit the program into their existing routines, and whether they disliked elements in the program.

Step 6: Development of evaluation design

In this final step, a plan was developed by which the evaluation for effectiveness and use of the altered intervention can be determined. Evaluation will progress into 2018 and contains, among other elements, conducting a longitudinal study on the level of implementation. The main outcome that will be assessed is the difference in the amount of PA between the baseline measurement and at 3 and 6 months. The relationship between social network, feelings of loneliness, and PA over time will also be assessed. Furthermore, an evaluation study will be conducted on the differences in the characteristics of the participants in relation to entry channel (Web-based or paper-based), on drop-out, and on effects.

Ethics approval and consent to participate

This study was reviewed and approved by the Committee for Ethics and Consent in Research of the Open University of the Netherlands (reference number: U2016/02373/HVM). Trial registration was not applicable as this study does not report on the results of an intervention. Participants provided written informed consent to participate in the study.

Results

In the Methods-section, the theoretical processes of the IM protocol, and the way these were addressed in this research, were stated. The results and practical implications of these steps are presented in the Results-section as per the individual step of the protocol.

Step 1: Needs assessment and determination of fit with the problem

Literature shows that at older age, the majority of the people have a chronic disease. In Europe, 43% of the people in the age group of 55 to 64 years has one or more chronic diseases; this increases from 53% (64-74 years), to 64% (75-84 years) to 69% (> 85 years) (European Union, 2015). The most prevalent are cardiac disease, chronic pulmonary disease, and diabetes mellitus. People with a chronic disease have an enhanced risk of developing another chronic disease, that is, multimorbidity (Marengoni, Winblad, Karp,

& Fratiglioni, 2008; Van den Bussche et al., 2011), which worsens the health situation. The prevalence of multimorbidity is increasing significantly since the last decade, not only because of the ageing of society but also due to changes in life style risk factors, such as a lack of PA (Van Oostrom et al., 2016). Enhancing or maintaining health is, therefore, at least equally important for the specific high-risk target population of Active Plus65 as for the original population of Active Plus50.

In the age group of 50 to 59 years, 16% of the general population report having a mobility limitation that impairs them in PA. This percentage increases from 25% (60-69 years), to 37% (70-79 years) to 61% (> 80 years) (Mottram, Peat, Thomas, Wilkie, & Croft, 2008). In general, people with a chronic disease are less physically active than healthy people (Chodzko-Zajko et al., 2009; Van Gool, Kempen, Penninx, Deeg, & Van Eijk, 2007). Chronic diseases commonly cause mobility limitations that form impairments regarding PA. People with a chronic disease may be between 1.2 and 2.7 times more likely to have a mobility disability compared with those who do not have a chronic disease (Hung, Ross, Boockvar, & Siu, 2012). Not only the mobility limitation in itself but also the fear of pain or fear of injury are related to a low level of PA for older people with a chronic disease (Cook et al., 2006; Larsson, Ekvall Hansson, Sundquist, & Jakobsson, 2016). The World Health Organisation (World Health Organisation, 2010a) recommends that all adults, regardless of age or the presence of a chronic disease, should perform a minimum of 150 minutes per week of at least moderate to intensive PA. The main behavioral target and primary aim for Active Plus65 is stimulating participants to reach a level of PA that meets this recommendation. This is the same as in the original intervention, although the point of departure with respect to PA differs substantially in the adapted target group, where all participants have one or more chronic diseases.

Apart from the limitations that are specific for older adults with a chronic disease, age in itself comes with limitations, such as impaired eyesight or hearing, which can interfere with PA (Elliott & Mihalic, 2004; Toepoel, 2013; Vandelanotte & Mummery, 2011; Vansteenkiste, Williams, & Ken, 2012). In addition, here the aim with regard to PA is the same in Active Plus50 and Active Plus65; however, the target population in Active Plus65 possesses some characteristics that require a refinement of the intervention.

Another significant feature of older adults who are less physically active, is the absence of a life partner (Masi et al., 2011; Toepoel, 2013). Single older adults are at risk for becoming socially isolated, especially bereaved older people (Chorus & Hopman-Rock, 2003; Hawton et al., 2014; Machielse, 2015). Living alone and social isolation often results in feelings of loneliness (Cohen-Mansfield et al., 2016). Loneliness is considered to have a significant negative influence on the physical and mental health of older adults (Das & Horton, 2012; Hildebrandt et al., 2013; Kruk, 2014). Feelings of loneliness increase with age: the highest percentages of people who are lonely are older than 65 years (Fokkema, De Jong Gierveld, & Dykstra, 2012; Luhmann & Hawkley, 2016; Victor & Yang, 2012). Participating in PA, when done with others, is a way to decrease loneliness as it stimulates social contacts (Cornwell

& Waite, 2009; Hawkley, Thisted, & Cacioppo, 2009). From this, the secondary goal of Active Plus65 is derived, which is stimulating PA together with other people.

The literature study, thus, reveals that the health problems and the related health behavior targeted by the original intervention (Active Plus50), are at least equally relevant for the target group in Active Plus65, which is a specific segment of the target population in the original intervention. The main aim of the original intervention, that is, to raise and maintain the level of PA, remains the same; however, an additional emphasis will be put on being physically active with others in order to increase the social network.

Step 2: Defining a logic model of change and matrices

The needs assessment (step 1) has revealed that Active Plus65 aims to increase and maintain the PA of single people older than 65 years with a chronic disease. As this primary behavioral outcome of Active Plus65 is the same as for Active Plus50, the performance objectives (as previously shown in Table 2.1) in both interventions are identical. The secondary behavioral outcome (i.e., to stimulate PA with others) is enclosed in the existing performance objectives. For example, in the second performance objective (i.e., the target population can indicate reasons to be physically active), one of the reasons to be physically active could be that it enables one to engage with other people when being active with others. Another example can be found in the third performance objective (i.e., the target population identifies solutions to remove barriers to being physically active); finding a stimulating partner to be physically active with can be a solution to remove a barrier.

In the Active Plus50 intervention (Van Stralen et al., 2008), important psychological determinants have been established that need to be addressed to stimulate PA. Three major characteristics can be identified in which the target population of Active Plus65 differs from the original Active Plus50 population; these characteristics can change the impact of the established determinants. The first of these is that the entire target population of Active Plus65 has one or more chronic diseases, whereas in Active Plus50, only 45% of the participants reported having a chronic disease (Peels, Bolman, et al., 2013). The number of chronic diseases, the physical limitations, and fatigue caused by the chronic disease can influence the amount of PA as well as the determinants (Cook et al., 2006; Newsom et al., 2012; Öztürk et al., 2011; Van Gool et al., 2007). The second characteristic is that the target population of Active Plus65 consists entirely of single people; in Active Plus50 only 21% of the participants were single. The social support of a partner, family, or friends as well as the available practical support they provide, such as having a sports companion, is known to influence PA (Hawkley et al., 2009; Hawton et al., 2014; Holt-Lunstad et al., 2015). The third characteristic in which the new target population differs from the original population is age; in Active Plus50 37% of the participants were older than 65 years, whereas in Active Plus65, this will be 100%. With regard to age, experience with PA in the past, as well as perceived level of fitness and general fitness (e.g., impaired eye-sight, i.e., not chronic diseases) may have an effect on PA (Bethancourt, Rosenberg, Beatty, & Arterburn, 2014; Bize, Johnson, &

Plotnikoff, 2007; Chodzko-Zajko et al., 2009). The potential influence of these characteristics on PA has been endorsed by the research of Peels et al. (Peels, De Vries, et al., 2013) on Active Plus50, which showed that especially single older people with a chronic disease expressed the need to receive more information about PA with their specific chronic disease, and the need for more personal interaction when being physically active.

Considering these characteristics, it is concluded that the determinants in Active Plus50 and Active Plus65 are identical but that the relative importance of the determinants is different. People with a chronic disease, for example, can develop a fear of PA as a result of pain avoidance beliefs (Chodzko-Zajko et al., 2009; Cook et al., 2006; Newsom et al., 2012; Öztürk et al., 2011). The personal determinant attitude, under which pain avoidance beliefs can be categorized, therefore, has a relative higher importance than it has in Active Plus50.

As the performance objectives and determinants are comparable in the Active Plus50 and Active Plus65 intervention, the intervention did not require major adaptations in overall structure. The change objectives did require further refinement as the relative importance of the determinants is different. These refinements were established by the interviews with the focus groups and by the input from the physiotherapists as described below.

Focus groups. The features of the 14 participants who took part in the focus groups are shown in Table 2.3.

Table 2.3 Features of the focus group participants

Characteristics	Focus group 1	Focus group 2
Gender		
Male, n	1	3
Female, n	7	3
Marital Status		
Married, n	4	3
Widowed, n	4	3
Mean age in years (range)	72 (62-83)	78 (70-94)
Participants with chronic disease, n	6	3

By conducting focus group interviews the opinions, wishes, and preferences of the target group were taken into consideration in the adaptation of the intervention, that is, in specifying the change objectives. Focus groups interviews were also used in the development of the original intervention (Van Stralen et al., 2008). According to literature, 2 focus groups are needed to discover the large majority of relevant themes (Guest, Namey, & McKenna, 2017). By also including people who did not comply with the characteristics of the target group, such as married people and people without a chronic disease, potential

differences of opinion between the target group and non-target group could be identified and discussion could be stimulated. The questions for the interviews were based on the I-Change-model (Ajzen, 1985; De Vries et al., 2003) and special attention was given to the characteristics that are stated above.

Attitude. The majority of the participants expressed that everyone can be physically active to some degree:

"I exercise more now that I have a chronic impairment… I live more conscious now. "

They also expressed the opinion that some people stop exercising because they experience pain because of performing their exercises in the wrong way. The reasons why the participants started exercising were diverse, such as for the exercise in itself or for the social contacts with other people during exercising:

"Someone who listens to you…, I really need that."

On the other hand, the participants indicated that they know people who are hesitant to join an exercise group because they do not feel comfortable to socially engage with people they do not know:

"Getting out and making contact with new people…I really had to learn that again after my husband died."

Self-Efficacy. The participants thought that most people do not exercise because they just do not know that there are simple exercises that one can do and, therefore, do not exercise at all:

"Some simple exercises that I could do in my own house would be really helpful."

Finding initial contacts with others awkward when joining an exercise-group for the first time may deter people from PA with others. About half of the participants said that a lot of venues where you can exercise are difficult to reach for older people, because you need a car to get there (and they often do not drive anymore). Some do not feel physically fit to walk alone to the exercise facility or consider their surroundings not safe enough, especially after dark:

"I really do not want to get into trouble, so I stay indoors in the evening".

Social influence. The participants who had lost their partners referred to the challenges of joining social activities again after bereavement and that personal support from friends and family is essential to get on with life. They expressed that they joined an exercise group for social contacts rather than for the exercise itself. The participants also referred to people who seem to be lonely, but not able to take action and socialize again:

"They just don't seem to be able to take action, no matter how much effort you put into them."

According to the participants it is very difficult to reach those people or to stimulate them to join exercise clubs. Not having a partner also has some practical barriers, like having no one to bring you to an exercise venue:

"Going places is difficult now that I am dependent on public transport."

Table 2.4 provides the most relevant results of the focus group interviews.

Table 2.4 Example of opinion of focus groups and resulting change in intervention

Determinants of PA [a]	Opinion focus groups	Recommended change in intervention
Attitude	Walking/cycling are unpleasant because of busy streets	Stressing that not only outdoor activities are relevant but that performing PA at home can also be beneficial
	Future benefits are an important reason for PA	Stressing that PA is beneficial for long-term health
	Possible contacts with others are an important reason for PA	Stressing that PA can be a way to interact with others
	Lack of knowledge about PA possibilities is why people do not exercise	Adding a list of local venues and providing specific information on PA that can be done together with others
	Fear of pain deters people from PA	Encouraging people to seek advice from their physiotherapist or general practitioner so they can be reassured that the pain does not have to be harmful
Self-Efficacy	Pain when exercising makes PA difficult	Adding information that pain is not necessarily bad and information on PA exercises that are less painful so people feel confident
	Facilities not accessible for those without a car	Stressing that there are exercises to do at home, or nearby with a list of local venues
	Fear of reaction by others when joining an exercise club	Stressing that everybody feels awkward the first time but that it becomes easier soon
Social Influence	Fear of going outside when it is dark	Stressing possibility to ask a friend to join them or to exercise in day time
	Lack of desire to engage in social contacts	Stressing that PA with someone else can be a pleasant way to combine sports and socializing and that after the first time exercising in a group becomes less awkward
	Fear of initial contacts if joining an existing PA-group	Using modelling to let a role model tell that they were hesitant to join a PA-group, but that they were pleasantly surprised by the welcome

[a] PA: physical activity

Survey of physiotherapists. Of the 35 physiotherapists that were invited to participate, 10 physiotherapists completed the questionnaire; known reasons for nonresponse were lack of time or no longer being active as physiotherapists. The physiotherapists indicated that cardiovascular problems, lung diseases and rheumatism resulted in the largest barriers for being physically active. Cerebrovascular incidents, diabetes, severe backaches and osteoporosis represented the second most important diseases, and overweight and arthritis the third. This information was used to determine the sequence in which advice on being physically active with a chronic disease was presented, that is, if a participant had multiple diseases, the participant only received tailored information on a maximum of 3 chronic diseases, and the disease for which a tailored advice is most important (i.e., resulted in the largest barriers for being physically active, as defined by the physiotherapists) is presented first.

The physiotherapists were asked to give a top 3 of types of PA that were to be recommended, and PA that were to be discouraged, per chronic disease. There was a large diversity in the kind of PA that was recommended per chronic disease; this was also the case for non-recommendable forms of PA. As reason for this diversity, all physiotherapists indicated that a standard PA advice cannot suffice because of the variability of complaints within a chronic disease and degrees of severity. Moreover, the physiotherapists explained that a lot of people have more than one chronic disease, and types of PA that are beneficial to one chronic disease may be harmful to the other chronic disease. In addition, older people generally have other issues, such as poor eyesight or balance, which might impair being physically active more than the chronic disease in itself. Apart from these physical matters, the physiotherapists express the opinion that other matters can interfere with PA, such as the level of insight that people have in the seriousness of the disease, the fear of pain, and the amount of PA earlier in life. However, these matters need not to deter people from being physically active by focusing on the possibilities instead of on the barriers. This feedback from the physiotherapists resulted in an increased prudence in advising participants to become more physically active; participants were, therefore, additionally advised to contact a physiotherapist or general practitioner when in doubt about their PA potential.

On the basis of the input from the focus groups with the target population and results from the survey among physiotherapists, the existing change objectives of Active Plus50 (Van Stralen et al., 2008) were refined for the more specific high-risk target population of Active Plus65. Table 2.5 shows examples of existing and new change objectives.

Table 2.5 Examples of change objectives (CO) in the original and adapted intervention

Performance objectives	Determinants			
	Attitude	**Action planning**	**Self-efficacy**	**Knowledge**
2. Participant indicates reasons to be physically active	Original CO [a]: participant feels positive about being sufficiently physically active			Original CO: participant knows about the health benefits of sufficient PA [b]
	Adapted CO: participant feels positive about being sufficiently physically active even if they sometimes experience pain			Adapted CO: participant knows about the health benefits of sufficient PA specifically for people with a chronic disease
3. Participant identifies solutions to remove the barriers to being physically active		Original CO: participant makes specific plans to remove barriers to being physically active	Original CO: participant feels confident about being able to take away the barriers to being physically active	Original CO: participant knows how to identify difficult situations and knows manners to take away these barriers
		Adapted CO: participant makes specific plans to remove barriers to being physically active and to incorporate others into their plans	Adapted CO: participant feels confident about being able to take away the specific barriers for chronically impaired	Adapted CO: participant knows how to identify situations that are specifically difficult for single people and knows manners to take these barriers away
5. Participant makes specific plans to become more physically active	Original CO: participant feels positive about making plans to increase their PA	Original CO: participant makes specific plans to increase their PA		
	Adapted CO: participant feels positive about making plans to increase their PA and to incorporate others into their plans	Adapted CO: participant makes specific plans to increase their PA-activities on their own as well as with others		

[a] CO: change objectives; [b] PA: physical activity

Step 3: Selection of theoretical methods and practical applications

No new theoretical methods and practical applications have been added, as the methods and applications used in the existing intervention already had been proven effective (Peels, Bolman, et al., 2013), and only needed more specific targeting to the population. Computer-tailoring remained the core of the intervention; single older adults with a chronic impairment in PA received adapted advice texts, whereas participants from other subgroups received the original advice texts. The practical content, therefore, has been refined to better meet the demands of the specific target population. This is discussed in Step 4.

Step 4: Producing programs

The questionnaire that the participants in Active Plus50 have to fill in is the core of the intervention, as it forms the input for providing tailored advice; this questionnaire was, therefore, also used in Active Plus65. All questions have been carefully reviewed to determine whether they matched the adapted change objectives.

In the questions where participants score positive and negative attributes of PA, additional items were added, based on the new change objectives. An example of a positive attribute is “PA brings me in contact with others” and an example of a negative attribute is “I avoid PA because of the pain I anticipate”. In the message library corresponding advice messages were added. For example, those participants who avoid PA because of anticipated pain receive an advice message on coping with unavoidable pain. In addition, questions were added to determine the loneliness experienced. In the message library, corresponding advices messages were added that emphasize the positive effects of being physically active with others. Furthermore, questions were added to check whether participants used devices such as walking sticks; considering the older age of the participants in Active Plus65 tailoring to being physically active with those devices is appropriate. For these people an advice message was added to the message-library explaining that PA with these devices is possible.

For all the advice messages of Active Plus50, it was checked whether they matched the target population adequately. First, text about being physically active with a spouse, for example, was removed. Furthermore, modelling videos, pictures, and voice-overs were replaced by content with age-matched persons, that is, people older than 65 years. When making these new videos and pictures, the emphasis was put on people who were exercising with others instead of alone. In the new modelling content, mainly walking was illustrated instead of cycling as walking can generally be done better and is safer at older age than cycling.

The adequateness of the intervention materials was further studied by presenting the participants of the focus groups with the following: (1) the part of the questionnaire that addresses physical impairments: (2) a bar graph showing the PA of the participant, the average PA in their age-category, and the daily recommended PA; and (3) a modelling

text. Focus group participants were asked to fill in the questionnaire to detect problems in the intervention or tailoring questionnaire. Half of the participants in the focus groups experienced difficulties while filling in the questionnaire, resulting in the redesign of this part of the questionnaire. The bar graph was shown and the focus groups were questioned to check whether they could interpret the bar graph correctly. The majority of the participants was not able to do so; therefore, a written explanation was added to the bar graph. The modelling text was also presented to the focus groups. Four participants found the text inspiring. One participant interpreted the text that PA could cure a chronic disease; therefore, the text was refined. In Table 2.6, examples are given of how the comments from the focus groups were used to adapt the practical content of Active Plus65.

Step 5: Development of an adaption and implementation plan

During the focus groups, participants were presented with the following recruitment materials for the program: (1) a personalized letter in which people are invited to join the program, (2) a flyer containing information about the program, and (3) information on a kick-off meeting. The flyer was considered to be clear and motivating, but all participants found the letter confusing and not arousing interest in the program. After the first focus group, the letter was altered and presented to the second focus group. In this group, the letter was considered to be clear and motivating. The participants were also asked whether they would participate in a kick-off meeting of the program where they could receive more information on the program and meet other participants; this produced positive reactions. In Table 2.7 examples of the alterations in implementation materials after conducting the focus groups are given.

Step 6: Development of evaluation design

To complete the systematic adaptation, a plan for the evaluation of the intervention was developed. For this, a longitudinal study will be conducted in one Dutch municipality. All citizens who are registered as single and are 65 years or older will be invited to participate in Active Plus65 (N = 6751). The invitation letter will make it clear that the program is especially targeted at single older people with a chronic disease.

The primary outcome is the difference in PA between baseline and 3 and 6 months. The amount of social contacts and perceived feelings of loneliness will also be measured. Furthermore, possible moderators or mediators of the results on the primary outcome will be assessed, such as age. To compare the effects on PA of the altered intervention with the proven effective intervention, data on participants in Active Plus50 will serve as a reference group. The evaluation of the intervention will also focus on the relationship between the demographics of the participants of Active Plus65 and characteristics such as participation in the Web-based and printed version as well as attrition ratios.

Table 2.6 Examples of changes in practical content

Determinant	Theoretical method	Practical strategy	Practical content Active Plus50	Practical content Active Plus65
Attitude	Feedback	Provide information on pro's and con's	General information on benefits of PA [a]	Adding more information on being physically active with specific impairments by adding factsheets about the recommended kind of PA per chronic condition
	Improve knowledge			Confirming that fear of pain can influence commencing PA but that there are special activities that can be done with a minimum level of pain: a specific suggestion is added: for example a person with arthritis is advised to join a local swim club for people with their impairment
Social Influence	Facilitating	Stimulate participants to seek partners for PA	General statements in tailored advice that PA is more entertaining when done with a partner	Adding more information on local sports clubs and local patient support groups
				Adding advice that PA is a possible way to engage with other people
				Adding possibilities on Active Plus65 website to look for a PA-buddy
				Adding a brochure of social activities for older people that are organized in the municipality
				Video and pictures of people exercising alone were replaced by comparable people exercising in a group
Self-Efficacy	Social modelling	Provide role model stories about difficult situations and how to cope	Picture or film of similar others (same age group and gender) with quotes about how they coped with a similar perceived difficult situation	The peers in the pictures and film were replaced by older people
				Less pictures and films with people cycling, as cycling is often too challenging for older adults, but more with people walking
				Content was added in the advice which acknowledges that it may be awkward to join an exercise-club for the first time, but that these feelings diminish soon

[a] PA: physical activity

Table 2.7 Examples of feedback from focus-groups and modifications to original Active Plus program

Results focus group	Objective/strategy	Modifications
Introduction letter is not clear about Web-based and printed possibilities	Raising participation-levels by giving people a choice in the delivery method of the intervention	Rewriting the introduction letter so that the choice between Web-based and printed is clearer
Identity of sender of introduction letter is not clear	Emphasizing importance of the intervention by making clear that the sender is the municipality	Having the letter signed by the principal council member of the local municipality
Kick-off meeting is considered to be interesting	Giving information about the program and giving opportunity to meet others	Organizing a kick-off meeting for potential participants

Discussion

Principal findings

The aim of this study was to describe the systematic development of a computer-tailored eHealth intervention aimed at increasing PA for single people older than 65 years who have a chronic disease. This intervention, Active Plus65, was developed by adapting the proven effective PA intervention, Active Plus50 (for the general population older than 50 years), to better fit the abovementioned narrower target population.

It is concluded that even when the new target population is a sizable segment of the original target population, the original proven effective intervention may not optimally fit the different subpopulations. Therefore, the original intervention needed enhancement to achieve this. The necessary adaptations were performed in a systematic way by using the IM protocol (Bartholomew et al., 2016) to ensure that both theory and empirical evidence are encased in the intervention. The intervention will be evaluated in a longitudinal study by comparing the adapted intervention with the original intervention.

Methodological issues

As adapting interventions in a systematically planned way increases the likelihood of effectiveness, the use of the IM protocol increases the chance that the adapted intervention will still demonstrate effectiveness. It enables the developer to retain the components that are crucial to the effectiveness by carefully considering the elements that can be modified without lowering the effectiveness substantially. Another strength of this study is that it combines data gathered from existing research, from focus groups, as well as from health care professionals. Different angles and interests could, therefore, be incorporated; limitations when using each of these research methods separately are thus overcome.

However, there are some limitations for the approach we used within this research that need to be considered. First of all, selection bias in the focus groups might have occurred as those who participated may not have been the most optimal representatives for the target population. The majority (57%) of participants in the focus groups consisted of the members of a gym club who are possibly more physically active than others of their age and more willing to participate in joined activities. However, 64% of them had one or more chronic diseases by which representativeness issues were balanced. By adding information from a literature study and from health care professionals, potential representativeness issues were also overcome. The latter have an expert opinion on PA for chronically ill older adults and, moreover, have practical experience with their PA behavior. Furthermore, as the main goal of the intervention is to raise the level of PA, preferably together with others, the opinion of people who already are physically active is of major interest.

Another matter to consider is that recommendations for the advised amount of PA for people with a chronic disease are not totally clear yet because of a lack of scientific evidence. For this reason, the focus in Active Plus65 is put mainly on increasing PA, and not on achieving an advised amount. The planned effect evaluation will, therefore, not be able to compare the effects with a generally accepted norm.

Furthermore, there are some practical matters to consider when applying the IM protocol to adapt an existing intervention. First of all, even when not designing a new intervention, but merely adapting an existing intervention, IM is a process that is time-consuming, which should be taken into account in planning human resources and applying for funds. Although we have been able to systematically follow the IM procedure completely, a lack of time or resources could potentially result in researchers skipping elements of IM. Second, another challenge was to adequately limit the information that was added to the intervention for the specific target population in order to prevent an overload of advice. By adding information on being physically active with others or on being physically active with a chronic impairment, a constant balance had to be made between what to add and what could possibly be deleted. The IM protocol for adapting interventions does not specifically seem to address the issue of potential information overload. Third, although IM describes the general tasks for each step of adapting an intervention, a practical elaboration on how these matters can be addressed is lacking. Adding this information to the protocol might form a practical and valuable guideline for researchers.

Conclusions

Notwithstanding the abovementioned limitations, it is concluded that this present paper provides valuable information for the process of adapting lifestyle interventions. The next phase in the adaptation process is a pilot testing of the adapted intervention, which may result in further refinement. After this, a longitudinal study of the implementation results will be conducted. If the effects are similar to the original Active Plus50 program, which has been proven to be effective, Active Plus65 will be implemented on a broader scale.

PART II

Intervention evaluation

Chapter 3

A Web-based and print-delivered computer-tailored physical activity intervention for older adults: pretest-posttest intervention study comparing delivery mode preference and attrition

Janet M. Boekhout
Denise A. Peels
Brenda A.J. Berendsen
Catherine A.W. Bolman
Lilian Lechner

Journal of Medical Internet Research; ***2019****: 21(8): e13416*
DOI: 10.2196/13416

Abstract

Introduction

Web-based interventions can play an important role in promoting physical activity (PA) behavior among older adults. Although the effectiveness of these Web-based interventions is promising, they often suffer from a low reach and high attrition, thereby threatening their potential public health impact. The aim of this study was to assess which participant characteristics are associated with either a Web-based or a printed delivery mode preference, and whether delivery modes or participant characteristics are associated with attrition of an intervention. This knowledge may enhance implementation, sustainability of participation and effectiveness of future interventions for older adults.

Methods

A real-life pretest-posttest intervention study was performed (N = 409) among community-dwelling single older adults aged over 65 years with physical impairments caused by chronic diseases. Measurements were taken at baseline and 3 months after the start of the intervention. Hierarchical logistic regression was used to assess demographic and behavioral characteristics (age, gender, body mass index, educational attainment, degree of loneliness, and PA-level) as well as psychosocial characteristics (social support for PA, modeling, self-efficacy, attitude, and intention) related to delivery mode preference at baseline and attrition after 3 months.

Results

The printed delivery mode achieved a higher participation (59%) than the Web-based delivery mode (41% (168/409)). Participating in the Web-based delivery mode was associated with younger age (B = -0.10; SE = 0.02; $Exp\ (B)$ = 0.91; $p < .001$) and higher levels of social support for PA (B = 0.38; SE = 0.14; $Exp\ (B)$ = 1.46; $p = .01$). Attrition was associated with participating in the Web-based delivery mode (B = 1.28, SE = 0.28; $Exp(B)$ = 3.58; $p < .001$) and with low educational attainment (B = -0.53; SE = 0.28; $Exp(B)$ = 0.59; $p = .049$).

Discussion

A total of 41% of the participants chose to start in the Web-based delivery mode, thus demonstrating a potential interest of single older adults with physical impairments in Web-based delivered interventions. However, attrition was demonstrated to be higher in the Web-based delivery mode and a lower educational attainment was found to be a predictor for attrition. Moreover, certain characteristics predict a preference for a printed delivery mode, i.e., being older and receiving less social support. Although Web-based delivery modes are generally less expensive and easier to distribute, it may be advisable to offer a printed delivery mode alongside a Web-based delivery mode to prevent exclusion of a large part of the target population.

Introduction

In Western societies a majority of older adults are not sufficiently physically active (World Health Organisation, 2010c). With societies ageing rapidly this poses a major public health concern, as insufficient physical activity (PA) is regarded as a major health risk (World Health Organisation, 2010). PA interventions that are cost-effective in targeting this health risk are thus needed. Computer-tailored interventions designed to improve PA, delivered either on the Web or printed, have therefore become increasingly popular in the last decade, with substantial evidence supporting their (cost)effectiveness (Golsteijn et al., 2014; Krebs et al., 2010; Muellmann et al., 2017). However, when delivering computer-tailored interventions on the Web, they may suffer from low reach (i.e., the proportion of people participating in an intervention), low long-term adherence (i.e., the proportion of people not following the intervention as intended), and high attrition (i.e., the proportion of participants not completing the intervention) (Davies, Spence, Vandelanotte, Caperchione, & Mummery, 2012), thus posing a serious threat for the effectiveness of the intervention (Donkin et al., 2011; Eysenbach, 2005; Norman et al., 2007), and potentially decreasing their public health impact. Especially among older adults (65 years and over) Web-based delivery modes can be challenging. Current data on internet use among older adults show that although delivering interventions on the Web is gaining popularity, there is still a digital divide (Tennant et al., 2015), with only 50% of older adults regularly using the internet; a total of 34% of this age group express that they have little-to-no confidence to use the internet properly. Moreover, the use of internet for health applications is only 15% in those over the age of 70 years (AARP Research, 2017; European Parliamentary Research Service, 2015). This highlights the importance of providing alternative delivery modes for this population. Not only higher age but also a lower educational attainment are characteristics of those on the disadvantaged side of the digital divide. Therefore, the individuals that are the most in need of health applications may not be reached with Web-based delivered interventions (Tennant et al., 2015). Some physical limitations that older adults are confronted with, such as impaired eyesight, hearing, and dexterity, are inherent to this age group and these may keep interfering with internet use also in future generations of older adults (Pew Research Center, 2017). As only offering interventions on the Web may lead to the exclusion of a vulnerable group, providing more insight in how the (demographic and psychosocial) characteristics of older adults are associated with a preference for a printed or Web-based delivery mode and with attrition can contribute to stimulating reach and sustainability of such interventions. Moreover, it may help to explain the effectiveness of interventions and the impact on the public health of certain subpopulations (Brouwer et al., 2011; Donkin et al., 2011; Norman et al., 2007).

Previously the computer-tailored Active Plus65 intervention was developed with a primary aim to stimulate PA and a secondary aim to decrease loneliness (Boekhout et al., 2017). The target population of Active Plus65 is single older adults with a physical

impairment caused by a chronic disease, as among this population insufficient PA and loneliness are highly prevalent (Barlow et al., 2015; Hawthorne, 2008; Vlaming et al., 2014). Active Plus65 is available in 2 delivery modes, that is Web-based (with both questionnaire and advice delivered through the internet) and printed (with a paper questionnaire and advice sent by paper post). As interventions are often delivered in a single delivery mode (such as either on the Web or printed), it may be difficult to establish whether reach and attrition are related to the intervention itself or to its delivery mode. Apart from some technical applications, the content of the Web-based and printed versions of the Active Plus65 intervention is the same. This allows a comparison of the Web-based and printed delivery mode of the computer-tailored Active Plus65 intervention.

There is a paucity of research determining the preferred and actually used delivery mode by really offering participants a choice in a real-life intervention setting. Previously, preferences have predominantly been researched by asking participants, hypothetically, what delivery mode they would prefer if they were to join an intervention (Daley et al., 2011; Forbes, Plotnikoff, Courneya, & Boulé, 2010; Jones & Courneya, 2002; Short et al., 2014). As far as could be determined there have been only 2 studies into delivery mode preference where participants could choose between participating in a printed and Web-based delivery mode of an intervention (Golsteijn et al., 2017; Greaney et al., 2014) . In those studies, participants who chose the printed delivery mode were older and lower educated. However, comparisons to the present study cannot be made straightforwardly, as the interventions in both studies were designed for different target groups than in Active Plus65. However, that the older and lower educated prefer a printed delivery mode is in line with data on the present digital divide (Kantar Public, 2018).

In 2012 the delivery mode preference and attrition of Active Plus50, a previous version of Active Plus65, were studied (Peels, Bolman, et al., 2012). In contrast to Active Plus65, where participants can freely choose between delivery modes, participants in Active Plus50 were randomly assigned to either the printed or Web-based delivery mode. Active Plus50 participants in the Web-based delivery mode were younger, more often male, had a higher Body Mass Index (BMI) and a lower intention to be physically active. Moreover, a low intention to be physically active was also found to be a predictor for attrition in both delivery modes. As intention had a predictive value for delivery mode preference as well as attrition in Active Plus50, it may be interesting to repeat these analyses in Active Plus65: considering the fact that in Active Plus50 participants could not freely choose their delivery mode, the role of intention in Active Plus65, where participants can freely choose the delivery mode, may be different. Moreover, as intention had a certain predictive value for delivery mode preference and attrition, it may be that other psychosocial variables (which according to several behavior change models are important determinants of intention) (Ajzen, 1991; De Vries et al., 2003; Fishbein & Ajzen, 2010) could also have a predictive value. It can be argued that as a low presence of intention was encountered in the Web-based delivery mode along with the fact that it predicted attrition in both

delivery modes, a negative attitude towards PA and low social support, modelling and self-efficacy (psychosocial determinants associated with behavior change) may also be associated with a preference for the Web-based delivery mode and with attrition. After all, in behavior changes theories these determinants are often the major determinants of behavioral intention and these are strongly related to predicting behavior change. Such knowledge may be useful in the enrolment process of the intervention to ensure that participants join a delivery mode that is best suited for them; if, for example, our findings would establish that those with low levels of social support prefer a printed delivery mode, it could be useful to either emphasize at enrolment how easy to use the printed delivery mode is or to point out that a helpdesk is available for Web-based participants. This may prevent participants with little social support, which could be assessed with a short pre-enrollment questionnaire, who are hesitant about starting an intervention from not starting an intervention at all. Support for the incorporation of a broad range of (psychosocial) individual characteristics in the study can also be found in the Persuasion-Communication Matrix of McGuire (McGuire, 1985). This model describes several factors that predict whether an individual will use an intervention, among which the broad characteristics of the user are also included. If for example the potential user has a low self-efficacy to be physically active and a low social support, it may require a different approach to stimulate this individual to join an intervention than an individual with high self-efficacy and a lot of social support for health behavior. When trying to understand which characteristics predict delivery mode preference, it may thus be interesting to focus on a broad range of determinants, including psycho-social determinants.

As Active Plus65 targets both PA and loneliness, this brings the opportunity to analyze whether the baseline level of PA and loneliness are predictors of delivery mode preference and attrition, as this could link target subgroups to the most appropriate delivery mode. Only 2 studies have been found that take PA into account when researching delivery mode preference (Short et al., 2014) or attrition (Guertler, Vandelanotte, Kirwan, & Duncan, 2015). In those studies, a higher level of PA was related to a lower likelihood of preferring Web-based delivery modes and to a lower attrition. Comparisons may be difficult to make: either the Web-based delivery mode was not compared with a printed delivery mode but was compared with face-to-face or group interventions (Short et al., 2014), or only daily steps were measured (Guertler et al., 2015) instead of a broad range of PA which Active Plus65 does. Moreover, these studies were performed among a general population of adults. As far as could be determined no previous research has taken loneliness into account when researching delivery mode and attrition of PA interventions for older adults, but some assumptions may be made. In general, among older adults social isolation and loneliness are more prevalent (Luhmann & Hawkley, 2016; Victor & Yang, 2012). Some studies have shown that social support is a prerequisite to adopt new technologies (Barnard, Bradley, Hodgson, & Lloyd, 2013; Tsai, Shillair, & Cotten, 2017) which would suggest that participants who are lonelier will not choose a Web-based delivery mode. Considering the lack of

studies for comparison, the analyses regarding PA and loneliness in our study will thus have a more exploratory character.

