
Efficacy of a web-based, center-based or combined physical activity intervention among older adults

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Abstract

With more social support and environment-centered interventions being recommended in web-based interventions, this study examined the efficacy of three intervention conditions aimed at promoting physical activity (PA) in older adults. The efficacy analyses included the self-reported PA level, stage of change for PA and awareness about PA among participants. Eligible participants ($N=149$; $M=65$ years old, $SD=6$), recruited in a unique Belgian French-speaking municipality, were randomized in four research arms for a 3-month intervention: (i) web-based; (ii) center-based; (iii) mixed (combination of web- and center-based); and (iv) control (no intervention). Web-based condition included a PA website and monthly tailored emails whereas center-based condition comprised 12 sessions (1 per week) of group exercising. With a significant increase in PA, the PA stage of change and the PA awareness at 12 months, the mixed intervention condition seemed to include the key social and motivating elements for sustainable behavior change. Center-based intervention was more likely to produce significant improvements of the PA level and the stage of change for PA change whereas web-based intervention was more likely to extend the awareness about PA.

150 minutes of moderate-intensity aerobic PA throughout the week reduces the risk of numerous chronic diseases including cardiovascular diseases, diabetes, bone and joint diseases, several types of cancer and even depression [1]. Thirty minutes of daily moderate PA reduces mortality risk by 19% compared with no activity [2]. As people age, evidence indicates that PA offers great opportunities to extend active and independent life expectancies, reduce disability, preserve health and function (physical and mental), and improve quality of life [3, 4]. Nevertheless, in 2008, more than 5.3 million of the 57 million deaths worldwide could be directly attributed to physical inactivity [5]. Moreover, adults are less likely to be regularly active and to meet public health recommendations as they age [6, 7]. Because of the aging population in Belgium, people older than 60 years will represent more than one-third of the entire population in 2050, with some major implications for public health costs [8]. The development of effective interventions stimulating PA among older adults is of utmost importance. Research has shown that interventions targeting PA behaviors of older adults can be effective [9–11], but comparative studies evaluating the effectiveness of diverse intervention are needed to identify those that are most likely to be successful in the initiation and maintenance of PA [11].

Innovative strategies such as web-based interventions are already successfully implemented in the health promotion sector (ehealth), even among seniors [12]. Despite uncertainty regarding the use of the Internet by senior adults, those 65 and older are currently the fastest growing group of Internet users [13]. Web-based interventions to promote PA have

Introduction

Regular physical activity (PA) is associated with a wide range of health benefits. Engaging in at least

already shown promising effects, with at least as many positive outcomes as nonweb-based interventions, and at a reduced cost [14, 15]. Nevertheless, change over the long term remains unclear [16], and high dropouts levels are observed in nearly all existing research protocols [17]. Maximizing social support, such as regular peer or counselor support, is a way to overcome high dropouts rates resulting in more exposure to healthy lifestyle interventions delivered via the Internet [18]. These social determinants, such as vicarious experiences (i.e. seeing someone performing the targeted behavior), are effective techniques for stimulating self-efficacy [19]. Center-based activities for seniors, performed in groups, could therefore result in more sustained engagement in regular PA, especially for the elderly or those with low income [20].

Moreover, environmental determinants are also of major relevance for interventions that promote PA as physical environment factors have consistent associations with PA behavior [21, 22]. In web-based interventions, additional environmental components have mixed results [23, 24], and more research is needed to clarify these early findings.

The aim of this study was 2-fold. First, we examined the efficacy of three intervention conditions (web-based, center-based or mixed) aimed at promoting PA in older adults. The efficacy analyses included the self-reported PA level, stage of change for PA and awareness about PA among participants. We hypothesize that the interventions would be effective in changing PA behaviors over 12 months compared with the control condition. Secondly, we aimed to examine the differences in efficacy among subgroups. We expected that the change in PA behavior would be higher in the group that received both web-based and center-based interventions.

Method

Participants and procedure

The procedure of the study (the enrollment phase, the 3-month intervention phase, and 1 year follow-up phase) is presented in Fig. 1. Participants were

recruited in a unique Belgian French-speaking municipality. This semi-rural municipality was chosen for its typicality regarding demographics (number of inhabitants, age pyramid), the coexistence of urban and rural areas, its size (34 km²) and density of population (361 inhabitants per km²) which is very close to the Belgian mean (360 inhabitants per km²). Participants were eligible to participate if they were a resident of this municipality, were 50 years old or older, had a sufficient understanding of the French language, and had regular (at least once a week) and autonomous access to the Internet. Participants were recruited via a mixture of online recruitment strategies (e.g. social media websites, municipality website), flyers and poster campaigns in the municipality, article in the municipality newsletter, or in local senior groups. The study was approved by the Ethics Committee of the Medical Faculty of the University of Liege (Liege, Belgium).

