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Motivational interviewing and self-determination theory in a web-based computer tailored physical activity intervention: A randomized controlled trial

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Objective: This study explores whether a web-based physical activity (PA) intervention grounded in self-determination theory (SDT) and motivational interviewing (MI) is more effective and better appreciated than a traditional web-based PA intervention.
Design: A randomized controlled trial was conducted, comparing (1) I Move; a web-based PA intervention based on SDT and MI, (2) Active Plus; a traditional web-based PA intervention and (3) a waiting list control condition.
Main outcome measures: Weekly minutes of moderate to vigorous PA and weekly days with ≥30 min PA were measured through self-report at baseline and at 3 and 6 months from baseline.
Results: I Move achieved a small, but significant increase in weekly minutes of moderate to vigorous PA, while Active Plus did not have a significant impact on this outcome. Both interventions were effective in increasing weekly days with ≥30 min PA, whereas Active Plus yielded a greater effect on this outcome.
Conclusion: Overall, the web-based PA intervention grounded in SDT and MI did not outperform the traditional web-based PA intervention. Further research should reveal whether this type of intervention is profitable for long-term maintenance of PA levels.

Keywords: physical activity; motivational interviewing self-determination theory

Background

Web-based computer tailored physical activity (PA) interventions are a promising approach to promote PA. In these interventions, the content is automatically adapted to each participant's characteristics, which enables the provision of personally relevant information. This approach increases the likelihood of positive PA outcomes compared to a non-tailored, generic approach (Broekhuizen, Kroeze, van Poppel, Oenema, & Brug, 2012; Enwald & Huotari, 2010; Lustria et al., 2013). Moreover, by using the internet as the delivery channel, large numbers of people who are not sufficiently active can be reached, while maintaining relatively low costs (del Hoyo-Barbolla, Kukafka,

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Arredondo, & Ortega, 2006; Lustria et al., 2013; Peels et al., 2012). The findings of a meta-analysis suggest that web-based computer tailored PA interventions have the potential of producing small but significant increases in PA (Davies, Spence, Vandelanotte, Caperchione, & Mummery, 2012).

Until now, most web-based computer tailored PA interventions have been based on traditional health behaviour theories such as social cognitive theory (SCT), self-regulation theory (SRT), the trans-theoretical model (TTM), and the theory of planned behaviour (TPB) (Davies et al., 2012). As a result of using these theories, interventions of this type, hereafter referred to as 'traditional interventions', are rather directive and instructive, which may not be the optimal method when it comes to promoting PA change (Hillsdon, Thorogood, White, & Foster, 2002; Patrick, Resnicow, Teixeira, & Williams, 2013). Indeed, current research on PA promotion increasingly shows the importance of encouraging autonomous motivation (Patrick et al., 2013; Teixeira, Carraça, Markland, Silva, & Ryan, 2012). When an individual is autonomously motivated, behaviour is self-endorsed (Deci & Ryan, 2008; Ryan & Deci, 2000; Ryan, Patrick, Deci, & Williams, 2008). Someone who is autonomously motivated to participate in sports, for instance, does not feel pressured to go to the gym, but experiences a sense of volition or self-endorsement in doing so. Substantial evidence suggests that the greater the autonomous motivation the higher the PA frequency and that autonomous motivation is especially important for maintenance of PA behaviour (Teixeira et al., 2012). Although motivation (or intention) is a common construct in research on health behaviour change, the quality of motivation is not accounted for in traditional health behaviour theories. Autonomous motivation does not play a role in traditional health behaviour theories such as SCT, SRT, TTM or TPB, but it is a key construct in self-determination theory (SDT) and motivational interviewing (MI) (Miller & Rollnick, 2013; Ryan & Deci, 2000). Therefore, web-based computer tailored PA interventions based on SDT and MI could be more effective in promoting PA behaviour than traditional web-based computer tailored interventions.

In this paper, we aim to explore whether a web-based computer tailored PA interventions grounded in SDT and MI is more effective and better appreciated than web-based PA interventions based on traditional health behaviour theories such as SCT, SRT, TTM and TPB. First, however, we provide some more background on SDT and MI in the context of PA and PA interventions.