The aim of this study was to determine 1) which individual characteristics predict differences in delivery mode preference between the printed or Web-based delivery mode and 2) which user characteristics and delivery mode predicts attrition. We hypothesize that a higher age, lower educational status, and lower presence of psycho-social determinants are predictors of a preference for a printed delivery mode and of attrition. Identifying the factors related to delivery mode preference and attrition could be of substantial use for researchers when optimizing the reach and sustainability of interventions, as this could increase their impact on public health, and could prevent an important target population from being excluded when switching to only Web-based delivery prematurely.

Methods

Study design

This study is part of a pretest-posttest trial evaluating the Active Plus65 intervention (Boekhout, Berendsen, Peels, Bolman, & Lechner, 2018; Boekhout et al., 2017). The trial was executed in a real-life setting without control group. As the delivery mode preference and attrition of the participants in the printed and Web-based delivery mode of the intervention are compared, no control group was required for this study. This study was approved by the Research Ethics Committee of the Open University of the Netherlands (reference number U2016/02373/HVM). The original Active Plus50 studies were registered at the Dutch Trial Register (NTR2297). All participants gave their informed consent before participation.

Intervention

Active Plus65 is a computer-tailored intervention primarily aiming to stimulate PA and secondarily aiming to decrease loneliness among single older adults with physical impairments caused by a chronic disease. Active Plus65 was systematically developed (Boekhout et al., 2017) and changes in PA (Boekhout et al., 2018) and loneliness (Boekhout, Berendsen, Peels, Bolman, & Lechner, 2019) have been demonstrated.

The advice is generated by computer-tailoring; in the Web-based delivery mode participants fill the questionnaire themselves on the intervention website, which in the printed delivery mode is done by the intervention providers after receiving the questionnaire by mail from the participant. The way and degree of tailoring in both delivery modes is identical; therefore the advice in both delivery modes also has identical content, with only some practical differences. For example, in the printed version modeling texts and pictures are used, versus modeling videos in the Web-based version: the role models that are portrayed are the same persons delivering exactly the same message. Moreover, the

design and format (such as images, typeface and lay out) of both questionnaires and advice are identical. A screenshot of the intervention website is provided in Figure 3.1.

Figure 3.1 The appearance of the intervention website

Both delivery modes provide a tailored advice at 3 time points (at the start of the intervention, 2 months after the start and 3 months after the start), on the basis of 2 questionnaires; the first one at the start (T0) of the intervention (on which advice 1 and 2 are based) and the second one after 3 months (T1) (for advice 3). A third questionnaire, 6 months after the start of the intervention (T2), does not result in an advice, but it serves as a follow-up measurement. The time needed to fill in the questionnaire is identical for both delivery modes, that is, about 15 minutes for the first and second questionnaire and 5 minutes for the third questionnaire. Figure 3.2 provides a schematic view of the intervention timelines.

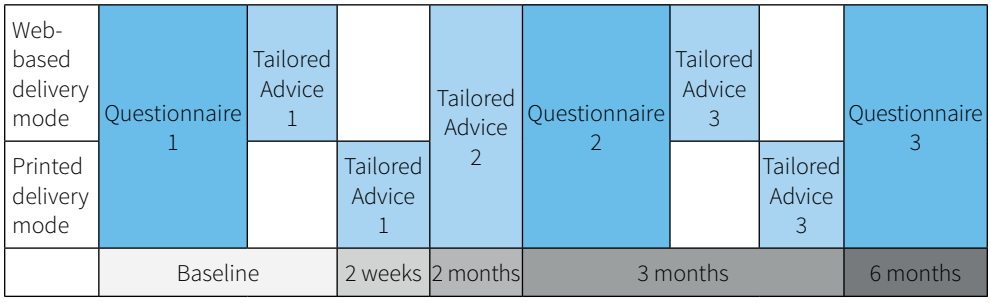


Figure 3.2 Intervention timelines per delivery mode

Each advice is tailored to the characteristics that are assessed in the questionnaire, including demographic and psychosocial determinants, the amount of PA, and the degree of loneliness. The first advice aims to increase insights into the present level of PA, which

is done by targeting pre-motivational psychosocial determinants, such as knowledge and awareness. The second advice motivates participants to become more physically active and focusses on the benefits of PA, especially when done with others: in this advice motivational psychosocial determinants, such as attitude, intention, and social influence, are targeted. Participants are also stimulated to prepare for difficult situations that might hinder them to become more active. The intervention also stimulates participants to transfer their motivation into sustainable behavior: depending on how active participants already are, this is done in the second or third advice by targeting post-motivational determinants, such as strategic planning and coping planning. Depending on the assessment, the advice comprises 7 to 12 pages (A4-format) of text, pictures, diagrams, etc. for (passive) reading (Multimedia Appendix 1, available online on journal website) and elements that require active contributions of the participants, such as planning sheets that have to be filled, schemes for handling difficult situations and formulating implementation intentions, and basic PA-exercises to be performed at home (Multimedia Appendix 2, available online on journal website). The organization that implements the intervention (usually a local council) adds information on PA- or social-meeting opportunities that are available in the area where the participant lives. A more extensive description is provided elsewhere (Boekhout et al., 2018; Boekhout et al., 2019; Boekhout et al., 2017).

Participants and procedures

All citizens of a Dutch municipality in the southern part of the Netherlands who were single, over the age of 65 years, and living independently in the community (n = 6751) were recruited by direct mailing. In this mailing, it was explained that Active Plus65 is specifically suited for participants who have physical impairments caused by chronic diseases. For this study, only participants with a physical impairment were included. Invitations were sent by personalized letter and contained information about the intervention. Both log-in details for those wishing to participate by internet and a prepaid response card for requesting a paper questionnaire were included. It was mentioned that personal assistance with using internet when filling in the questionnaire on the Web was available upon request. Only participants who completed the baseline questionnaire were enrolled. For the second assessment after 3 months, a printed invitation letter with the questionnaire and prepaid response envelope was sent to all participants who had completed the first questionnaire by the printed delivery mode. The participants in the Web-based delivery mode received an invitation by email for the follow-up questionnaires, with a direct link to the Web-based questionnaire. After 6 months a third questionnaire was sent in the same procedure as for the second questionnaire.

Measurements

Demographic characteristics, psychosocial determinants, the amount of PA and the degree of loneliness were assessed at baseline. In the second questionnaire, the same

variables were assessed, except for the demographic characteristics considering their stable qualities. In the third questionnaire, only the amount and type of PA and the degree of loneliness were assessed. Other variables were assessed, but as they are outside the scope of this study, they are not discussed here.

Demographic characteristics. The assessed demographic characteristics were age, gender, height, weight, educational attainment, and presence of physical impairments caused by chronic diseases. Height and weight were used to calculate the BMI by dividing weight in kilograms by height in meters squared. Educational attainment was categorized into *low* (lower vocational education, medium general secondary education, secondary vocational education, and higher general secondary education) and *high* (higher vocational education and university education). The presence of physical impairments was categorized into *yes* or *no*.

Psychosocial determinants. The assessed psychosocial determinants were attitude, modeling, social support, self-efficacy and intention to be sufficiently physically active. Attitude to be sufficiently physically active was measured by 17 items (e.g., "PA gives me a satisfied feeling") on a 5 point scale (1= *totally disagree* to 5 = *totally agree*). Modeling was measured asking: "Are the following persons physically active for at least 30 minutes per day on at least 5 days per week?" in 2 items, one for family, one for friends, on a 5 point scale (1 = *never* to 5 = *always*). Social support for PA was also measured by 2 items (one relating to family, one relating to friends) by asking "To what degree do you expect to get support to be sufficiently physically active?" with answers on a 5 point scale (1 = *never* to 5 = *always*). Self-efficacy was measured by asking to what degree one would manage to be physically active for at least 30 minutes per day for different situations (e.g., "when the weather is bad") with 11 items on a 5 point scale (1 = *definitely not* to 5 = *definitely sure*). The intention for performing sufficient PA was measured by 3 items on a 10-point scale (e.g., "How likely do you think it is that you will stay or become sufficiently physically active?"). The scales to assess the psycho-social variables were based on validated questionnaires (Lechner & De Vries, 1995a, 1995b; Resnick & Jenkins, 2000; Sallis, Grossman, Pinski, Patterson, & Nader, 1987; Sheeran & Orbell, 1999) and their usability has been demonstrated by pilot tests among the target population (Boekhout et al., 2017).

Physical activity. The amount of PA was assessed with the Short Questionnaire to Assess Health Enhancing Physical Activity (SQUASH) (Wendel-Vos, Schuit, Saris, & Kromhout, 2003). This questionnaire assesses the amount and intensity of different types of PA performed during (volunteering)work, commuting, household and leisure time. It allows for calculating the total minutes per week of PA performed with moderate to vigorous intensity (MVPA) (World Health Organisation, 2010a). The psychometric properties of the SQUASH have been found acceptable (De Hollander, Zwart, De Vries, & Wendel-Vos, 2012; Wagenmakers et al., 2008; Wendel-Vos et al., 2003).

Loneliness. Loneliness was assessed with the De Jong Gierveld 6-item Loneliness Scale, whose psychometric properties have been found acceptable (De Jong Gierveld &

Van Tilburg, 2010). This scale has 6 items (e.g., "I often feel rejected") on originally a 6-point scale, but was adapted to a 10-point scale (1 = *absolutely not*; 10 = *absolutely sure*) as this was deemed more fitting for older adults (Krosnick, 2010; Remillard, Mazor, Cutrona, Gurwitz, & Tjia, 2014). Items with answer ranges from 6 to and including 10 (indicating loneliness) are summed, resulting in a potential score of loneliness between 0 (not lonely) and 6 (extremely lonely).

Statistical analyses

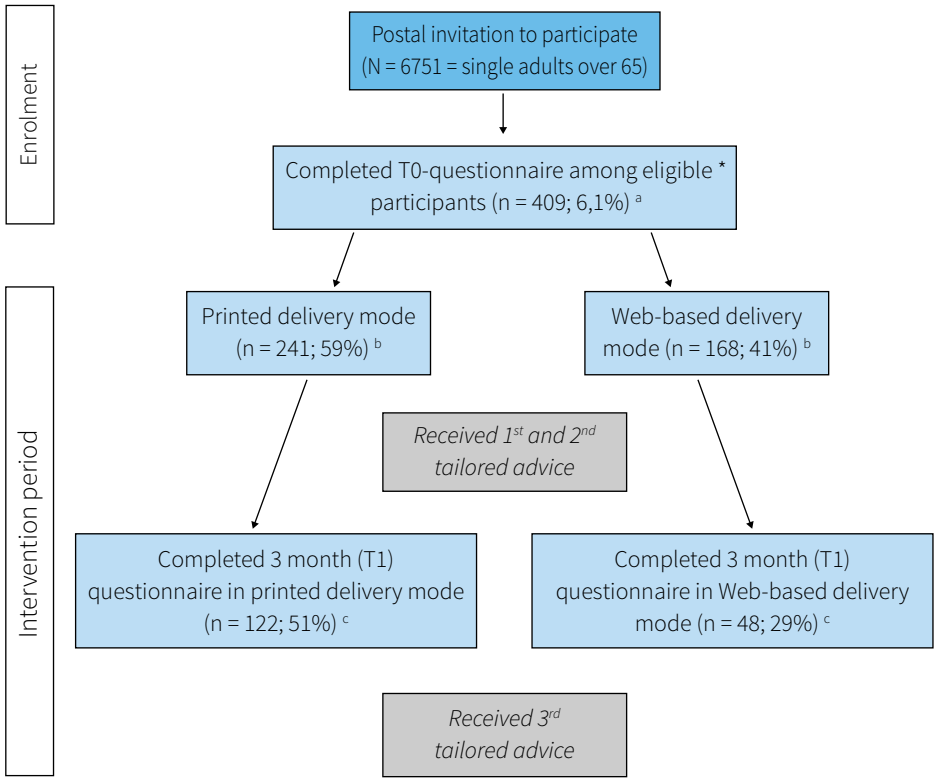
Differences in delivery mode preference. Statistical analyses were performed on those participants who completed the baseline questionnaire. Univariate one-way analyses of variance (ANOVA) and chi-square tests were performed on age, gender, educational attainment, BMI, PA, loneliness, modeling, social support, attitude, self-efficacy and intention to assess whether participants differed at baseline between the printed and Web-based delivery mode. Hierarchical logistic regression was performed on the T0-data to determine which of those user characteristics predict differences in the preference for the printed or Web-based delivery mode. Outcome measure was the dichotomous variable of delivery mode. Step 1 of the analyses contained the demographic variables and also the weekly minutes of MVPA and loneliness. In step 2, the psycho-social determinants were added. In step 3, interaction-terms were added: as previous research provided no directions for formulating hypotheses on potential interaction effects, only interaction effects for those determinants that were significant in step 2 were included (e.g., the interaction between age and social support).

Differences in attrition. Differences in attrition between the printed and Web-based delivery mode were analyzed with a chi-square test. To identify potential factors related to attrition, hierarchical logistic regression analysis was performed on the T1-data, as this is the moment when participants have to fill the second questionnaire which will provide them with the third advice. When participants do not fill this questionnaire, attrition has occurred. The outcome measure is the dichotomous variable of attrition. In step 1 of the analysis the demographic characteristics, weekly minutes of MVPA and degree of loneliness were added. In step 2 the delivery mode was added and in step 3 the psycho-social determinants were added. In step 4 interaction terms of user characteristics and delivery mode were added, to assess whether dropout is associated with certain combinations of user characteristics and delivery mode: gender, age and educational attainment were selected on the basis of previous research (Golsteijn et al., 2017; Greaney et al., 2014; Short et al., 2014).

All significance levels were set at $p = .05$, except for the final step of the regression analyses where significance was set at $p = .10$, as interaction terms are known to have less power (Twisk, 2006). SPSS version 24 was used to perform all analyses.

Results

Of all eligible participants of Active Plus65, 241 (59% (241/409)) participants participated in de printed delivery mode, and 168 (41% (168/409)) participants participated in the Web-based delivery mode. In total, a response rate of 6% of invited participants was realized. Figure 3.3 provides an overview.



[a] Reported as percentage of invited participants
[b] Reported as percentage of all participants completing T0-questionnaire
[c] Reported as percentage of all participants starting in either printed or Web-based delivery mode
* Eligible participants are those that meet all requirements of being single, over the age of 65, and physically impaired in PA

Figure 3.3 Flow chart of reach and attrition in printed and Web-based delivery mode

Delivery mode preference

Several of the baseline characteristics of the printed and Web-based group differed significantly (Table 3.1). Participants in the printed delivery mode were older (p < .001), had a lower educational attainment (p < .001), were more often female (p = .02), were less physically active (p < .001), had fewer family and friends who are sufficiently physically

active as modeling-roles (p < .001), received less social support for PA (p < .001) and had a lower intention to be sufficiently physically active (p = .01).

Table 3.1 Baseline characteristics of participants in printed and Web-based delivery mode

	Printed ***n*** **= 241 (58.92%)**	**Web-based** ***n*** **= 168 (41.08%)**	***p*** **- value**
Age (years) [a]	79.22 (7.59)	73.29 (6.61)	<.001
BMI [a]	27.01 (4.89)	27.82 (5.27)	.12
Educational attainment (% low)	70.8	51.2	<.001
Gender (% men)	30.7	42.3	.02
MVPA [a]	387.72 (527.11)	606.51 (687.41)	<.001
Loneliness [a]	3.2 (1.98)	2.94 (2.06)	.21
Modeling [a]	2.55 (1.49)	3.07 (1.14)	<.001
Social support [a]	1.79 (1.27)	2.33 (1.07)	<.001
Attitude [a]	3.42 (0.57)	3.49 (0.59)	.28
Self-efficacy [a]	3.47 (0.98)	3.42 (0.96)	.58
Intention [a]	6.51 (1.61)	6.99 (1.73)	.01

[a] (mean ± SD)

Baseline user-characteristics related to delivery mode preference are presented in Table 3.2. In Step 1, age and degree of loneliness were significant predictors of delivery mode preference. Participants in the printed delivery mode were older (B = -0.10; SE = 0.02; Exp (B) = 0.91; p < .001) and more lonely (B = -0.14; SE = 0.06; Exp (B) = 0.87; p = .03) than the participants who chose the Web-based delivery mode. When entering the psychosocial variables to the analyses, age still was a significant predictor (B = -0.10; SE = 0.02; Exp (B) = 0.91; p < .001), but loneliness became non-significant (p = .16) and social support for PA then emerged as a significant predictor (B = 0.38; SE = 0.14; Exp (B) = 1.46; p = .01), with participants in the Web-based delivery mode having higher levels of social support than participants in the printed delivery mode. Explained variance (R^2) in the steps ranged between 0.15 and 0.19. The interaction in step 3 between age and social support was not significant (p = .34), indicating that the effect of age on delivery mode preference did not differ depending on the degree of social support.

Table 3.2 Hierarchical logistic regression to study whether user characteristics predict differences in delivery mode preference

Determinants	Step 1 (R^2 = 0.152) [a]				Step 2 (R^2 =0.186) [a]			
	Exp (B)	*B*	*SE*	*p* - value	*Exp (B)*	*B*	*SE*	*p* - value
First block [b]								
Age	0.91	-0.10	0.02	<.001	0.91	-0.10	0.02	<.001
Gender [c]	0.79	-0.24	0.26	.36	0.71	-0.34	0.27	.21
Education [d]	1.43	0.36	0.26	.17	1.32	0.28	0.27	.30
BMI	1.01	0.01	0.02	.56	1.02	0.02	0.03	.48
MVPA	1.00	0.00	0.00	.40	1.00	0.00	0.00	.49
Loneliness	0.87	-0.14	0.06	.03	0.91	-0.10	0.07	.16
Second block [b]								
Modeling					0.95	-0.05	0.13	.71
Social support					1.46	0.38	0.14	.01
Attitude					0.84	-0.17	0.28	.54
Self-efficacy					0.77	-0.27	0.17	.11
Intention					1.15	0.14	0.10	.19

[a] Explained variance (Nagelkerke R^2)
[b] Printed coded 0, Web-based coded 1
[c] Men coded 0, women coded 1
[d] Low educational attainment coded 0, high educational attainment coded 1

Attrition

Attrition differed significantly between the delivery modes, that is, 50% in the printed delivery mode and 71% in the Web-based delivery mode (p < .001). Table 3.3 provides an overview of the predictors of attrition during the intervention. The assessed demographic variables in step 1 were all non-significant. The delivery mode, added in step 2, was a significant predictor of attrition (B = 1.34; SE = 0.27; $Exp(B)$ = 3.81; p < .001), with attrition higher among participants in the Web-based delivery mode than in the printed delivery mode. By adding the psychosocial determinants to the analyses in step 3, delivery mode remained significant (B = 1.28; SE = 0.28; $Exp(B)$ = 3.58; p < .001), and educational attainment also became significant (B = -0.53; SE = 0.28; $Exp(B)$ = 0.59; p = .049): attrition was higher among participants in the Web-based delivery mode and among participants with a low educational attainment than for those in the printed delivery mode and for participants with a high educational attainment. Explained variance (R^2) in the steps ranged between 0.02 and 0.12. The interactions that were assessed in step 4 (i.e., delivery mode x gender

(p = .11), delivery mode x age (p = .22), and delivery mode x education (p = .26)) were all non-significant.

Table 3.3 Hierarchical logistic regression to study whether user characteristics and delivery mode predict differences in attrition

Determinants	**Step 1 (R^2 = .023)** [a]				**Step 2 (R^2 = .101)** [a]				**Step 3 (R^2 = .118)** [a]			
	Exp (B)	***B***	***SE***	***p* - value**	***Exp (B)***	***B***	***SE***	***p* - value**	***Exp (B)***	***B***	***SE***	***p* - value**
First block [b]												
Gender [c]	0.86	-0.16	0.25	.53	0.91	-0.09	0.26	.73	0.85	-0.16	0.27	.55
Age	0.97	-0.03	0.02	.11	1.00	0.00	0.02	.92	1.00	0.00	0.02	.94
Education [d]	0.70	-0.36	0.24	.14	0.61	-0.49	0.26	.06	0.59	-0.53	0.28	.049
BMI	0.97	-0.04	0.02	.13	0.96	-0.04	0.02	.08	0.96	-0.04	0.03	.09
MVPA	1.00	0.00	0.00	.29	1.00	0.00	0.00	.18	1.00	0.00	0.00	.23
Loneliness	0.94	-0.07	0.06	.26	0.97	-0.03	0.06	.64	0.98	-0.02	0.07	.73
Second block [b]												
Delivery mode [e]					3.81	1.34	0.27	<.001	3.58	1.28	0.28	<.001
Third block [b]												
Self-efficacy									0.80	-0.22	0.16	.16
Intention									0.99	0.00	0.10	.99
Modeling									1.16	0.15	0.13	.23
Social support									1.08	0.07	0.14	.60
Attitude									1.11	0.11	0.27	.69

[a] Explained variance (Nagelkerke R^2)
[b] Non-attrition coded 0, attrition coded 1
[c] Men coded 0, women coded 1
[d] Low coded 0, high coded 1
[e] Printed coded 0, Web-based coded 1

Discussion

This study aimed to determine which user characteristics predict the preference for either a Web-based or printed delivery mode of a PA intervention for single older adults with a physical impairment. In addition, this study examines what user characteristics and which delivery mode predict attrition. This provides insights into which factors should be considered when designing PA interventions for this target population.

Delivery mode preference

A total of 41% of the participants chose to start in the Web-based delivery mode. Although this demonstrates a potential interest of single older adults with physical impairments in Web-based delivered interventions, the majority still prefers a printed delivery mode. This is in line with data on the still present digital divide showing that only 50% of older adults regularly use the internet, with only 15% of older adults using health applications (AARP Research, 2017; European Parliamentary Research Service, 2015; Pew Research Center, 2017). These findings corroborate previous research and data that suggests that although internet use among older adults has increased over the last decade, it may take many years before internet delivery mode will be the leading preference among all age groups (Friemel, 2016; A. K. Hall, Bernhardt, Dodd, & Vollrath, 2015; Latulippe, Hamel, & Giroux, 2017). Therefore, presently, intervention-developers should not rule out printed delivery modes for this target population, as this could lead to the exclusion of a large segment of the target population.

Age was found to be a significant predictor of delivery mode preference, with older participants preferring the printed delivery mode more often. This finding is in line with our hypothesis as well as with previous research (Golsteijn et al., 2017; Greaney et al., 2014; Peels, Bolman, et al., 2012). Corroboration for this finding is also encountered in the Unified Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh, Morris, Davis, & Davis, 2003). In this model performance expectancy, effort expectancy and social influence determine usage intention, and through intention they influence behavior. According to UTAUT it may be that as older adults have less experience with internet (Dutch Central Bureau of Statistics, 2016a; Statista, 2018) they may expect the Web-based delivery mode of Active Plus65 to be more difficult and consequently choose the printed delivery mode; this preference may be enhanced by the social influence of peers who have the same expectations.

In contrast to our hypothesis, educational attainment was not found to be a significant predictor of delivery mode preference. It could be that the lower use of internet for health enhancing interventions among people with a lower educational attainment (De Veer et al., 2015; Latulippe et al., 2017; Lustria et al., 2013; Van Deursen, Van Dijk, & Ten Klooster, 2015) is outweighed by a general increase in availability and use of internet by older adults (Dutch Central Bureau of Statistics, 2016a). Another explanation is that the assistance with internet

that was offered when inviting participants for Active Plus65 has given lower educated participants enough confidence to start in the Web-based delivery mode. In practice, only 10% of participants used this offer, but other assistance such as by the participants' own social network may have been received. This explanation is supported by the review of Kampmeijer, Pavlova, Tambor, Golinowska, and Groot (2016) who found that support is essential to give older adults the confidence to experiment with new technologies. Another explanation may lie in the overrepresentation of the female gender (65%) and low educational attainment (63%) at baseline. As educational opportunities have long been in the disadvantage of women it may be that for older women educational attainment is less indicative of intelligence or for digital literacy and therefore does not have a predictive value for delivery mode.

In step 1 of the exploratory analyses into the predictive value of PA and loneliness on delivery mode preference, only loneliness was found to be a significant predictor: among participants in the printed delivery mode, a higher degree of loneliness was found. In step 2 of the analyses loneliness became non-significant and social support for being physically active emerged as a significant predictor: participants with a lower social support for being physically active preferred printed participation. Possibly, participants who receive less social support for being physically active, also receive less social support for other parts of life, such as for digitalization, thus making them less inclined to participate in a Web-based intervention. This is supported by previous studies that argue that those with close social support receive explanation and encouragement to use new technologies, such as internet, making it easier for them to adopt Web-based interventions (Friemel, 2016; Hill, Betts, & Gardner, 2015; Vroman, Arthanat, & Lysack, 2015). Policy makers who strive to increase internet use within health care (e.g., for budgetary reasons) should pay special attention to those who are older and have lower social support. As this group demonstrated to prefer a printed delivery mode, steering them strictly towards internet delivery could risk losing them altogether for the intervention. For this subgroup it may be essential to emphasize that the Web-based intervention is easy to use. In addition, future intermediaries of interventions could consider providing internet training opportunities to stimulate the use of internet delivered interventions. A pre-enrollment questionnaire that assesses the level of internet literacy could be useful to determine the optimum format of the intervention.

Attrition

Overall, attrition from the intervention was 58%. Although this is considerable, it is not uncommon: other studies into PA-interventions for older adults have shown widely varying attrition rates ranging from 22% to 76% (Jancey et al., 2007; Mouton & Cloes, 2013; Mullen et al., 2013). However, several more recent studies have shown relatively low attrition rates (ranging from 0% to 51%, with a mean of 21%) (Alley et al., 2018; Van der Deijl, Etman, Kamphuis, & Van Lenthe, 2014), and these provide indications that an association between lower attrition and higher age may be present (Peels, Bolman, et al., 2012; Van der Deijl et

al., 2014). When considering these studies, the attrition from our intervention appears relatively high. Considering the relatively high attrition, for future research a deeper analysis into the appreciation of the intervention would be useful.

Only delivery mode and educational attainment were found to be significant predictors of attrition: attrition was higher among participants in the Web-based delivery mode and among those with a lower educational attainment. The fact that only 2 determinants were found to predict attrition could be an indication that the computer-tailoring in Active Plus65 delivers advice that is equally valued in a broad range of participants. To provide corroboration for the finding that both Web-based delivery mode and low educational attainment are predictors of attrition, 2 models can be outlined, that is, the Senior Technology Acceptance and Adoption Model (STAM) (Renaud & Biljon, 2008) and the Cycle of Technology Acquirement by Independent Living Seniors Model (C-TAILS) (Peek et al., 2017). In STAM the ease of learning is a crucial determinant for conversion to a new technology. It may thus be that the lower educated participants who started in the Web-based delivery mode, are unable to succeed in comfortably using the Web-based delivery mode, and consequently stop using the intervention. In addition, C-TAILS stipulates that a new technology needs to be aligned with an individual's needs: as Active Plus65 is not acquired on the participants' initiative, it may be that their need for an intervention is lower and that especially for the lower educated participants initial difficulties with using the Web-based intervention results in attrition. It may have some practical implications that attrition is higher in the Web-based delivery mode and among those with a lower educational attainment. For future intervention development including targeted retention techniques specifically for Web-based delivery, such as email prompts, or delivering not all advice at once but in stages, could decrease attrition (Brouwer et al., 2011; Schneider, De Vries, Candel, Van de Kar, & Van Osch, 2013). Several studies show that presentation strategies of interventions may need to be tailored in more accordance with low educational attainment to decrease attrition: examples are using more graphic materials instead of text and using entertaining or interactive elements (Bennett, 2009; Milward, Drummond, Fincham-Campbell, & Deluca, 2018).

It was also hypothesized that older age would be a predictor of higher attrition, but this was not established. An explanation may lie in the specific characteristics of our target population: participants who are older, have a poor health status and are unemployed more often use an intervention as intended and will thus show a lower attrition (Reinwand, Schulz, Crutzen, Kremers, & De Vries, 2015). Those demographic determinants are comparable with the characteristics of the participants of Active Plus65 who are older, have physical impairments, and are mostly retired: although being retired may not be directly comparable to being unemployed there are obvious similarities. Conversely, another characteristic specific to our target population, i.e, being single, may have had an opposite effect on attrition: it has been demonstrated that not having a life partner negatively influences internet use (Friemel, 2016), which could contribute to a higher attrition.

Our assumption that a stronger presence of the psychosocial determinants associated with behavior change would be related to a lower attrition was not confirmed. At 3 months in the intervention participants have already received advice 2 times. It could be that from this advice participants obtained the anticipated aid they needed from the intervention, and decide to discontinue use. That may even be more so the case for those with a higher presence of variables associated with behavior change: Active Plus65 focuses strongly on stimulating the motivation for PA, and it could be that for participants who already have a higher commitment for behavior change the additional value of Active Plus65 is less distinct. It has been suggested that especially in Web-based interventions participants may stop using an intervention once they achieved outcomes they consider adequate (Ritterband, Thorndike, Cox, Kovatchev, & Gonder-Frederick, 2009). Attrition from this point of view may not even be negative but rather be an affirmation of realizing what participants had expected to gain. The above demonstrates that a solid insight into the pre-intervention characteristics that are predictive of attrition may be useful before enrolling participants in the intervention: in line with that, more insight into the appreciation of the intervention could also provide valuable information.

Strengths and limitations

As far as could be determined, this is the only study that assesses reach and attrition of the Web-based and printed delivery mode of an intervention with identical content among a population of single older adults with a physical impairment. As this population is growing fast, this study provides valuable insights. However, some limitations need to be acknowledged.

First, with 6% the response rate appears to be quite low. Although a recent review showed that this is in line with similar interventions (Zubala et al., 2017), low response rates limit the public health impact of these kind of interventions. The relatively low response rates and the fact that no information on non-participants is available makes it impossible to perform predictive analyses on who is interested in this kind of interventions. We can only provide insight into the older adults who actually chose to participate. Second, only the baseline characteristics were included as potential predictors of attrition: it could be that other variables, such as digital literacy, engagement or satisfaction with the intervention are related to attrition, but this could not be determined. Third, attrition from the intervention was relatively high, although this is common in eHealth interventions and in line with comparable studies (Davies et al., 2012; Geraghty, Torres, Leykin, Pérez-Stable, & Muñoz, 2013). Fourthly, our study focusses on a specific part of older adults, that is, those who have a physical impairment and are single. As older age is generally accompanied with the onset of physical impairments, the majority of older adults will meet this particular characteristic of our target population. However, this will not be applicable for the characteristic of being single, which may have implications for the generalizability of our findings. Considering the aim of our intervention, that is, stimulating PA preferably

done with others, it could be that our intervention has another impact for singles and non-singles. It may thus be advisable to repeat our studies in a population of mixed marital status. Finally, the proportion of variance explained by our analyses appears relatively low (2% to 19%), despite the fact that a broad range of potential demographic, health and psychosocial determinants for delivery mode preference or for attrition were included. Nonetheless, these results are in line with comparable studies (Golsteijn et al., 2017; Peels, Bolman, et al., 2012).

Conclusions

The findings of our study contribute to outline which delivery modes are likely to be the most advisable for specific target populations, thus increasing the impact that interventions can potentially have on public health. Our results show that participants who are older and have lower levels of social support for PA are more attracted to the printed delivery mode of Active Plus65. Attrition was higher among those with a lower educational attainment, indicating that for these participants print delivered interventions would yield higher participation rates than Web-based delivered interventions. Whereas the Web-based delivery mode showed a higher attrition, printed delivery modes in general have the downside of being more expensive. It may therefore be advisable that printed delivery modes and Web-based delivery modes are offered alongside each other. Further research may also provide potential solutions to decrease attrition among the lower educated. As the speed in which changes in internet-use develop is high, a continuous research into delivery mode preference and attrition is needed.

Chapter 4

Evaluation of a computer-tailored healthy ageing intervention to promote physical activity among single older adults with a chronic disease

Janet M. Boekhout
Brenda A.J. Berendsen
Denise A. Peels
Catherine A.W. Bolman
Lilian Lechner

International Journal of Environmental Research and Public Health; ***2018****,15, 346*
DOI: 10.3390/ijerph15020346

Abstract

Introduction

This study explores the effectiveness of the Active Plus65 intervention designed to stimulate physical activity among single older adults with a chronic physical impairment.

Methods

A quasi-experimental pretest-posttest study was performed. The intervention group (n = 411; mean age = 76.75; SD = 7.75) was assessed at baseline, 3 months, and 6 months. Data of comparable older adults who completed the original Active Plus intervention served as reference group (n = 87; mean age = 74.36; SD = 6.26). Multilevel regression analyses were applied: outcome measures were weekly minutes of moderate to vigorous physical activity (MVPA) and days per week with at least 30 minutes of MVPA.

Results

Although Active Plus65 did not outperform the original intervention, in itself Active Plus65 effectuated a significant increase in the weekly minutes of MVPA (B = 208.26; p < 0.001; Effect Size (ES) = 0.45) and in the days per week with sufficient MVPA (B = 1.20; p < 0.001; ES = 0.61) after 3 months. After 6 months, it effectuated a significant increase in the days per week with sufficient MVPA (B = 0.67; p = 0.001; ES = 0.34) but not for the weekly minutes of MVPA (p = 0.745).

Discussion

As Active Plus65 increased MVPA at 3 months with a higher ES than average interventions for this vulnerable target group, it potentially makes an interesting intervention. Further development should focus on long-term maintenance of effects.

Introduction

It is expected that by 2040 the number of people older than 65 will have doubled worldwide (World Health Organisation, 2015). Aging populations come with high costs for society, as health care expenditure rises with age, showing a steep incline from the age of 65 (Organisation for Economic Cooperation and Development, 2016). One of the reasons of this increase in health care expenditure is that the majority of people develop 1 or more non-communicable chronic disease(s) (NCCD) later in life (Ding et al., 2016; European Union, 2015). Literature shows no uniform definition of what a NCCD is. A frequently used definition states that "chronic diseases are generally characterized by uncertain etiology, multiple risk factors, a long latency period, a prolonged course of illness, noncontagious origin, functional impairment or disability, and incurability" (McKenna & Collins, 2010), which, similar to most definitions, includes the presence of some degree of functional impairment regarding physical activity (PA) (Goodman et al., 2013). Being sufficiently physically active can prevent or postpone the development of several NCCDs and has a beneficial effect on the course of already present NCCDs (Ekelund et al., 2016; Hamer, Lavoie, & Bacon, 2014; Matheson et al., 2013; World Health Organisation, 2010a). For older adults (65 years and over), sufficient PA has additional beneficial effects. The risk of developing cognitive decline is lower and balance is preserved longer, reducing the risk of fall-related injuries (Gajewski & Falkenstein, 2016; World Health Organisation, 2007). However, the number of adults that achieve the recommended level of PA (defined by the World Health Organisation (2010a) as a minimum of 150 minutes per week of moderate to vigorous physical activity (MVPA), which is comparable to the Dutch recommendation (Dutch Department of Health Wellbeing and Sports, 2015b) of a minimum of 30 minutes of MVPA per day on at least 5 days per week), decreases steadily as people age (European Union, 2015; Sun, Norman, & While, 2013). This is especially the case for older adults with a NCCD, who are often confronted with physical impairments and are thus facing additional barriers regarding PA (Newsom et al., 2012; Öztürk et al., 2011; World Health Organisation, 2011). In the Netherlands, 84% of healthy people over the age of 55 achieve the recommended level of PA; for people with a NCCD, this is 71%, and for people with a physical limitation caused by a NCCD, this is 42% (Dutch Department of Health Wellbeing and Sports, 2015a): Western society in general shows similar figures (World Health Organisation, 2010c). Besides older people who have a NCCD, older people who are single are also reported to be less physically active than those living with a partner (Cattan, White, Bond, & Learmouth, 2005; Hawkley et al., 2009; Hawton et al., 2014).