Study design

This study utilized a parallel-group randomized control trial (RCT) in which the intervention groups and the control group received evaluation assessments (i.e. questionnaires) at baseline (T0), 3 months after baseline (T1; just after the end of the intervention period), 6 months after baseline (T2) and 12 months after baseline (T3). An official agreement regarding this study was signed between the researchers and the local authorities prior to starting this research. All participants were solicited to participate voluntarily in the study and, after consenting to participate via an online consent form, they were incorporated and randomly assigned to one of the four research arms: (i) web-based intervention; (ii) center-based intervention; (iii) mixed (center- and web-based) intervention; or (iv) control group, which did not receive any intervention. A stratified randomization (using random permuted blocks) was performed according to the age and gender of each participant to ensure enough similarities between groups. To ensure anonymity, steps were taken to blind the assessments by using a user ID (numerical code) once a participant was enrolled in the study and provided contact information.

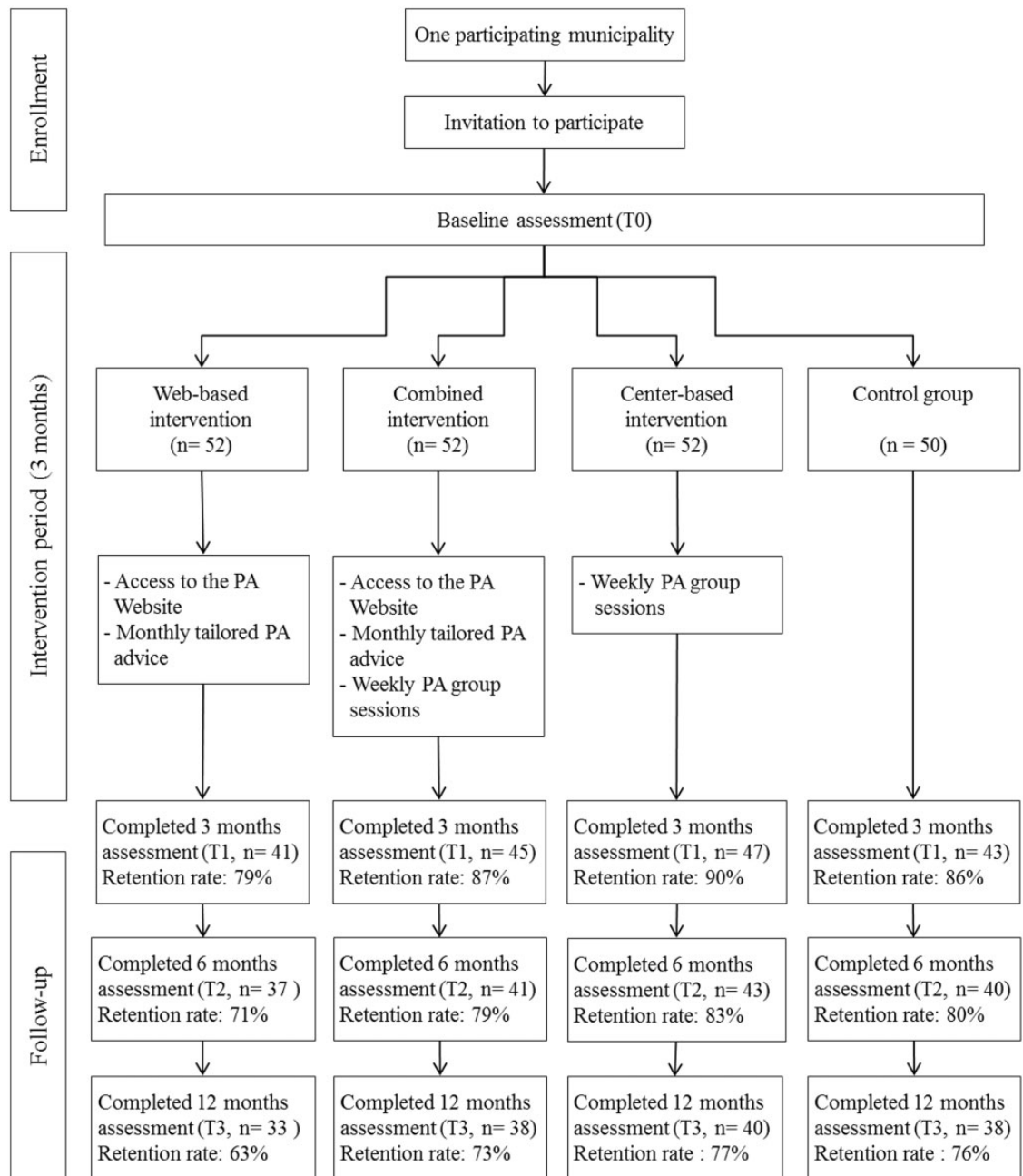


Fig. 1. Flow diagram of the selection, enrollment and participation of respondents. Percentages are reported in contrast to the number of baseline participants.

Intervention

The *Move More* intervention is a municipality-based intervention focusing on promoting PA among people aged 50 or over. This 3-month intervention could be divided into two key components: A web-based intervention and a center-based intervention. The web-based group received the web-based intervention; the center-based group received the center-based intervention; whereas the mixed group received both interventions.

