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Review

eHealth interventions to promote objectively measured physical activity in community-dwelling older people

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ABSTRACT

eHealth solutions are increasingly being applied to deliver interventions for promoting an active lifestyle in the general population but also in older people. Objective assessment of daily physical activity (PA) is essential to accurately and reliably evaluate the effectiveness of such interventions. This review presents an overview of eHealth interventions that focus on promoting PA in community-dwelling older people, and discusses the methods used to objectively assess PA, and the effectiveness of the eHealth interventions in increasing PA. The twelve eHealth intervention studies that met our inclusion criteria used a variety of digital solutions, ranging from solely the use of an accelerometer or text messages, to interactive websites with access to (animated) coaches and peer support. Besides evaluating the effectiveness of an intervention on objectively assessed PA, all interventions also included continuous self-monitoring of PA as part of the intervention. Procedures for the collection and analysis of PA data varied across studies; five studies used pedometers to objectively assess PA and seven used tri-axial accelerometers. Main reported outcomes were daily step counts and minutes spent on PA. The current evidence seems to point to a positive short-term effect of increased PA (i.e. right after administering the intervention), but evidence for long-term effects is lacking. Many studies were underpowered to detect any intervention effects, and therefore larger studies with longer follow-up are needed to provide evidence on sustaining the PA increases that follow eHealth interventions in older people.

1. Introduction

Continuing or commencing an active lifestyle with ageing is associated with health benefits. It is well-documented that higher levels of daily physical activity (PA) are associated with better physical and mental well-being in older people [1–3]. Adopting an active lifestyle at old age has also shown strong positive effects for older people, such as improved functioning [4], reduced fall risk [5], and improved quality of life[6]. In addition, physical *in*activity can boost physical decline as a result of ageing [7]. Given its potential for counteracting or slowing down detrimental outcomes, interventions for promoting an active lifestyle are widely considered in aging populations [8].

Over the past decades, the use of information and communication technology (ICT) to deliver lifestyle interventions has grown exponentially. The use of ICT solutions in healthcare services is often called electronic health or eHealth [9]. eHealth interventions that use electronic devices, such as computers, smartphones or tablets, for promoting an active lifestyle have shown positive results on PA in the general population [10], as well as in older people [9]. eHealth interventions are presumed to have great potential to increase access to interventions, increase compliance, lessen the burden on healthcare staff, and are highly scalable. Moreover, the use of a digital environment allows for delivery of continuous feedback and application of additional behaviour change techniques within the technology [11]. It further facilitates the tailoring of the intervention to the individual [12]. Those aged ≥55 years may be more familiar with using electronic devices and wearable technology than previous generations [13], and prior evidence has shown that this generation finds electronic devices promoting PA acceptable [14].

When evaluating the health benefits of lifestyle interventions for older people, it is essential to consider theories underlying the intervention to understand working mechanisms [15]. Besides piloting

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feasibility of newly developed eHealth interventions in a small sample, evaluating intermediate outcomes related to health, such as PA, is considered crucial to prove effectiveness and establish the causal pathways of long-term health benefits [15]. A recent systematic review showed that eHealth lifestyle interventions are effective in promoting PA in people above 50 years; however, the majority of studies in this review measured PA self-reported by questionnaires [9]. Although questionnaires are inexpensive, quick and easy to administer, they are prone to recall bias, might lead to variable and socially desirable answers and generally do not assess light PA or ordinary activities in daily life [16,17]. Questionnaires therefore do not provide a very accurate reflection of a person's daily PA. Increased availability of wearable devices, such as pedometers or inertial sensors, allows collection of objective PA data in daily life [18]. Pedometers count steps while walking, whereas inertial sensors collect and store data over longer periods, later analysed to extract multiple features of PA. Inertial sensors, particularly tri-axial accelerometers, have shown better reliability in capturing daily PA than pedometers and uniaxial accelerometers due to their ability to detect light PA [19].

This review presents an overview of recent eHealth interventions for promoting PA in community-dwelling older people with objective measurements of PA (i.e. by pedometer, uni-axial or tri-axial accelerometers). We discuss the eHealth interventions developed for promoting sPA in the older target population, as well as the employed methods to assess PA objectively. Finally, we discuss the effectiveness of the interventions on PA behaviour.