The subpopulation of single older adults with a NCCD therefore deserves special attention regarding their health: not only is this group highly vulnerable for health problems associated with a lack of PA, but also because of its present and future proportion in society. Although much research is available on health promotion interventions, and healthy ageing has a strong scientific and societal relevance, the specific strongly growing

target population of single older adults with a chronic limitation seems to have been often overlooked in research. Promoting PA by means of eHealth interventions is a relatively low-cost way to improve the health of this subpopulation. Although research is available regarding the effectiveness of eHealth interventions for older adults, so far research has mainly focused on the younger age groups of older adults (i.e., 50–70 years) or on multiple health behaviors instead of only PA (Muellmann et al., 2017). Also, research often focusses on health behaviors with a particular disease (Elbert et al., 2014), whereas multimorbidity is highly prevalent (World Health Organisation, 2010b). The current study provides insight in the effectiveness of the Active Plus65 eHealth intervention, which is an adapted version of the proven effective Active Plus50 intervention. The intervention is adapted to better suit the needs of single people aged over 65 with a chronic disease (Boekhout et al., 2017) by, among other adaptations, stimulating participants to be physically active together with others in order to prevent or decrease loneliness, which is an independent risk for mental and physical health. To our knowledge, no interventions with a focus on this specific highly vulnerable and growing target population have been researched so far.

The present study provides insight into the effects of the Active Plus65 intervention on PA and it examines whether the adaptations made to Active Plus65 result in comparable or even better results than the original proven effective intervention that was less adapted to this specific target population. Although a large amount of literature is available on health promotion interventions that were proven successful in randomized clinical trial (RCT)-settings, rather limited research is available regarding the effectiveness of the same interventions in real-life implementation settings. As Active Plus50 has been extensively studied (and proven effective) in a research setting (Peels, Bolman, et al., 2013; Peels et al., 2014), the current study is performed in a real-life setting to provide a realistic insight into the potential effects of the Active Plus intervention on public health (Curran, Bauer, Mittman, Pyne, & Stetler, 2012; Glasgow, Vogt, & Boles, 1999).

Methods

Intervention

Active Plus65 is a computer-tailored healthy aging intervention designed to stimulate or maintain sufficient PA among single older people with an impairment in PA caused by a NCCD. The tailored advice can be delivered either in an internet-based version or in a printed version and is presented in a predominantly text-based format, supplemented with graphs, pictures (printed version), or short videos (internet-based version). There are no differences between the content of the printed or internet-based version. The tailored information is based on the participants' demographic and psychosocial characteristics (e.g., age, attitude, motivation, and self-efficacy regarding PA), their present PA level, and the stage of behavioral change they are in (Boekhout et al., 2017). Depending on the

assessed characteristics and determinants, the dispensed form of each advice consists of 7 to 12 pages (A4-format). In addition, each advice comes with activating elements such as (1) planning sheets that the participant is stimulated to use in order to plan PA, (2) formats that the participant has to fill out in advance on how they plan to deal with difficult situations that may interfere with PA, (3) formats where they are asked to formulate and write down their implementation intentions, (4) brochures from local PA-exercise groups, and (5) medical information on exercising with a physical limitation.

During the intervention period of 4 months, participants receive personal PA-advice on 3 occasions, based on 2 assessments using self-report questionnaires. The first advice aims to raise consciousness of the current level of PA by targeting pre-motivational psychosocial constructs, such as awareness and knowledge. The second advice motivates participants to increase PA by targeting motivational psychosocial constructs such as attitude, self-efficacy, social influence, intrinsic motivation, and intention. Moreover, participants are stimulated to plan their PA, and to prepare for difficult situations. The intervention also helps to overcome barriers with regard to PA, and thus helps the participants to transfer their motivation into sustainable behavior: depending on the degree in which participants are already active, this is done at the second or the third advice stage by targeting post-motivational psychosocial constructs, such as strategic, action-, and coping-planning. A follow-up assessment is performed 6 months after the start of the intervention: this assessment serves only to measure the level of PA and does not result in the provision of advice.

Active Plus65 was developed in 2016 (Boekhout et al., 2017) using the Intervention Mapping Protocol (Bartholomew et al., 2016), and is rooted in influential health behavior change theories, such as the I-Change model (De Vries et al., 2003), Trans Theoretical model (Prochaska et al., 2008), self-determination theory (Ryan & Deci, 2000), self-regulation theory (Baumeister & Vohs, 2004), and Health Action Process Approach (Schwarzer & Luszczynska, 2008). Active Plus65 is an adaptation of the Active Plus50 intervention, which was previously developed to stimulate the initiation and maintenance of PA for people over the age of 50 (Peels, Van Stralen, et al., 2012; Van Stralen et al., 2008). Although Active Plus50 was proven effective for the general population of people over the age of 50 (Peels, Bolman, et al., 2013; Peels et al., 2014), showing higher Effect Sizes (ESs) for people aged over 65 than younger age groups, program evaluations showed that single older adults with an impairment in PA caused by a NCCD preferred more information about the possibilities for PA that match their impairment and about increasing their social network while being physically active (Peels, Bolman, et al., 2013; Peels et al., 2014). These preferences are in line with other research that has shown that effectiveness of eHealth interventions for older adults increases with the level of individual tailoring and if the advice contains a referral to local possibilities for PA (Hobbs et al., 2013). Based on these findings, Active Plus65 tailors more in-depth to the physical impairments that the participants report, motivates participants to find other persons to be physically active with, and refers to local activities where one can be physically active, preferably in a social group.

Study design and procedures

As Active Plus50 has been proven effective in an RCT (Peels, Bolman, et al., 2013; Peels et al., 2014), the study of Active Plus65 was conducted in a real-life implementation setting. The restrictive setting and standardized protocols of RCTs can result in an over- or underestimation of the effectiveness of interventions when compared to studies that are performed in an implementation setting. This is due to several differences in the characteristics of RCTs and implementation settings (Guertler et al., 2015; Neve, Collins, & Morgan, 2010; Wanner, Martin-Diener, Braun-Fahrländer, Bauer, & Martin, 2009). One of these differences is that the motivations of participants who are aware that they are part of a scientific study may differ from the motivations of participants that join an intervention in real life. Also, intervention and control groups often undergo an intensive screening to determine eligibility and may thus have different features than people in a real-life setting. The current design thus provides a realistic insight into the effects that Active Plus65 may have on public health (Curran et al., 2012).

A quasi-experimental pretest-posttest study was conducted with 3 assessment time points. The assessment time points during the intervention-period were at baseline (T0), at 3 months after baseline (T1), and a follow-up assessment at 6 months after baseline (T2). The study of Active Plus65 was conducted in a real-life implementation setting and compared to existing data from a previously conducted RCT of Active Plus50.

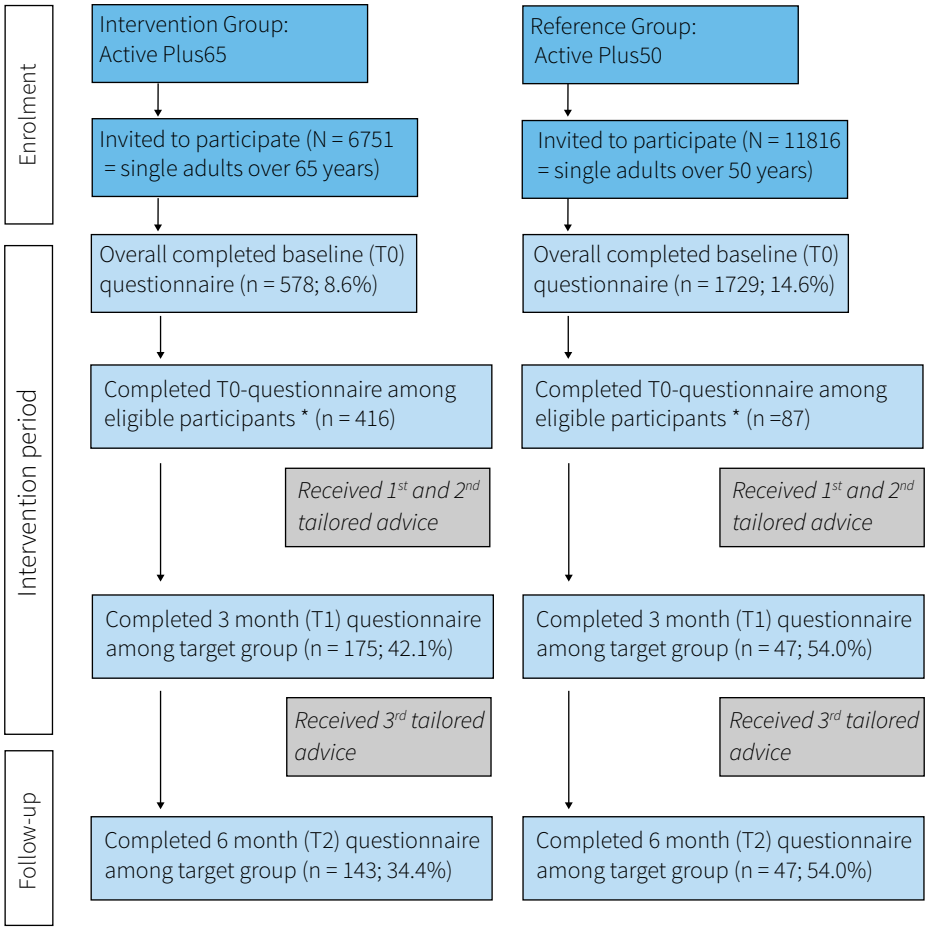
Participants for the intervention group were gathered from a Dutch municipality. All inhabitants who, according to the municipal data, were single and 65 years or older (*n* = 6751) were invited in April 2016 by direct mailing by their municipality to participate in Active Plus65. Invitations were sent by post, containing a personalized information letter including log-in details for internet-based participation and a prepaid response card to request a paper questionnaire for those preferring the printed version of the intervention. Inclusion of participants lasted from early April until the end of May 2016. Advice was sent to the participants immediately after completing the baseline assessment for the internet-based version (in their web browser and by email) or within 2 weeks after returning the completed printed questionnaire (by post). After 3 months, all participants received the second questionnaire: this was sent by the same method the participants had used for the first questionnaire (i.e., email or printed mail). The time schedule of sending the advice was similar for sending the advice for T0. Six months after baseline (i.e., 2 months after the end of the intervention-period), all participants received a follow-up questionnaire.

As Active Plus65 was designed to better meet the wishes and needs of the specific target population (Boekhout et al., 2017) in comparison to its predecessor, Active Plus50 (which was designed for all adults aged over 50, regardless of their marital status or the presence of a NCCD), Active Plus65 was compared to Active Plus50. For this comparison, the Active Plus50 data from a previously performed randomized clinical trial (RCT) (Peels et al., 2014) was used. From this data, a reference group was created by extracting only the data of those participants of the intervention group of Active Plus50 who were aged

over 65 years, single, and living with a physical impairment caused by a NCCD. Due to the implementation of the Active Plus65 in real life, no control group was available, and the number of participants in the control group of the original Active Plus50 studies that met the requirements was too low to supply sufficient power in the analyses. In line with the recommendations of Curran et al. (Curran et al., 2012; Glasgow et al., 1999), this study compares an adapted version of the intervention in a real-life implementation setting with its predecessor that has been proven effective in an RCT. Such a blending of study design components has been proposed previously: Curran et al. (2012) describe the benefits that "effectiveness-implementation hybrid designs" have. These hybrid forms could prevent the possibility that interventions that are proven effective in the controlled setting of an RCT do not properly address the issues that determine its effectiveness in implementation settings. The current study design meets the description and assumptions of such a hybrid design (i.e., examining the effects of an intervention in an implementation setting while taking into account the outcomes gathered in a RCT setting).

There were some differences in data collection for Active Plus65 and Active Plus50. In the invitation letter of Active Plus65, it was explained that the intervention was specifically designed for single, chronically impaired people aged over 65, whereas in Active Plus50, the general population of people aged over 50 was targeted. Contrary to Active Plus65, where participants could choose themselves between a printed or internet-based program, the participants in Active Plus50 had been randomized to either a printed or internet-based intervention group or a control group. Despite these differences, Active Plus50 can be considered a fitting reference group. Figure 4.1 presents an overview of the reach and attrition of intervention and reference group. From both data sets, only eligible participants (i.e., participants who met the criteria of being single, over 65 years, and chronically impaired) were analyzed.

A sample size calculation (Faul, Erdfelder, Lang, & Buchner, 2007) showed that inclusion of a total of 296 participants for the between groups comparison was required (ES = 0.29, power = 90%) for the outcome-measure of weekly minutes of MVPA. The ES and power are based on the previous study into the effectiveness of Active Plus50, where an average ES of 0.29 was found on this outcome measure (Peels et al., 2014). For weekly days with sufficient PA, the average ES was 0.22, resulting in a required total of 514 participants. Based on the same parameters, 130 participants were required for the within group analyses.



* Eligible participants are those that meet all requirements of being single, over the age of 65, and chronically impaired in PA)
Note: T0 is reported as percentage of invited participants; T1 and T2 are reported as percentage of baseline numbers

Figure 4.1 Flow chart of reach and attrition in intervention and reference group

All subjects gave their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Research Ethics Committee of the Open University of the Netherlands (reference number U2016/02373/HVM). The data from Active Plus50 received approval under the Dutch law for medical scientific research (reference number NTR2297) (Peels, Van Stralen, et al., 2012).

Measures

Outcome measures. Outcome measures are the weekly minutes of MVPA and the days per week with sufficient MVPA, both measured using the Short Questionnaire to Assess Health Enhancing Physical Activity (SQUASH) (De Hollander et al., 2012; Wagenmakers et al., 2008; Wendel-Vos et al., 2003). The relative validity (*rSpearman* = 0.45; 95% CI = 0.17–0.66) and reproducibility (*rSpearman* = 0.58; 95% CI = 0.36–0.74) of this questionnaire can be considered to be reasonable. The SQUASH was filled in based on an average normal week in the last month. PA was scored on 4 types of activities, i.e., during commuting by foot and bicycle, at (volunteering) work or study, during domestic chores, and during leisure-time/ sport activities. The participants reported on how many days a week they performed this activity (in a number between 1 and 7), how much time per day this took (in hours and/ or minutes), and how demanding these activities were (with 3 options; *light*, *moderate*, and *vigorous).* The outcome measure of weekly minutes of MVPA is calculated by multiplying the frequency (days per week) and duration (hours/minutes per day) of activities that were performed with moderate to vigorous intensity. The outcome measure of days per week with sufficient MVPA was measured by a single item in the questionnaire: "How many days per week (on average in the past month) are you, in total, at least moderately physically active by undertaking, for example, brisk walking, cycling, household chores, gardening, sports or other physical activities for at least 30 min?".

Demographics. Age, gender, educational level, Body Mass Index (BMI), intention to be sufficiently physically active, way of entry (internet-based or printed), degree of impairment, and the 2 outcome-measures were assessed at baseline. Educational level was categorized into low (elementary, medium general, preparatory vocational, lower vocational, higher general secondary, preparatory academic education, medium vocational school) and high (higher vocational school or university) according to the Dutch educational system. BMI is the division of self-reported weight by height in meters squared. The intention to be sufficiently physically active was measured by 3 items on a 10-point scale, ranging from 1 (*absolutely not*) to 10 (*absolutely sure*); an example of such an item is: "How likely do you think it is that you will stay or become sufficiently physically active?" (Fishbein & Ajzen, 2010; Sheeran & Orbell, 1999; Van Stralen, De Vries, Mudde, Bolman, & Lechner, 2011; Van Stralen et al., 2009). The degree of impairment was measured in different ways in Active Plus65 and Active Plus50. In Active Plus65, the participant was asked for 10 prevalent NCCDs to state to what degree he/she is limited in his/her PA by 1 of the mentioned diseases or by another not mentioned disease. For each disease, the participant could score the degree of impairment on a 4-point scale ranging from 1 = not at all/hardly, 2 = a little, 3 = very, to 4 = extremely: the highest reported level of impairment on the stated NCCDs determined the degree of impairment. Though the above is not a validated question, its usability has been successfully pilot tested among the target population (Boekhout et al., 2017). In Active Plus50, the degree of impairment of all potentially present NCCDs was measured by 1 single

item ("To what degree are you impaired in PA?") on a comparable 4-point scale as in Active Plus65.

Furthermore, all psychosocial variables necessary to provide the participants with tailored advice (e.g., one's attitude, motivation, and self-efficacy regarding PA) were assessed, but will not be elaborated on, as these are not included in the analyses of the current study.

Statistical analyses

All analyses were conducted in SPSS for Windows (version 22) (IBM Statistical Package for Social Sciences, Armonk, NY, US). In all tests, a reproducibility level of 95% was applied ($\alpha = 0.05$). Analyses were applied without imputation of missing data, as applying multilevel analyses to an incomplete dataset has been shown to result in more accurate estimations than using multiple imputation (Twisk, De Boer, De Vente, & Heymans, 2013). Baseline differences (on days per week with sufficient MVPA, weekly minutes of MVPA, age, gender, education, BMI, way of entry, impairment, and intention) between participants of Active Plus50 and Active Plus65 were analyzed by t-tests and Chi-square tests. Binary logistic regression was applied to test for selective drop-out for the same variables as the analyses for baseline differences. As measurement points were nested within participants, resulting in possible interdependence, multilevel linear regression analyses were conducted with random intercepts (time and participants) to study the intervention effect on PA (within group comparison with 2 separate analyses, i.e., 1 per dependent variable), and to compare the differences between the intervention group and reference group (between group comparison with 2 separate analyses, i.e., 1 per dependent variable). Dependent variables were days per week with sufficient MVPA and weekly minutes of MVPA. Intervention effects between intervention group and reference group were compared between T0 and T1, and between T0 and T2. In the analyses of the between groups comparison, the independent variables were the dummies of the different groups (Active Plus65 and reference group), baseline value of PA, and the a priori selected covariates (gender, educational level, BMI, intention, and way of entry (internet-based or printed)). In the within group analyses, the same independent variables were applied, with exclusion of the dummy for the different groups. Cohen's *d* Effect Sizes *(*ESs) were calculated, in which ESs were defined as the mean differences in PA between T0 and the following measurement (i.e., T1 or T2) divided by the pooled standard deviation (SD) of those means (Morris & DeShon, 2002). For the ESs of change in PA within each group (Active Plus65 and reference group), T1 and T2 were compared to T0 with an ES calculator for within group effects (York University, 2017); for the between groups comparison of the ESs of the intervention group with the reference group, their respective individual means and SDs were used in an ES calculator for between groups effects (University of Colorado, 2017). ESs of 0.20, 0.50, and 0.80 were considered to be, respectively, small, medium, or large (Cohen, 1992).

Results

Characteristics of the study population

Table 4.1 Baseline characteristics of the research groups

Variables	Active Plus65 (*n* = 416)	Reference group (*n* = 86)	*p* - value
Days per week with sufficient MVPA[a] (mean ± SD)	2.36 (2.31)	3.46 (2.24)	<0.001
Weekly minutes of MVPA (mean ± SD)	491.49 (±635.63)	539.28 (±616.18)	0.526
Age (years) (mean ± SD)	76.75 (±7.75)	74.36 (±6.26)	0.002
Gender (% male)	35.60	22.40	0.018
Education (% low)	67.40	62.80	0.413
BMI (mean ± SD)	27.3 (±5.05)	26.8 (±5.0)	0.390
Way of entry (% online)	41.10	30.20	0.060
Degree of impairment (% very to extremely impaired)	51.80	32.60	0.002
Intention to be physically active	6.71 (±1.67)	6.48 (±2.13)	0.355

[a] Moderate to vigorous physical activity
Note: Degree of impairment is measured differently in Active Plus65 and the reference group, as explained in the demographics section

The way of entry was the only significant predictor of drop-out, with online participants less likely to fill in the 6 month questionnaire ($B = 0.663$; $p = 0.003$). At baseline, participants in Active Plus65 were older, more often male, more often perceived severe physical impairments, and had fewer days per week with sufficient MVPA compared to the reference group (Table 4.1).

Intervention effects on PA

The within group analyses revealed that overall, the days per week with sufficient MVPA of the Active Plus65 group increased significantly at T1 compared to T0 ($B = 1.20$; $p < 0.001$; ES = 0.61). Weekly minutes of MVPA also increased ($B = 208.26$; $p < 0.001$; ES = 0.45). Between T1 and T2, the days per week with sufficient MVPA decreased, but the total increase between T0 and T2 was still significant ($B = 0.67$; $p = 0.001$; ES = 0.34). For weekly minutes of PA, the decrease between T1 and T2 was larger, causing the overall effect between T0 and T2 to become non-significant ($B = -17.3$; $p = 0.745$). ESs are small, except for the ES for days per week with sufficient MVPA at T1, which has a medium ES.

In the between groups analyses, no significant differences between Active Plus65 and the reference group were found for the days per week with sufficient MVPA between T0, T1,

and T2 (Table 4.2). For the weekly minutes of MVPA, a significant difference between Active Plus65 and the reference group was only found between T0 and T2 (B = 370.94; p = 0.004; ES = 0.25), in favor of the reference group: the ES can be considered small.

Table 4.2 Difference in physical activity (PA)-outcomes between Active Plus65 and reference group

	B	***SE***	***p***	**95% CI**	**ES**
Effects on days per week with sufficient MVPA[a]					
T1	−0.18	0.36	0.626	−0.89/0.53	0.07
T2	0.29	0.40	0.473	−0.50/1.08	0.03
Effects on weekly minutes of MVPA					
T1	205.03	118.48	0.084	−27.88/437.93	0.11
T2	370.94	127.18	0.004	120.96/620.91	0.25

[a] MVPA: moderate to vigorous physical activity
Note: Active Plus65 is coded as 0 ; the reference group is coded as 1

For all analyses, age and intention were significant covariates: a higher increase in days per week with sufficient MVPA and in weekly minutes of MVPA was seen when participants were younger and had a higher intention to be physically active. For days per week with sufficient MVPA, BMI was also a significant covariate: a higher increase in days per week with sufficient MVPA was seen when participants had a lower BMI. Gender was an additional significant covariate for weekly minutes of MVPA, where a higher increase was seen for males.

Discussion

The present study evaluated the potential of the Active Plus65 intervention to affect PA. Active Plus65 was compared to the proven effective Active Plus50 intervention in order to determine whether the effects of the adaptations that were done to Active Plus50 to better meet the needs of the specific target population (Boekhout et al., 2017) showed results. This study provides insights into the feasibility of interventions that are specifically designed for the vulnerable, growing, and so far often overlooked target group of single older adults with a chronic impairment in PA.

Intervention effects on PA

The Active Plus65 intervention group in itself showed a significant increase in PA for the days per week with sufficient MVPA at 3 months as well as at the follow-up measurement at 6 months in comparison to the baseline. Although weekly minutes of

MVPA also showed a significant increase after 3 months, at 6 months this effect had almost completely evaporated. This discrepancy between the maintenance of the increase of days with sufficient PA but decrease in weekly minutes of MVPA after 6 months may indicate that in the course of the intervention, participants did not increase their total amount of PA but distributed their PA more evenly over the week. A more evenly distributed amount of PA is in line with recommendations to decrease sedentary behavior (Gardner, Smith, Lorencatto, Hamer, & Biddle, 2016), which is increasingly emerging as an independent risk factor to health (Bankoski et al., 2011; Van der Ploeg, Chey, Korda, Banks, & Bauman, 2012). Furthermore, the comparison of single bouts of exercise with energy-expenditure matched PA activities that are distributed more evenly over a time-period has been reported to result in more favorable health outcomes for the latter (Duvivier et al., 2017). The outcome measure of weekly days with sufficient MVPA, entailing a more evenly distributed amount of PA, therefore seems relatively more relevant than the outcome measure of weekly minutes of MVPA. In Active Plus65, the outcome measure of weekly days with sufficient MVPA is measured with a single-item question: research supports the validity and reliability of single-item self-reports of PA (Milton, Clemes, & Bull, 2013; Wanner et al., 2014), as they often result in a more accurate measurement of PA than multiple items that determine the total weekly minutes of MVPA. The finding that weekly days with sufficient PA did show an increase in Active Plus65 might therefore be more valuable in determining the effectiveness of Active Plus65 than the finding that the increase of weekly minutes of MVPA had almost evaporated after 6 months. The decrease in PA in the within groups analyses between 3 months and 6 months in this study is in line with other interventions aimed at PA, where generally effectiveness on the longer term decreases (Greaves et al., 2011). Although the long-term sustainability of lifestyle interventions is of major importance to achieve a sustained impact on public health, and several behavior change models have shown that post-motivational factors might play an important role in the maintenance of behaviors (Kwasnicka, Dombrowski, White, & Sniehotta, 2016), research was not able to identify a single factor that determines long-term sustainability of health behavior change (Ory, Smith, Mier, & Wernicke, 2010). The study of Brouwer et al. (2011) demonstrates, however, that, in interventions for older populations, personal contact in the form of follow-up phone calls shows promising effects on the long-term sustainability of intervention effects. This was also the case for personal contact in the form of email interaction with intervention supervisors (Greaney et al., 2012; Schneider et al., 2013; Schneider, Van Osch, Schulz, Kremers, & De Vries, 2012). As including personal contact would come with higher costs, providing additional automated (e)mailed advice between T1 and T2, or even thereafter, may potentially be a way to increase the long-term effectiveness of Active Plus65 without adding substantial implementation costs to the intervention: previous studies (Greaney et al., 2012; Schneider et al., 2013; Schneider et al., 2012) have shown promising results regarding the sustainability of intervention effectiveness when automated emails are added.

The ES of Active Plus65 in itself on days per week with sufficient MVPA after 3 months is 0.61. This is high when compared to the findings in the review of Chase (Chase, 2015), where an average effect of 0.23 was found for single group pre-post intervention studies for older adults. A possible explanation for the higher ES of Active Plus65 may lie in the additional tailoring that has been made to enable PA with a physical impairment. The target group may be in greater need for fitting interventions than the general population of older adults: the relatively high ES may show that Active Plus65 is especially suited for this target group. It may also be an indication that this group is fairly motivated, which is underwritten by the positive baseline assessment of intention, especially when presented with an intervention that fits their needs and requirements.

Although we were not able to compare the effect of the Active Plus intervention to a no-intervention control group, the ES found in the current study is also higher than the ES of a previous study on Active Plus in which a control group was included (Peels et al., 2014).

Although the Active Plus65 group in itself showed a relatively high increase in PA, it did not achieve better results than observed in the reference group of its proven effective predecessor, Active Plus50. When comparing both interventions, there were no significant differences in effectiveness over time, except on the weekly minutes of PA at the 6 months assessment, where Active Plus50 outperformed Active Plus65. The finding that Active Plus65 did not show a higher increase in PA than Active Plus50, despite the efforts that were made to better suit this target population when designing Active Plus65 (Boekhout et al., 2017), may be explained by the baseline differences and the way participants were recruited, and, consequently, by the representativeness and characteristics of the participants included in the different groups. The recruitment for Active Plus65 emphasized that the intervention was only meant for people with a chronic impairment in PA. Although for the current study only those participants who were over the age of 65 years as well as single and physically impaired by a NCCD were extracted from the intervention group of Active Plus50, the recruitment of Active Plus50 targeted everyone over 50 years of age, impaired or not. Possibly for Active Plus65, this appealed to participants with a higher degree of impairment, as they may have been especially drawn to this intervention. Baseline analyses confirm that 52% of the Active Plus65 participants were very to extremely impaired in their PA behavior caused by a NCCD; in Active Plus50, this was 33%. Participants in Active Plus65 also had a significant lower amount of days per week with sufficient PA at baseline, which may also be an indication of a higher degree of impairment. A higher degree of impairment could result in a lower potential to increase PA. Conn et al. (Conn, Hafdahl, Brown, & Brown, 2008) showed that the effectiveness of PA interventions among older adults with a NCCD varies substantially between different groups of chronic diseases. While Conn et al. (Conn et al., 2008) do not examine the degree of impairment caused by NCCDs, there may be a link: a mild case of one NCCD may be more physically disabling than a severe case of another NCCD. Participants in Active Plus65 were also older than the participants in the reference group: this could also account for a difference in PA, as effectiveness of PA interventions is

found to be lower in older age groups (Dishman & Buckworth, 1996). Participants in Active Plus65 may thus have had a lower overall potential to increase PA when compared to the participants in Active Plus50. As there were differences in the way of measuring the degree of impairment, this could not be incorporated into the analyses. In future research on interventions for older adults with impairments, more in-depth analyses on the effects of impairments on PA is called for: at present there is no validated, or even widely accepted, instrument to measure the degree of impairment caused by NCCDs (Goodman et al., 2013), making comparisons with other research difficult.

Methodological issues

As far as could be determined by the researchers, this is the first study that evaluates a computer-tailored healthy aging intervention aiming to stimulate PA for single older adults with a chronic impairment in PA. This group will become a major target population for public health enhancing interventions, as the average age in Western societies is increasing rapidly, and thus also the amount of people with 1 or more NCCDs and impairments caused by NCCDs. To our knowledge, research so far has not filled the need for healthy ageing interventions for this vulnerable group, as studies so far have predominantly focused on younger age groups of the older adults or multiple health behaviors (Muellmann et al., 2017), or on people with a specific chronic disease (Elbert et al., 2014), whereas multi-morbidity is highly prevalent (World Health Organisation, 2010b). Furthermore, PA was measured on 2 outcomes by using a validated instrument.

Despite these strengths, the study design has some limitations. First of all, the robustness of our study design is not as high as a RCT. However, by adding a reference group we have attempted to address the most important methodological issue of pretest-posttest designs, i.e., not being able to compare to a control group. Moreover, it has been established that real-life implementation settings, such as in our study, overcome disadvantages associated with RCTs, such as not addressing issues that the intervention may encounter in a community setting (Glasgow et al., 1999; Guertler et al., 2015; Neve et al., 2010; Wanner et al., 2009). Our study is in line with recommendations to apply a hybrid design, where an intervention is evaluated in a real-life setting after effectiveness has been established in a RCT (Curran et al., 2012). The difference in outcomes could thus partially be explained by the different research settings, where Active Plus50 was tested in the setting of a RCT, and Active Plus65 was tested in a community setting: as described by Glasgow et al. (Glasgow et al., 1999), this could account for either an over- or underestimation of effects.

Secondly, the study showed a considerable degree of attrition. However, this is common in eHealth interventions, and comparable to other studies with a similar design (Eysenbach, 2005). By conducting multilevel analyses in this study, the most accurate way of handling missing data was applied (Twisk et al., 2013). Thirdly, self-report-questionnaires are prone to bias (Adams, Leibbrandt, & Moon, 2011; Brouwer et al., 2011). However, for monitoring PA,

self-reported data are pragmatic and generally considered appropriate when studying large populations (Brown, Burton, Marshall, & Miller, 2008). Moreover, the use of more objective measurement instruments, such as accelerometers, is usually more stressful, especially for older populations (Webster, Khan, & Nitz, 2011). Another advantage of self-reported questionnaires compared to accelerometers is that the latter might have difficulties detecting upper body movement. As older people generally walk less but are still active in household activities, for this specific target population a self-reported questionnaire is the designated way of measurement (Harris et al., 2009). Fourthly, apart from the aforementioned way of recruitment, there are some other differences between the intervention group and the reference group that have to be taken into account when comparing the 2 groups, such as the time of collecting information (2016 in Active Plus65 versus 2011 in Active Plus50) and the way of entry (free choice in Active Plus65 versus assigned in Active Plus50). Although the time lapse between 2016 and 2011 is a considerable amount of time, no research has been found that shows major shifts in PA behavior for older adults during this period. An increase in the use and availability of the internet among older adults in Europe can be seen in this time lapse (European Union, 2017), but this will most likely only have affected the preference for internet-based way of entry, which is accounted for as a covariate. Seasonal influences may have played a role but are difficult to determine due to differences in inclusion periods: the inclusion period of Active Plus50 lasted from November through to March, and that of Active Plus65 lasted from April through to May; as both interventions started in winter/spring, the difference in seasonal effects between both interventions can considered to be minor. A control group that did not undergo an intervention was not possible due to the implementation setting of Active Plus65 and the low number of suited participants in Active Plus50. However, the study design that was employed allowed for a comparison of the adapted version of the intervention, i.e., Active Plus65, with its predecessor, and non-adapted version, Active Plus50, thus giving insights into the effects of the adaptations. Finally, when performing the a priori power analyses, effect sizes of the original Active Plus50 study (Peels et al., 2014) were used. In that study, an intervention group was compared to a no intervention control group, probably resulting in larger ESs than in the comparison of Active Plus65 with the reference group that, in contrast to the control group in Active Plus50, did receive an intervention. Post hoc analyses on achieved power showed that, for the found effect on the outcome measure of weekly minutes of MVPA between TO and T2, a power of 68% was achieved, which is relatively low, but acceptable.

Conclusions

Notwithstanding the abovementioned limitations, it can be concluded from the present findings that PA showed a significant increase in the Active Plus65 group, with a higher ES at 3 months than the average computer-tailored intervention, potentially making it an interesting healthy aging intervention to implement on a larger scale among the vulnerable target population of single older adults with a chronic impairment in PA.

Active Plus65 did not outperform its predecessor Active Plus50, but the larger amount of participants with severe physical impairments in Active Plus65 may be accountable for this. In further development of Active Plus65, extra attention may be given to factors that support the long-term maintenance of the intervention effects, and to strategies that are particularly suitable for this target group with its specific characteristics.

Chapter 5

Physical impairments disrupt the association between physical activity and loneliness: a longitudinal study

Janet M. Boekhout
Brenda A.J. Berendsen
Denise A. Peels
Catherine A.W. Bolman
Lilian Lechner

Journal of Aging and Physical Activity; ***2019*** *(In press)*
https://doi.org/10.1123/japa.2018-0325

Abstract

Introduction

This study explores the association between physical activity (PA), loneliness, and the presence of physical chronic impairments among single older adults.

Methods

A longitudinal study (N = 575; mean age 76 ± 8 years) was conducted. The association between self-reported weekly minutes of moderate to vigorous PA, loneliness, and presence of physical impairments was assessed with multilevel analyses at baseline, 3 months and 6 months.

Results

Improvements in moderate to vigorous PA were associated with decreases in loneliness (B = - 0.09; SE = 0.04; p = .020); this association became non-significant when including the presence of physical impairments in the analyses (p = .824), which in itself was positively associated with loneliness (B = 0.51; SE = 0.10; p <.001).

Discussion

Findings indicate that physical impairments have a larger influence on loneliness than the level of PA. Interventions targeting PA and loneliness should tailor specifically to physical impairments.

Introduction

Worldwide, the population is ageing rapidly, and it is expected that between now and 2040, the absolute number of older adults (65 years and older) will double (World Health Organisation, 2015). The degree of loneliness varies across the life span, with the highest percentages of loneliness among older adults (Fokkema et al., 2012; Hawkley & Cacioppo, 2010; Luhmann & Hawkley, 2016; Victor & Yang, 2012). As populations are aging rapidly the relevance of preventing and decreasing loneliness (and related problems) is growing.

Loneliness is defined as "the unpleasant experience or feelings associated with a lack of close relationships" (De Jong-Gierveld, 1998). Loneliness has a detrimental effect on the development and deterioration of several chronic physical diseases such as heart conditions and arthritis and also mental diseases such as depression (Courtin & Knapp, 2017; Leigh-Hunt et al., 2017; Ong et al., 2016). Loneliness has been identified as an independent risk factor for mortality of a magnitude comparable to well-known risk factors such as smoking (Holt-Lunstad et al., 2015).

According to the World Health Organisation (2015) 40% of older adults report feeling lonely. The reason that loneliness is prevalent as people age is the variety of changes related with an increasing age, such as deteriorating health, diminishing social contacts after retirement, and the loss of a spouse (Schneider et al., 2017). Not only the loss of a spouse, but also being single in itself is associated with loneliness (De Jong-Gierveld, 1998; Kumanyika, Jeffery, Morabia, Ritenbaugh, & Antipatis, 2002). Furthermore, loneliness is encountered more often and in higher levels in individuals with a chronic disease than in those without (Richard et al., 2017). Moreover, for individuals with a chronic disease, feelings of loneliness increase stronger over the years (Barlow et al., 2015; Pampel, Denney, & Krueger, 2012; Vlaming et al., 2014). Single older adults, especially those with chronic diseases, are thus particularly vulnerable to experiencing feelings of loneliness. Preventing or diminishing loneliness among single older adults is therefore of major relevance for public health, as loneliness is not only detrimental to health, but also because of the present and future proportion of this group at risk.