Web-based intervention

The Web-based intervention was composed of two main components. First, a PA promotion website was specifically developed for this study (www.bougerplus.be). The design and framework of the website was developed in consultation with a team of PA and Informatic Technology (IT) professionals experienced in the implementation of research-based PA interventions in older adults. Transtheoretical model of health behavior change [25] constructs were integrated into an ecological model [26] to focus on positive influences of the individual (e.g. self-efficacy) and environmental (e.g. perceived opportunities of local PA) concepts on PA behaviors [22]. This emphasis on environmental (social and built) information has been highlighted by a preliminary exploratory study conducted on a sample of 75 older adults from the same municipality [27]. Users had a free access to the following sections: Why should I Move? (i.e. benefits of PA), *What is PA?* (i.e. the definition, the different types and intensities of PA), What are the recommendations? [28], Success stories (i.e. testimonies of older adults who succeed in becoming physically active), Useful links (i.e. other PA-related websites), Tips to start (e.g. establish PA routines), Fixing goals (i.e. setting SMART objectives), Overcome barriers (e.g. the weather is bad), Choose an activity (regarding personality and goals), Examples of exercises (i.e. endurance, strength, balance and flexibility exercises), My PA journal (i.e. write down past activities), Tools to measure PA (i.e. pedometers and heart rate monitors), Local PA opportunities (i.e. PA associations and facilities in the municipality), Local PA

trails (i.e. cycling and walking trails in the municipality), Online forum (e.g. ask questions to other participants) and *News* (e.g. upcoming PA events in the municipality). This website was designed in a browser format, and did not control for the participants' actions with mandatory linear pathways.

Second, participants in the web-based intervention received a monthly tailored feedback. At the beginning of each month of the intervention, web-based participants completed a questionnaire (18 items) which is part of the global questionnaire for all groups. This included the stage of change (SOC) questionnaire for PA, a four-item assessment tool developed by Marcus et al. [29]; and multiple choice questions concerning the awareness of PA that could be divided into two categories: Eight questions regarding the awareness of PA in general (e.g. at least how many minutes of moderate PA do you need to perform each week?) and six questions about the opportunities to engage in PA in the municipality (e.g. In which neighborhood of the municipality is there a fitness trail?). The answer to this questionnaire was mandatory in order to continue to browse on the website. The automatically sent feedback was firstly composed of some tips tailored to the specific SOC of the participant that were adapted from Marcus et al. [30]. Then, feedback regarding awareness of PA, in general and about local opportunities, was also provided to the participants depending on their respective scores. Participants were encouraged to visit some sections of the website according to their SOC level (e.g. at precontemplation stage, participants were advised to visit the Why should I move? section), their general awareness about PA (e.g. low scores, below four out of eight, were advised to visit the What is PA? or the What are the recommendations? sections) and their awareness about the local opportunities for PA (e.g. low scores, below three out of six, were advised to visit the Local PA opportunities section).

Center-based intervention

Participants in the center-based intervention were invited to join to a 3-month PA program in a

municipality facility. This program included 12 sessions (one session per week) of group exercising. The program was developed and supervised by trained physical educators familiar with senior PA promotion. Each exercising session included: light cardiorespiratory, muscular and articular warm-up; a combination of endurance, strength, flexibility and balance training; and a light cool-down based on relaxation. Indeed, specific care was taken to provide exercising sessions that senior participants could reproduce safely on their own, at home, and with minimum equipment. On each exercising session, the physical educator gave PA motivational advice and PA environmental advice to the participants. Motivational advice included, e.g. 'create a PA calendar' or 'fix your personal goals,' while environmental advice included, for example, 'be aware of the local facilities for PA in the municipality' or 'find a PA partner in your social environment.'

Data collection

All participants were requested to fill out a questionnaire at baseline (T0), 3 (T1), 6 (T2) and 12 (T3) months. Participants in the web-based intervention completed the T0 and T1 questionnaires online while participants in the other intervention groups completed a paper-based version. The follow-up assessments (T2 and T3) were conducted by phone for all groups. For the purposes of this study, only the T0 and T3 measures were used.

Demographics

At baseline, the following demographic information was collected: age, gender, height and weight (for calculating body mass index), educational level (from level 1 = elementary school, to level 5 = university or higher education degree), employment status (from level 1 = retired/unemployed, to level 6 = more than 40 hours/week), income status (from 1 = very unfavorable, to 4 = very favorable), perceived health status (from 1 = very poor, to 4 = very good), and the presence of a chronic physical limitation (0 = absent; 1 = present).