2. Methods

For this narrative review, we followed the guidelines for database search, selection of studies and data extraction from Cochrane [20]. We searched PubMed (from January 1990 to January 2018) with key search terms and synonyms for "older people", "telemedicine", "exercise", "ambulatory monitoring", and "randomized trials" (see Supplementary Table 1 for the search syntax). Studies were included in the current review if they: 1) included community-dwelling people with a mean or median age > 55 years; 2) evaluated an intervention that aimed to promote physical activity and/or reduce sedentary behaviour; 3) used a computer, tablet, smartphone, or smartwatch to deliver the main component of the intervention; 4) used objective assessment of the amount of physical activity to evaluate the effectiveness of the intervention; and 5) had a randomised trial design. We excluded studies that focused on a target group with a specific disease (e.g. stroke or Parkinson's disease).

3. Results

3.1. eHealth interventions for promoting physical activity

Twelve different studies met our inclusion criteria [21–32] (Table 1 for details and Fig. 1 for a flowchart of the search). Sample sizes of studies varied from 40 [28] to 263 [21], with eight out of twelve studies including < 100 participants. The ICT modalities that were used by studies to deliver the interventions differed considerably, and four studies compared multiple interventions with one control condition [23,24,29,30]. The study by Thompson and colleagues simply compared wearing a smartwatch accelerometer, which provided feedback on PA, to a control condition [31], whereas the other studies evaluated more extensive eHealth solutions for changing PA behaviour. Six studies used an interactive website that participants could use for goal-setting, planning, self-monitoring progress and receiving feedback [23,24,26,29,30,32]. Three studies used an application on a tablet for this purpose [21,25,28] and two of these studies also used a smartphone application [27,29]. Other ICT components employed by studies consisted of sending text messages [22,29], video clips [27], and tools for peer interaction [23–25,28,30]. Wijsman et al. [32] provided

Table 1
Description of populations and interventions of included studies, stratified by method of data collection for outcome of objective assessment of physical activity.

Study	Sample size	Study population	ICT-based intervention components	Control condition
Pedometer assessment				
Bickmore et al. [21] USA	263	Inactive people ≥65 years	2 months pedometer + tablet with animated coach	Pedometer
Kim & Glanz [22] USA	45	People 60–85 years	6 weeks pedometer + 3 motivational text messages per day on 3 days per week	Pedometer
Kullgren et al. [23] USA	92	People ≥65 years who want to be more physically active	16 weeks pedometer + website for peer forum	Pedometer
Rowley et al. [24] USA	170	Insufficiently active people 55–80 years	12 weeks pedometer + interactive website including peer forum	Waitlist (usual practice)
Uni-axial accelerometer assessment				
Lewis et al. [25] USA	40	Inactive people 55–74 years	12 weeks accelerometer for step counting + tablet with application including peer support + 1 counseling session	Pedometer + 1 counselling session
Tri-axial accelerometer assessment				
Cadmus-Bertram et al. [26] USA	51	Inactive post-menopausal women	6 weeks accelerometer + web interface + 1 follow-up phone call	Pedometer
Fukuoka et al. [27] USA	61	Inactive people ≥35 years, at risk of type 2 diabetes mellitus	20 weeks pedometer + smartphone application with daily messages/videoclips	Pedometer
Lyons et al. [28] USA	40	Inactive people 55–79 years	12 weeks accelerometer + tablet application including peer support + 1 session + weekly phone calls	Waitlist (usual practice)
Martin et al. [29] USA	48	Inactive people 18–69 years, at risk of cardiovascular disease	4 weeks accelerometer + smartphone and web interfaces (+ smartphone-delivered text messages for additional group)	Blinded activity tracking
Suboc et al. [30] USA	114	Insufficiently active people 50–80 years	12 weeks pedometer + interactive website including peer forum	Usual practice
Thompson et al. [31] USA	49	Sedentary people ≥65 years	6 months accelerometer + bi-monthly face-to-face sessions + weekly telephone calls	Blinded activity tracking
Wijsman et al. [32] NL	235	Inactive people 60–70 years	12 weeks accelerometer + personal interactive website with e-coach	Waitlist (usual practice)