A well-known risk factor that is associated with both the health and feelings of loneliness of older adults is a lack of physical activity (PA). The amount of PA decreases with age; 55% of the older adults are not sufficiently physically active in contrast to 19% of the younger adults (World Health Organisation, 2010c). Among specific subpopulations of older adults, this lack of PA is even more prevalent, such as single older adults (Masi et al., 2011; Toepoel, 2013), and adults with physical impairments (World Health Organisation, 2011). Several studies have shown that lower levels of PA are associated with increased feelings of loneliness (Lindsay Smith et al., 2017; Pels & Kleinert, 2016). This association may be explained by the Loneliness Model of Hawkley and Cacioppo (2010). This model suggests that feelings of loneliness are accompanied by lower levels of self-regulation. Not being able to adequately regulate one's feelings, emotions, and behavior can result in a diminished

likelihood of performing health- enhancing behavior, such as PA. Biological processes may also provide an explanation as PA stimulates the production of “feel good” hormones such as serotonin (Lubans et al., 2016). Another approach focuses on the compensating effects of having meaningful contacts with others while being active, which may partially replace lost contacts with a spouse (Ferraro & Farmer, 1995), or which may generate a sense of purpose in life (Lemon et al., 1972).

There are indications that the association between PA and loneliness may be different for people with and without physical impairments caused by a chronic disease or aging (i.e., all characteristics of chronic diseases or age-related impairments (e.g., visual or hearing) that in some degree hinder mobility). It has been demonstrated that physical impairments are associated with a lower social engagement (Bianchetti et al., 2017; Meek et al., 2018), and with stronger feelings of loneliness in chronically ill older people (Penninx et al., 1999). Another indication for the influence of physical impairments can be found in the motivational theory of life span development (Heckhausen, Wrosch, & Schulz, 2010). Goal setting strategies, such as striving for a certain level of PA, may help people to cope with difficult situations in life, such as bereavement. Physical impairments may diminish the potential for PA and may thus obstruct goal setting strategies, consequently making it more difficult to overcome aversive situations in life. From a more practical view point, physical impairments may obstruct general mobility, such as transport, making it difficult to participate in regular social activities like visiting friends. It may, therefore, be that the association between PA and loneliness as often demonstrated in the literature so far differs between single older adults with physical impairments and those without. If so, interventions targeting PA and loneliness would require different approaches for those with an impairment and for those without. With aging populations, an increase in older adults with physical impairments can be expected; to optimize the design of effective interventions, more insight into this association would be useful.

As pointed out in recent reviews (Petitte et al., 2015; Poscia et al., 2018), there is a paucity in research focusing on diminishing loneliness in persons with chronic diseases. Moreover, longitudinal studies into the association between PA and loneliness for the growing target population of single, community-dwelling older adults are particularly sparse. The aim of this study is twofold: (a) to determine whether there is an association between changes in PA and loneliness; and (b) to determine whether a potential association between changes in PA and loneliness is different for single older adults with a physical impairment than for single older adults without such an impairment. Identifying the role of physical impairments could give valuable insights into whether and how physical impairments should be addressed when targeting PA and loneliness in interventions. It could be that non-impaired older adults require a different strategy in interventions than the impaired. As this target population is expected to grow substantially in the next decades, interventions that are optimally suited to the presence of physical impairments could make a valuable contribution to public health.

Methods

Study design

For the purpose of this study, a longitudinal single-group pretest-posttest study in a real-life setting was conducted in which the Active Plus65 intervention provided information that focused on increasing PA and decreasing feelings of loneliness. The study had 3 moments of assessment, measuring all variables, that is, at the start (T0), 3 months after baseline (T1), and a follow-up measurement 6 months after baseline (T2).

Intervention

Active Plus65 is a systematically developed computer-tailored intervention for the target population of single, community-dwelling older adults aged over 65 years and has earlier been described in detail (Boekhout et al., 2017). The main aim of the intervention is stimulating participants to stay or become sufficiently physically active; a secondary goal is to stimulate social contacts while being physically active in order to decrease loneliness. A study into the effectiveness on PA of Active Plus65 demonstrated a significant increase in PA after 3 months as well as at follow-up after 6 months (Boekhout et al., 2018).

Participants receive an advice on 3 occasions, which is tailored to the answers from 2 self-report questionnaires. The first advice targets consciousness of the present level of PA by targeting pre-motivational psychosocial constructs, such as awareness and knowledge. The second advice motivates participants to become more physically active: the advice focuses on the benefits of PA, preferably with others, by targeting motivational psychosocial constructs such as attitude, self-efficacy, and social influence. The intervention also stimulates participants to transfer their motivation into sustainable behavior and to deal with difficult situations; this is mainly done in the third advice by targeting post-motivational psychosocial constructs, such as action planning.

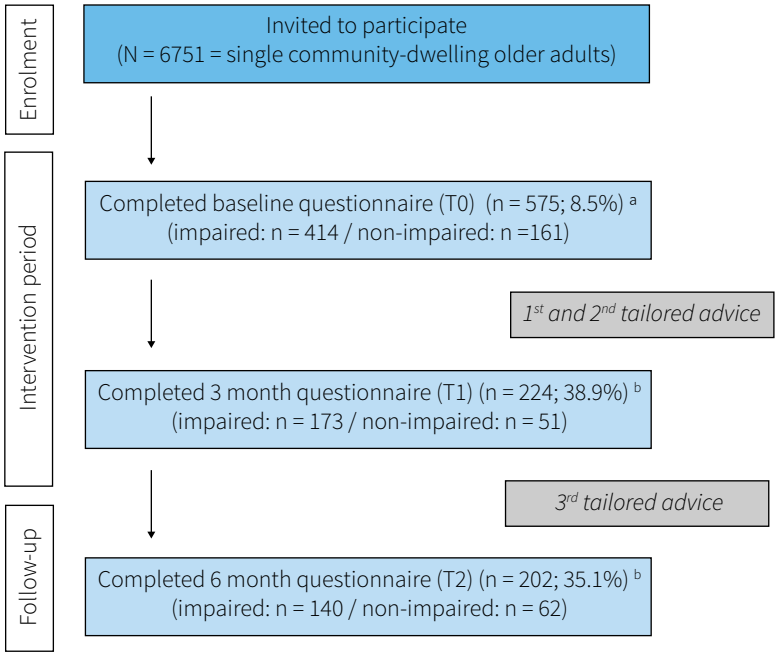
The advice in Active Plus65 is generated by computer-tailoring and is tailored to the participant's demographics, psychosocial characteristics, current PA level, and the presence of a physical impairment (Peels, Van Stralen, et al., 2012; Van Stralen et al., 2008). The format of the advice (in both the printed and the online version) is mostly text based, with complementary graphs, pictures (printed version), and short films (internet-based version). In addition each advice contains activating components such as basic PA exercises that can be performed in one's own house. As the intervention is designed to be implemented in local municipalities or councils, local information on PA-activities or social meeting opportunities is also added. Medical information on being active with physical impairments caused by the chronic disease the participant has is also included.

Procedures

All inhabitants in 1 Dutch municipality who were registered to be single, community-dwelling, and over the age of 65 years (N = 6751) were invited by direct postal mailing to

participate in Active Plus65; in the letter it was explained that Active Plus65 is suited for people with physical impairments. Participants were enrolled in April and May 2016. The mailing sent to the potential participants contained a personalized information letter including login details for internet-based participation and a prepaid response card. The internet-based questionnaire could be accessed immediately with the login details given in the personalized letter. With the response card a printed questionnaire could be requested which was then sent to the participants within a week. Immediately after filling in the internet-based questionnaire, the advice was emailed to the participants and could also be accessed on the Active Plus65 website. The printed advice was sent by paper post to the participants within 2 weeks after they had returned the questionnaire. Participants received the second questionnaire (3 months after baseline) and third questionnaire (6 months after baseline) in the same way of entry (i.e., printed or Internet) as they had chosen for the first questionnaire. Advice was also dispensed in the same way as the first advice. Figure 5.1 presents an overview of the reach and attrition in this study.

This study received approval from the Commission Ethical Audit Research of The Open University of the Netherlands (reference number U2016/02373/HVM). Participants provided informed consent.



[a] Presented in percentage of invited participants
[b] Presented in percentage of baseline completed questionnaires

Figure 5.1 Flow chart of participants

Measures

PA is assessed using the Short Questionnaire to Assess Health-Enhancing Physical Activity (SQUASH) (De Hollander et al., 2012; Wendel-Vos et al., 2003), which has an acceptable relative validity (Spearman's r = .45; 95% confidence interval [.17, .66) and reproducibility (Spearman's r = .58; 95% confidence interval [.36, .74). The questionnaire has to be filled in based on an average week in the past month. PA is assessed on 5 types of activities (during commuting by foot and bicycle, [volunteering] work or study, housekeeping tasks, leisure-time activities [walking and gardening], and sports). Participants have to fill in how many days per week they performed these activities (in a number between 1 and 7), how much time per week they spent on these activities (in hours and/or minutes), and with what intensity these activities were performed (choice between light, moderate, and vigorous). As the World Health Organisation advises older adults to be physically active with moderate intensity for at least 150 minutes/week or with vigorous intensity for at least 75 minutes/week (World Health Organisation, 2010a), the outcome measure of weekly minutes of moderate to vigorous PA (MVPA) was used. Moreover, this is also the most commonly used outcome measure in PA intervention studies. MVPA is calculated by multiplying the days per week with the hours and/or minutes per day of the activities performed with a moderate or vigorous intensity. The SQUASH differentiates the intensity of PA per age category. From the age of 55, activities are classified in higher metabolic equivalents which can result in a classification in a higher intensity category (i.e., from light to moderate, or from moderate to vigorous) (Wendel-Vos & Schuit, 2004).

Loneliness is assessed using the self-administered 6-item De Jong Gierveld Loneliness Scale, which is widely accepted in Europe: the psychometric properties can be considered acceptable with a scale reliability ranging between .80 to .90 (Cronbach's alpha) and a homogeneity of the scale ranging between .30 to .50 (De Jong Gierveld & Van Tilburg, 2006). This scale has 6 items (e.g., "Often I feel abandoned" or "I have a lot of people I trust completely") on originally a 5-point scale (i.e., *yes*!, *yes*, *more or less*, *no*, *no*!). For the present study the scale was adapted to a 10 point scale (1 = *absolutely not* and 10 = *absolutely sure*), because the original scales were considered to be potentially ambiguous and not completely mutually exclusive, which are not in line with the relevant statistical recommendations (Krosnick, 2010). Moreover, as placement, presentation, and typeface size are of importance when designing questionnaires for older adults (Remillard et al., 2014), the original scales were deemed less fitting. The 10 item scale was most often used throughout the questionnaire for the assessment of psychosocial variables and was thus in line with the presentation of the questionnaire; the use of exclamation marks may not be fitting considering the fact that as typeface size matters for older adults they may not detect the exclamation mark that easily. After recoding the items in the same direction, answers from 1 to 5 on the scale indicate no loneliness, and answers from 6 to 10 on the scale indicate loneliness, similar to the data handling as described originally (De Jong Gierveld & Van Tilburg, 1999). The score on loneliness is calculated in accordance with the manual

of this scale (De Jong Gierveld & Van Tilburg, 1999), by counting the answers that indicate loneliness with a total potential score on loneliness between 0 (not lonely) and 6 (extremely lonely); when more than 1 item was not answered, the whole set of items was treated as missing.

Several demographics were assessed such as age (in years) and gender (0 = *male / 1 = female*). The presence of physical impairments caused by a chronic disease was assessed by asking whether participants experienced physical impairments caused by chronic diseases (0 = *non-impaired*, 1 = *impaired*); to indicate what constitutes a chronic disease and for advice reasons, a list of highly prevalent chronic diseases (e.g., arthritis, chronic obstructive pulmonary disease, diabetes, other not mentioned chronic diseases) and other physical impairments that could limit mobility (e.g., visual or hearing impairments caused by old age) was provided to the participants.

Statistical analyses

All analyses were performed with SPSS for Windows (IBM Corp. Released 2016. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp). In all tests a reproducibility level of 95% was applied ($\alpha = .05$).

Descriptive analyses. Descriptive statistics were performed to describe baseline characteristics, potential selective dropout and correlation. Baseline characteristics of the study population were assessed for weekly minutes of MVPA, loneliness, presence of a physical impairment, age, and gender. To test for selective dropout (i.e., not filling in the questionnaire at T1 and/or T2), binary logistic regression was used on the same variables as for the baseline analysis. By calculating correlation coefficients (i.e., Spearman's, Point-biserial's or Cramer's coefficients, depending on the level of the variables), correlation was assessed between weekly minutes of MVPA, loneliness, presence of a physical impairment, age, and gender. The development of the weekly minutes of MVPA and loneliness during the intervention period was visualized for the physically impaired and non-impaired participants.

Association analyses. To test our hypotheses that changes in PA are associated with changes in loneliness over time and that this association differs for the impaired and non-impaired, 3 multilevel models were analyzed. PA and loneliness measurements at baseline, 3 months and 6 months were included in the analyses. The multilevel models involved a two-level design with repeated measures as the first level (AR I covariance structure for serial correlation) and participant as the second level (unstructured covariance). In all models, loneliness was the outcome variable. The predictor variable(s) differed per model. The 3 multilevel models were used to determine a) the associations of PA with loneliness over time and b) the differences in this association between participants with and without a physical impairment. In the first model, the predictor variables were the weekly minutes of MVPA, measurement time point and the interaction term between MVPA and the measurement time point. In the second model, the first model was adjusted for presence

of physical impairments by adding this as a predictor variable, and by adding 2 two-way interaction terms (i.e., MVPA x presence of a physical impairment and also the presence of a physical impairment x measurement time point) and a three-way interaction term (MVPA x measurement time point x presence of a physical impairment). The interaction terms in the second model were added to analyze whether the association between PA and loneliness varied as a function of having physical impairments, and whether these differentiated associations varied over time. The third model includes correction for the a priori selected covariates age and gender, by adding them as predictor variables.

T tests were used to assess if potential differences in MVPA and loneliness between the physically impaired and non-impaired at T0, T1, and T2 have an effect on the change in MVPA and loneliness. When significant differences were detected, 2 multilevel analyses were performed. In the first model, the outcome variable was MVPA; in the second model, the outcome variable was loneliness. In both models, the predictor variables were the weekly minutes of MVPA, measurement time point, and an interaction term between the weekly minutes of MVPA and measurement time point.

Imputation of missing data was not applied, as it has been established that the use of incomplete cases in multilevel analysis results in more accurate estimations than applying imputation (Twisk et al., 2013). A sample size calculation showed that for the applied multilevel analyses (in which all participants who filled in at least 1 measurement are included), a total of 140 participants was required (effect size = 0.20; power 0.95; dropout 0.65 in which the effect size was based a recent review into the effectiveness of PA interventions on loneliness (Shvedko et al., 2017), and dropout was based on a previous study into Active Plus, (Peels et al., 2014) indicating that sufficient power was achieved.

Results

Descriptive analyses

Table 5.1 summarizes the baseline characteristics for all assessed variables of participants with a physical impairment and for those without. It demonstrates that at baseline significant differences between the participants with a physical impairment and those without such an impairment were present for the weekly minutes of MVPA, loneliness, and age. The participants with physical impairments had lower levels of weekly minutes of MVPA, higher levels of loneliness, and were older than those without physical impairments.

Table 5.1 Description of M (SD) for the assessed variables at baseline

	Impaired (*n* = 414)	**Non-impaired (*n* = 161)**	***P* - value**
Weekly minutes of MVPA [a]	482.78 (622.66)	1001.12 (894.05)	<.001
Loneliness [b]	3.10 (2.01)	2.13 (2.04)	<.001
Age (years)	76.71 (7.76)	72.81 (6.74)	<.001
Gender (% male)	35.4	42.2	.125

[a] Moderate to vigorous physical activity
[b] Represented in range between 0 (not lonely) to 6 (extremely lonely)

The dropout analyses showed that of the assessed variables only the weekly minutes of MVPA were a significant predictor for dropout, with those having fewer weekly minutes of MVPA more likely to dropout. Correlation analyses showed that of the assessed variables at baseline the presence of a physical impairment and weekly minutes of MVPA are significantly correlated with loneliness (table 5.2).

Table 5.2 Correlation coefficients between assessed variables at T0

	MVPA [a]	**Loneliness**	**Presence of impairment**	**Age**	**Gender**
Weekly minutes of MVPA	-				
Loneliness	-.13 [b]*	-			
Presence of impairment	-.31 [c]**	.21 [c]**	-		
Age	-.37 [b]**	.01 [b]	.23 [c]**	-	
Gender	-.15 [c]**	.02 [c]	.06 [d]	.09 [c]*	-

[a] MVPA = moderate to vigorous physical activity
[b] Spearman's correlation coefficient (r_s)
[c] Point-biserial correlation coefficient (r_{pb})
[d] Cramer's correlation coefficient (*V)*
*Significant difference < .05 (two-tailed)
** Significant difference < .01 (two-tailed)

In figure 5.2 and 5.3 the development of the weekly minutes of MVPA and loneliness during the intervention period is visualized for the physically impaired and non-impaired participants.

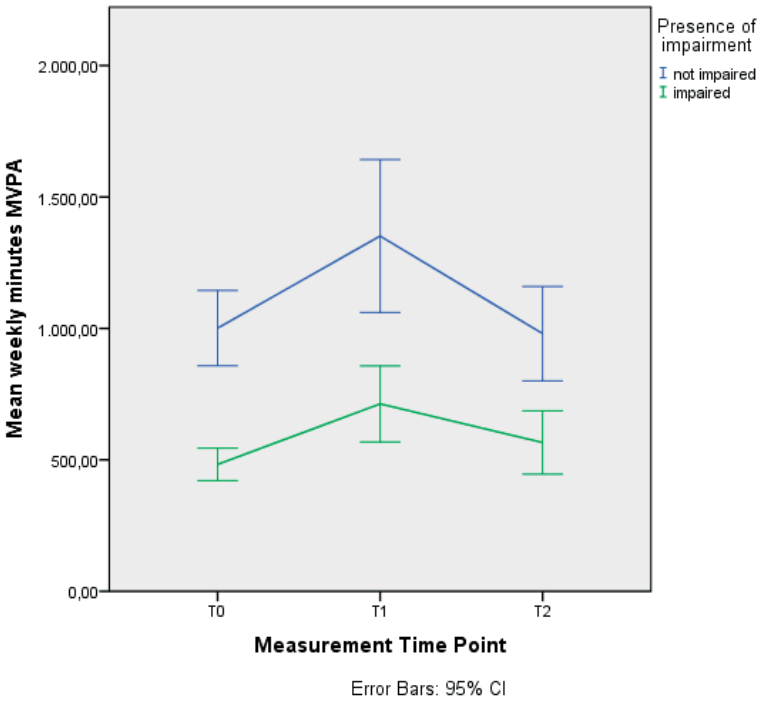


Figure 5.2 Development over time of weekly minutes of MVPA (= moderate to vigorous activity) for the physically impaired and non-impaired

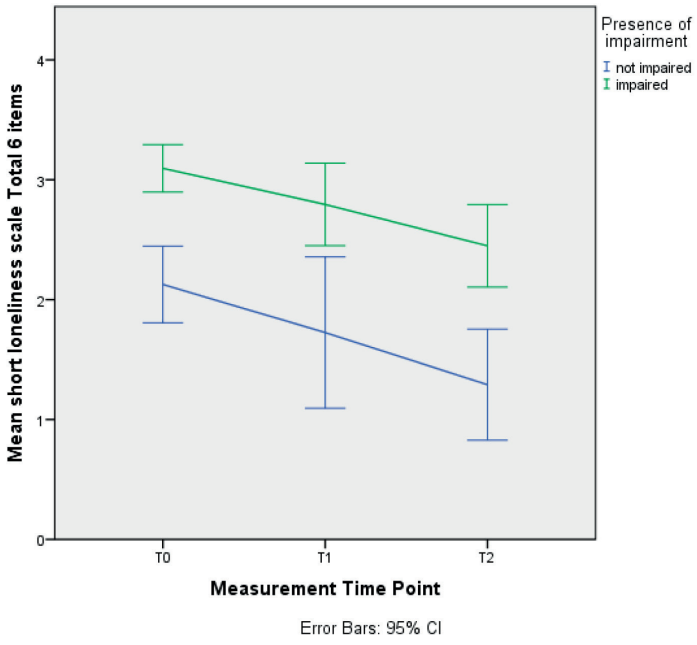


Figure 5.3 Development over time of loneliness for the physically impaired and not impaired

Association analyses

Table 5.3 presents the results of the different models applied to analyze the associations.

Table 5.3 Hierarchical multilevel analyses into the T0-T2 association between physical activity and physical impairments (predictors) and loneliness (outcome variable) and interactions

	B	***SE***	***p***
Model 1 (*n* = 548)			
MVPA [a]	-0.09	0.04	0.020
Measurement time point [b]	-0.12	0.02	<0.001
MVPA x measurement time point	-0.03	0.03	0.240
Model 2 (*n* = 547)			
MVPA	-0.01	0.06	0.824
Impairment [c]	0.51	0.10	<0.001
Measurement time point	-0.15	0.05	0.001
MVPA x impairment	-0.04	0.08	0.639
MVPA x measurement time point	0.02	0.05	0.642
Measurement time point x impairment	0.03	0.06	0.621
Measurement time point x impairment x MVPA	-0.09	0.06	0.128
Model 3 (*n* = 546)			
MVPA	-0.02	0.06	0.767
Impairment	0.52	0.10	<0.001
Measurement time point	-0.15	0.05	0.001
MVPA x impairment	-0.04	0.08	0.613
MVPA x measurement time point	0.02	0.05	0.630
Measurement time point x impairment	0.03	0.06	0.610
Measurement time point x impairment x MVPA	-0.08	0.06	0.141
Gender [d]	-0.04	0.08	0.643
Age	-0.01	0.01	0.376

[a] Weekly minutes of MVPA = moderate to vigorous physical activity
[b] Measurements at T0, T1, and T2
[c] Impaired coded as 1 and non-impaired coded as 0
[d] Women coded as 1 and men coded as 0.

The first model, analyzing the association between changes in PA and loneliness, shows that an increase in the predictor variable of weekly minutes of MVPA between T0 and T2 was associated with a decrease in the outcome measure of loneliness (B = -0.09, SE = 0.04, p = .020). In model 2 the differences in this association between participants with and without physical impairments were analyzed. After adding the presence of a physical impairment in Model 2, the association between increased MVPA and decreased loneliness between T0 and T2 became non-significant (p = .824). Having a physical impairment in itself was related to a higher degree of loneliness (B = 0.51, SE = 0.10, p < .001). However, the interaction between weekly minutes of MVPA and the presence of physical impairment was non-significant (p = .639). This indicates that the effect of MVPA on loneliness did not differ between participants with a physical impairment and those without such an impairment. In the third model, the a priori selected covariates age and gender were entered. This showed that neither gender (p = .643) nor age (p = .376) resulted in changes in significance for the other assessed variables between T0 and T2.

As Table 5.4 shows, the differences between the participants with and without physical impairments for weekly minutes of MVPA and loneliness on the different times of measurement are all significant, indicating that on all times of measurement those with a physical impairment have a lower level of MVPA and a higher level of loneliness than those without a physical impairment.

Table 5.4 T-test analyses into the differences in means (M) with standard deviation (SD) between impaired and non-impaired on weekly minutes of MVPA a and loneliness on different times of measurement

	Non-impaired			Impaired				
MVPA [a]	***n***	***M***	***SD***	***n***	***M***	***SD***	***t***	***p***
Baseline	152	1001.12	894.05	391	482.78	622.66	6.56	<0.001
3 months	54	1438.76	1225.47	164	712.90	937.89	3.99	<0.001
6 months	63	980.17	712.94	145	565.92	735.68	3.77	<0.001
Loneliness								
Baseline	158	2.13	2.04	399	3.10	2.01	-5.11	<0.001
3 months	52	1.69	2.24	160	2.79	2.20	-3.12	0.002
6 months	62	1.29	1.82	127	2.45	1.96	-3.90	<0.001

[a] Moderate to vigorous physical activity

Table 5.5 shows that the interaction of time and physical impairment was not significant for neither MVPA as outcome variable nor loneliness as outcome variable. This indicates that the development of both PA and loneliness over time did not differ between the physically impaired and non-impaired group.

Table 5.5 Changes in respectively weekly minutes of MVPA [a] and loneliness as outcome variable with the predictor variables of presence of impairment, time between T0 and T2 and interaction, assessed by multilevel analysis

MVPA [a]	***B***	***SE***	***p***
Presence of impairment [b]	-470.83	70.77	<0.001
Measurement time points	-26.10	33.85	0.441
Presence of impairment x measurement time points	44.19	40.24	0.273
Loneliness			
Presence of impairment [b]	0.51	0.09	<0.001
Measurement time points	-0.15	0.04	0.001
Presence of impairment x measurement time points	0.04	0.05	0.458

[a] Moderate to vigorous physical activity
[b] Impaired coded as 1, non-impaired coded as 0

Discussion

This study investigated the interplay of PA, loneliness, and the presence of a physical impairment for the fast growing and vulnerable target population of single, community-dwelling older adults. A significant negative association was found between PA and loneliness; when PA increased, a decrease in loneliness was observed (Table 5.3, model 1). Similar associations can be found in several recent reviews assessing the effectiveness of PA interventions to alleviate loneliness. In these reviews, it was found that stimulating social contacts while being physically active, as Active Plus65 does, is an important factor to alleviate loneliness (Dickens, Richards, Greaves, & Campbell, 2011; Robins, Jansons, et al., 2016). Another review (Gardiner et al., 2018) found that interventions to alleviate loneliness show better results when they are adapted to the local situation where people live, when the target population was involved in the design of the intervention, and when active engagement in activities was supported. That Active Plus65 meets the criteria associated with increases in PA and decreases in loneliness as found in recent reviews could explain the found association between changes in PA and loneliness in our study.

The results of our study also demonstrated that by including the presence of a physical impairment in the analyses, the significant association between PA and loneliness

was disrupted. The presence of a physical impairment was positively associated with loneliness, when assessed independently as well as when combined with the other variables (Table 5.3, Model 2). This finding implies that the presence of an impairment has a larger influence on loneliness than the level of PA has. This result potentially reveals that the association between PA and loneliness that is often posited in the literature may have different working mechanisms for physically impaired single older adults than so far assumed. A comparable finding was reported by Robins, Hill, et al. (2016) where a significant association between recreational PA and social isolation became non-significant when other variables (such as self-reported ill-health) were included in the analyses. Although self-reported ill-health is not directly comparable to the presence of physical impairments, it can be assumed that those with physical impairments regard their health as more negative than those without such impairments. To our knowledge no other previous studies into the influence of PA interventions on loneliness have specifically taken into account the presence of a physical impairment. This finding, however, could have implications for practice as it may require that intervention advice needs to be tailored better to the barriers that physical impairments may impose on both increasing PA and alleviating loneliness.

Some recent reviews have demonstrated limited evidence for an association between PA and loneliness (Cohen-Mansfield & Perach, 2015; Shvedko et al., 2017). These reviews, however, cover studies that examine a more general target group than ours (i.e., the general population of older adults instead of single older adults). Potentially, the association between PA and loneliness could be different for the general population of older adults, where an average distribution of singles and non-singles is present, than for a population of only singles. It could be that single older adults may find it harder than general (older) adults to get into contact with other people. According to Hawkley and Cacioppo (2010) loneliness is often accompanied by feelings of hostility and a tendency to approach others with a negative attitude, thus inducing a negative response to others, ultimately resulting in a reduced capacity to make contacts with others. Besides, these reviews (Cohen-Mansfield & Perach, 2015; Shvedko et al., 2017) focus mainly on exercise instead of a wider definition of PA as used in this study. Older adults may give up exercising at a certain point in life but may not give up recreational and household activities (Benzinger et al., 2014; Loprinzi, Lee, & Cardinal, 2015; Mertens et al., 2017; Souto Barreto, 2015). Recreational and household activities may still be performed with an intensity equal to exercise. When only measuring exercise, it may not give a good representation of all activities performed with moderate to vigorous intensity. This may account for the limited evidence for an association between PA and loneliness in those studies (Cohen-Mansfield & Perach, 2015; Shvedko et al., 2017), contrasting with our study where not only exercise but also a wide spectrum of PA was researched. Regarding this spectrum of PA, it may be advisable for further research to not only assess the association between MVPA and loneliness but also between light PA and loneliness. Although comfortable speech should still be possible with moderate PA (Reed

& Pipe, 2016), it can be reasoned that social contacts can be improved more easily during light-intensity activities, because people are then still able to comfortably chat without any increased breathing. However, as far as could be determined, research so far has not established an association between light PA and loneliness (Buman, 2011; Ku, Fox, Liao, Sun, & Chen, 2016; Robins, Hill, et al., 2016). That other mechanisms may be accountable for the association between PA and loneliness is also suggested in the review of Chipps, Jarvis, and Ramlall (2017) where it was concluded that processes like connecting to the outside world, gaining social support, and boosting self-confidence may be important when studying interventions to alleviate loneliness. This is also corroborated by Hawkley and Cacioppo (2010), who posit that having a physical impairment may decrease one's potential for self-regulation, thus influencing the potential to increase PA and to decrease loneliness.

Our study demonstrated that on all times of measurement those with physical impairments were less physically active and lonelier than those without physical impairments (Table 5.4). This finding may be corroborated by the 5-year longitudinal study of Newall, Chipperfield, and Bailis (2014). Their study demonstrated that those who were persistently lonely were more often living alone and perceived their health and control over their overall life situation as worse than those who were not persistently lonely; changes in feelings of loneliness were seen in those who perceived a change in control over their overall life situation. In our study, the development over time of PA and loneliness did not differ (Table 5.5), but this could be contributed to the shorter time span of our study compared to Newall' et al.'s study. For our target population, this may mean that physical impairments may bring along a lower perceived control over life, as impairments often result in pain, limited mobility, and loss of independence (Barlow et al., 2015; Hawkley & Cacioppo, 2010). Physical impairments in itself and the confrontation with the functional incapacitations they bring along could thus contribute to feelings of loneliness. This finding might imply that interventions for this target population may need to focus specifically on enhancing feelings of control over both the potential to increase PA as the potential to increase social contacts while being physically active. Future research should focus on whether this strategy would indeed lead to an increase in PA and a decrease in loneliness, and whether low perceived control is indeed a crucial factor for being lonely in single impaired older adults. In addition, it may be advisable to repeat our study in a natural setting instead of in an intervention setting. The commitment to change may be different for those who decide to become more physically active by themselves than for those who are triggered by an intervention that is offered to them. It could be that in a natural setting different associations will be found.

Strengths and limitations

As far as could be established, this is the first study that focuses on the longitudinal association between PA, loneliness, and the presence of physical impairments among single, older community-dwelling adults. The longitudinal design with measurements taken

at baseline, during the intervention, and at follow-up gave this study a strong potential to gain insight into patterns of and associations between PA, loneliness, and physical impairments.

Despite these strenghts, there are also some limitations that should be noted. First, all data were based on self-reports. This may lead to bias, for example, by over reporting, as is common in PA, or via socially desirable reponses; considering the stigma that is associated with loneliness (Cohen-Mansfield et al., 2016), it may be that older people report much lower levels of loneliness than they actually experience. However, research has shown that for PA self-reported measurements provide valid insights and can be deemed appropriate when studying large groups and when compared with similar instruments (Helmerhorst, Brage, Warren, Besson, & Ekelund, 2012). Moreover, for measuring loneliness no tools that are considered to be more objective than self-administred questionnaires have been established. Both the questionnaires for PA (De Hollander et al., 2012; Wagenmakers et al., 2008; Wendel-Vos et al., 2003) and for loneliness (De Jong Gierveld & Van Tilburg, 2006, 2010) that are incorporated into our study have been found valid and reliable. The changes we have made to the scale of the loneliness questionnaire are in line with recommendations for designing questionnaires for older adults and therefore the validity of this questionnaire can be deemed unviolated (Krosnick, 2010). Second, there was a considerable degree of attrition, which may have consequences for generalization of the results to the whole population of single older adults. High attrition, however, is regularly seen in eHealth interventions and is comparable to similarly designed studies (Eysenbach, 2005).

Conclusions

In previous research, increases in PA were often associated with decreases in loneliness. Our findings suggest that the presence of physical impairments may have a larger influence on loneliness than PA. When developing interventions for single older adults, it may therefore be essential to tailor the advice in greater detail to the possibilities of being physically active despite having physical impairments. To facilitate this, it would be advisable to elaborately assess what the perception is of participants about their potential to be physically active. Future research into the interplay between PA, loneliness, and the presence of physical impairments may bring additional insights into the working mechanisms of the found associations. For this, it may be essential to perform a study in a natural setting (without the influence of an intervention as we had now). This may help to maximize the public health impact of interventions targeting this large and growing target population.

Chapter 6

General discussion

General discussion

This dissertation addressed physical activity (PA) and loneliness of single older adults with physical impairments as part of the Active Plus65 project. The Active Plus65 project is rooted within the societal need for healthy ageing interventions. The main objectives of this dissertation were a) to describe the systematic development of Active Plus65, b) to investigate which user characteristics predict delivery mode preference and which user characteristics and delivery mode predict attrition, c) to evaluate the effectiveness of Active Plus65 on PA, and d) to evaluate the longitudinal association between PA, loneliness and physical impairments. In this general discussion section, a summary and discussion of the main findings are provided, methodological issues are considered, and suggestions for future research, for improving the intervention and for implementation of the intervention in public health practice are indicated. Finally, general conclusions are provided.

Summary and discussion of main findings

Part 1: Intervention development

The original Active Plus intervention was developed in 2008 as a print-delivered computer-tailored intervention aiming to stimulate a sufficient level of PA in people over the age of 50 (Van Stralen et al., 2008). Based on evaluation studies, the intervention was adapted in 2012 to optimize reach and effects, and an online delivery mode was developed, added and tested on (cost) effectiveness (Peels, Van Stralen, et al., 2012): in the present dissertation this version of the intervention is called Active Plus50. Evaluations from the previously developed, proven effective Active Plus50 intervention demonstrated that the subpopulation of single older adults (aged 65 years and older), many of whom have physical impairments caused by chronic diseases, found the intervention not sufficiently adapted to their specific needs and wishes regarding PA. Also, they indicated that a lack of awareness about PA possibilities in their neighborhoods could interfere with a desire to be more physically active. Furthermore, this subpopulation expressed the need to integrate more social contacts while being physically active. In addition, on a societal level, the high prevalence of loneliness among older adults was a call for action. For these reasons an adapted version of Active Plus50, named Active Plus65, was developed, combining both input from intervention evaluations as well as from societal issues. Active Plus65 aims primarily to increase the amount of PA, preferably to the level of the PA guideline, among single older adults with physical impairments. The secondary aim is to decrease loneliness, through stimulating physical and social activity.

The Intervention Mapping (IM) Protocol (Bartholomew et al., 2016) was applied to adapt Active Plus50 into Active Plus65 (see ***Chapter 2***). As mentioned above, this adaptation was required as Active Plus65 has a more specific target population than Active Plus50, and has an additional goal. The IM protocol originates from 1998 and is generally considered to be a highly useful instrument for developing new interventions. Using it to adapt an existing intervention is relatively new, as only since 2016 the protocol contains guidance on this specific application of the protocol. Adding an additional goal as well as including the needs and wishes of a more specific target population within the boundaries of the existing intervention proved challenging: a constant balance had to be made between what to add, what to change, and what to eliminate. Despite the guidance that IM provides for this, it remained a relatively time consuming process.

In the needs assessment it was found that the determinants for behavior change in our target population were identical to those found in Active Plus50, but that they have a different relative importance: fear of pain for example plays a larger role in a population of people who have physical impairments than in a general population. The issues that this target population face also differ greatly from individual to individual, emphasizing the need for an individually tailored advice. Computer-tailoring, which is also the core of the Active Plus50 intervention (Peels, Bolman, et al., 2013; Peels et al., 2014), is considered to be a highly suitable method for information provision, as it omits unnecessary information, gives the possibility to personalize information and enables behavioral change (De Vries & Brug, 1999; Noar, Benac, & Harris, 2007). The tailored messages were extended and enhanced to align them with the needs and requirements of the target population and the aims of the intervention. Although computer-tailoring provides each individual with a custom-made advice, there are certain boundaries to consider. The challenges that the target population face (for example, differences in the degree of impairment, in insight in the chronic disease, in fear of pain, in the amount of PA earlier in life) may be so individual and specific that they stretch the practical possibilities of computer-tailoring. In principle, this all can be assessed, but in order to avoid an unfeasibly long questionnaire, a balance has to be made between what one optimally would want to assess in a clinical research setting and what is feasible in an intervention setting.