Physical activity level

Self-reported PA data were collected using the short version of the International Physical Activity Questionnaire (IPAQ-S). The IPAQ instrument has been validated and adapted in 12 countries [31], with the short French version as the subject of a reproducibility study [32]. Even if the IPAQ-S has fair to moderate agreement with accelerometer-measured PA, including seniors [33, 34], we expressed concerns about the length of the long version of the IPAQ that would result in significant participant drop out. The IPAQ-S asked participants to report PA performed for at least 10 min during the last 7 days. Respondents were requested to report information on time (i.e. number of sessions and average time per session) spent in PA performed across leisure time, occupational, household, and transport at three intensities: walking, moderate, and vigorous. Concrete examples of PA commonly performed were provided for each intensity (e.g. 'heavy lifting, digging, aerobics or fast bicycling' for vigorous activities). Using the IPAQ scoring protocol [35], total weekly PA was computed by weighting time spent in each intensity level by its estimated Metabolic Equivalent of Task (i.e. 8, 4 and 3.3 METs, respectively, for vigorous, moderate and walking activities). The data could be reported in categorical (low, moderate and high) or continuous (expressed in MET min/week) indicators of PA level. For the purpose of this study, only the continuous data were used.

SOC for PA

Measurement of an individual's readiness to engage in regular PA, consistent with the transtheoretical model of health behavior change [25], was performed in this study. In this assessment tool developed by Marcus et al. [29], four items were included: 'I'm currently physically active (Yes/No)', 'I intend to become more physically active in the next 6 months (Yes/No)', 'I am currently engaged in regular PA (Yes/No)' and 'I have been regularly physically active for the last 6 months (Yes/No)'. The algorithm of B Marcus and L Forsyth [30] was used to classify

SOC: Precontemplation (lack of intention to engage in PA), contemplation (thinking of engaging in PA), preparation (planning to engage in PA), action (currently engaged in PA) and maintenance (sustained engagement in PA). In the web-based intervention groups, SOC was used to provide participants with specific feedback (see above).

Awareness of PA

Participants' awareness of PA was assessed in all groups using the same instrument as the one described in the web-based interventions groups for feedback purposes (see above). Eight questions regarding the awareness of PA in general and six questions regarding awareness about the opportunities for PA in the municipality were used to create global scores based on the number of correct answers given by each participant (one point provided for each correct answer).

Process evaluation

Participant acceptance of the interventions was measured with ratings of perceived satisfaction. Just after the intervention period (T1, 3-month assessment), the questionnaire also included questions about the participants' subjective opinion and satisfaction regarding the intervention. This includes global satisfaction, satisfaction for each part of the intervention (i.e. the website and the online feedback for web-based intervention, the exercising sessions for the center-based intervention), and willingness to recommend the program to his or her relatives. For each item, participants were asked to rate their opinion on a seven-point Likert scale (from 1 'Not at all', to 7 'Extremely'). Three final open-ended questions asked participants about both positive and negative aspects, as well as suggestions regarding the intervention. The three most cited answers for each open-ended question were considered in this study. Level of exposure to the website (i.e. number of visits) was also recorded in order to observe differences between the groups that had access to this material. Other process evaluations were also assessed, but are not described here as they were highly specific to each

intervention condition and therefore difficult to compare in this particular study.

Statistical analysis

One-way analyses of variance (ANOVAs) and Chi-square tests were conducted to test for differences in participants' baseline characteristics and for the level of satisfaction scores between the intervention conditions. Logistic regression analyses were conducted to examine whether dropout was associated with baseline characteristics. As no major differences were found, only the results of the complete cases analyses (without dropouts) are presented. Each outcome measure was controlled for the different intervention conditions independently (with the control group as a reference case), baseline values (T0) and covariates (gender, age, education, BMI, intervention type, employment status, income status, perceived health status and having a chronic limitation). The analyses were repeated with different intervention conditions as a reference case to study the comparisons between the intervention groups. Using outcome values controlled for baseline values, providing a residual change score, are preferred over absolute change scores because groups with lower levels are more likely to increase their levels by chance than groups with higher levels [36]. According to the guidelines for data processing and analysis of the IPAQ, outliers were excluded from the analyses when they reported more than 960 min (16 h) of weekly walking, moderate and vigorous PA [35]. For improved interpretation and comparison, we calculated Cohen's effect sizes (ESs) for each intervention condition compared to the control group. Cohen's ESs are calculated by dividing the difference between two means at follow-up by the pooled baseline standard deviation [37]. Following Cohen's rule for interpreting ESs, a "small" ES is 0.20, a "medium" ES is 0.50 and a "large" ES is 0.80. Finally, Spearman correlations were performed to examine whether the level of exposure to the website was significantly associated with the change in each outcome measure in groups with access. Analyses were performed using SPSS for Windows (Version

19). Statistical significance was set with an alpha level of 0.05.

Results

Participant characteristics

Baseline characteristics of the four groups included in this study are shown in Table I. Despite the stratified randomization performed before the allocation of participants to each intervention condition, some of the oldest participants ($n = 5$) allocated to the web-based intervention conditions were not able to complete the online questionnaire at baseline (T0). Consequently, the web-based intervention group was significantly younger than the center-based intervention group ($P < 0.001$). Participants in the center-based intervention were also more likely to be retired than participants in the web-based intervention ($P < 0.001$). No other significant differences were found between the intervention groups at baseline. Of the initial sample, 149 (72%) participants

completed the 12-month questionnaire. Six participants (two in each experimental condition, no one in the control group) were excluded from our analyses because they reported a total of at least 16 hours of weekly walking, moderate and vigorous PA at one or more assessment periods. Younger participants ($B = 0.374$, $P < 0.001$), those in the web-based group ($B = .214$, $P = 0.006$), precontemplators and contemplators ($B = 0.174$, $P = 0.012$), and those with a higher employment status ($B = 0.141$, $P = 0.023$) were more likely to dropout. No other significant differences were found for the remaining demographic variables, PA level or environment awareness.

Intervention effect on outcomes measures

PA level

In the analyses presented in Table II, only the mixed intervention was effective for increasing PA level ($B = 182.56$; $P = 0.041$) when compared to the control group, with a relatively small ES ($ES = 0.20$).

Table I. Baseline characteristics of the four groups (mean \pm SD or %) included at 12 months

	Web-based ($n = 33$) mean \pm SD	Center-based ($n = 40$) mean \pm SD	Mixed ($n = 38$) mean \pm SD	Control ($n = 38$) mean \pm SD	<i>P</i> value
Demographics					
Gender (% men)	39.6 %	32.2 %	35.3 %	38.3 %	0.231
Age (years)	61.2 \pm 6.3	69.8 \pm 7.4	63.2 \pm 5.7	66.1 \pm 6.8	0.012
BMI (kg/m ²)	23.5 \pm 4.3	25.2 \pm 4.3	25.1 \pm 4.5	23.7 \pm 4.1	0.102
Education (% \geq higher education level)	52.9%	43.1%	45.1%	44%	.378
Employment (% retired)	64.6%	74.2%	70.9%	69.5%	0.008
Income (% \geq favorable)	60.3 %	53.8 %	52.9 %	54.1 %	0.213
Health (% \geq good)	64.7%	70.8%	70.6%	72.2%	0.412
Physical limitation (%)	13.7%	9.6%	11.8%	12.5%	0.321
Physical activity (PA)					
PA level (MET-min/week)	1215.3 \pm 766.9	1324.2 \pm 867.7	1340.4 \pm 710.8	1394.9 \pm 836.34	0.183
Stages of change					
Precontemplation	7.9 %	8.4 %	6.8 %	9.8 %	0.126
Contemplation	19.2%	19.8%	22.7%	16.3%	
Preparation	18.3%	20.5%	17.3%	15.4%	
Action	19.7%	18.3%	15.8%	14.8%	
Maintenance	34.9%	33%	37.4	43.7%	
Awareness about PA					
General awareness (/8)	3.1 \pm 1.4	2.4 \pm 1.3	2.9 \pm 1.56	2.5 \pm 1.14	.313
Opportunities in municipality (/6)	1.9 \pm 1.1	1.6 \pm 1.2	2.1 \pm 1.6	2 \pm 1.5	.417

Table II. Intervention effect on outcome measures per intervention condition at 12 months

	<i>B</i>	<i>SE</i>	<i>P</i> value	95% confidence interval	Effect size
PA level (<i>MET-min/week</i>)					
Web-based	96.13	62.17	0.247	−28.21 to 220.47	0.06
Center-based	165.18	68.13	0.083	28.92–301.44	0.14
Mixed	182.56	67.67	0.041	47.22–317.9	0.20
Stage of change for PA					
Web-based	0.26	0.19	0.113	−0.12 to 0.64	0.13
Center-based	0.68	0.20	0.002	0.28–1.08	0.25
Mixed	0.89	0.21	0.001	0.47–1.31	0.31
Awareness of PA (general)					
Web-based	1.38	0.51	0.023	0.36–2.4	0.20
Center-based	1.17	0.54	0.093	0.09–2.25	0.13
Mixed	1.69	0.58	0.003	0.53–2.85	0.24
Awareness of PA (opportunities in municipality)					
Web-based	1.17	0.35	0.002	0.47–1.87	0.26
Center-based	1.09	0.41	0.029	0.27–1.91	0.20
Mixed	1.43	0.38	0.001	0.67–2.19	0.29

Results are presented in contrast to the control group. The bold numbers reflect a significant intervention effect ($P < 0.05$).

The PA level increased on average 238 MET min/week whereas the control group decreased on average 21 MET min/week. In both the web-based intervention group and the center-based intervention group, no significant increases in PA level were observed. However, a borderline effect of the center-based intervention was found ($B = 165.18$; $P = 0.083$; $ES = 0.14$) with an average increase of 189 MET min/week in this group. The PA level in the web-based intervention group increased on average 94 MET min/week. No assessed participants' baseline characteristics (gender, education, age, BMI, intervention type, employment status, income status, perceived health status and having a chronic limitation) were significant predictors of the intervention effect on PA level for each intervention condition.