Another matter to consider is that Active Plus50 was designed as an individual intervention that the participant can follow independently. Active Plus65 is extended with more community-based elements, such as specifically arranged PA-opportunities in the neighborhood. Adding information on community-based elements could not be accomplished with computer-tailoring due to the changing nature of the community-based activities on offer. For this, brochures were added: although following the IM protocol enables retaining the components that are essential to the effectiveness of the intervention, the protocol does not specifically seem to address the issue of adding practical applications that were not in the original intervention.

Overall it is concluded that the IM protocol provides useful guidance for adapting existing interventions whilst retaining their effectiveness. The process of adapting an existing intervention, however, still requires a fair amount of time-consuming deliberations, which should not be underestimated when planning such adaptations.

Part II: Evaluation of the intervention

Use of the intervention

The evaluation of the use of the intervention **(*Chapter 3*)** consisted of an assessment of the delivery mode preference and insight into attrition of the intervention. Delivery mode preference was assessed with a cross-sectional study at baseline; attrition was assessed with a single group pretest-posttest study comparing baseline and 3-months measurements. It was expected that higher age, lower educational attainment, and a lower presence of psycho-social determinants associated with behavior change would be predictors of a preference for a printed delivery mode and of attrition.

Our evaluation showed a significantly higher preference for the printed delivery mode as 59% chose to start in the printed delivery mode versus 41% in the online delivery mode. A preference for the printed delivery mode is in line with data showing that in 2016 (when we performed our study), 50% of older adults between 65 and 74 years, and 26% of older adults of 75 years and older, used the internet for health related purposes (Dutch Central Bureau of Statistics, 2018b). These data are also in line with our finding that age was a significant predictor of delivery mode preference: the older the participant, the more likely a preference for the printed delivery mode. When the present trend continues, this relation may become less strong in the next years, as the use of internet for health related purposes has almost doubled in the last 6 years among older adults (Dutch Central Bureau of Statistics, 2018b). Another predictor of delivery mode preference was social support for PA: those with less social support preferred the printed delivery mode. It may be that those who receive less social support for PA also receive less support for other parts of life, such as getting familiar with digitalization. However, it may also be inherent to our target population of singles: previous studies have shown that living alone makes older adults less likely to explore the use of new technologies, whereas those with close social contacts receive explanation and encouragement to use new technologies, making it easier for them to experiment with online applications (Friemel, 2016; Hill et al., 2015; Vroman et al., 2015). In order to stimulate the use of the online delivery mode, which is most likely more cost-effective to implement than the printed delivery mode, face-to-face assistance for filling in the questionnaires online was offered. However, only a small minority of participants used this offer. It could be that those willing to try the online delivery mode received assistance from their own social network, but it can also be questioned whether providing assistance has not resulted in the opposite effect, i.e., steering participants to the printed delivery

mode instead of the online delivery mode as we hoped. It may be that offering assistance for using the online version of Active Plus65 has given older adults the idea that the online delivery mode was probably too difficult for them. This could be the result of negative ageist stereotypes that older adults are often confronted with: these stereotypes not only define how older adults are treated but also how they perceive themselves and whether they endorse or even internalize these negative ageist stereotypes (Lagace, Charmarkeh, Laplante, & Tanguay, 2015).

Attrition differed significantly between the printed delivery mode (50%) and the online delivery mode (71%). Moreover, compared to other recent PA-interventions for older adults, these attrition rates appear relatively high (Alley et al., 2018; Golsteijn et al., 2017; Peels, Bolman, et al., 2012; Van der Deijl et al., 2014). Regarding the attrition some assumptions can be made. The relatively high attrition may be explained by the low socio-economic status (SES) of the participants, as the municipality where Active Plus65 was implemented has a lower than average SES (Heerlen Municipality, 2016). It has been suggested that those with a low SES have limited access to up-to-date computers and may thus experience incompatibilities between online interventions and their hard- or software, resulting in computer-errors and ultimately in attrition from the intervention (Remillard et al., 2014). It could also be that the invitation for the second questionnaire was not engaging enough or that the questionnaire was found to be too extensive. An eHealth intervention study of Van der Mispel, Poppe, Crombez, Verloigne, and De Bourdeaudhuij (2017) concluded that in eHealth interventions extensive questionnaires should be avoided as attrition rates were higher in interventions that required filling in (lengthy) questionnaires than in interventions with an interactive character. Although an extensive questionnaire allows for adequate tailoring, it may be possible to shorten it: some sets of questions are rather lengthy because they also function to assess determinants in a validated matter to enable scientific reporting. It may be that when the sole purpose of an intervention is to provide an advice, some determinants could have been measured with fewer items. In contrast to the potential explanations described above, attrition is not necessarily an indication that the participants do not value the intervention. At the time point where we measured attrition (i.e., 3 months after the start of the intervention), the participants have already received 2 extensive sets of advice; attrition can therefore also indicate that the participants feel that the intervention has delivered them what they had expected and feel this is adequate, which may especially be the case for online interventions (Ritterband et al., 2009). A study into the appreciation of the intervention could provide more answers for why attrition was relatively high.

Although attrition in general was high, only 2 determinants were found to predict attrition, i.e., lower educational attainment and online delivery mode. And explanation for this can be found in the models of STAM (Renaud & Biljon, 2008) and C-TAILS (Peek et al., 2017): those with a low education may have a difficulty with learning how to use interventions or may have a lower need for new technologies. It may thus be that Active

Plus65 is not aligned with the potential of the lower educated to use online interventions, or maybe these participants just started in the intervention because it was offered and not because they were intrinsically motivated to use it.

The fact that educational attainment predicts attrition but does not predict a preference for a printed delivery mode is rather surprising as internet use is lower among less educated individuals (Kantar Public, 2018). It may be that those with a lower educational attainment choose an online version because they expect it to be more entertaining than a printed version, but are disappointed with the features of the online delivery mode. It is a fact that although Active Plu65 is offered online, it is not as entertaining, interactive or engaging as some health-behavior apps that are available online, and even in the online version the advice consists mostly of text.

The contemplations above demonstrate that the specific characteristics of our target population may have implications regarding delivery mode preference and attrition. For those with a low educational attainment the intervention may need alternative elements in the advice. Despite the increase in older adults' internet use, offering a printed delivery mode next to an online delivery mode appears to be essential. Although a printed delivery mode is more time- and labor-intensive and could thus potentially limit the prospective public health impact of the intervention, offering it could prevent the exclusion of a vulnerable target population.

Physical activity

For testing the effectiveness on PA (see ***Chapter 4***) we used a quasi-experimental design in which the intervention group (i.e., the participants in Active Plus65) were compared to a reference group. The reference group was drawn from the existing data of the Active Plus50 project: all participants who, like the intervention group, were single, over the age of 65 and had physical impairments were selected to form a reference group. In this paragraph we reflect on how Active Plus65 performed comparing the results with Active Plus50, and with other interventions.

Effects of Active Plus65 versus Active Plus50. Comparisons in effectiveness between Active Plus65 and Active Plus50 need to be made with reservations. When calculating effect sizes, we compared Active Plus65 to another intervention condition (i.e., the intervention condition of Active Plus50); when the effects of Active Plus50 were calculated (Peels, Bolman, et al., 2013; Peels et al., 2014), the intervention condition of Active Plus50 was compared to a control condition.

Contrary to expectations, Active Plus65 did not outperform its predecessor Active Plus50. This may be explained by differences in recruitment between both interventions. For Active Plus65 it was emphasized at recruitment that the intervention was particularly suited for those with physical impairments, which was not the case for Active Plus50. This could be why in Active Plus65 about half of the participants rated themselves to be very to extremely impaired, which in Active Plus50 was only about a third. Because of these

impairments, participants in Active Plus65 may thus encounter more barriers to increase their PA: this is reflected in the baseline level of PA which is lower among participants in Active Plus65 than in Active Plus50.

Apart from differences in impairments, other explanations may be present for why Active Plus65 showed less effectiveness than expected. When performing the needs-assessment in the IM process we concluded that the determinants for PA in single older adults with impairments were identical to general older adults, but that some determinants had a larger influence: pain, fear of injury and lack of energy, for example, are more important barriers for older adults with physical impairments (Kenniscentrum Sport, 2016). It may be that although we included additional tailoring on being physically active with an impairment, this tailoring needs to be even more fine-tuned. It may thus be that participants need to be convinced more strongly that the PA as stimulated in the intervention is adapted to their specific chronic disease. In addition, older adults may have some specific barriers and facilitators for PA that we did not include in the tailoring of Active Plus65, such as a preference for productive or meaningful PA instead of recreational PA: older adults have grown up in a time were being physically active just for recreational purposes was not common (Olanrewaju et al., 2016). Although this theme did not come up in our focus groups, it could be that in Active Plus65 we need to tailor more elaborately on intrinsic motivation, for example on the joy and benefits of recreational PA or on the importance of performing domestic chores for as long as possible.

Short-term and follow-up effects. Apart from comparing Active Plus65 to Active Plus50, as done above, it is interesting to compare Active Plus65 to other interventions. Although a large amount of studies examining the effectiveness of PA interventions is available, it needs to be acknowledged that comparisons may be hard to make due to large differences in target populations, intervention content, intervention timeframes and age cutoff points (Olanrewaju et al., 2016; Seah et al., 2019; Zubala et al., 2017). In their review Enam, Torres-Bonilla, and Eriksson (2018) promote a unified way of evaluations, but also stress that transferability of found effects in studies may not be achievable as eHealth interventions are very context-specific and thus difficult to compare. This matter also emerges when comparing the effect sizes of Active Plus65 with other interventions. When comparing Active Plus65 to Active Plus50, effect sizes ranged between 0.07 and 0.25 (Boekhout et al., 2018), depending on outcome measure and measurement time: the meta-analysis of Chase (2015) showed an effect size of 0.18 for studies comparing intervention and control groups. Although comparisons may not be straightforward to make, we can conclude that both in our study and in the meta-analysis of Chase (2015), effect sizes can be considered small (Cohen, 1992). Even in populations of older adults where it would seem easier to achieve good results (i.e., a population that is younger, has no physical impairments and receives a more intensive intervention than Active Plus65) low effects are found (French, Olander, Chisholm, & Mc Sharry, 2014). Despite our previous suggestions

regarding a more intensive tailoring, this could be an indication that our tailoring performs adequately for our target population.

Although after 3 months the intervention showed significant increases in weekly minutes of PA and days per week with sufficient PA, this effect had largely evaporated after 6 months. Decreasing effects over time are in line with previous research: despite the considerable evidence that PA interventions can contribute to behavior change, there is limited evidence on the sustainability of PA interventions for older adults (Jonkman, Van Schooten, Maier, & Pijnappels, 2018; Muellmann et al., 2017). This is not only because interventions effects decrease over time, but also because many interventions perform follow-up measurements only shortly after the intervention has ended, which makes analyzing the long-term effects difficult (Muller & Khoo, 2014). Nevertheless, compared to Active Plus50 which still had relatively large effects at 6 months (Peels, Bolman, et al., 2013; Peels et al., 2014), the effects in Active Plus65 decrease sooner, and therefore it is interesting to reflect on the suggestions that have been given to increase sustainability of effects.

Suggestions to increase sustainability appear to be rather divergent, and focus for example on the possibilities in the environment for PA, on personal contacts or on social media. Kwasnicka et al. (2016) emphasize the importance of providing individuals with environmental facilities for PA in order to enhance sustainability. Although our intervention provides information on PA in the local neighborhood and municipality, it could be that the offer of PA was too limited or did not suit the specific needs of this target population. In that line the study of Olanrewaju et al. (2016) is also relevant: they point out the importance of including attention for social structures in interventions, such as how protective families are, or how supportive friends are: for this, additional tailoring may be needed.

Studies have shown that personal contact in the form of follow-up phone calls, emails or dialogue support from intervention implementers shows promising results to keep participants engaged in order to increase long-term sustainability of interventions (Brouwer et al., 2011; Chase, 2013; Kelders, Kok, Ossebaard, & Van Gemert-Pijnen, 2012; Schippers, Adam, Smolenski, Wong, & Wit, 2017). However, when using a blended approach with more personal contact the intervention cannot be fully automated, which might decrease the intervention's reach and impact on public health (Glasgow et al., 1999). For this, social media applications in interventions, like Facebook or Twitter, may provide a solution: social media applications have been demonstrated to be able to change lifestyle behavior (Bennett, 2009; Cavallo et al., 2014; Tong et al., 2019) and can limit the involvement of intervention-professionals (Aalbers, Baars, & Rikkert, 2011). A matter to consider however is that Active Plus65 also aims to alleviate loneliness: some studies have found that social media increases loneliness (Nowland, Necka, & Cacioppo, 2018; C. Wilson, 2018) or that older adults in general need help to use social media (Aarts, 2018), which may not be available for single older adults. Whether including more personal contact with intervention staff or providing the option to use social media in the intervention is recommendable thus remains inconclusive.

Regarding the evaluation of the effects of the Active Plus65 intervention on PA we can conclude that Active Plus65 potentially makes an interesting healthy ageing intervention for the vulnerable target population of single older adults with physical impairments. However, the intervention would most likely benefit from additional tailoring to being physically active with physical impairments, and from adaptations to improve engagement with the intervention.

Loneliness

To assess whether there is an association between changes in PA and loneliness, and whether this potential association differs between participants with and without physical impairments, we performed a single-group pretest-posttest study (baseline - 6 months after baseline) (see ***Chapter 5***). Participants in Active Plus65 demonstrated a decrease in loneliness between baseline and follow-up. Improvements in weekly minutes of MVPA were found to be associated with decreases in loneliness. Also the presence of physical impairments was found to be negatively associated with loneliness when assessed independently as well as combined with the weekly minutes of MVPA. However, when combined in 1 analysis, weekly minutes of MVPA no longer showed an association with loneliness. This indicates that for single older adults the presence of physical impairments has a larger influence on loneliness than the level of PA has on loneliness.

Defining loneliness. An important issue to consider when interpreting our results is the matter of defining loneliness. The definition of loneliness that we have applied is "the unpleasant experience or feelings associated with a lack of close relationships" (De Jong-Gierveld, 1998). An issue that arises when targeting loneliness in interventions is that in definitions loneliness is often used interchangeably with concepts like social isolation or social disconnectedness (Gardiner et al., 2018). Although related to loneliness, these should be considered as different concepts as they refer to more objective states (i.e., having minimal to no contacts with other people), whereas loneliness is a subjective state (Cohen-Mansfield & Perach, 2015). McHugh Power, Dolezal, Kee, and Lawlor (2018) argued that it is hard to formulate 1 ultimate definition of loneliness, as in literature many theories exist on what constitutes loneliness. Moreover they argue that this lack of consensus may explain the limited effectiveness of interventions aiming to alleviate loneliness. The next paragraph will further explain the relevance of an ultimate definition and theory of loneliness.

Social activity versus loneliness. An important assumption in our studies was that stimulating and increasing social activity while being physically active could lead to a decrease in loneliness. Although many interventions that target loneliness are based on this assumption (Dickens et al., 2011; Robins, Jansons, et al., 2016), much is still unknown about the working mechanisms of this relation. A recent review pointed out that it may be that the determinants that need to be addressed to target social activity are different from those that need to be addressed to target loneliness (O'Rourke, Collins, & Sidani, 2018). Increasing social activity does not automatically mean that the contacts that are acquired

during social activity are valued or that they provide any emotional connectedness, which both are prerequisites for decreasing loneliness (Asante & Castillo, 2018; Courtin & Knapp, 2017; Machielse, 2015). Merely stimulating social activity may therefore be just a first step in decreasing loneliness as it provides the necessary presence of social contacts. After all, when no contacts are present loneliness is more prone to arise than when contacts are present (Courtin & Knapp, 2017).

It has been argued that the potential effects on loneliness of interventions that stimulate PA in a social context (which Active Plus65 does) depends on the degree in which PA can improve social competence and can enhance a perceived good quality of social relations (Pels & Kleinert, 2016). However, it may not be that straightforward to improve social competence or to enhance the quality of social relations as loneliness is often accompanied with feelings of hostility (Hawkley & Cacioppo, 2010), or with unrealistic perceptions about the size and quality of social relations (Schoenmakers, Fokkema, & Van Tilburg, 2014). As the perception of social relations is important, it could be that our tailoring requires a shift in focus. Some reviews provide valuable guidelines, indicating that effectiveness can be stimulated by emphasizing the pleasure that social interaction brings along, the positive short-term mobility gains or psychosocial outcomes, and goal-oriented engagement (Devereux-Fitzgerald, Powell, Dewhurst, & French, 2016; Gardiner et al., 2018).

Social activity versus physical activity. The above may also be of interest regarding our finding that the association between PA and loneliness becomes disrupted when the presence of physical impairments is added to the analysis, which may indicate that the in literature often found negative association between PA and loneliness has different working mechanisms for physically impaired single older adults. It may be that the physical impairments are so hindering that they not only diminish the potential for being physically active but also for being socially active: if one is no longer able to comfortably walk to a friend's house or to take a bus to a sports or leisure club, the mere potential to be physically as well as socially active diminishes. The finding of Robins, Hill, et al. (2016) that higher levels of household PA were related to lower levels of social isolation is also relevant: they argue that older adults who are still able to keep their house clean are more likely to invite friends. When we discussed our results on PA we suggested that our intervention might require additional tailoring on being physically active with physical impairments. It may thus also be that our intervention could benefit from additional tailoring on being socially active with physical impairments.

But there may be other matters that could influence what we should focus on when tailoring. The study of Bruggencate et al. (2018) showed that older adults want to contribute to society and do not want to be treated differently than adults who are younger. This is also supported by a review by O'Rourke et al. (2018) who found that older adults prefer to engage in purposeful activities instead of purely recreational activities. Many studies into the relation between PA and loneliness however focus solely on interventions promoting recreational PA or exercise, whereas Active Plus65 focusses on a wide range of PA. If older

adults prefer purposeful activities, then focusing on volunteering work for example may be a useful addition in the formulated PA-advice.

Although the intended decrease of loneliness among participants of Active Plus65 was achieved, the contemplations above demonstrate that the association between PA, loneliness and physical impairments is complex: it remains open for debate whether this decrease was achieved by stimulating PA, social activity or other components we did not include in our study. What emerges is that being physically impaired decreases the potential to increase both physical and social activity. Although increasing social activity may not be the ultimate way to decrease loneliness, it may be a very relevant starting point. Additional tailoring on being socially active with physical impairments may thus be in place.

Strengths and limitations

The results of the studies in this dissertation should be interpreted bearing in mind the methodological issues of these studies. The current section discusses the strengths and limitations regarding the study design, intervention, and measurements.

Study design

A strength of our study design is that we have applied a hybrid design in which an intervention is evaluated in a real-life implementation setting after effectiveness has been established in a Randomized Controlled Trial (RCT). Although an RCT is less prone to bias than our design, previous research has shown that RCT's are not always the most appropriate study design (Glasgow et al., 1999) and therefore hybrid designs, such as in our study, are recommended (Curran et al., 2012; Vandelanotte et al., 2018). The study results could also have been influenced by recruitment strategy, reach and attrition which we will analyze in more detail.

Recruitment strategy. The participants for the studies in this dissertation were recruited by a direct mailing sent by a local municipality in the Netherlands. This recruitment method allowed us to specifically invite our target population. Participants were offered the choice between either an online or printed delivery mode; providing the intervention in the preferred delivery mode of the participants might have increased reach, appreciation and intervention effects compared to studies where participants did not have a free choice (Daley et al., 2011; Forbes et al., 2010; Kongsved, Basnov, Holm-Christensen, & Hjollund, 2007; Short et al., 2014). Another benefit of this recruitment strategy is that also less motived individuals may have been reached, who may not have responded to more general ways of promotion, for example an advertisement for the intervention in a local newspaper.

Only participants from 1 local municipality in the south of the Netherlands were recruited. As there are some demographics in which this municipality differs from the rest

of the country, caution is in place when generalizing the results to the general population of single older adults with physical impairments: in Heerlen the socio economic standard (SES), educational attainment, level of PA and (self-rated) health are lower, and loneliness is higher (Heerlen Municipality, 2016). As SES, educational attainment and health are negatively related to PA and positively to loneliness (Dutch Department of Health Wellbeing and Sports, 2018c) these demographic differences may have influenced our findings. The sample population included in the studies in this dissertation showed an overrepresentation of lower educated participants. This may be a reflection of the population in this particular municipality, but it may also be that our intervention appeals to those with a low educational attainment. This could be considered positive as those with low educational attainments are often most in need of health enhancing interventions, but most difficult to reach (Dutch Department of Health Wellbeing and Sports, 2018a).

Active Plus65 is predominantly presented as a PA program: this may have implications for our sample of participants: it may have drawn participants who primarily intended to increase PA and who did not specifically intended to alleviate feelings of loneliness. On the other hand, because of the stigma that is often associated with loneliness, many people may not admit to being lonely (Cohen-Mansfield et al., 2016), and this may consequently refrain them from joining a loneliness intervention: emphasizing the intervention's PA aims may have prevented this.

Reach. Of all invited participants, 9% completed the baseline questionnaire: when compared to Active Plus50 (Peels, Bolman, et al., 2012), where the reach was 15%. This appears relatively low, especially considering the efforts that were put in optimizing the reach, such as a kick-off event and including local stakeholders. A possible reason for the low reach was that the invitation letter was rather lengthy, which for older adults may be a barrier (Paterson, McGowan, & Jordan, 2013). Also the questionnaire may have been too lengthy or too difficult (Van der Mispel et al., 2017). Another explanation may be found in the low SES in Heerlen: whereas the RCT of Active Plus50 was performed in 5 different regions of the Netherlands with a proportionate sample of SES, the municipality of Heerlen has a relatively low SES: those with a low SES are generally more difficult to reach with interventions (Bukman et al., 2014; Dutch Department of Health Wellbeing and Sports, 2016a).

The rather low reach and the fact that no information could be gathered on individuals who chose not to participate in the study may have implications for the generalizability of our findings. It could well be that individuals who have a low intention to become more physically active or to increase their social contacts were not reached. It is impossible to determine if this implies that those who participated had a higher or lower level of PA and loneliness than those who did not participate in the study. However, not being able to gather information on non-participants is a common issue in research on the promotion of PA (C. R. Hall, Rodgers, Wilson, & Norman, 2010).

The relatively large study population (ranging from n = 409 to n = 575 at baseline between the studies) can be regarded as a strength. This not only enabled sufficient power

in the statistical analyses, but it is also high compared to similar studies as recent reviews showed an average of 239 participants at baseline (Muller & Khoo, 2014; Robins, Jansons, et al., 2016; Shvedko et al., 2017).

Attrition. An important limitation of the studies presented in this dissertation is the high attrition. In our studies into the effects on PA only about 1 quarter of the participants from the baseline population completed the follow-up measurement: for the loneliness studies this was about 1 third. Although attrition is common in studies on health behavior interventions (Eysenbach, 2005) it is still a serious issue as high percentages of missing data make it more difficult to draw conclusions on intervention effects. This should also be taken in to account in our study, where online delivery mode was a predictor of attrition; for the other assessed determinants only educational attainment was found to be a predictor of drop-out. Apart from the potential issues to draw conclusions on intervention effects, high attrition can lower the public health impact of interventions (Eysenbach, 2005). By conducting multilevel analyses to the incomplete dataset we aimed to handle missing data in the most accurate way as it is proven that this gives better estimations than using multiple imputation (Twisk et al., 2013). Nevertheless, the relatively high attrition needs consideration especially as in some recent studies a higher age has found to be related to a lower attrition (Alley et al., 2018; Van der Deijl et al., 2014), which contrasts with our study that has relatively old participants. To explain the relatively high attrition, a study into the use and appreciation may be advisable.

Intervention

Regarding the intervention, some strengths and limitations can be mentioned. Firstly, to our knowledge, Active Plus65 is the first computer-tailored healthy ageing intervention especially designed for the growing and vulnerable target population of single older adults with physical impairments. This is considered to be an important strength as this target population so far often seems to be forgotten in research on PA and loneliness. The intervention aims to stimulate both physical and social activity. Although this is a broad approach, computer-tailoring has proven to be able to achieve behavior change and by using computer-tailoring only individually relevant advice could be provided (Broekhuizen, Kroeze, Van Poppel, Oenema, & Brug, 2012; Krebs et al., 2010).

Secondly, the intervention is developed by modifying an existing intervention using the IM Protocol (Bartholomew et al., 2016): such a theory- and evidence based method for intervention development increases the chance that an intervention retains its effectiveness after modifications have been made. Comparisons with the proven effective Active Plus50 interventions are not straightforward, considering the different target population and additional goals, but participants in Active Plus65 showed an increase in PA on the short term and a decrease on loneliness at follow-up, indicating that Active Plus65 achieved its aims.

Thirdly, the intervention allows implementers to balance costs and reach of the intervention. The intervention can be implemented in 2 delivery modes. Although internet-use is increasing in our target population, many older adults have not embraced the internet completely, and it can be considered a great benefit that Active Plus65 not only has an online delivery mode, but also a printed delivery mode. Admittedly, the printed delivery mode is more labor effective, but offering it alongside the online delivery mode may increase the reach and decrease the attrition of the intervention. In addition, the intervention can be implemented with as much information on local opportunities for physical and social activities as wished: the implementer can decide on how much effort they want to put into this. On the other hand, this brings along the risk that implementers choose the easiest and cheapest option by including a minimum of information on local opportunities.

Fourthly, the online intervention may have less entertaining and interactive elements than participants at present day expect from online delivered interventions. Especially for some target populations, such as lower educated individuals, this may be a deterrent for use. Also, the intervention is mainly text-based and therefore less suited for those who have limited conceptual reading skills or health skills.

Measurements

Measurements were taken at multiple time points, both during the intervention period (i.e., at baseline and 3 months after baseline) and at follow-up (i.e., 6 months after baseline). This enabled us to provide a detailed picture of the effects of the intervention: not only information on short-term effects, but also on sustainability after the intervention period has ended. However, a longer timeframe for measurements would be useful to determine the long-term effects of the intervention, considering that intervention-effects of PA tend to decrease over time (Muellmann et al., 2017), and that loneliness is considered to be a slowly changing state (Hawkley & Cacioppo, 2010).

A strength of our way of measuring is that both PA (Wendel-Vos et al., 2003) and loneliness (De Jong Gierveld & Van Tilburg, 2006, 2010) were assessed using questionnaires (respectively the SQUASH and the De Jong Gierveld 6-item Loneliness Scale) that have been proven valid and reliable. In international studies the IPAQ-questionnaire (Craig et al., 2003) and the UCLA-questionnaire (Russell, 1996) seem to be more frequently used than respectively the SQUASH-questionnaire and the De Jong Gierveld 6-item Loneliness Scale questionnaire. The SQUASH however has been specifically designed for the Dutch population (De Hollander et al., 2012; Wendel-Vos et al., 2003), for example giving specific attention to cycling, thus making it a relevant instrument for our target population. Moreover, the SQUASH is more extensive than the IPAQ, allowing for more intensive tailoring. Regarding the De Jong Gierveld 6-item Loneliness Scale, a recent study demonstrated that because of the broader conceptual framework and the multidimensional character of the De Jong Gierveld 6-item Loneliness Scale, the latter

is to be preferred in research (Dutch Central Bureau of Statistics, 2018c). We have chosen to use the total scale for loneliness in our analyses instead of the separate subscales for social and emotional loneliness. Both the total scale and the subscales have been found valid, and which one to choose depends on the research question under consideration (De Jong Gierveld & Van Tilburg, 2006). It can be argued that for our research question using the subscales would be appropriate, as it may be easier to alleviate social loneliness by stimulating social activity than it would be to alleviate emotional loneliness. However, when using the total scale, both dimensions of the overarching concept of loneliness are included: support for this can be found in the study of Dahlberg and McKee (2014), who showed that social factors explain the most variance in social loneliness, but psychological and health factors explain the most variance in emotional loneliness. Considering the fact that in our target population all these factors play a large role, using the total scale appears recommendable. This is supported by additional in depth analyses using the subscales which showed that PA was not significantly associated with social loneliness, but it was negatively associated with emotional loneliness. A resemblance can be seen with the study of Queen, Stawski, Ryan, and Smith (2014) who found that the social context does not moderate the relation between PA and loneliness; lonely older adults experience similar levels of positive emotions regardless of whether PA was done alone or with others: the quality of the contacts may thus be more important than the presence of contacts, providing more base for using the total scales of loneliness. Considering the above, our measurement tools for PA and loneliness can thus be deemed appropriate.

For loneliness, self-report questionnaires are the only viable option. For PA however, self-report questionnaires are not always the most evident option. Although self-report questionnaires are the most feasible method when assessing PA in large-scale studies (Helmerhorst et al., 2012), objective observations may be more accurate as they overcome problems with recall and memory bias (Prince et al., 2008; Smyth & Stone, 2003; Stone & Shiffman, 2002). For older adults there may be some other matters to consider. For objective observations, accelerometers are often used, but especially older adults with physical impairments may find wearing accelerometers too much of a hassle (Webster et al., 2011). Moreover, accelerometers are not always able to detect upper body movement, such as arm movements in resistance training, or cleaning windows as household activity (Andre & Wolf, 2007; Harris et al., 2009; Lee & Shiroma, 2014): arm resistance training is even one of the PA examples that is used in the Active Plus65 advice. A recent study where a version of Active Plus was used to stimulate PA among individuals recovering from cancer, used both objective and subjective measures of PA: they found that both measures showed PA outcomes in the same direction (Golsteijn et al., 2018). Still, it is possible that certain findings would have been different when using objective measures and therefore using questionnaires as well as more objective measures of PA should be taken in consideration in future research.

We have measured MVPA as this is the most common used measurement of PA. It may be argued that especially light PA could facilitate combining physical and social activity as during light PA comfortable chatting is easier than during moderate or vigorous PA; however, research shows very limited associations between light PA and loneliness (Buman, 2011; Ku et al., 2016; Robins, Hill, et al., 2016). Another line of research may be to make a distinction in the analyses of PA that is done with others and PA that is done alone. After all, although stimulating all sorts of PA is beneficial for health, stimulating PA done with others increases social activity which was one of the aims of our study. Unfortunately with the available data we cannot make this distinction.

For measuring the presence of impairments or a degree of impairment, no validated instrument was used as to our knowledge no validated instruments that solely measures level of impairments is available: most instruments measure much wider concepts such as ability to work, psycho-social functioning, or self-reliance. Our considerations in this general discussion have shown that intensive tailoring on physical impairments may be essential, and for this a validated instrument may be appropriate. However, it may not be a matter of using a validated instrument but a matter of using an instrument that is most suited to make a tailored advice. The requirements for questionnaires in scientific research are not necessarily identical to what is required for providing an effective advice in an intervention setting: validated instruments may be useful for scientific research purposes, but for optimum tailoring it may be more relevant to examine what questions would provide the best tailored advice. A qualitative study among single older adults in how to measure the degree of impairment might bring valuable information in what would work best in questionnaires.

Implications for future research and practice

As far as could be established, the studies presented in this dissertation were the first to evaluate the feasibility and effects of a healthy ageing intervention aiming to promote PA and to decrease loneliness in community-dwelling single older adults with physical impairments. The findings of our studies lead to several suggestions for future research and practice, which will be discussed below.

Suggestions for future research

Much is still unknown about the relation between PA, social activity and loneliness: future research should provide a deeper insight into the working mechanisms of this relation. At present, stimulating social activity can be regarded as a first step to decrease loneliness. More insights into the working mechanisms would provide intervention developers valuable guidelines how to target loneliness optimally with PA interventions including a social component. A potential way to stimulate social activity could be to

address maladaptive cognitions about social interactions (Masi et al., 2011): lonely individuals tend to approach other individuals with more hostility and may for example need suggestions on how not to interpret actions of others as overly negative.

An interesting line of future research would be to use Ecological Momentary Assessment (EMA). EMA provides the possibility to assess the current behavior and feelings in real-time in the participants' natural environment. By repeatedly assessing both the activity as well as the context (alone or in the presence of others) and feelings, deeper insights in the relation between activity, context and feelings of loneliness could be attained.

Although a lot of research has been done into engagement with eHealth interventions, there seems to be a paucity on research investigating the engagement of older adults with eHealth interventions. Optimizing engagement with interventions, such as adding personal contact, reminder messages or more interactive features, has often been suggested as a way to decrease attrition (Alkhaldi et al., 2016; Kelders et al., 2012; Perski, Blandford, West, & Michie, 2017), but interventions often focus solely on influencing determinants of health behavior change, and fail to take into account the determinants of engagement with online interventions (Short, Rebar, Plotnikoff, & Vandelanotte, 2015). This way present-day intervention studies provide no insight into how the content of interventions should best be delivered, such as a fully automated or a more blended approach with personal contact. This would make a valuable line of research which could increase the impact of Active Plus65.

A final matter that would be useful to examine is more insight into the factors that facilitate or inhibit implementation of interventions by intermediaries. After all, when intermediaries do not implement interventions, they cannot have any effect on public health. When intermediaries would have had a bigger role or would have had a higher commitment to make Active Plus65 successful, the reach of the intervention may have been higher: intermediaries may have better access to (in)formal networks of the target population or participants may be more motivated when a well-known intermediary is positive about the intervention. These assumptions however may be a bit tentative, as few studies have addressed the determinants of implementation of proven effective interventions. Moreover, most studies focus on individual adopters (i.e., the end user of the intervention) instead of on the organizational level adopters (Greenhalgh et al., 2017). Regarding the organizational level adopters, not only the role of intermediaries may be important, but also the role of other health care professionals who have regular contact with older adults (such as general practitioners or home-care organizations): a positive opinion of them may also stimulate reach and use of the intervention. Moreover, several reports have pointed out the gap between scientific knowledge on effective interventions aiming to increase public health and public health practice (Rabin, Brownson, Kerner, & Glasgow, 2006; Wandersman et al., 2008; Wilson, Petticrew, Calnan, & Nazareth, 2010). Therefore, a study into the implementation determinants of intermediaries would be useful.

Suggestions for practical improvement of the intervention

This dissertation provides several suggestions that may be useful to improve the intervention. First of all, as this dissertation demonstrates that offering an online and printed delivery mode alongside each other is advisable in order to decrease attrition and to increase reach, optimizing both delivery modes is essential. A study where a combination between printed and online delivery mode was possible showed that this combination resulted in higher appreciation for the intervention, a higher motivation and a more intensive use of the intervention (Bolman et al., 2019). As in our study the printed delivery mode was chosen more often by older adults, it would be useful to offer this in a format that is most suited for older adults. Things to consider would be a larger type size, using more pictures, or splitting the advice in more modules to prevent too much text at once. As the printed delivery mode is also more often chosen by those with little social support, a blended approach, where contact with an intervention implementer or with other participants is included, would be useful, such as adding the option for telephone assistance or discussion platforms with other participants: also including SMS-messages may be useful as this has been proven effective to support people to achieve healthy lifestyle behaviors (Orr & King, 2015; Vandelanotte et al., 2016). For the online delivery mode, where attrition was higher, it would be useful to increase adherence, especially for those with a low educational attainment. Changes to consider would be updating the webpage with a more up-to-date look, with more interactive elements, or with options for dialogue boxes with intervention implementers.

Secondly, our findings indicate that although we tailored the intervention to being physically active with a chronic disease and provided specific information on do's and don'ts for PA with certain chronic diseases, this tailoring may still not have been sufficient. In addition to that, it may also be a matter of presentation. In the intervention the advice, the main text focuses on being physically active with a chronic disease in general, and an additional leaflet is provided for PA with the participant's individual disease. It could be that the information on the leaflet should be enclosed within the text-advice as this may emphasize more strongly how specifically suited the PA-advice is for the individual. Replacing text with pictures, graphs or animations could also improve presentation. In addition, the tailoring should also focus on the limitations for social activity that physical impairments may bring along. For this it may be essential to not only add environmental information on possibilities for being active with others, but also information on easy-transport options, such as discounts on taxis that many municipalities offer for older adults.

Thirdly, the tailoring focusses on increasing social activity, but it may be recommendable to enhance and extend the text messages: things to consider would be more attention to the perception of social activities or extra attention to increasing social competence. It could for example be useful to emphasize in the text messages that most people feel hesitant to approach people they do not know, but that these feelings of awkwardness generally are over once the first step has been made. Also suggesting actions

to intensify existing contacts could increase social competence, such as offering to mow the neighbors' lawn or to walk their dog could be provided.