SOC for PA

Center-based and mixed interventions were both effective in increasing the SOC for PA ($B = 0.68$; $P = 0.002$; $ES = 0.25$ and $B = 0.89$; $P = 0.001$; $ES = 0.31$, respectively). Percentage of participants reaching at least the action stage increased by 11.3% in the mixed intervention group, 9.8% in the center-based intervention group, 4.7% in the web-based

intervention group and 1.4% in the control group. The effect of the intervention on the SOC for PA was moderated by the participants' baseline education level in the center-based and mixed intervention groups ($B = 0.23$; $SE = 0.08$; $P = 0.032$ and $B = 0.20$; $SE = 0.07$; $P = 0.039$, respectively). No other baseline characteristics were significant predictors of the intervention effect on SOC for PA for each intervention condition.

Awareness of PA

The awareness of PA in general increased significantly in the mixed and Web-based intervention conditions ($B = 1.69$; $P = 0.003$; $ES = 0.24$ and $B = 1.38$; $P = 0.023$; $ES = 0.20$, respectively). On an eight-point scale, this represents an average increase of 1.4 points in the mixed intervention group and of 1.1 points in the Web-based intervention group. The center-based intervention group and the control group also increased their average score but not significantly (0.8 point and 0.3 point, respectively). Only age moderated the effect of the intervention regarding awareness of PA in general in the mixed intervention group ($B = 0.78$; $SE = 0.29$; $P = 0.002$) and in the web-based intervention group ($B = 0.61$; $SE = 0.22$; $P = 0.009$).

The awareness about the opportunities for PA in the municipality was significantly increased in all intervention conditions. Nevertheless, ESs and level of significance were greater in the mixed intervention ($B = 1.43$; $P = 0.001$; $ES = 0.29$) and in the Web-based intervention ($B = 1.17$; $P = 0.003$; $ES = 0.26$) than in the center-based intervention ($B = 1.09$; $P = 0.029$; $ES = 0.20$). Average increases of scores (on a six-point scale) were of 1.3 points in the mixed intervention group, 1.1 points in the web-based intervention group and 0.7 point in the center-based intervention group whereas the control group slightly increased of 0.1 point. Age and education level were significant predictors of the intervention effect on the awareness of opportunities for PA in the municipality in the mixed ($B = 0.69$; $SE = 0.23$; $P = 0.001$, and $B = 0.29$; $SE = 0.11$; $P = 0.010$, respectively) and the web-based intervention conditions ($B = 0.58$; $SE = 0.20$; $P = 0.004$, and $B = 0.26$; $SE = 0.12$; $P = 0.017$, respectively) whereas only age was a significant predictor in the center-based intervention ($B = 0.56$; $SE = 0.22$; $P = 0.009$).

Process evaluation

Ratings of perceived satisfaction in intervention groups are reported in Table III. Globally, participants in the mixed ($P < 0.001$) and center-based ($P = 0.007$) interventions were much more satisfied compared to those in the web-based intervention. Satisfaction regarding the website was significantly greater in the mixed intervention group than in the web-based intervention group ($P = 0.021$). Level of

exposure to the website was also significantly different between those groups, with an average of 18 ($SD = 14$) visits to the website for the Web-based group and an average of 39 ($SD = 21$) visits for the mixed group during the 3-month intervention period. The correlation between level of exposure to the website and the change in outcome measures was incidentally significant for the SOC for PA ($r = 0.20$, $P = 0.019$), for awareness of PA in general ($r = 0.27$, $P = 0.006$) and for awareness of opportunities for PA in the municipality ($r = 0.32$, $P = 0.001$). The level of recommendation of the intervention to relatives also differed significantly between the interventions, with higher scores for mixed ($P = 0.002$) and center-based ($P = 0.015$) interventions compared to the web-based intervention. Key positive and negative aspects, as well as suggestions proposed by participants regarding each intervention condition are displayed in Table IV.

Discussion

This study aimed to examine the efficacy of three PA promotion interventions in changing the PA level, the stage of change for PA and the awareness about PA among older adults. Based on the results, the first conclusion we can draw is that only the mixed intervention condition, comprising both online and offline components, resulted in a significant increase of PA levels at 12 months. This increase could mainly be attributed to the offline components of the intervention as the center-based intervention was borderline effective ($ES = 0.14$;

Table III. Participants' satisfaction regarding the intervention on a 7-point scale (from 1 'Not at all', to 7 'Extremely')

Satisfaction components	Web-based ($n = 33$) Mean \pm SD	Center-based ($n = 40$) Mean \pm SD	Mixed ($n = 38$) Mean \pm SD	<i>P</i> value
Intervention	4.44 \pm 1.24	6.09 \pm 1.17	5.83 \pm 1.13	0.001
Website	4.45 \pm 1.06	NA	5.32 \pm 1.19	0.021
Online feedback	4.35 \pm 1.25	NA	5.01 \pm 1.02	0.092
Exercising sessions	NA	6.12 \pm 1.19	6.19 \pm 0.95	0.513
Recommendation to relatives	5.21 \pm 1.03	6.33 \pm 0.86	6.39 \pm 0.72	0.009

The bold numbers reflect a significant between groups difference ($P < 0.05$). NA = not applicable.

Table IV. Positive aspects, negative aspects and suggestions proposed by participants for each intervention condition

	Web-based (<i>n</i> = 33)	Center-based (<i>n</i> = 40)	Mixed (<i>n</i> = 38)
Positive aspects	<ol style="list-style-type: none"> 1. <i>Website design</i> 2. <i>Website usability</i> 3. <i>Focus on PA opportunities in the municipality</i> 	<ol style="list-style-type: none"> 1. Motivational and environmental advice 2. Physical educator attitudes 3. Conviviality 	<ol style="list-style-type: none"> 1. Social interactions 2. Physical instructors attitudes 3. <i>Website design and informations</i>
Negative aspects	<ol style="list-style-type: none"> 1. <i>Website accessibility</i> 2. <i>Lack of website updates</i> 3. <i>Questionnaire overload</i> 	<ol style="list-style-type: none"> 1. Lack of individualization 2. Lack of diversity 3. Lack of flexibility training 	<ol style="list-style-type: none"> 1. <i>Lack of website updates</i> 2. <i>Website accessibility</i> 3. Lack of individualization
Suggestions	<ol style="list-style-type: none"> 1. <i>Facilitate access to the website</i> 2. <i>Highlight website updates</i> 3. <i>Provide computer training courses</i> 	<ol style="list-style-type: none"> 1. Increase number of sessions/week 2. Adapt for PA level 3. Adapt for physical limitations 	<ol style="list-style-type: none"> 1. Adapt for PA level 2. Increase number of sessions/week 3. <i>Facilitate access to the website</i>

Items presented in the table are the most cited by participants in each intervention condition. Items are indicated in italicized (online) or in normal (offline) styles according to the targeted components of the intervention.

$P = 0.083$) in increasing PA level. Nevertheless, the addition of online components seems to be beneficial, without indicating that a web-based intervention alone is sufficient to significantly increase PA among older adults. These results are consistent with the findings of another recent study analyzing the efficacy at 12-months follow-up of a web-based intervention among older adults [23]. The same research group observed that web-based intervention materials were used less often and less appreciated than printed intervention materials [38]. The level of exposure to the website in this study was indeed much lower in the web-based intervention condition compared to the mixed intervention condition. This highlights the important role of social support which could result in more exposure to the website [18] and more sustainable engagement in an intervention promoting PA among older adults [20]. Even if the levels of exposure to the website materials observed in this study are relatively low, another study revealed that older adults spent more time, visited more regularly, and were less likely to drop out in a PA website-delivered intervention than younger age groups [39]. This underlines the acceptability of a web-based intervention for this population for whom having lower computer knowledge and skills should not be considered insurmountable barriers

for behavioral change. However, an initial assessment of the computer literacy of the participants, or more specifically of the eHealth literacy of the participants, could help future research protocols in the field to recruit older adults enough familiarized with the use of new information technologies [40]. This baseline assessment would have limited the between groups difference observed in our study.

Because human interactions are powerful motivators for exercise [41], this might have also contributed to the lower dropout level observed in the center-based intervention and mixed intervention conditions. Since a clear dose–response relationship between the intensity of the intervention and resulting behavior change has been established [16], the greater intensity of the features provided in the mixed intervention condition could also explain the differences observed between those groups. The monthly feedback addressed to participants in the Web-based intervention, inspired by previous research in the field [23, 24], could therefore not be sufficient to elicit an adequate engagement in the intervention.

Both mixed intervention and center-based intervention were effective at increasing the PA SOC at 12 months. This trend is very similar to the one

identified for the PA level, with significant increases observed in the mixed and center-based intervention conditions, but not in the web-based intervention condition. However, the added value of the online components seems to be slightly less obvious in this case because the center-based intervention condition already brought about significant improvements. The web-based intervention condition did not lead to as large of improvements as those observed previously. In a comparable study design among older adults over 55 years, Irvine et al. [42] reported a significant increase of the PA SOC after a 12-weeks web-based intervention. While almost half of the participants in our study had at least a higher education level (university or higher education degree), one might raise the question of the digital divide. Because lower rates of Internet use are observed in people with lower levels of education, such as people with lower incomes, research in web-based PA promotion should actively explore how to reach those socioeconomically disadvantaged groups with restricted access to digital technologies. Currently, Internet access is no longer synonymous with going online via a computer, and groups that have traditionally been on the other side of the digital divide are more likely to use their phones to access to the Internet [43]. Additionally, the use of mobile devices has already lead to improved PA levels among older adults [44].