General conclusion

Our study into the development, use and effects of a healthy ageing intervention for single older adults with physical impairments led to several insights. The physical, social and mental health of this target population could benefit from the Active Plus65 interventions as it demonstrates positive effects on PA and loneliness. For PA, increasing long-term effectiveness is however required, which we were unable to confirm. To further strengthen the intervention effects, the results suggest that for this particular target population the assessment of the physical impairments needs to be performed more thoroughly in order to provide an advice that is tailored in great detail on being both physically and socially active despite the presence of physical impairments. Secondly, as the working mechanisms in the relation between social activity and loneliness proved to be highly complex, increasing social activity should be integrated as a goal in itself in the Active Plus65 intervention as sufficient social activity is a prerequisite for decreasing or preventing loneliness. Thirdly, results show that offering interventions such as Active Plus65 in a printed delivery mode alongside an online delivery mode is still necessary for this target population, and may be for many more years to come. Overall, our findings provide new evidence for the benefits of healthy ageing interventions for public health, and offer valuable insights for research and practice.

Chapter 7

References

A

Aalbers, T., Baars, M. A. E., & Rikkert, M. G. M. O. (2011). Characteristics of effective Internet-mediated interventions to change lifestyle in people aged 50 and older: A systematic review. *Ageing Research Reviews, 10*(4), 487-497. doi:10.1016/j.arr.2011.05.001

AARP Research (2017). Technology Use and attitudes among mid-life and older Americans.

Aarts, S. (2018). Social media and loneliness among community-dwelling older adults. *International Journal of Geriatric Psychiatry, 33*(3), 554-555. doi:10.1002/gps.4769

Acree, L. S., Longfors, J., Fjeldstad, A. S., Fjeldstad, C., Schank, B., Nickel, K. J., Gardner, A. W. (2006). Physical activity is related to quality of life in older adults. *Health and Quality of Life Outcomes, 4*, 37-37. doi:10.1186/1477-7525-4-37

Adams, K. B., Leibbrandt, S., & Moon, H. (2011). A critical review of the literature on social and leisure activity and wellbeing in later life. *Ageing Society, 31*(4), 683-712. doi:10.1017/s0144686x10001091

Ajzen, I. (1985). From intentions to actions: A theory of planned behaviour. In J. Kuhl & J. Beckman (Eds.), *Action control: From cognition to behaviour* (pp. 11-39). Heidelberg: Springer.

Ajzen, I. (1991). The Theory of Planned Behavior. *Organ Behav Hum Dec, 50*. doi:https://doi.org/10.1016/0749-5978(91)90020-T

Alkhaldi, G., Hamilton, F. L., Lau, R., Webster, R., Michie, S., & Murray, E. (2016). The Effectiveness of Prompts to Promote Engagement With Digital Interventions: A Systematic Review. *J Med Internet Res, 18*(1), e6. doi:10.2196/jmir.4790

Alley, S. J., Kolt, G. S., Duncan, M. J., Caperchione, C. M., Savage, T. N., Maeder, A. J., Vandelanotte, C. (2018). The effectiveness of a web 2.0 physical activity intervention in older adults – a randomised controlled trial. *International Journal of Behavioral Nutrition and Physical Activity, 15*(1), 4. doi:10.1186/s12966-017-0641-5

Anaby, D., Miller, W. C., Eng, J. J., Jarus, T., & Noreau, L. (2009). Can personal and environmental factors explain participation of older adults? *Disability and Rehabilitation: An International, Multidisciplinary Journal, 31*(15), 1275-1282. doi:10.1080/09638280802572940

Anderson-Bill, E. S., Winett, R. A., & Wojcik, J. R. (2011). Social cognitive determinants of nutrition and physical activity among web-health users enrolling in an online intervention: the influence of social support, self-efficacy, outcome expectations, and self-regulation. *J Med Internet Res, 13*(1), e28. doi:10.2196/jmir.1551

Andre, D., & Wolf, D. L. (2007). Recent Advances in Free-Living Physical Activity Monitoring: A Review. *Journal of Diabetes Science & Technology, 1*(5), 760-767.

Asante, S., & Castillo, J. (2018). Social connectedness, perceived social support, and health among older adults. *Innovation in Aging, 2*(suppl_1), 737-737. doi:10.1093/geroni/igy023.2719

B

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs: NJ: Prentice Hall.

Bankoski, A., Harris, T. B., McClain, J. J., Brychta, R. J., Caserotti, P., Chen, K. Y., Koster, A. (2011). Sedentary Activity Associated With Metabolic Syndrome Independent of Physical Activity. *Diabetes Care, 34*(2), 497-503. doi:10.2337/dc10-0987

Barg, C. J., Latimer, A. E., Pomery, E. A., Rivers, S. E., Rench, T. A., Prapavessis, H., & Salovey, P. (2012). Examining predictors of physical activity among inactive middle-aged women: an application of the health action process approach. *Psychol Health, 27*(7), 829-845. doi:10.1080/08870446.2011.609595

Barlow, M. A., Liu, S. Y., & Wrosch, C. (2015). Chronic illness and loneliness in older adulthood: The role of self-protective control strategies. *Health Psychology, 34*(8), 870-879. doi:DOI: 10.1037/hea0000182

Barnard, Y., Bradley, M. D., Hodgson, F., & Lloyd, A. D. (2013). Learning to use new technologies by older adults: Perceived difficulties, experimentation behaviour and usability. *Computers in Human Behavior, 29*(4), 1715-1724. doi:https://doi.org/10.1016/j.chb.2013.02.006

Barnett, A., Zhang, C. J. P., Johnston, J. M., & Cerin, E. (2018). Relationships between the neighborhood environment and depression in older adults: a systematic review and meta-analysis. *Int Psychogeriatr, 30*(8), 1153-1176. doi:10.1017/s104161021700271x

Bartholomew, L. K., Markham, C. M., Ruiter, R. A. C., Fernandez, M. E., Kok, G., & Parcel, G. S. (2016). *Planning health promotion programs: an intervention mapping approach. Fourth edition*. San Francisco: Jossey-Bass.

Baumeister, R. F., & Vohs, K. D. (2004). *Handbook of self-regulation: research, theory, and applications*. New York: The Guilford Press.

Beard, J. R., Officer, A., de Carvalho, I. A., Sadana, R., Pot, A. M., Michel, J.-P., Chatterji, S. (2016). The World report on ageing and health: a policy framework for healthy ageing. *Lancet, 387*(10033), 2145-2154. doi:10.1016/S0140-6736(15)00516-4

Bennett, G. G. (2009). The delivery of public health interventions via the internet: actualizing their potential. *Annu Rev Public Health, 30*, 273-292.

Benzinger, P., Iwarsson, S., Kroog, A., Beische, D., Lindemann, U., Klenk, J., & Becker, C. (2014). The association between the home environment and physical activity in community-dwelling older adults. *Aging: Clinical and Experimental Research, 26*(4), 377-385.

Bethancourt, H. J., Rosenberg, D. E., Beatty, T., & Arterburn, D. E. (2014). Barriers to and facilitators of physical activity program use among older adults. *Clinical Medicine & Research, 12*(1/2), 10-20. doi:10.3121/cmr.2013.1171

Bianchetti, L., Squazzoni, F., Casnici, N., Bianchini, D., Garrafa, E., Archetti, C., Marengoni, A. (2017). Social networks and health status in the elderly: the 'ANZIANI IN-RETE' population-based study. *Aging: Clinical and Experimental Research, 29*(6), 1173-1179.

Bierbauer, W., Inauen, J., Schaefer, S., Kleemeyer, M. M., Luscher, J., Konig, C., Scholz, U. (2017). Health Behavior Change in Older Adults: Testing the Health Action Process Approach at the Inter- and Intraindividual Level. *Appl Psychol Health Well Being, 9*(3), 324-348. doi:10.1111/aphw.12094

Bize, R., Johnson, J. A., & Plotnikoff, R. C. (2007). Physical activity level and health-related quality of life in the general adult population: A systematic review. *Preventive Medicine: An International Journal Devoted to Practice and Theory, 45*(6), 401-415. doi:10.1016/j.ypmed.2007.07.017

Boekhout, J. M., Berendsen, B. A., Peels, D. A., Bolman, C., & Lechner, L. (2018). Evaluation of a Computer-Tailored Healthy Ageing Intervention to Promote Physical Activity among Single Older Adults with a Chronic Disease. *International Journal of Environmental Research and Public Health, 15*(2), 346. doi:10.3390/ijerph15020346

Boekhout, J. M., Berendsen, B. A. J., Peels, D. A., Bolman, C., & Lechner, L. (2019). Physical Impairments Disrupt the Association Between Physical Activity and Loneliness: A Longitudinal Study. *Journal of Ageing and Physical Activity. Advanced Online Publication*. doi:https://doi.org/10.1123/japa.2018-0325

Boekhout, J. M., Peels, D. A., Berendsen, B. A. J., Bolman, C., & Lechner, L. (2017). An eHealth Intervention to Promote Physical Activity and Social Network of Single, Chronically Impaired Older Adults: Adaptation of an Existing Intervention Using Intervention Mapping. *JMIR Research Proposals, 2017*(6(11)), e230. doi:DOI: 10.2196/resprot.8093

Bolman, C. A. W., Golsteijn, R. H. J., Van der Ven, R. E. F., Peels, D. A., Volders, E., & Lechner, L. (2019). *Influence of delivery mode on use, appreciation & motivational value; the case for a tailored physical activity intervention for prostate and colorectal cancer patients and survivors*. Paper presented at the ISBNPA, Prague.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*(2), 77-101. doi:10.1191/1478088706qp063oa

Broekhuizen, K., Kroeze, W., Van Poppel, M. N. M., Oenema, A., & Brug, J. (2012). A systematic review of randomized controlled trials on the effectiveness of computer-tailored physical activity and dietary behavior promotion programs: an update. *Annals Behavioural Medicine, 44*(2), 259-286.

Brooks, J. M., Iwanaga, K., Chiu, C. Y., Cotton, B. P., Deiches, J., Morrison, B., Chan, F. (2017). Relationships between self-determination theory and theory of planned behavior applied to physical activity and exercise behavior in chronic pain. *Psychol Health Med, 22*(7), 814-822. doi:10.1080/13548506.2017.1282161

Brouwer, W. B. F., Kroeze, W., Crutzen, R., De Nooijer, J., De Vries, N., Brug, J., & Oenema, A. (2011). Which intervention characteristics are related to more exposure to internet-delivered healthy lifestyle promotion interventions? A systematic review. *Journal Medical Internet Research, 13*(1), e2. doi:DOI: 10.2196/jmir.1639

Brown, W. J., Burton, N. W., Marshall, A. L., & Miller, Y. D. (2008). Reliability and validity of a modified self-administered version of the Active Australia physical activity survey in a sample of mid-age women. *Australian and New Zealand Journal of Public Health, 32*(6), 535-541. doi:10.1111/j.1753-6405.2008.00305.x

Bruggencate, T. T., Luijkx, K. G., & Sturm, J. (2018). Social needs of older people: a systematic literature review. *Ageing & Society, 38*(9), 1745-1770. doi:10.1017/S0144686X17000150

Bukman, A. J., Teuscher, D., Feskens, E. J. M., van Baak, M. A., Meershoek, A., & Renes, R. J. (2014). Perceptions on healthy eating, physical activity and lifestyle advice: opportunities for adapting lifestyle interventions to individuals with low socioeconomic status. *BMC Public Health, 14*, 1036-1036. doi:10.1186/1471-2458-14-1036

Buman, M. P. (2011). *Peer-assisted social cognitive physical activity intervention for older adults*. ProQuest Information & Learning, US. Retrieved from http://search.ebscohost.com/login.aspx?direct=true&db=psyh&AN=2011-99100-322&site=ehost-live Available from EBSCOhost psyh database.

C

Cacioppo, J. T., Hawkley, L. C., Crawford, E., Ernst, J. M., Burleson, M. H., Kowalewski, R. B., Berntson, G. G. (2002). Loneliness and health: Potential mechanisms. *Psychosomatic Medicine, 64*(3), 407-417. doi:10.1097/00006842-200205000-00005

Cardol, M., de Jong, B. A., van den Bos, G. A. M., Beelen, A., de Groot, I. J. M., & de Haan, R. J. (2002). Beyond disability: Perceived participation in people with a chronic disabling condition. *Clinical Rehabilitation, 16*(1), 27-35. doi:10.1191/0269215502cr464oa

Cattan, M., White, M., Bond, J., & Learmouth, A. (2005). Preventing social isolation and loneliness among older people: a systematic review of health promotion interventions. *Ageing and Society, 25*(01), 44-67. doi:10.1017/s0144686x04002594

Cavallo, D. N., Tate, D. F., Ward, D. S., DeVellis, R. F., Thayer, L. M., & Ammerman, A. S. (2014). Social support for physical activity-role of Facebook with and without structured intervention. *Translational Behavioral Medicine, 4*(4), 346-354. doi:10.1007/s13142-014-0269-9

Chase, J. D. (2013). Physical activity interventions among older adults: a literature review. *Research and theory for nursing practice, 27*(1), 53-80.

Chase, J. D. (2015). Interventions to Increase Physical Activity Among Older Adults: A Meta-Analysis. *The Gerontologist, 55*(4), 706-718. doi:10.1093/geront/gnu090

Chekroud, S. R., Gueorguieva, R., Zheutlin, A. B., Paulus, M., Krumholz, H. M., Krystal, J. H., & Chekroud, A. M. (2018). Association between physical exercise and mental health in 1.2 million individuals in the USA between 2011 and 2015: a cross-sectional study. *Lancet Psychiatry, 5*(9), 739-746. doi:10.1016/s2215-0366(18)30227-x

Chipps, J., Jarvis, M. A., & Ramlall, S. (2017). The effectiveness of e-Interventions on reducing social isolation in older persons: A systematic review of systematic reviews. *Journal of Telemedicine and Telecare, 23*(10), 817-827.

Chodzko-Zajko, W. J., Proctor, D. N., Fiatarone Singh, M. A., Minson, C. T., Nigg, C. R., Salem, G. J., & Skinner, J. S. (2009). American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc, 41*(7), 1510-1530. doi:10.1249/MSS.0b013e3181a0c95c

Chorus, A., & Hopman-Rock, M. (2003). *Chronically ill and physical activity: a quick scan*. Retrieved from: https://www.tno.nl/nl/zoeken/?q=chronisch+zieken+en+bewegen https://www.bewegenismedicijn.nl/files/downloads/1._tno-preventieengezondheid2003.pdf (accessed 15-02-2017)

Cohen-Mansfield, J., Hazan, H., Lerman, Y., & Shalom, V. (2016). Correlates and predictors of loneliness in older-adults: A review of quantitative results informed by qualitative insights. *International Psychogeriatrics, 28*(4), 557-576. doi:10.1017/S1041610215001532

Cohen-Mansfield, J., & Perach, R. (2015). Interventions for Alleviating Loneliness among Older Persons: A Critical Review. *American Journal of Health Promotion, 29*(3), e109-e125. doi:10.4278/ajhp.130418-LIT-182

Cohen, J. (1992). A Power Primer. *Psychological Bulletin, 112*(1), 155-159.

Conn, V. S., Hafdahl, A. R., Brown, S. A., & Brown, L. M. (2008). Meta-analysis of patient education interventions to increase physical activity among chronically ill adults. *Patient Education and Counseling, 70*(2), 157-172. doi:http://dx.doi.org/10.1016/j.pec.2007.10.004

Cook, A. J., Brawer, P. A., & Vowles, K. E. (2006). The fear-avoidance model of chronic pain: Validation and age analysis using structural equation modeling. *Pain, 121*(3), 195-206. doi:10.1016/j.pain.2005.11.018

Cornwell, E. Y., & Waite, L. J. (2009). Social disconnectedness, perceived isolation, and health among older adults. *Journal of Health and Social Behavior, 50*(1), 31-48. doi:10.1177/002214650905000103

Courtin, E., & Knapp, M. (2017). Social isolation, loneliness and health in old age: a scoping review. *Health & Social Care in the Community, 25*(3), 799-812. doi:10.1111/hsc.12311

Craig, C. L., Marshall, A. L., Sjostrom, M., Bauman, A. E., Booth, M. L., Ainsworth, B. E., Oja, P. (2003). International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc, 35*(8), 1381-1395. doi:10.1249/01.mss.0000078924.61453.fb

Curran, G. M., Bauer, M., Mittman, B., Pyne, J. M., & Stetler, C. (2012). Effectiveness-implementation Hybrid Designs: Combining Elements of Clinical Effectiveness and Implementation Research to Enhance Public Health Impact. *Medical Care, 50*(3), 217-226. doi:10.1097/MLR.0b013e3182408812

D

Dahlberg, L., & McKee, K. J. (2014). Correlates of social and emotional loneliness in older people: evidence from an English community study. *Aging & Mental Health, 18*(4), 504-514. doi:10.1080/13607863.2013.856863

Daley, A., Stokes-Lampard, H., Wilson, S., Rees, M., Roalfe, A., & MacArthur, C. (2011). What women want? Exercise preferences of menopausal women. *Maturitas, 68*(2), 174-178. doi:10.1016/j.maturitas.2010.11.011

Das, P., & Horton, R. (2012). Rethinking our approach to physical activity. *The Lancet, 380*(9838), 189-190. doi: 10.1016/S0140-6736(12)61024-1

Davies, C. A., Spence, J. C., Vandelanotte, C., Caperchione, C. M., & Mummery, W. K. (2012). Meta-analysis of internet-delivered interventions to increase physical activity levels. *Int J Behav Nutr Phys Act, 9*, 52. doi:DOI: 10.1186/1479-5868-9-52

De Hollander, E. L., Zwart, L., De Vries, S. I., & Wendel-Vos, G. C. W. (2012). The SQUASH was a more valid tool than the OBIN for categorizing adults according to the Dutch physical activity guideline. *Journal of Clinical Epidemiology, 65*(1), 73-81. doi:http://dx.doi.org/10.1016/j.jclinepi.2011.05.005

De Jong-Gierveld, J. (1998). A review of loneliness: concept and definitions, determinants and consequences. *Clinical Gerontology*(8), 73-80.

De Jong Gierveld, J., & Van Tilburg, T. (1999). *Manual of the Loneliness Scale. Department of Social Research Methodology*. [Department of Social Research Methodology, Vrije Universiteit Amsterdam, Amsterdam (updated version 18.01.02). Unpublished manuscript]. Amsterdam.

De Jong Gierveld, J., & Van Tilburg, T. (2006). A 6-Item Scale for Overall, Emotional, and Social Loneliness: Confirmatory Tests on Survey Data. *Research on Aging, 28*(5), 582-598. doi:10.1177/0164027506289723

De Jong Gierveld, J., & Van Tilburg, T. (2010). The De Jong Gierveld short scales for emotional and social loneliness: Tested on data from 7 countries in the UN generations and gender surveys. *European Journal of Ageing, 7*(2), 121-130. doi:10.1007/s10433-010-0144-6

De Veer, A. J. E., Peeters, J. M., Brabers, A. E. M., Schellevis, F. G., Rademakers, J. J. M., & Franke, A. L. (2015). Determinants of the intention to use e-health by community dwelling older people. *BMC Health Services Research, 15*(103). doi:10.1186/s12913-015-0756-8

De Vries, H., & Brug, J. (1999). Computer-tailored interventions motivate people to adopt health promoting behaviours: Introduction to a new approach. *Patient Educ Couns, 36*(2), 99-105.

De Vries, H., Mudde, A. N., Leijs, I., Charlton, A., Vartiainen, E., Buijs, G., Kremers, S. (2003). The European Smoking prevention Framework Approach (EFSA): an example of integral prevention. *Health Education Research, 18*(5), 611-626.

Devereux-Fitzgerald, A., Powell, R., Dewhurst, A., & French, D. P. (2016). The acceptability of physical activity interventions to older adults: A systematic review and meta-synthesis. *Social Science & Medicine, 158*, 14-23. doi:https://doi.org/10.1016/j.socscimed.2016.04.006

Dickens, A., Richards, S., Greaves, C., & Campbell, J. (2011). Interventions targeting social isolation in older people: a systematic review. *BMC Public Health, 11*(1), 647-647.

Ding, D., Lawson, K. D., Kolbe-Alexander, T. L., Finkelstein, E. A., Katzmarzyk, P. T., van Mechelen, W., & Pratt, M. (2016). The economic burden of physical inactivity: a global analysis of major non-communicable diseases. *Lancet, 388*(10051), 1311-1324. doi:10.1016/s0140-6736(16)30383-x

Dishman, R. K., & Buckworth, J. (1996). Increasing physical activity: a quantitative synthesis. *Medicine & Science in Sports & Exercise, 28*(6), 706-719.

Donkin, L., Christensen, H., Naismith, S. L., Neal, B., Hickie, I. B., & Glozier, N. (2011). A Systematic Review of the Impact of Adherence on the Effectiveness of e-Therapies. Journal of Medical Internet Research, 13(3), 8-8. doi:10.2196/jmir.1772

Dutch Central Bureau of Statistics. (2016a). Eight Percent of Dutch Population never on internet. Retrieved from https://www.cbs.nl/nl-nl/nieuws/2016/22/acht-procent-van-de-nederlanders-nooit-op-internet

Dutch Central Bureau of Statistics. (2016b). Loneliness in the Netherlands. Retrieved from file:///C:/Users/JBH/Downloads/eenzaamheid-in-nederland%20(1).pdf

Dutch Central Bureau of Statistics. (2017). Lifestlye and (preventive) health research: personal characteristics. Retrieved 01-08-2018 https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83021NED/table?ts=1533126236901/

Dutch Central Bureau of Statistics. (2018a). Health questionnaire 2018. Retrieved from https://www.cbs.nl/nl-nl/maatwerk/2019/12/leefstijl-2018

Dutch Central Bureau of Statistics. (2018b). Internet: access, use and facilities. Retrieved from https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83429NED/table?dl=5386

Dutch Central Bureau of Statistics. (2018c). Measuring loneliness. Retrieved from https://www.cbs.nl/nl-nl/achtergrond/2018/39/meten-van-eenzaamheid

Dutch Central Bureau of Statistics. (2018d). Population prognosis 2018-2060. Retrieved 24-10-2018 https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83784NED/table?dl=5053

Dutch Department of Health Wellbeing and Sports. Chronic diseases and multimorbidity. Retrieved from https://www.volksgezondheidenzorg.info/onderwerp/chronische-ziekten-en-multimorbiditeit/cijfers-context/huidige-situatie (accessed 15-01-2016)

Dutch Department of Health Wellbeing and Sports. (2014). Public Health Status and Foresight Report: A healthier Netherlands. Retrieved from http://www.volksgezondheidtoekomstverkenning.nl/Over_deze_VTV/Nieuwsoverzicht/A_healthier_Netherlands /

Dutch Department of Health Wellbeing and Sports. (2015a). Physical activity and sports behavior of people with a chronic condition. Retrieved from http://www.rivm.nl/Documenten_en_publicaties/Algemeen_Actueel/Nieuwsberichten/2015/Mensen_met_een_beperking_sporten_minder

Dutch Department of Health Wellbeing and Sports. (2015b). Physical Activity Guidelines. Retrieved from https://www.volksgezondheidenzorg.info/sport/kernindicatoren/beweeg-en-zitgedrag#definitie-node-normen-en-adviezen-voor-sport-en-bewegen

Dutch Department of Health Wellbeing and Sports. (2016a). Belemmeringen en drijfveren voor sport en bewegen bij ondervertegenwoordigde groepen. Retrieved from https://www.rivm.nl/bibliotheek/rapporten/2016-0201.pdf

Dutch Department of Health Wellbeing and Sports. (2016b). Chronic diseases and multimorbidity. Retrieved from https://www.volksgezondheidenzorg.info/onderwerp/chronische-ziekten-en-multimorbiditeit/cijfers-context/huidige-situatie#node-aantal-mensen-met-chronische-ziekte-bekend-bij-de-huisarts

Dutch Department of Health Wellbeing and Sports. (2016c). Loneliness in the Netherlands by age. Retrieved from https://www.volksgezondheidenzorg.info/onderwerp/eenzaamheid/cijfers-context/huidige-situatie#!node-eenzaamheid-naar-leeftijd

Dutch Department of Health Wellbeing and Sports. (2017). Situation of public health and care. Retrieved from https://www.staatvenz.nl/kerncijfers/beweeggedrag-beweegrichtlijnen

Dutch Department of Health Wellbeing and Sports. (2018a). *Lifestyle monitor*. Retrieved from https://www.rivm.nl/leefstijlmonitor

Dutch Department of Health Wellbeing and Sports. (2018b). Loneliness: present situation. Retrieved from https://www.volksgezondheidenzorg.info/onderwerp/eenzaamheid/cijfers-context/huidige-situatie

Dutch Department of Health Wellbeing and Sports. (2018c). *Public Health Status and Foresight Report 2018*. Retrieved from: file:///C:/Users/JBH/Downloads/volksgezondheid-toekomst-verkenning-2018-een-gezond-vooruitzicht-synthese.pdf

Duvivier, B., Schaper, N., Hesselink, M., Kan, L., Stienen, N., Winkens, B., Savelberg, H. (2017). Breaking sitting with light activities vs structured exercise: a randomised crossover study demonstrating benefits for glycaemic control and insulin sensitivity in type 2 diabetes. *Diabetologia, 60*(3), 490-498.

E

Eime, R., Young, J., Harvey, J., Charity, M., & Payne, W. (2013). A systematic review of the psychological and social benefits of participation in sport for adults: informing development of a conceptual model of health through sport. *International Journal of Behavioral Nutrition and Physical Activity, 10*(1), 135-135. doi: 10.1186/1479-5868-10-135

Ekelund, U., Steene-Johannessen, J., Brown, W. J., Fagerland, M. W., Owen, N., Powell, K. E., Lee, I. M. (2016). Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet, 388*(10051), 1302-1310. doi:10.1016/s0140-6736(16)30370-1

Ekvall-Hansson, E., Sundquist, K., Jakobsson, U., & Larsson, C. (2016). Impact of pain characteristics and fear-avoidance beliefs on physical activity levels among older adults with chronic pain: a population-based, longitudinal study. *BMC Geriatrics, 16*(1), 1-8. doi:doi:10.1186/s12877-016-0224-3

Elbert, N. J., van Os-Medendorp, H., van Renselaar, W., Ekeland, A. G., Hakkaart-van Roijen, L., Raat, H., Pasmans, S. G. M. A. (2014). Effectiveness and cost-effectiveness of eHealth interventions in somatic diseases: A systematic review of systematic reviews and meta-analyses. *Journal of Medical Internet Research, 16*(4), 1-23. doi:10.2196/jmir.2790

Elliott, D. S., & Mihalic, S. (2004). Issues in disseminating and replicating effective prevention programs. *Prevention Science, 5*(1), 47-52. doi:10.1023/B:PREV.0000013981.28071.52

Enam, A., Torres-Bonilla, J., & Eriksson, H. (2018). Evidence-Based Evaluation of eHealth Interventions: Systematic Literature Review. *Journal of Medical Internet Research, 20*(11), 1-1. doi:10.2196/10971

European Parliamentary Research Service. (2015). Bridging the digital divide in the EU. Retrieved from http://www.europarl.europa.eu/RegData/etudes/BRIE/2015/573884/EPRS_BRI(2015)573884_EN.pdf

European Union. (2015). *Quality of life: facts and views*. Luxemburg: European Union.

European Union. (2017, 03-05-2017). Digital economy and society statistics: households and individuals. Retrieved from http://ec.europa.eu/eurostat/statistics-explained/index.php/Digital_economy_and_society_statistics_-_households_and_individuals/http://www.webcitation.org/6qBPBQ3SC

Eysenbach, G. (2005). The law of attrition. *Journal Medical Internet Research, 7*(1), e11. doi:10.2196/jmir.7.1.e11

F

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175-191.

Ferraro, K. F., & Farmer, M. M. (1995). Social compensation in adulthood and later life. In R. A. Dixon, L. Bäckman, R. A. Dixon, & L. Bäckman (Eds.), *Compensating for psychological deficits and declines: Managing losses and promoting gains.* (pp. 127-145). Hillsdale, NJ, US: Lawrence Erlbaum Associates, Inc.

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. New York, NY, US: Psychology Press.

Fokkema, T., De Jong Gierveld, J., & Dykstra, P. A. (2012). Cross-national differences in older adult loneliness. *The Journal of Psychology: Interdisciplinary and Applied, 146*(1-2), 201-228. doi:10.1080/00223980.2011.631612

Forbes, C. C., Plotnikoff, R. C., Courneya, K. S., & Boulé, N. G. (2010). Physical Activity Preferences and Type 2 Diabetes. *The Diabetes Educator, 36*(5), 801-815. doi:10.1177/0145721710378538

French, D. P., Olander, E. K., Chisholm, A., & Mc Sharry, J. (2014). Which behaviour change techniques are most effective at increasing older adults' self-efficacy and physical activity behaviour? A systematic review. *Ann Behav Med, 48*(2), 225-234. doi:10.1007/s12160-014-9593-z

Friemel, T. N. (2016). The digital divide has grown old: Determinants of a digital divide among seniors. *New Media & Society, 18*(2), 313-331. doi:https://doi.org/10.1177/1461444814538648

G

Gajewski, P., & Falkenstein, M. (2016). Physical activity and neurocognitive functioning in aging - a condensed updated review. *European Reviews of Aging and Physical Activity, 13*(1), 1-7.

Gardiner, C., Geldenhuys, G., & Gott, M. (2018). Interventions to reduce social isolation and loneliness among older people: an integrative review. *Health Soc Care Community, 26*(2), 147-157. doi:10.1111/hsc.12367

Gardner, B., Smith, L., Lorencatto, F., Hamer, M., & Biddle, S. J. H. (2016). How to reduce sitting time? A review of behaviour change strategies used in sedentary behaviour reduction interventions among adults. *Health Psychology Review, 10*(1), 89-112. doi:10.1080/17437199.2015.1082146

Geraghty, A. W. A., Torres, L. D., Leykin, Y., Pérez-Stable, E. J., & Muñoz, R. F. (2013). Understanding attrition from international internet health interventions: A step towards global eHealth. *Health Promotion International, 28*(3), 442-452. doi:10.1093/heapro/das029

Glasgow, R. E., Vogt, T. M., & Boles, S. M. (1999). Evaluating the public health impact of health promotion interventions: the RE-AIM framework. *Am J Public Health, 89*(9), 1322-1327.

Golsteijn, R., Bolman, C., Peels, D. A., Volders, E., De Vries, H., & Lechner, L. (2017). A Web-Based and Print-Based Computer-Tailored Physical Activity Intervention for Prostate and Colorectal Cancer Survivors: A Comparison of User Characteristics and Intervention Use. *Journal of Medical Internet Research, 19*(8), 1-1. doi:10.2196/jmir.7838

Golsteijn, R., Bolman, C., Volders, E., Peels, D. A., de Vries, H., & Lechner, L. (2018). Short-term efficacy of a computer-tailored physical activity intervention for prostate and colorectal cancer patients and survivors: a randomized controlled trial. *Int J Behav Nutr Phys Act, 15*(1), 106. doi:10.1186/s12966-018-0734-9

Golsteijn, R., Peels, D. A., Evers, S. M. A. A., Bolman, C., Mudde, A. N., de Vries, H., & Lechner, L. (2014). Cost-effectiveness and cost-utility of a web-based or print-delivered tailored intervention to promote physical activity among adults aged over fifty: An economic evaluation of the Active Plus intervention. *The International Journal of Behavioral Nutrition and Physical Activity, 11*. doi:DOI: 10.1186/s12966-014-0122-z

Gomez-Pinilla, F., & Hillman, C. (2013). The Influence of Exercise on Cognitive Abilities. *Comprehensive Physiology* (3 (1)), 403-428. doi:doi: 10.1002/cphy.c110063

Goodman, R. A., Posner, S. F., Huang, E. S., Parekh, A. K., & Koh, H. K. (2013). Defining and Measuring Chronic Conditions: Imperatives for Research, Policy, Program, and Practice. *Preventing Chronic Disease, 10*, E66. doi:10.5888/pcd10.120239

Greaney, M. L., Puleo, E., Bennett, G. G., Haines, J., Viswanath, K., Gillman, M. W., Emmons, K. M. (2014). Factors Associated with Choice of Web or Print Intervention Materials in the Healthy Directions 2 Study. *Health Education & Behavior, 41*(1), 52-62. doi:10.1177/1090198113486803

Greaney, M. L., Sprunck-Harrild, K., Bennett, G. G., Puleo, E., Haines, J., Viswanath, K. V., & Emmons, K. M. (2012). Use of Email and Telephone Prompts to Increase Self-Monitoring in a Web-Based Intervention: Randomized Controlled Trial. *Journal of Medical Internet Research, 14*(4), e96. doi:10.2196/jmir.1981

Greaves, C. J., Sheppard, K. E., Abraham, C., Hardeman, W., Roden, M., Evans, P. H., & Schwarz, P. (2011). Systematic review of reviews of intervention components associated with increased effectiveness in dietary and physical activity interventions. *BMC Public Health, 11*(1), 119-130. doi:10.1186/1471-2458-11-119

Greenhalgh, T., Wherton, J., Papoutsi, C., Lynch, J., Hughes, G., A'Court, C., Shaw, S. (2017). Beyond adoption: A new framework for theorizing and evaluating nonadoption, abandonment, and challenges to the scale-up, spread, and sustainability of health and care technologies. *Journal of Medical Internet Research, 19*(11).

Gualtieri, L., Phillips, J., Rosenbluth, S., & Synoracki, S. (2018). Digital Literacy: A Barrier to Adoption of Connected Health Technologies in Older Adults. *Journal of Medical Internet Research, 20*(9), 12-12. doi:10.2196/11803

Guertler, D., Vandelanotte, C., Kirwan, M., & Duncan, M. J. (2015). Engagement and nonusage attrition with a free physical activity promotion program: The case of 10,000 steps Australia. *Journal of Medical Internet Research, 17*(7). doi:10.2196/jmir.4339

Guest, G., Namey, E., & McKenna, K. (2017). How Many Focus Groups Are Enough? Building an Evidence Base for Nonprobability Sample Sizes. *Field Methods, 29*(1), 3-22.

H

Hall, A. K., Bernhardt, J. M., Dodd, V., & Vollrath, M. W. (2015). The digital health divide: evaluating online health information access and use among older adults. *Health Educ Behav, 42*(2), 202-209. doi:10.1177/1090198114547815

Hall, C. R., Rodgers, W. M., Wilson, P. M., & Norman, P. (2010). Imagery use and self-determined motivations in a community sample of exercisers and non-exercisers. *Journal of Applied Social Psychology, 40*(1), 135-152. doi:10.1111/j.1559-1816.2009.00566.x

Hamer, M., Lavoie, K. L., & Bacon, S. L. (2014). Taking up physical activity in later life and healthy ageing: the English longitudinal study of ageing. *Br J Sports Med, 48*(3), 239-243. doi:10.1136/bjsports-2013-092993

Harris, T. J., Owen, C. G., Victor, C. R., Adams, R., Ekelund, U., & Cook, D. G. (2009). A Comparison of Questionnaire, Accelerometer, and Pedometer: Measures in Older People. *Medicine & Science in Sports & Exercise, 41*(7), 1392-1402. doi:10.1249/MSS.0b013e31819b3533

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., Bauman, A. (2007). Physical activity and public health: Updated recommendation for adults from the american college of sports medicine and the American Heart Association. *Circulation, 116*(9), 1081-1093.