The awareness of PA in general increased almost significantly in the three intervention conditions, with again better improvements observed in the mixed intervention condition. Moreover, the awareness of the opportunities for PA in the municipality increased significantly in all intervention conditions. A first concern of PA awareness is related to the low and declining with age scores observed on average in every group. As observed on a larger scale [45], this lack of awareness and knowledge about PA is quite concerning since specific knowledge about the opportunities for PA is considered a strong predictor of being physically active [46]. Unlike the findings observed for PA level and PA SOC, the web-based intervention condition had larger improvements in PA awareness than the center-based intervention condition. This could be explained by the increased

exposure to PA awareness information in the web-based intervention. In addition to permanent access to the website informing about PA, participants in this group received a monthly (three times) questionnaire (and automatic feedback) proposing the same questions as those provided in the assessment questionnaires. However, participants in the center-based intervention condition only received motivational and environmental advice that were provided only once during the intervention. This means that physical educators could introduce more specific information about PA within their session, and that future research should analyze more carefully their behaviors in order to take into account the role of the educational context regarding the behavior change process.

Nevertheless, face-to-face advice can also lead to positive outcomes but to a slightly lesser extent. Those observed improvements are rather beneficial because some studies revealed that the awareness of the local environment for PA was positively associated with PA Behaviors [46, 47]. More specifically, the perceived availability of PA opportunities is also considered a strong correlate of PA behavior [48]. Nevertheless, existing findings still present some inconsistencies [47, 49]. Identifying the psychosocial and environmental underlying processes in future interventions is then needed to understand the role played by the awareness of PA on the subsequent PA outcomes.

While rare, this research enabled the collection of more qualitative information about the intervention. Perceived satisfaction of the intervention was significantly higher in the mixed and center-based conditions than in the web-based condition. This reflects the moderate appreciation of the online components of the intervention, underlined by the lack of website updates and difficult accessibility were the main negative perceived aspects. It would therefore be important to provide more regular updates of the website, usually resulting in longer visits and more logins on the website [18]. In addition to the perceived questionnaire overload, the restricted access to the website requiring a login and password for each connection might have contributed to the higher dropout rates observed in groups with

online components. This is also supported by the fact that participants in the mixed condition have mainly negative remarks for the Web-based part of the intervention and positive remarks for the center-based part of the intervention. According to the self-determination theory (SDT), autonomous motivation is more likely to arise in an individual when the social context supports the basic psychological needs for autonomy, competence and relatedness [50]. According to Friederichs et al. [51], adopting this participant-centered approach in future Web-based PA research might enhance the effectiveness and the participant's appreciation of the intervention. As requested by participants, computer training could be stimulated and incorporated in PA promotion interventions in order to increase their self-efficacy regarding the Internet tool. Moreover, the website design should be specifically adapted to the senior population. Tools have been developed to create more 'senior friendly' websites with several adaptations, such as a larger text size or a single mouse click to access to the information [52]. Except for the relative lack of individualization and lack of diversity due to the relatively standardized sessions of group exercising, participants in the center-based intervention condition highlighted the role of the social interactions, especially with the coach. In a multidisciplinary approach integrating other health professionals [53], those physical educators could therefore be considered as key motivators to engage seniors in regular PA. In-depth exploration of the educational materials in future PA promotion interventions should help future research to go beyond the traditional effects analysis that is mainly conducted in the existing literature.

Limitations

This study was subject to some limitations. Due to the moderate sample size, the results should be interpreted carefully. According to the total number of people aged over 50 in the selected municipality ($n = 5020$), a sample size of 357 participants would have been more appropriate (95% confidence interval). Participants were volunteers and may not

be representative of the general population, causing self-selection bias. Results might also be biased by the selective dropout (28%), thus retaining the more motivated participants and influencing the overall effectiveness of the study. However, this dropout rate is comparable to those observed in previous web-based trials [17]. Because participants were included in this study only if they mastered a sufficient understanding of the French language and had a regular and autonomous access to the Internet, future research should focus on disadvantaged older adults in order to bridge the digital divide. Indeed, our study sample was mainly highly educated, with a favorable income level and few physical limitations. Another limitation is related to the use of self-report questionnaires subject to social desirability bias and recall bias. The IPAQ has a tendency towards overreporting [54]. Self-reported questionnaires are, however, most commonly used to assess PA behaviors, even if the validation of the intervention effects with objective measurements would be recommended. Besides, the different modes of administration of the questionnaire (telephone or self-reported) could also impact the results, even so the correlation coefficients between those two are acceptable ($\rho =$ between 0.47 and 0.80) [55]. Results are also specific to a Belgian French-speaking municipality, with its particular sociodemographic characteristics. Further larger scale or multiple sites implementation could help to overcome some of these biases.

Conclusions

With a significant increase in PA level, the PA SOC and PA awareness at 12 months, the mixed intervention condition could encompass the key social and motivating elements for sustainable behavior change. Center-based components of the intervention were more likely to produce PA behavior change whereas Web-based components were more likely to extend awareness of PA. The role of social support appears to be crucial for sustainable participation in PA promotion interventions. However, increasing the appreciation and the

usability of the web-based intervention components could lead to improved outcomes and reduced dropout rates. Implementing larger scale studies, focusing on disadvantaged seniors, adopting a participant-centered approach (SDT), exploring the underlying processes of the interventions or validating the intervention effects with objective measurements are possibilities for future research to explore.

Conflict of interest statement

None declared.

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