Hawkley, L. C., & Cacioppo, J. T. (2010). Loneliness Matters: A Theoretical and Empirical Review of Consequences and Mechanisms. *Annals of behavioral medicine : a publication of the Society of Behavioral Medicine, 40*(2), 10.1007/s12160-12010-19210-12168. doi:10.1007/s12160-010-9210-8

Hawkley, L. C., Thisted, R. A., & Cacioppo, J. T. (2009). Loneliness predicts reduced physical activity: Cross-sectional & longitudinal analyses. *Health Psychology, 28*(3), 354-363. doi:10.1037/a0014400

Hawthorne, G. (2008). Perceived social isolation in a community sample: its prevalence and correlates with aspects of peoples' lives. *Social Psychiatry and Psychiatric Epidemiology, 43*(2), 140-150. doi:DOI: 10.1007/s00127-007-0279-8

Hawton, A., Green, C., Dickens, A. P., Richards, S. H., Taylor, R. S., Edwards, R., Campbell, J. L. (2014). The impact of social isolation on the health status and health-related quality of life of older people. *Quality of Life, 20*, 57-67. doi:10.1007s/11136-010-9717-2

Heckhausen, J., Wrosch, C., & Schulz, R. (2010). A motivational theory of life-span development. *Psychological Review, 117*(1), 32-60. doi:10.1037/a0017668

Heerlen Municipality. (2016). Regional Income distribution. Retrieved from https://heerlen.incijfers.nl/dashboard/Inkomen/

Heinrich, L. M., & Gullone, E. (2006). The clinical significance of loneliness: a literature review. *Clin Psychol Rev, 26*(6), 695-718. doi:10.1016/j.cpr.2006.04.002

Helmerhorst, H. J. F., Brage, S., Warren, J., Besson, H., & Ekelund, U. (2012). A systematic review of reliability and objective criterion-related validity of physical activity questionnaires. *Int J Behav Nutr Phys Act, 9*, 103.

Hildebrandt, V. H., Bernaards, C. M., & Stubbe, J. H. (2013). *Trendrapport on physical activity and health 2010/2011*. Leiden: De Bink.

Hill, R., Betts, L. R., & Gardner, S. E. (2015). Older adults' experiences and perceptions of digital technology: (Dis)empowerment, wellbeing, and inclusion. *Computers in Human Behavior, 48*, 415-423. doi:10.1016/j.chb.2015.01.062

Hobbs, N., Godfrey, A., Lara, J., Errington, L., Meyer, T. D., Rochester, L., Sniehotta, F. F. (2013). Are behavioural interventions effective in increasing physical activity at 12 to 36 months in adults aged 55 to 70 years? A systematic review and meta-analysis. *BMC Medicine, 11*, 75. doi:10.1186/1741-7015-11-75

Holt-Lunstad, J., Smith, T. B., Baker, M., Harris, T., & Stephenson, D. (2015). Loneliness and social isolation as risk factors for mortality: A meta-analytic review. *Perspectives on Psychological Science, 10*(2), 227-237. doi:10.1177/1745691614568352

Hung, W. W., Ross, J. S., Boockvar, K. S., & Siu, A. L. (2012). Association of chronic diseases and impairments with disability in older adults: A decade of change? *Medical Care, 50*(6), 501-507. doi:10.1097/MLR.0b013e318245a0e0

I

Izawa, K. P., Watanabe, S., Oka, K., Hiraki, K., Morio, Y., Kasahara, Y., Omiya, K. (2011). Physical activity in relation to exercise capacity in chronic heart failure patients. *International Journal of Cardiology, 152*(1), 152-153.

J

Jancey, J., Lee, A., Howat, P., Clarke, A., Wang, K., & Shilton, T. (2007). Reducing attrition in physical activity programs for older adults. *J Aging Phys Act, 15*(2), 152-165.

Jones, L. W., & Courneya, K. S. (2002). Exercise Counseling and Programming Preferences of CancerSurvivors. *Cancer Practice, 10*(4), 208-215. doi:10.1046/j.1523-5394.2002.104003.x

Jonkman, N. H., van Schooten, K. S., Maier, A. B., & Pijnappels, M. (2018). eHealth interventions to promote objectively measured physical activity in community-dwelling older people. *Maturitas, 113*, 32-39. doi:10.1016/j.maturitas.2018.04.010

K

Kampmeijer, R., Pavlova, M., Tambor, M., Golinowska, S., & Groot, W. (2016). The use of e-health and m-health tools in health promotion and primary prevention among older adults: a systematic literature review. *BMC Health Services Research, 16*, 467-479. doi:10.1186/s12913-016-1522-3

Kantar Public. (2018). How media-wise are the Netherlands? Retrieved from https://www.mediawijzer.net/wp-content/uploads/sites/6/2018/09/Rapport-Mediawijsheid-volwassenen-2018.pdf http://www.webcitation.org/73nME4gJo

Kelders, S. M., Kok, R. N., Ossebaard, H. C., & Van Gemert-Pijnen, J. E. W. C. (2012). Persuasive system design does matter: A systematic review of adherence to web-based interventions. *Journal of Medical Internet Research, 14*(6), p16-p39. doi:10.2196/jmir.2104

Kenniscentrum Sport. (2016). *What moves people with a chronic disease? A research into stimulating and hindering factors to move among people with a chronic disease.* Retrieved from https://www.kenniscentrumsport.nl/publicatie/?wat-beweegt-mensen-met-een-chronische-aandoening&kb_id=17408

Kok, G., Gottlieb, N. H., Peters, G. J., Mullen, P. D., Parcel, G. S., Ruiter, R. A., Bartholomew, L. K. (2016). A taxonomy of behaviour change methods: an Intervention Mapping approach. *Health Psychol Rev, 10*(3), 297-312. doi:10.1080/17437199.2015.1077155

Kongsved, S. M., Basnov, M., Holm-Christensen, K., & Hjollund, N. H. (2007). Response rate and completeness of questionnaires: a randomized study of Internet versus paper-and-pencil versions. *J Med Internet Res, 9*(3), e25.

Kosteli, M. C., Williams, S. E., & Cumming, J. (2016). Investigating the psychosocial determinants of physical activity in older adults: A qualitative approach. *Psychol Health, 31*(6), 730-749. doi:10.1080/08870446.2016.1143943

Krebs, P., Prochaska, J. O., & Rossi, J. S. (2010). A meta-analysis of computer-tailored interventions for health behaviour change. *Prev Med, 51*, 214-221. doi:DOI: 10.1016/j.ypmed.2010.06.004

Krosnick, C. A., Presser, S. (2010). *Question and Questionnaire Design*: Emereld Group Publishing Limited.

Kruk, J. J. (2014). Health and economic costs of physical inactivity. *Asian Pacific Journal of Cancer Prevention*(15-2014), 7499-7503. doi:http://dx.doi.org/10.7314/APJCP.2014.15.18.7499

Ku, P.W., Fox, K. R., Liao, Y., Sun, W.J., & Chen, L.J. (2016). Prospective associations of objectively assessed physical activity at different intensities with subjective well-being in older adults. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care & Rehabilitation, 25*(11), 2909-2919. doi:10.1007/s11136-016-1309-3

Kuiper, J. S., Oude Voshaar, R. C., Zuidema, S. U., Stolk, R. P., Zuidersma, M., & Smidt, N. (2017). The relationship between social functioning and subjective memory complaints in older persons: a population-based longitudinal cohort study. *International Journal of Geriatric Psychiatry, 32*(10), 1059-1071.

Kumanyika, S., Jeffery, R. W., Morabia, A., Ritenbaugh, C., & Antipatis, V. J. (2002). Obesity prevention: the case for action. *Int J Obes Relat Metab Disord, 26*. doi:10.1038/sj.ijo.0801938

Kwasnicka, D., Dombrowski, S. U., White, M., & Sniehotta, F. (2016). Theoretical explanations for maintenance of behaviour change: a systematic review of behaviour theories. *Health Psychology Review, 10*(3), 277-296. doi:10.1080/17437199.2016.1151372

L

Lagace, M., Charmarkeh, H., Laplante, J., & Tanguay, A. (2015). How Ageism Contributes to the Second-Level Digital Divide: The Case of Canadian Seniors. *Journal of Technologies & Human Usability, 11*(4), 1-13.

Larsson, C., Ekvall Hansson, E., Sundquist, K., & Jakobsson, U. (2016). Impact of pain characteristics and fear-avoidance beliefs on physical activity levels among older adults with chronic pain: a population-based, longitudinal study. *BMC Geriatr, 16*, 50. doi:10.1186/s12877-016-0224-3

Latulippe, K., Hamel, C., & Giroux, D. (2017). Social Health Inequalities and eHealth: A Literature Review With Qualitative Synthesis of Theoretical and Empirical Studies. *J Med Internet Res, 19*(4), e136. doi:10.2196/jmir.6731

Lechner, L., & De Vries, H. (1995a). Participation in an employee fitness program: determinants of high adherence low adherence, and dropout. *Journal of Occupational and Environmental Medicine, 37*(4), 429-436.

Lechner, L., & De Vries, H. (1995b). Starting participation in an employee fitness program: attitudes, social influence, and self-efficacy. *Preventive Medicine, 24*(6), 624-633.

Lee, I. M., & Shiroma, E. (2014). Using accelerometers to measure physical activity in large-scale epidemiological studies: issues and challenges. *Br J Sports Med, 48*(3), 197-201. doi:10.1136/bjsports-2013-093154

Leigh-Hunt, N., Bagguley, D., Bash, K., Turner, V., Turnbull, S., Valtorta, N., & Caan, W. (2017). An overview of systematic reviews on the public health consequences of social isolation and loneliness. *Public Health, 152*(1), 157-171.

Lemon, B. W., Bengtson, V. L., & Peterson, J. A. (1972). An exploration of the activity theory of aging: activity types and life satisfaction among in-movers to a retirement community. *J Gerontol, 27*(4), 511-523.

Levasseur, M., Généreux, M., Bruneau, J.F., Vanasse, A., Chabot, É., Beaulac, C., & Bédard, M.M. (2015). Importance of proximity to resources, social support, transportation and neighborhood security for mobility and social participation in older adults: results from a scoping study. *BMC Public Health, 15*(1), 1-19.

Lindsay Smith, G., Banting, L., Eime, R., O'Sullivan, G., & van Uffelen, J. G. Z. (2017). The association between social support and physical activity in older adults: a systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 14*(1), 56. doi:10.1186/s12966-017-0509-8

Loprinzi, P. D., Lee, H., & Cardinal, B. J. (2015). Evidence to support including lifestyle light-intensity recommendations in physical activity guidelines for older adults. *American Journal of Health Promotion, 29*(5), 277-284. doi:10.4278/ajhp.130709-QUAN-354

Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., Biddle, S. (2016). Physical Activity for Cognitive and Mental Health in Youth: A Systematic Review of Mechanisms. *Pediatrics, 138*(3), 1-13. doi:10.1542/peds.2016-1642

Luhmann, M., & Hawkley, L. C. (2016). Age differences in loneliness from late adolescence to oldest old age. *Developmental Psychology, 52*(6), 943-959. doi:10.1037/dev0000117

Luo, Y., Hawkley, L. C., Waite, L. J., & Cacioppo, J. T. (2012). Loneliness, health, and mortality in old age: A national longitudinal study. *Social Science & Medicine, 74*(6), 907-914. doi:https://doi.org/10.1016/j.socscimed.2011.11.028

Lustria, M. L. A., Noar, S. M., Cortese, J., Van Stee, K., Glueckauf, R. L., & Lee, J. (2013). A meta-analysis of Web-delivered tailored health behaviour change interventions. *J Health Commun, 18*(9), 1039-1069. doi:10.1080/10810730.2013.768727

M

Machielse, A. (2015). The heterogeneity of socially isolated older adults: A social isolation typology. *Journal of Gerontological Social Work, 58*(338-356). doi:10.180/01634372.2015.1007258

Marengoni, A., Winblad, B., Karp, A., & Fratiglioni, L. (2008). Prevalence of chronic diseases and multimorbidity among the elderly population in Sweden. *American Journal of Public Health, 98*(7), 1198-1200. doi:10.2105/AJPH.2007.121137

Masi, C. M., Chen, H.Y., Hawkley, L. C., & Cacioppo, J. T. (2011). A meta-analysis of interventions to reduce loneliness. *Personality and Social Psychology Review, 15*(3), 219-266. doi:10.1177/1088868310377394

Matheson, G., Klügl, M., Engebretsen, L., Bendiksen, F., Blair, S., Börjesson, M., Ljungqvist, A. (2013). Prevention and management of non-communicable disease: The IOC consensus statement, Lausanne 2013. *Sports Medicine, 43*(11), 1075-1088. doi:10.1007/s40279-013-0104-3

McEachan, R. R. C., Conner, M., Taylor, N. J., & Lawton, R. J. (2011). Prospective prediction of health-related behaviours with the Theory of Planned Behaviour: a meta-analysis. *Health Psychology Review, 5*(2), 97-144. doi:10.1080/17437199.2010.521684

McGuire, W. J. (1985). *Attitudes and attitude change*. New York: Random House.

McHugh Power, J. E., Dolezal, L., Kee, F., & Lawlor, B. A. (2018). Conceptualizing loneliness in health research: Philosophical and psychological ways forward. *Journal of Theoretical and Philosophical Psychology, 38*(4), 219-234. doi:10.1037/teo0000099

McKenna, M., & Collins, J. (2010). Current issues and challenges in chronic disease control. In B. R. Remington PL, Wegner MV, (Ed.), *Chronic disease epidemiology and control* (pp. 1-24). Washington (DC): American Public Health Association.

McPhee, J. S., French, D. P., Jackson, D., Nazroo, J., Pendleton, N., & Degens, H. (2016). Physical activity in older age: perspectives for healthy ageing and frailty. *Biogerontology, 17*(3), 567-580. doi:10.1007/s10522-016-9641-0

Meek, K. P., Bergeron, C. D., Towne, S. D., Ahn, S., Ory, M. G., & Smith, M. L. (2018). Restricted Social Engagement among Adults Living with Chronic Conditions. *Int J Environ Res Public Health, 15*(1). doi:10.3390/ijerph15010158

Mertens, L., Compernolle, S., Deforche, B., Mackenbach, J. D., Lakerveld, J., Brug, J., Glonti, K. (2017). Built environmental correlates of cycling for transport across Europe. *Health Place, 44*. doi:10.1016/j.healthplace.2017.01.007

Milton, K., Clemes, S., & Bull, F. (2013). Can a single question provide an accurate measure of physical activity? *Br J Sports Med, 47*(1), 44-48. doi:10.1136/bjsports-2011-090899

Milward, J., Drummond, C., Fincham-Campbell, S., & Deluca, P. (2018). What makes online substance-use interventions engaging? A systematic review and narrative synthesis. *Digit Health, 4*, 2055207617743354. doi:10.1177/2055207617743354

Moran, M., Van Cauwenberg, J., Hercky-Linnewiel, R., Cerin, E., Deforche, B., & Plaut, P. (2014). Understanding the relationships between the physical environment and physical activity in older adults: a systematic review of qualitative studies. *Int J Behav Nutr Phys Act, 11*, 79. doi:10.1186/1479-5868-11-79

Morris, S. B., & DeShon, R. P. (2002). Combining effect size estimates in meta-analysis with repeated measures and independent-groups designs. *Psychological Methods, 7*(1), 105-125. doi:10.1037/1082-989X.7.1.105

Mottram, S., Peat, G., Thomas, E., Wilkie, R., & Croft, P. (2008). Patterns of pain and mobility limitation in older people: cross-sectional findings from a population survey of 18,497 adults aged 50 years and over. *Quality of Life Research, 17*(4), 529-539. doi:10.1007/s11136-008-9324-7

Mouton, A., & Cloes, M. (2013). Web-based interventions to promote physical activity by older adults: promising perspectives for a public health challenge. *Arch Public Health, 71*(1), 16. doi:10.1186/0778-7367-71-16

Muellmann, S., Forberger, S., Mollers, T., Broring, E., Zeeb, H., & Pischke, C. R. (2017). Effectiveness of eHealth interventions for the promotion of physical activity in older adults: A systematic review. *Prev Med, 108*, 93-110. doi:10.1016/j.ypmed.2017.12.026

Mullen, S. P., Wójcicki, T. R., Mailey, E. L., Szabo, A. N., Gothe, N. P., Olson, E. A., McAuley, E. (2013). A profile for predicting attrition from exercise in older adults. *Prevention science: the official journal of the Society for Prevention Research, 14*(5), 489-496. doi:10.1007/s11121-012-0325-y

Muller, A. M., & Khoo, S. (2014). Non-face-to-face physical activity interventions in older adults: a systematic review. *Int J Behav Nutr Phys Act, 11*(1), 35.

N

Nelson, M. E., Rejeski, W. J., Blair, S. N., Duncan, P. W., Judge, J. O., King, A. C., Castaneda-Sceppa, C. (2007). Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc, 39*(8), 1435-1445.

Neve, M. J., Collins, C. E., & Morgan, P. J. (2010). Dropout, nonusage attrition, and pretreatment predictors of non usage attrition in a commercial web-based weight loss program. *Journal of Medical Internet Research, 12*(4), 81-96. doi:10.2196/jmir.1640

Newall, N. E. G., Chipperfield, J. G., & Bailis, D. S. (2014). Predicting stability and change in loneliness in later life. *Journal of social and personal relationships, 31*(3), 335-351. doi:10.1177/0265407513494951

Newsom, J. T., Huguet, N., McCarthy, M. J., Ramage-Morin, P., Kaplan, M. S., J., B., Oderkirk, J. (2012). Health behavior change following chronic illness in middle and later life. *Journal of Gerontology and Psycholology and Social Science, 67*(b), 279-288. doi:10.1093/geronb/gbr103

Noar, S. M., Benac, C. N., & Harris, M. S. (2007). Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychol Bull, 133*(4), 673-693.

Norman, G. J., Zabinski, M. F., Adams, M. A., Rosenberg, D. E., Yaroch, A. L., & Atienza, A. A. A Review of eHealth Interventions for Physical Activity and Dietary Behavior Change. *American Journal of Preventive Medicine, 33*(4), 336-345.e316. doi:10.1016/j.amepre.2007.05.007

Nowland, R., Necka, E. A., & Cacioppo, J. T. (2018). Loneliness and Social Internet Use: Pathways to Reconnection in a Digital World? *Perspectives on Psychological Science, 13*(1), 70-87.

O

O'Rourke, H., Collins, L., & Sidani, S. (2018). Interventions to address social connectedness and loneliness for older adults: a scoping review. *BMC Geriatrics, 18*(1), 1-13.

Olanrewaju, O., Kelly, S., Cowan, A., Brayne, C., & Lafortune, L. (2016). Physical Activity in Community Dwelling Older People: A Systematic Review of Reviews of Interventions and Context. *PLoS ONE, 11*(12), 1-19. doi:10.1371/journal.pone.0168614

Ong, A. D., Uchino, B. N., & Wethington, E. (2016). Loneliness and Health in Older Adults: A Mini-Review and Synthesis. *Gerontology, 62*(4), 443-449. doi:10.1159/000441651

Organisation for Economic Cooperation and Development. (2016). Expenditure by disease, age and gender. Retrieved from URL:http://www.oecd.org/els/health-systems/Expenditure-by-disease-age-and-gender-FOCUS-April2016.pdf. Accessed: 2017-05-31. (Archived by WebCite® at http://www.webcitation.org/6qrjVY3LC)

Orr, J. A., & King, R. J. (2015). Mobile phone SMS messages can enhance healthy behaviour: a meta-analysis of randomised controlled trials. *Health Psychology Review, 9*(4), 397-416.

Ory, M. G., Smith, M. L., Mier, N., & Wernicke, M. M. (2010). The Science of Sustaining Health Behavior Change: The Health Maintenance Consortium. *American Journal of Health Behavior, 34*(6), 647-659.

Öztürk, A., Şimşek, T. T., Yümin, E. T., Sertel, M., & Yümin, M. (2011). The relationship between physical, functional capacity and quality of life (QoL) among elderly people with a chronic disease. *Archives of Gerontology and Geriatrics, 53*(3), 278-283. doi:10.1016/j.archger.2010.12.011

P

Pampel, F. C., Denney, J. T., & Krueger, P. M. (2012). Obesity, SES, and economic development: a test of the reversal hypothesis. *Soc Sci Med, 74*. doi:10.1016/j.socscimed.2011.12.028

Park, S. K., Meldrum, C. A., & Larson, J. L. (2013). Subgroup analysis of symptoms and their effect on functioning, exercise capacity, and physical activity in patients with severe chronic obstructive pulmonary disease. *Heart & Lung: the Journal of Acute and Critical Care, 42*(6), 465-472. doi:DOI: 10.1016/j.hrtlng.2013.08.008

Parschau, L., Barz, M., Richert, J., Knoll, N., Lippke, S., & Schwarzer, R. (2014). Physical activity among adults with obesity: testing the Health Action Process Approach. *Rehabil Psychol, 59*(1), 42-49. doi:10.1037/a0035290

Paterson, K. B., McGowan, V. A., & Jordan, T. R. (2013). Effects of adult aging on reading filtered text: evidence from eye movements. *PeerJ, 1*, e63-e63. doi:10.7717/peerj.63

Pedersen, B. K., & Saltin, B. (2015). Exercise as medicine: Evidence for prescribing exercise as therapy in 26 different chronic diseases. *Scandinavian Journal of Medicine & Science in Sports, 25*(Suppl 3), 1-72. doi:10.1111/sms.12581

Peek, S., Luijkx, K., Vrijhoef, H., Nieboer, M., Aarts, S., Voort, C., Wouters, E. (2017). Origins and consequences of technology acquirement by independent-living seniors: towards an integrative model. *BMC Geriatrics, 17*(1), 1-18. doi:DOI: 10.1186/s12877-017-0582-5

Peels, D. A., Bolman, C., Golsteijn, R. H. J., De Vries, H., Mudde, A. N., Van Stralen, M. M., & Lechner, L. (2013). Long-term efficacy of a tailored physical activity intervention among older adults. *International Journal of Behavior Nutrition and Physical Activity, 10*, 104.

Peels, D. A., Bolman, C., Golsteijn, R. H. J., De Vries, H, Mudde, A. N., Van Stralen, M. M., & Lechner, L. (2012). Differences in reach and attrition between Web-based and print-delivered tailored interventions among adults over 50 years of age: clustered randomized trial. *Journal of Medical Internet Research, 16*(6). doi:10.2196/jmir.2229

Peels, D. A., De Vries, H., Bolman, C., Golsteijn, R. H. J., Van Stralen, M. M., Mudde, A. N., & Lechner, L. (2013). Differences in the use and appreciation of a Web-based or printed computer tailored physical activity intervention for people aged over fifty. *Health Education Research, 28*(4), 715-731. doi: 10.1093/her/cyt065

Peels, D. A., Van Stralen, M. M., Bolman, C., Golsteijn, R. H. J., De Vries, H., Mudde, A. N., & Lechner, L. (2012). The development of a web-based computer tailored advice to promote physical activity among people older than 50 years. *Journal of Medical Internet Research, 14*(2), e39. doi: 10.2196/jmir.1742

Peels, D. A., Van Stralen, M. M., Bolman, C., Golsteijn, R. H. J., De Vries, H., Mudde, A. N., & Lechner, L. (2014). The differentiated (short-term) effectiveness of a printed versus a Web-based tailored intervention to promote physical activity among the over-fifties: a randomized controlled trial. *Health Educational Research, 29*(5), 870-882. doi: 10.1093/her/cyu039

Pels, F., & Kleinert, J. (2016). Loneliness and physical activity: A systematic review. *International Review of Sport and Exercise Psychology, 9*(1), 231-260. doi:10.1080/1750984X.2016.1177849

Penninx, B. W. J. H., van Tilburg, T., Kriegsman, D. M. W., Boeke, A. J. P., Deeg, D. J. H., & van Eijk, J. T. M. (1999). Social Network, Social Support, and Loneliness in Older Persons with Different Chronic Diseases. *Journal of Aging and Health, 11*(2), 151-168. doi:10.1177/089826439901100202

Perski, O., Blandford, A., West, R., & Michie, S. (2017). Conceptualising engagement with digital behaviour change interventions: a systematic review using principles from critical interpretive synthesis. *Translational Behavioral Medicine, 7*(2), 254-267. doi:10.1007/s13142-016-0453-1

Petitte, T., Mallow, J., Barnes, E., Petrone, A., Barr, T., & Theeke, L. (2015). A Systematic Review of Loneliness and Common Chronic Physical Conditions in Adults. *The open psychology journal, 8*(Suppl 2), 113-132. doi:10.2174/1874350101508010113

Pew Research Center. (2017). *Tech Adoption Climbs Among Older Adults*. Retrieved from http://www.pewinternet.org/2017/05/17/tech-adoption-climbs-among-older-adults/

Phillips, S., Wójcicki, T., & McAuley, E. (2013). Physical activity and quality of life in older adults: an 18-month panel analysis. *Quality of Life Research, 22*(7), 1647-1654. doi:10.1007/s11136-012-0319-z

Poscia, A., Stojanovic, J., La Milia, D. I., Duplaga, M., Grysztar, M., Moscato, U., Magnavita, N. (2018). Interventions targeting loneliness and social isolation among the older people: An update systematic review. *Experimental Gerontology, 102*, 133-144. doi:10.1016/j.exger.2017.11.017

Prince, S. A., Adamo, K. B., Hamel, M. E., Hardt, J., Gorber, S., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: A systematic review. *The International Journal of Behavioral Nutrition and Physical Activity, 5*.

Pritchard, E., Barker, A., Day, L., Clemson, L., Brown, T., & Haines, T. (2015). Factors impacting the household and recreation participation of older adults living in the community. *Disability & Rehabilitation, 37*(1), 56-63.

Prochaska, J., Redding, C., & Evers, K. (2008). The Transtheoretical Model and stages of change. In K. Glanz, B. K. Rimer, & K. Viswanath (Eds.), *Health behaviour and health education: theory, research, and practice*. San Francisco: Jossey-Bass.

Pucci, G., Reis, R., Rech, C., & Hallal, P. (2012). Quality of life and physical activity among adults: population-based study in Brazilian adults. *Quality of Life Research, 21*(9), 1537-1543.

Q

Queen, T. L., Stawski, R. S., Ryan, L. H., & Smith, J. (2014). Loneliness in a day: activity engagement, time alone, and experienced emotions. *Psychol Aging, 29*(2), 297-305. doi:10.1037/a0036889

R

Rabin, B. A., Brownson, R. C., Kerner, J. F., & Glasgow, R. E. (2006). Methodological challenges in disseminating evidence-based interventions to promote physical activity. *Am J Prev Med, 31*(4s), 24-34.

Reed, J. L., & Pipe, A. L. (2016). Practical Approaches to Prescribing Physical Activity and Monitoring Exercise Intensity. *Canadian Journal of Cardiology, 32*(4), 514-522.

Reinwand, D. A., Schulz, D. N., Crutzen, R., Kremers, S. P. J., & de Vries, H. (2015). Who follows eHealth interventions as recommended? A study of participants' personal characteristics from the experimental arm of a randomized controlled trial. *Journal of Medical Internet Research, 17*(5). doi:10.2196/jmir.3932

Remillard, M. L., Mazor, K. M., Cutrona, S. L., Gurwitz, J. H., & Tjia, J. (2014). Systematic Review of the Use of Online Questionnaires among the Geriatric Population. *Journal of the American Geriatrics Society, 62*(4), 696-705. doi:10.1111/jgs.12747

Renaud, K., & Biljon, J. (2008). *Predicting technology acceptance and adoption by the elderly: A qualitative study. Proceedings of the South African Institue of Computer Scientists and Information Technologists; 2008; Wilderness; South Africa. ECM Digital Library*.

Resnick, B., & Jenkins, L. S. (2000). Testing the reliability and validity of the Self-Efficacy for Exercise scale. *Nursing Research, 49*, 154-159.

Richard, A., Rohrmann, S., Vandeleur, C. L., Schmid, M., Barth, J., & Eichholzer, M. (2017). Loneliness is adversely associated with physical and mental health and lifestyle factors: Results from a Swiss national survey. *PLoS ONE, 12*(7), e0181442. doi:10.1371/journal.pone.0181442

Ritterband, L., Thorndike, F., Cox, D., Kovatchev, B., & Gonder-Frederick, L. (2009). A Behavior Change Model for Internet Interventions. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine, 38*(1), 18-27. doi:10.1007/s12160-009-9133-4

Robins, L. M., Hill, K. D., Finch, C. F., Clemson, L., & Haines, T. (2016). The association between physical activity and social isolation in community-dwelling older adults. *Aging & Mental Health*, 1-8. doi:10.1080/13607863.2016.1242116

Robins, L. M., Jansons, P., & Haines, T. (2016). The impact of physical activity interventions on social isolation among community-dwelling older adults: a systematic review. *Research & Reviews: Journal of Nursing and Health Sciences, 2*(1), 62-71.

Rogers, E. M. (2003). *Diffusion of innovations*. New York: The Free Press.

Russell, D. W. (1996). UCLA Loneliness Scale (Version 3): reliability, validity, and factor structure. *J Pers Assess, 66*(1), 20-40. doi:10.1207/s15327752jpa6601_2

Ryan, R., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

S

Sallis, J. F., Grossman, R. M., Pinski, R. B., Patterson, T. L., & Nader, P. R. (1987). The development of scales to measure social support for diet and exercise behaviour. *Preventive Medicine, 16*(6), 825-836. doi:http://dx.doi.org.ezproxy.elib10.ub.unimaas.nl/10.1016/0091-7435(87)90022-3

Schippers, M., Adam, P. C. G., Smolenski, D. J., Wong, H. T. H., & Wit, J. B. F. (2017). A meta-analysis of overall effects of weight loss interventions delivered via mobile phones and effect size differences according to delivery mode, personal contact, and intervention intensity and duration. *Obesity Reviews, 18*(4), 450-459. doi:10.1111/obr.12492

Schneider, F., De Vries, H., Candel, M., van de Kar, A., & van Osch, L. (2013). Periodic email prompts to re-use an Internet-delivered computer-tailored lifestyle program: Influence of prompt content and timing. *Journal of Medical Internet Research, 15*(1), 91-102. doi:10.2196/jmir.2151

Schneider, F., van Osch, L., Schulz, D. N., Kremers, S. P. J., & de Vries, H. (2012). The Influence of User Characteristics and a Periodic Email Prompt on Exposure to an Internet-Delivered Computer-Tailored Lifestyle Program. *Journal of Medical Internet Research, 14*(2), e40. doi:10.2196/jmir.1939

Schneider, S., Diehl, K., Görig, T., Schilling, L., De Bock, F., Hoffmann, K., Fischer, J. (2017). Contextual influences on physical activity and eating habits -options for action on the community level. *BMC Public Health, 17*(1), 760. doi:10.1186/s12889-017-4790-x

Schoenmakers, E., Fokkema, T., & Van Tilburg, T. (2014). Eenzaamheid is moeilijk op te lossen en treft niet alleen ouderen. *Demos, 30*, 5-7.

Schuster, C., Petosa, R., & Petosa, S. (1995). Using Social Cognitive Theory to Predict Intentional Exercise in Post-Retirement Adults. *Journal of Health Education, 26*(1), 14-24.

Schwarzer, R., & Luszczynska, A. (2008). How to overcome health-compromising behaviors: The health action process approach. *European Psychologist, 13*(2), 141-151. doi:10.1027/1016-9040.13.2.141

Seah, B., Kowitlawakul, Y., Jiang, Y., Ang, E., Chokkanathan, S., & Wang, W. (2019). A review on healthy ageing interventions addressing physical, mental and social health of independent community-dwelling older adults. *Geriatric Nursing, 40*(1), 37-50. doi:https://doi.org/10.1016/j.gerinurse.2018.06.002

Sheeran, P., & Orbell, S. (1999). Implementation intentions and repeated behaviour: augmenting the predictive validity of the theory of planned behaviour. *European Journal of Social Psychology, 29*(2/3), 349-369. doi:https://doi.org/10.1002/(SICI)1099-0992(199903/05)29:2/3<349::AID-EJSP931>3.0.CO;2-Y

Short, C., Rebar, A., Plotnikoff, R. C., & Vandelanotte, C. (2015). Designing engaging online behaviour change interventions: a proposed model of user engagement. *The European Health Psychologist, 17*(1), 32-38.

Short, C., Vandelanotte, C., & Duncan, M. J. (2014). Individual characteristics associated with physical activity intervention delivery mode preferences among adults. *Int J Behav Nutr Phys Act, 11*(1), 25. doi:10.1186/1479-5868-11-25

Shvedko, A., Whittaker, A. C., Thompson, J. L., & Greig, C. A. (2017). Physical activity interventions for treatment of social isolation, loneliness or low social support in older adults: A systematic review and meta-analysis of randomised controlled trials. *Psychology of Sport and Exercise, 34*(1), 128-137.

Smyth, J., & Stone, A. (2003). Ecological Momentary Assessment Research in Behavioral medicine. *Journal of Happiness Studies, 4*(1), 35-52.

Souto Barreto, P. (2015). Time to Challenge Public Health Guidelines on Physical Activity. *Sports Medicine, 45*(6), 769-773. doi:10.1007/s40279-015-0326-7

Statista. (2018). Adult internet usage. Retrieved from https://www.statista.com/statistics/184389/adult-internet-users-in-the-us-by-age-since-2000/http://www.webcitation.org/75lLgh5Us

Stolte, E., Hopman-Rock, M., Aartsen, M. J., van Tilburg, T. G., & Chorus, A. (2017). The Theory of Planned Behavior and Physical Activity Change: Outcomes of the Aging Well and Healthily Intervention Program for Older Adults. *J Aging Phys Act, 25*(3), 438-445. doi:10.1123/japa.2016-0182

Stone, A., & Shiffman, S. (2002). Capturing momentary, self-report data: A proposal for reporting guidelines. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine, 24*(3), 236-243.

Sun, R., Norman, J., & While, A. (2013). Physical activity in older people: a systematic review. *BMC Public Health, 13*(449).

Sundström, G., Fransson, E., Malmberg, B., & Davey, A. (2009). Loneliness among older Europeans. *European Journal of Ageing, 6*(4), 267-275. doi:10.1007/s10433-009-0134-8

T

Tennant, B., Stellefson, M., Dodd, V., Chaney, B., Chaney, D., Paige, S., & Alber, J. (2015). eHealth literacy and Web 2.0 health information seeking behaviors among baby boomers and older adults. *Journal of Medical Internet Research, 17*(3). doi:DOI: 10.2196/jmir.3992

Thornton, C. M., Kerr, J., Conway, T. L., Saelens, B. E., Sallis, J. F., Ahn, D. K., King, A. C. (2017). Physical Activity in Older Adults: an Ecological Approach. *Ann Behav Med, 51*(2), 159-169. doi:10.1007/s12160-016-9837-1

Toepoel, V. (2013). Ageing, leisure, and social connectedness: How could leisure help reduce social isolation of older people? *Social Indicators Research, 113*(1), 355-372. doi:10.1007/s11205-012-0097-6

Tong, H. L., Coiera, E., Tong, W., Wang, Y., Quiroz, J. C., Martin, P., & Laranjo, L. (2019). Efficacy of a Mobile Social Networking Intervention in Promoting Physical Activity: Quasi-Experimental Study. *JMIR Mhealth Uhealth, 7*(3), e12181. doi:10.2196/12181

Tsai, H.y. S., Shillair, R., & Cotten, S. R. (2017). Social support and 'playing around': An examination of how older adults acquire digital literacy with tablet computers. *Journal of Applied Gerontology, 36*(1), 29-55. doi:10.1177/0733464815609440

Twisk, J. (2006). *Applied Multilevel analysis*. Cambridge: Cambridge University Press.

Twisk, J., de Boer, M., de Vente, W., & Heymans, M. (2013). Multiple imputation of missing values was not necessary before performing a longitudinal mixed-model analysis. *Journal of Clinical Epidemiology, 66*(9), 1022-1028.

U

University of Colorado. (2017). Effect size calculator. Retrieved from https://www.uccs.edu/~lbecker/

V

Vagetti, G. C., Barbosa Filho, V. C., Moreira, N. B., de Oliveira, V., Mazzardo, O., & de Campos, W. (2014). Association between physical activity and quality of life in the elderly: a systematic review, 2000-2012. *Revista Brasileira de Psiquiatria, 36*(1), 76-88. doi:10.1590/1516-4446-2012-0895

Van Cauwenberg, J., Nathan, A., Barnett, A., Barnett, D. W., & Cerin, E. (2018). Relationships Between Neighbourhood Physical Environmental Attributes and Older Adults' Leisure-Time Physical Activity: A Systematic Review and Meta-Analysis. *Sports Med, 48*(7), 1635-1660. doi:10.1007/s40279-018-0917-1

Van den Bussche, H., Koller, D., Kolonko, T., Hansen, H., Wegscheider, K., Glaeske, G., Schön, G. (2011). Which chronic diseases and disease combinations are specific to multimorbidity in the elderly? Results of a claims data based cross-sectional study in Germany. *BMC Public Health, 11*(1), 101-101. doi: 10.1186/1471-2458-11-101

Van der Deijl, M., Etman, A., Kamphuis, C. B., & van Lenthe, F. J. (2014). Participation levels of physical activity programs for community-dwelling older adults: a systematic review. *BMC Public Health, 14*, 1301. doi:10.1186/1471-2458-14-1301

Van der Mispel, C., Poppe, L., Crombez, G., Verloigne, M., & De Bourdeaudhuij, I. (2017). A Self-Regulation-Based eHealth Intervention to Promote a Healthy Lifestyle: Investigating User and Website Characteristics Related to Attrition. *J Med Internet Res, 19*(7), e241. doi:10.2196/jmir.7277

Van der Ploeg, H. P., Chey, T., Korda, R. J., Banks, E., & Bauman, A. (2012). Sitting time and all-cause mortality risk in 222 497 australian adults. *Archives of Internal Medicine, 172*(6), 494-500. doi:10.1001/archinternmed.2011.2174

Van Deursen, A. J. A. M., Van Dijk, J. A. G. M., & Ten Klooster, P. M. (2015). Increasing inequalities in what we do online: A longitudinal cross sectional analysis of Internet activities among the Dutch population (2010 to 2013) over gender, age, education, and income. *Telematics and Informatics, 32*(2), 259-272. doi:http://dx.doi.org/10.1016/j.tele.2014.09.003

Van Gool, C. H., Kempen, G. I. J. M., Penninx, B. W. J. H., Deeg, D. J. H., & Van Eijk, J. T. M. (2007). Chronic disease and lifestyle transitions; results from the longitudinal aging study amsterdam. *Journal of Aging and Health, 19*(3), 416-438. doi:doi: 10.1177/0898264307300189

Van Oostrom, S. H., Gijsen, R., Stirbu, I., Korevaar, J. C., Schellevis, F. G., Picavet, H. S. J., & Hoeymans, N. (2016). Time trends in prevalence of chronic diseases and multimorbidity not only due to aging: data from general practices and health surveys. *PLoS ONE, 11*(8), 1-14. doi:10.1371/journal.pone.0160264

Van Stralen, M., De Vries, H., Mudde, A. N., Bolman, C., & Lechner, L. (2011). The long-term efficacy of two computer-tailored physical activity interventions for older adults: Main effects and mediators. *Health Psychology, 30*(4), 442-452. doi:10.1037/a0023579 10.1037/a0023579.supp (Supplemental)

Van Stralen, M., Kok, G., De Vries, H., Mudde, A. N., Bolman, C., & Lechner, L. (2008). The Active Plus protocol: systematic development of two theory and evidence-based tailored physical activity interventions for the over-fifties. *BMC Public Health, 8*, 399. doi: 10.1186/1471-2458-8-399

Van Stralen, M., De Vries, H., Mudde, A. N., Bolman, C., & Lechner, L. (2009). Determinants of initiation and maintenance of physical activity among older adults: a literature review. *Health Psychol Rev, 3*. doi:10.1080/17437190903229462

Vandelanotte, C., Duncan, M. J., Kolt, G. S., Caperchione, C. M., Savage, T. N., Van Itallie, A., Mummery, W. K. (2018). More real-world trials are needed to establish if web-based physical activity interventions are effective. *Br J Sports Med*. doi:10.1136/bjsports-2018-099437

Vandelanotte, C., Müller, A. M., Short, C. E., Hingle, M., Nathan, N., Williams, S. L., Maher, C. A. (2016). Past, present, and future of eHealth and mHealth research to improve physical activity and dietary behaviors. *Journal of Nutrition Education and Behavior, 48*(3), 219-228. doi:10.1016/j.jneb.2015.12.006

Vandelanotte, C., & Mummery, W. K. (2011). Qualitative and quantitative research into the development and feasibility of a video-tailored physical activity intervention. *International Journal of Behavioral Nutrition & Physical Activity, 8*, 70-80. doi:10.1186/1479-5868-8-70

Vansteenkiste, M., Williams, G. C., & Ken, R. (2012). Toward systematic integration between Self-Determination Theory and Motivational Interviewing as examples of top-down and bottom-up intervention development: Autonomy or volition as a fundamental theoretical principle. *The International Journal of Behavioral Nutrition and Physical Activity, 9*. doi:10.1186/1479-5868-9-23

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS Quarterly: Management Information Systems, 27*, 425-478. doi:10.2307/30036540

Victor, C. R., & Yang, K. (2012). The prevalence of loneliness among adults: A case study of the United Kingdom. *The Journal of Psychology: Interdisciplinary and Applied, 146*(1-2), 85-104. doi:10.1080/00223980.2011.613875

Vlaming, R., Haveman-Nies, A., Groeniger, I. B.O., De Groot, L., & Van't Veer, P. (2014). Determinants of trends in loneliness among Dutch older people over the period 2005-2010. *Journal of Aging and Health, 26*(3), 422-440. doi:10.1177/0898264313518066

Vroman, K. G., Arthanat, S., & Lysack, C. (2015). "Who over 65 is online?" Older adults' dispositions toward information communication technology. *Computers in Human Behavior, 43*(1), 156-166. doi:https://doi.org/10.1016/j.chb.2014.10.018

W

Wagenmakers, R., Akker-Scheek, I., Groothoff, J., Zijlstra, W., Bulstra, S., Kootstra, J., Stevens, M. (2008). Reliability and validity of the short questionnaire to assess health-enhancing physical activity (SQUASH) in patients after total hip arthroplasty. *BMC Musculoskeletal Disorders, 9*(1), 141. doi: DOI: 10.1186/1471-2474-9-141

Wandersman, A., Duffy, J., Flaspohler, P., Noonan, R., Lubell, K., Stillman, L., Saul, J. (2008). Bridging the gap between prevention research and practice: The Interactive Systems Framework for Dissemination and Implementation. *American Journal of Community Psychology, 41*(3-4), 171-181. doi:10.1007/s10464-008-9174-z

Wanner, M., Martin-Diener, E., Braun-Fahrländer, C., Bauer, G., & Martin, B. W. (2009). Effectiveness of Active-Online, an Individually Tailored Physical Activity Intervention, in a Real-Life Setting: Randomized Controlled Trial. *Journal of Medical Internet Research, 11*(3), e23. doi:10.2196/jmir.1179

Wanner, M., Probst-Hensch, N., Kriemler, S., Meier, F., Bauman, A., & Martin, B. W. (2014). What physical activity surveillance needs: validity of a single-item questionnaire. *Br J Sports Med, 48*(21), 1570-1576. doi:10.1136/bjsports-2012-092122

Webster, S., Khan, A., & Nitz, J. C. (2011). A brief questionnaire is able to measure population physical activity levels accurately: A comparative validation study. *Journal of Clinical Gerontology and Geriatrics, 2*(3), 83-87.

Weggemans, R. M., Backx, F. J. G., Borghouts, L., Chinapaw, M., Hopman, M. T. E., Koster, A., de Geus, E. J. C. (2018). The 2017 Dutch Physical Activity Guidelines. *International Journal of Behavioral Nutrition and Physical Activity, 15*(1), 58. doi:10.1186/s12966-018-0661-9

Wendel-Vos, G. C. W., & Schuit, A. J. (2004). *SQUASH Manual*. Retrieved from Bilthoven: https://docplayer.nl/42290368-Squash-short-questionnaire-to-asses-health-enhancing-physical-activity-wanda-wendel-vos-jantine-schuit-juli-2004.html

Wendel-Vos, G. C. W., Schuit, A. J., Saris, W. H. M., & Kromhout, D. (2003). Reproducibility and relative validity of the short questionnaire to assess health-enhancing physical activity. *Journal of Clinical Epidemiology, 56*(12), 1163-1169.

White, S. M., Wójcicki, T. R., & McAuley, E. (2012). Social Cognitive Influences on Physical Activity Behavior in Middle-Aged and Older Adults. *Journals of Gerontology Series B: Psychological Sciences & Social Sciences, 67B*(1), 18-26.

Wilkie, R., Peat, G., Thomas, E., & Croft, P. (2007). Factors associated with participation restriction in community-dwelling adults aged 50 years and over. *Quality of Life Research: An International Journal of Quality of Life Aspects of Treatment, Care & Rehabilitation, 16*(7), 1147-1156. doi:10.1007/s11136-007-9221-5

Wilson, Petticrew, M., Calnan, M., & Nazareth, I. (2010). Disseminating research findings: what should researchers do? A systematic scoping review of conceptual frameworks. *Implementation Science, 5*(1), 91.

Wilson, C. (2018). Is it love or loneliness? Exploring the impact of everyday digital technology use on the wellbeing of older adults. *Ageing & Society, 38*(7), 1307-1331. doi:10.1017/S0144686X16001537

World Health Organisation. (2007). Global report on falls prevention in older adults. Retrieved from https://books.google.nl/books?hl=nl&lr=&id=ms9o2dvfaQkC&oi=fnd&pg=PA1&dq=world+health+organisation+balance+older+adults&ots=5JFZH-DULVP&sig=t88_W268r7Em4gkAayyDsBjZAMA#v=onepage&q=world%20health%20organisation%20balance%20older%20adults&f=false. Accessed: 2017-05-31.

World Health Organisation. (2010a). *Global recommendations on physical activity for health* Switzerland: World Health Organisation.

World Health Organisation. (2010b). *Global status report on non-communicable diseases* 2014. Retrieved from: http://www.who.int/nmh/publications/ncd-status-report-2014/en/

World Health Organisation. (2010c). *Prevalence of insufficient physical activity*. Switzerland: World Health Organisation.

World Health Organisation. (2011). *World Report on Disability*. Switzerland: World Health Organisation.

World Health Organisation. (2013). *Global action plan for the prevention and control of NCD's*

(2013-2020). Retrieved from http://www.who.int/nmh/publications/ncd-action-plan/en/
World Health Organisation. (2015). *World report on ageing and health*. Luxembourg: World Health Organisation.
World Health Organisation. (2018). What is healthy ageing. Retrieved from http://www.who.int/ageing/healthy-ageing/en/

Y

York University, D. o. P. (2017). Effect size calculator. Retrieved from http://www.yorku.ca/ncepeda/effectsize.html

Z

Zubala, A., Macgillivray, S., Frost, H., Kroll, T., Skelton, D. A., Gavine, A., Morris, J. (2017). Promotion of physical activity interventions for community dwelling older adults: A systematic review of reviews. PLoS ONE, 12(7), 1-36. doi:10.1371/journal.pone.0180902

Chapter 8

Addenda

Summary

Physical activity and loneliness: a healthy ageing intervention for single older adults with physical impairments

Insufficient physical activity (PA) and loneliness are both independent risk factors for morbidity and mortality, and impede healthy ageing. Especially among single older adults with physical impairments, insufficient PA and loneliness are highly prevalent. The aim of this dissertation was to develop, implement and evaluate a healthy ageing intervention for the target population of single older adults with physical impairments. This computer-tailored intervention, named Active Plus65, aims primarily to stimulate PA, and secondarily to stimulate social activity, while being physically active, in order to decrease loneliness. Developing this healthy aging intervention is of main importance as society is ageing rapidly: older age is accompanied with more physical, mental and social health issues, and the pressure on public health is increasing. Stimulating PA and decreasing loneliness among older adults, especially with interventions, can contribute to reducing public health pressure. The current dissertation presents the delivery mode preference, attrition and effects on PA and loneliness of the Active Plus65 intervention, as these determine the eligibility of the intervention to be implemented on a large scale and to have an impact on public health.

Chapter 1 provides the background and rationale of this dissertation and highlights the importance of stimulating PA and alleviating loneliness, especially for single older adults with physical impairments. This chapter also introduces the relevant determinants of physical and social activity (i.e., pre-motivational, motivational, post-motivational and environmental determinants) for the specific target population of single older adults with physical impairments. Also, it is discussed what is known so far about the associations between PA, social activity and loneliness. In addition, an overview is given about previously conducted studies evaluating interventions targeting PA and loneliness for older adults.

Chapter 2 describes how the previously developed theory- and evidence based Active Plus50 intervention was systematically adapted into the Active Plus65 intervention. This adaptation was needed as, compared to its predecessor, Active Plus65 has a more specific target population (i.e., single adults over the age of 65 with physical impairments instead of general adults over the age of 50) and an additional goal (i.e., decreasing loneliness through stimulating physical and social activity instead of only stimulating PA). The adaptation was performed based on the Intervention Mapping protocol. A literature study was done and both qualitative and quantitative data were collected from the target population as well as from health care professionals to obtain an insight in the relevant determinants of physical

and social activity. Information based on these insights was systematically integrated into the adapted intervention.

Chapter 3 aims to provide insight into the use of the intervention, by analyzing delivery mode preference and attrition. Results showed that the preference for the printed delivery mode was higher than for the online delivery mode (59% versus 41%). Higher age and lower levels of social support were predictors of preferring the printed delivery mode. Attrition was higher in the online delivery mode than in the printed delivery mode (71% versus 50%); lower educational attainment was a predictor of attrition. Although the last years have shown an increase in internet use among older adults, the findings show that only offering an online delivery mode may lead to the exclusion of a vulnerable segment of older adults. This would indicate that offering both a printed and online delivery mode alongside each other is still advisable for this target population.

Chapter 4 presents the effects of the intervention on PA both within the intervention period (3 months after baseline) and at follow-up (6 months after baseline). After 3 months Active Plus65 effectuated a significant increase in weekly minutes of PA performed with moderate to vigorous intensity, and in the days per week with sufficient PA (according to the Dutch norm for sufficient PA); both were within group effects. After 6 months, only the days per week with sufficient PA still showed a significant increase compared to baseline: the increase in weekly minutes of moderate to vigorous PA was no longer significant. In addition to these within group effects, a comparison was made with a reference group from the Active Plus50 data for which those participants who were single, over the age of 65 and had physical impairments were selected. Despite the adaptations made to the intervention, Active Plus65 did not show higher effects on PA than Active Plus50 did. The main explanation for this may be that Active Plus65 has attracted participants that were generally more physically impaired than the participants in the reference group. Participants in Active Plus65 may thus encounter more barriers to increase their PA. Although we aimed to reach these participants, their special characteristics make it less straightforward to compare the performance of Active Plus65 with Active Plus50. Still, our findings could be an indication that more extensive tailoring on being physically active with physical impairments is highly relevant.

Chapter 5 assesses the association between PA, loneliness and physical impairments in the timeframe between the baseline measurement and the follow-up at 6 months after baseline. A significant decrease of loneliness was seen between baseline and follow-up. At all times of measurement, the participants with physical impairments had lower levels of PA and higher levels of loneliness than those who have no physical impairments. Although improvements in PA were found to be associated with decreases in loneliness, this association became non-significant when the presence of physical impairments was included in the analyses. This indicates that physical impairments have a larger influence on loneliness than the level of PA has on loneliness, which suggests that physical impairments may not only impair PA, but also social activity. This contributes

to the findings from chapter 4, where the importance of extensive tailoring on physical impairments was already highlighted.

Chapter 6 presents a summary and discussion of the main findings of the different studies in this dissertation, reflects on the strengths and limitations and discusses the practical implications and suggestions for future research. Important strengths are that the intervention focusses on core components of healthy ageing, that it is designed for a highly vulnerable target population, and that it achieved an increase in PA and a decrease in loneliness. Other strengths are the relatively large study population and the hybrid design combining findings from an RCT with implementation-data. Limitations include the low reach, considerable attrition and the less than optimal generalizability of our findings. Although participants of Active Plus65 showed an increase in PA and a decrease in loneliness, these strengths and limitations should be taken into account when interpreting the effects.

The most relevant implications for future research are the investigation of strategies to reduce attrition to increase long-term sustainability of intervention effects. More insights into the working mechanisms of the relation between PA, social activity and loneliness are also needed. In addition, it would be useful to examine the factors that determine the implementation of interventions like Active Plus65 by intermediaries such as local municipalities.

Several suggestions for future intervention development can be given. As this dissertation shows that offering a printed and online delivery mode alongside each other is essential, it would be advisable to optimize both delivery modes in order to increase reach and to decrease attrition. Ways to do this may be to make the intervention less text-based by replacing text with pictures, by using interactive elements like animations, or by splitting up the advice in several shorter pieces of advice. Using a more blended approach, including contact with intervention intermediaries or with other participants may also be advisable. Adding more environmental information on possibilities for being active with others or on easy transport options may also be recommendable. In addition, it could be useful to tailor to the perception of social activities or to increase social competence.

To conclude, this dissertation shows that participants of the Active Plus65 intervention have demonstrated a short-term increase in PA and a sustained decrease in loneliness. Although the intervention could be further improved to reach sustained effects on PA, Active Plus65 may have the potential to be a healthy ageing intervention that could have a positive impact on several aspects of public health.

Samenvatting

Fysieke activiteit en eenzaamheid: een Healthy Ageing interventie voor alleenstaande ouderen met lichamelijke beperkingen

Fysieke inactiviteit en eenzaamheid zijn beiden onafhankelijke risicofactoren voor ziekte en overlijden, en belemmeren gezond ouder worden. In het bijzonder onder alleenstaande ouderen met lichamelijke beperkingen komen fysieke inactiviteit en eenzaamheid vaak voor. Het doel van dit proefschrift was het ontwerpen, evalueren en implementeren van een Healthy Ageing interventie voor de doelgroep van alleenstaande ouderen met lichamelijke beperkingen. Het primaire doel van deze advies-op-maat interventie, genaamd Actief Plus65, is het stimuleren van fysieke activiteit, het secundaire doel is het stimuleren van sociale activiteit, terwijl men fysiek actief is, teneinde eenzaamheid te verlagen. Het ontwikkelen van deze Healthy Ageing interventie is van groot belang aangezien de maatschappij snel aan het vergrijzen is: ouderdom gaat vergezeld van meer psychische, mentale en sociale gezondheidskwesties, en de druk op de publieke gezondheid neemt meer en meer toe. Het stimuleren van fysieke activiteit en het verlagen van eenzaamheid onder ouderen, in het bijzonder met interventies, kan bijdragen aan het verlagen van de druk op de publieke gezondheid. Het huidige proefschrift presenteert de voorkeuren voor de aanbiedingsvorm, de uitval, en de effecten op fysieke activiteit en eenzaamheid van de Actief Plus65 interventie, aangezien deze bepalen of de interventie geschikt is om op grote schaal geïmplementeerd te worden en een effect kan hebben op de publieke gezondheid.

Hoofdstuk 1 presenteert de achtergrond en redenen van dit proefschrift en benadrukt het belang van het stimuleren van fysieke activiteit en het verlichten van eenzaamheid, in het bijzonder voor alleenstaande ouderen met lichamelijke beperkingen. Dit hoofdstuk introduceert ook de relevante determinanten van fysieke en sociale activiteit (zijnde pre-motivationele, motivationele, post-motivationele en omgevingsdeterminanten) voor de specifieke doelgroep van alleenstaande ouderen met lichamelijke beperkingen. Tevens wordt besproken wat tot nu toe bekend is over de verbanden tussen fysieke activiteit, sociale activiteit en eenzaamheid. Daarnaast wordt een overzicht gegeven van eerder uitgevoerde onderzoeken welke interventies evalueren die zich richten op fysieke activiteit en eenzaamheid bij ouderen.

Hoofdstuk 2 beschrijft hoe de eerder ontwikkelde en op theorie en bewijs gebaseerde Actief Plus50 interventie systematisch is aangepast in de Actief Plus65 interventie. Deze aanpassing was nodig omdat, in vergelijking met haar voorganger, Actief Plus65 een meer specifieke doelgroep heeft (namelijk alleenstaande volwassenen ouder dan 65 jaar met een lichamelijke beperking in plaats van de algemene bevolking van boven de 50 jaar)

en een aanvullend doel (namelijk het verlagen van eenzaamheid door het stimuleren van fysieke en sociale activiteit in plaats van het enkel stimuleren van fysieke activiteit). De aanpassingen zijn uitgevoerd met het Intervention Mapping protocol als leidraad. Er is een literatuurstudie uitgevoerd en zowel kwalitatieve als kwantitatieve data zijn verzameld, zowel bij de doelgroep als bij professionals in de gezondheidszorg, ten einde inzicht te krijgen in de relevante determinanten van fysieke en sociale activiteit. De verkregen inzichten zijn systematisch geïntegreerd in de aangepaste interventie.

Hoofdstuk 3 geeft inzicht in het gebruik van de interventie door het analyseren van voorkeuren voor de aanbiedingsvorm en uitval. De uitkomsten laten zien dat er een hogere voorkeur was voor de geprinte aanbiedingsvorm dan voor de online aanbiedingsvorm (59% versus 41%). Een hogere leeftijd en lagere niveaus van sociale steun waren voorspellers van een voorkeur voor de geprinte aanbiedingsvorm. Uitval was hoger in de online aanbiedingsvorm dan in de geprinte aanbiedingsvorm (71% versus 50%); een lager opleidingsniveau was een voorspeller van uitval. Ofschoon er de laatste jaren een toename zichtbaar is in internetgebruik onder ouderen, laten de bevindingen zien dat het enkel verstrekken van een online aanbiedingsvorm zou kunnen leiden tot uitsluiting van een kwetsbare groep ouderen. Dit zou kunnen betekenen dat het aanbieden van zowel een geprinte als een online aanbiedingsvorm wenselijk is voor deze doelgroep.

Hoofdstuk 4 presenteert de effecten van de interventie op fysieke activiteit tijdens de interventieperiode (3 maanden na de start van de interventie) en erna bij de eindmeting (6 maanden na de start van de interventie). Na 3 maanden waren de wekelijkse minuten matige tot intensieve fysieke activiteit, en de dagen per week met voldoende fysieke activiteit (volgens de Nederlandse norm voor voldoende fysieke activiteit) significant toegenomen bij de Actief Plus65-deelnemers. Na 6 maanden was alleen het aantal dagen per week met voldoende fysieke activiteit significant hoger t.o.v. de beginmeting; de stijging in wekelijkse minuten met matige tot intensieve inspanning was niet langer significant. In vergelijking met een referentiegroep uit de Actief Plus50 data (waarvoor de deelnemers die alleenstaand waren, ouder dan 65 jaar en lichamelijke beperkingen hadden zijn geselecteerd) bleek dat Actief Plus65 ondanks de aanpassingen aan de interventie geen grotere effecten liet zien dan Actief Plus50. De voornaamste verklaring hiervoor zou kunnen zijn dat Actief Plus65 deelnemers heeft aangetrokken die in het algemeen meer lichamelijk beperkt waren dan de deelnemers in de referentiegroep. Deelnemers aan Actief Plus65 kunnen om die reden te maken hebben met meer barrières ten aanzien van fysieke activiteit. Ofschoon we ernaar streefden om deze deelnemers te bereiken, belemmeren deze specifieke kenmerken het maken van directe vergelijkingen met Actief Plus50. Desalniettemin, onze bevindingen kunnen een indicatie zijn dat het relevant is om de adviezen-op-maat nog verder toe te spitsen op fysieke activiteit met lichamelijke beperkingen.

Hoofdstuk 5 laat de verbanden zien tussen fysieke activiteit, eenzaamheid en lichamelijke beperkingen in de periode tussen de beginmeting en na 6 maanden. Na 3 en 6 maanden was een significante daling van eenzaamheid zichtbaar. Op alle meetmomenten

hadden de deelnemers met lichamelijke beperkingen lagere niveaus van fysieke activiteit en hogere niveaus van eenzaamheid dan degenen zonder lichamelijke beperkingen. Ofschoon stijgingen in fysieke activiteit geassocieerd bleken te zijn met dalingen in eenzaamheid werd dit verband niet significant wanneer de aanwezigheid van lichamelijke beperkingen werd meegenomen in de analyses. Dit is een indicatie dat lichamelijke beperkingen een grotere invloed hebben op eenzaamheid dan dat fysieke activiteit dat heeft; dit suggereert dat lichamelijke beperkingen niet alleen fysieke activiteit belemmeren maar ook sociale activiteit. Dit draagt bij aan de bevindingen van hoofdstuk 4, waar al werd benadrukt hoe belangrijk het is om lichamelijke beperkingen goed te verwerken in de adviezen-op-maat.

Hoofdstuk 6 presenteert een samenvatting en discussie van de belangrijkste bevindingen van de verschillende studies in dit proefschrift, reflecteert op de sterke punten en beperkingen en bespreekt de praktische implicaties en suggesties voor verder onderzoek. De belangrijkste sterke punten zijn de relatief grote steekproef alsmede het hybride design waarin bevindingen van een RCT worden gecombineerd met implementatie gegevens. Beperkingen zijn het lage bereik, de aanzienlijke uitval en de minder dan optimale generaliseerbaarheid van onze bevindingen. Ofschoon deelnemers aan Actief Plus65 een stijging in fysieke activiteit lieten zien en een daling in eenzaamheid, horen deze sterke punten en beperkingen in acht te worden genomen wanneer de uitkomsten van het onderzoek worden geïnterpreteerd.

De meest relevante implicaties voor vervolgstudies zijn het onderzoeken van strategieën om uitval te verminderen en effecten op langere termijn te behouden. Meer inzicht in het werkingsmechanisme van de relatie tussen fysieke activiteit, sociale activiteit en eenzaamheid zijn ook benodigd. In aanvulling daarop zou het zinvol zijn om de determinanten van implementatie van interventies zoals Actief Plus65 door intermediairs, zoals gemeenten, te bestuderen.

Er kunnen diverse suggesties worden gegeven voor verdere ontwikkeling van de interventie. Zoals dit proefschrift heeft laten zien is het naast elkaar aanbieden van een geprinte en online aanbiedingsvorm essentieel: om die reden wordt geadviseerd om beide aanbiedingsvorm te optimaliseren teneinde bereik te verbeteren en uitval te verminderen. Dit zou bijvoorbeeld gedaan kunnen worden door meer tekst in de adviezen te vervangen door beeldmateriaal, door het gebruiken van interactieve elementen zoals animaties of door de tekst op te delen in kortere stukken. Ook het aanbieden van een meer gemengde vorm, waarin contact met intermediairs of met andere deelnemers is opgenomen, kan zinvol zijn. Meer informatie over de omgeving zoals lokale mogelijkheden om samen met anderen actief te zijn of comfortabele transportmogelijkheden kunnen ook aanbevelingswaardig zijn. Daarnaast kan het zinvol zijn om het advies-op-maat toe te spitsen op de perceptie van sociale activiteiten of op het verbeteren van sociale competentie.

Afsluitend kan gesteld worden dat deelnemers aan de Actief Plus65 interventie een stijging in fysieke activiteit op de korte termijn hebben laten zien en daling van eenzaamheid op de langere termijn. Ofschoon de interventie verder verbeterd kan worden teneinde de effecten op langere termijn te verlengen heeft Actief Plu65 de potentie om een Healthy Ageing interventie te zijn die een positieve invloed kan hebben op diverse aspecten van de publieke gezondheid.

List of publications

Journal articles

Boekhout, J.M., Peels, D.A., Berendsen, B.A.J., Bolman, C.A.W., & Lechner, L. (2017). An eHealth Intervention to Promote Physical Activity and Social Network of Single, Chronically Impaired Older Adults: Adaptation of an Existing Intervention Using Intervention Mapping. *Journal of Medical Internet Research Protocols*, 6(11): e230. DOI: 10.2196/resprot.8093

Boekhout, J.M., Berendsen, B.A.J., Peels, D.A., Bolman, C.A.W., & Lechner, L. (2018). Evaluation of a Computer-Tailored Healthy Ageing Intervention to Promote Physical Activity among Single Older Adults with a Chronic Disease. *International Journal of Environmental Research and Public Health*, 15(2), 346. DOI: 10.3390/ijerph15020346

Boekhout, J.M., Berendsen, B.A.J., Peels, D.A., Bolman, C.A.W., & Lechner, L. (2019). Physical Impairments Disrupt the Association Between Physical Activity and Loneliness: A Longitudinal Study. *Journal of Aging and Physical Activity*. (in press) DOI: 10.1123/japa.2018-0325

Boekhout, J.M., Peels, D.A., Berendsen, B.A.J., Bolman, C.A.W., & Lechner, L. (2019). A Web-Based and Print-Delivered Computer-Tailored Physical Activity Intervention for Older Adults: Pretest-Posttest Intervention Study Comparing Delivery Mode Preference and Attrition. *Journal of Medical Internet Research*; 2019;21(8):e13416 DOI: 10.2196/13416

Invited talks

Boekhout, J.M. (2018): eHealth interventions for older adults: Key note presentation at the International Conference on Bio Psycho Social Issues, organized by the Catholic University Soegijapranata, Semarang, Indonesia.

Boekhout, J.M. (2018): Introduction to designing eHealth interventions: Workshop at the International Conference on Bio Psycho Social Issues, organized by the Catholic University Soegijapranata, Semarang, Indonesia.

Boekhout, J.M. & Peels, D.A. (2018): Actief Plus: Bevorderen van het beweeggedrag en de sociale interactie van 65-plussers: Oral presentation at the Congrestival Sociaal & Gezond, organized by Movisie, Utrecht, The Netherlands.

Presentations

Boekhout, J.M. (2018): Feasibility and effectiveness of eHealth interventions promoting physical activity in older adults: Initiation and organisation of Symposium at the Annual Meeting of the Society of Behavioral Nutrition and Physical Activity, Hong Kong, China.

Boekhout, J.M. (2018): The Active Plus65 eHealth intervention; changes in physical activity and loneliness among single older adults with a chronic disease: Oral presentation at the Annual Meeting of the Society of Behavioral Nutrition and Physical Activity, Hong Kong, China.

Boekhout, J.M. (2018): Using Intervention Mapping to adapt a physical activity intervention for single, chronically impaired older adults: Oral presentation at the Annual Meeting of the Society of Behavioral Nutrition and Physical Activity, Hong Kong, China.

Boekhout, J.M. (2018): Physical impairments blur the association between physical activity and loneliness: a longitudinal study: Poster Presentation at New Directions in Psychology of Behavior Change Conference, organized by Radboud University, Nijmegen, The Netherlands.

Boekhout, J.M. (2019): Delivery mode choice and attrition in an online and print delivered physical activity intervention for older adults: Oral presentation at the Annual Meeting of the Society of Behavioral Nutrition and Physical Activity, Prague, Czech Republic.

Boekhout, J.M. (2019): Mobility limitations affect the association between physical activity and loneliness: Oral presentation at the Annual Meeting of the Society of Behavioral Nutrition and Physical Activity, Prague, Czech Republic.

Other publications

Boekhout, J.M., Nijkamp, M., & Völlink, T. (2019): Health Behavior: Interaction between individual and environment. In *Health Behavior: interaction between individual and environment (*pp 9-18), Heerlen, The Netherlands: Open University of the Netherlands.

Boekhout, J.M. (2019): The obesogenic environment. In *Health Behavior: interaction between individual and environment* (pp 21-36), Heerlen, The Netherlands: Open University of the Netherlands.

Boekhout, J.M., Nijkamp, M., & Völlink, T. (2019): Interventions with an environmental focus. In *Health Behavior: interaction between individual and environment* (pp 193-198), Heerlen, The Netherlands, Open University of the Netherlands.

About the author

Janet Boekhout was born on February 15, 1970 in Terneuzen, The Netherlands. After finishing pre-university education in 1988, she started a study of business economics at the HZ University of Applied Science from which she graduated in 1992.

After graduation Janet worked in corporate finance in the banking industry, living in Groningen, Drenthe and Limburg: her experience comprises commercial, analytical and management positions. Combining work with study, from 2012 to 2016 Janet studied health psychology at the Open University of the Netherlands, from which she graduated with honors.

In 2016 Janet started her external PhD-trajectory at the Department of Psychology and Educational Science at the Open University of the Netherlands. At the same time she left the banking industry and started working at the Open University. Janet now works as an assistant professor at the Open University teaching courses in the field of health psychology, eHealth, psycho-social counselling, environmental psychology, and tutors students in their bachelor thesis. Janet has also worked as a guest lecturer at Semarang University in Indonesia and is co-chair of the Special Interest Group on Ageing of the International Society of Behavioral Nutrition and Physical Activity.

In the PhD trajectory, Janet conducted research on physical activity and loneliness among single older adults together with her research team. She published articles in several international journals, is a regular reviewer for peer-reviewed journals (among which the Journal of Medical Internet Research) and presented her work at national and international conferences.

Dankwoord

En ineens is het dan zover: na 3 jaar is het zware werk gedaan en kan ik mijn proefschrift gaan afronden. Graag wil ik iedereen bedanken die heeft bijgedragen aan de totstandkoming van dit proefschrift. Een aantal mensen heeft een grote bijdrage geleverd, en hen wil ik graag in het bijzonder danken.

Allereerst wil ik graag mijn promotores **Lilian** en **Catherine** bedanken. Jullie stonden niet alleen altijd klaar voor overleg en advies, maar gaven me ook altijd het vertrouwen dat ik dit project kon uitvoeren. Bedankt voor jullie grote betrokkenheid en inspirerende meetings: ik heb ontzettend veel van jullie geleerd!

Denise, met jou is dit hele proefschrift-traject eigenlijk begonnen toen ik als OU-studente in jouw bachelorthesisgroep zat. Bedankt voor je inhoudelijke adviezen, maar vooral ook voor je positiviteit: na overleg met jou had ik altijd weer het gevoel dat ik goed bezig was! Wat heb ik geboft met jou als co-promotor!

Brenda, ook heel veel dank aan jou. Je betrokkenheid heeft zich niet beperkt tot het co-auteurschap van alle artikelen: ook jij stond altijd voor me klaar met raad, daad, statistiek uitleg en (vrolijke) ondersteuning!

De leden van de beoordelingscommissie, **Prof. dr. Greet Cardon, Prof. Dr. Rob Ruiter, Prof. dr. Ingrid Steenhuis en Prof. dr. Arjan Bos,** en de overige leden van de corona wil ik graag bedanken voor hun tijd en aandacht bij het lezen en beoordelen van dit proefschrift.

Ook wil ik graag **FNO** bedanken: zonder hun subsidie was dit project niet mogelijk geweest. De **gemeente Heerlen** en **Pole Consultants & Counsellors** dank ik voor hun betrokkenheid bij het werven van deelnemers voor dit onderzoek. De **deelnemers** zelf wil ik natuurlijk ook graag bedanken. Verder een woord van dank voor de **gezondheidszorgprofessionals** in de gemeente Heerlen die hun input hebben gegeven tijdens het aanpassen van de interventie. Verder grote dank aan **OverNiteSoftware Europe** voor de hulp bij het soepel laten lopen van de online versie van Actief Plus65.

Sandra en **Vivian**: dankzij jullie zag al het materiaal voor de interventie er altijd perfect uit: dank jullie wel!

Ook mijn **collega's van de Open Universiteit**, speciaal die van Gezondheidspsychologie, wil ik graag bedanken. Wat een goede sfeer en wat een behulpzaamheid: jullie zijn een topteam! Speciaal dank aan **Esmee**: altijd fijn om met jou onze promotie-perikelen, maar

ook veel gezelligheid op onze werkkamer te kunnen delen: blij dat je tijdens de promotie naast me staat! Met jouw promotie gaat het zeker helemaal goed komen!

Mijn vrienden en kennissen bedank ik voor hun betrokkenheid tijdens het promotietraject. Speciale dank voor **Daniëlla**: leuk dat we vanuit de financiële wereld allebei een heel andere kant op zijn gegaan: fijn om met iemand te kunnen praten die snapt wat het roer omgooien betekent! En… paranimf moet je nou eenmaal in je leven geweest zijn…

Een dikke kus voor mijn **familie**, speciaal voor mijn vader: lieve **pa**, bedankt voor je liefde, zorg en steun. Helaas maakt mijn moeder de promotie niet meer mee, maar **ma**, in mijn hart ben je er gewoon bij.

En dan tot slot **Willy**: je bent er altijd voor me: zonder jouw liefde en steun had ik dit nooit gekund! Je hebt geduldig mijn verhalen aangehoord, frustraties weggepraat, concepten gecontroleerd, en we hebben alle mijlpalen (klein en groot) samen gevierd. Jij maakt me vrolijk, altijd! Thanks, Chap!

Open Universiteit
www.ou.nl