Self-determination theory & motivational interviewing

SDT is a broad-based theory of human motivation (Deci & Ryan, 2008; Ryan & Deci, 2000; Ryan et al., 2008). The literature indicates that this theory can be especially helpful for understanding PA motivation (Teixeira et al., 2012). One of the main principles of SDT is that motivation varies in the extent to which it is experienced as autonomous or controlled (Deci & Ryan, 2008; Ryan & Deci, 2000). Researchers hypothesise that activities mainly driven by controlled forms of motivation generate intrapersonal conflict which hinders the availability of volitional resources such as the capacity to exert sustained effort (Koestner, Otis, Powers, Pelletier, & Gagnon, 2008). Although controlled motivation may sometimes cause short-lived behaviour change, it is expected not to be capable of inducing maintenance of behaviour (Deci & Ryan, 2008; Markland

& Ingledew, 2007; Ryan & Deci, 2000; Teixeira et al., 2012). Individuals who are autonomously motivated to be active often display many positive emotions, high levels of perceived behavioural competence and reflective self-endorsement, and are typically willing to engage in the behaviour for prolonged periods of time (Teixeira et al., 2012). Therefore, these individuals are usually more likely to engage in maintained PA behaviour than those who are merely driven by controlling motives (Deci & Ryan, 2008; Markland & Ingledew, 2007; Ryan & Deci, 2000; Teixeira et al., 2012).

SDT states that there are three basic psychological needs that must be supported in order for an individual to develop autonomous motivation. These are (1) the need for autonomy (e.g. the need the need to experience our actions as result of autonomous choice), (2) the need for competence (the need to feel competent and confident) and (3) the need for relatedness (the need to feel connected to and understood by others) (Deci & Ryan, 2008; Ryan & Deci, 2000). These needs can be either supported or thwarted by the social environment (which, for example, can be a friend, a fitness instructor, or a PA counsellor). Autonomous motivation is most likely to arise in an individual when all three basic psychological needs are supported (Deci & Ryan, 2008; Ryan & Deci, 2000; Ryan et al., 2008). Several authors argue that these basic psychological needs can be supported by skilfully applying the key principles of MI (Markland, Ryan, Tobin, & Rollnick, 2005; Patrick et al., 2013; Patrick & Williams, 2012; Vansteenkiste & Sheldon, 2006; Vansteenkiste, Williams, & Resnicow, 2012).

MI is defined as 'a collaborative conversation style for strengthening a person's own motivation and commitment to change' (Miller & Rollnick, 2013). The core or 'spirit' of MI encompasses principles of partnership (i.e. counsellor and client are considered equal collaborators in the behaviour change process), acceptance and compassion (i.e. the counsellor displays profound acceptance for the client, and a priority for the client's needs) and evocation (i.e. the clients already have much of what is needed within them and the counsellor's task is to help find it). Along with these principles, four overlapping processes are discerned in MI: (1) engaging (involving the client in the counselling process and establishing a trusting and respectful helping relationship between client and counsellor), (2) focusing (collaboratively finding topics for conversation and consultation), (3) evoking (eliciting the client's own motivation for change by prompting self-determined motivational statements or change talk) and (4) planning (collaboratively developing a specific change plan). To carry out these principles and processes, the practice of MI implies applying specific communication skills: asking open questions, affirming, reflective listening, summarising and informing or advising (Miller & Rollnick, 2013).

Although SDT and MI were developed independently of one another, several scholars propose that SDT can offer a theoretical framework for deepening our understanding of the effects of MI (Markland et al., 2005; Patrick et al., 2013; Patrick & Williams, 2012; Vansteenkiste & Sheldon, 2006; Vansteenkiste et al., 2012). More precisely, it is argued that the specific strategies in MI can be used to support the client's basic psychological needs for competence (e.g. by limiting negative feedback and providing optimally challenging tasks), autonomy (e.g. by taking the perspective of the client, supporting their choices, and minimising pressure) and relatedness (e.g. by creating an empathetic and positive environment, and showing unconditional regard). As such, researchers propose the practical strategies from MI can be used to put the theoretical foundation of SDT into practice (Markland et al., 2005; Patrick et al., 2013; Patrick & Williams, 2012; Vansteenkiste & Sheldon, 2006; Vansteenkiste et al., 2012).

Over the recent past years, quite a few counselling PA interventions that combine the theoretical framework of SDT with the practical strategies from MI have been developed and evaluated in randomized controlled trials (Duda et al., 2014; Fortier, Duda, Guerin, & Teixeira, 2012; Fortier et al., 2007, 2011; Jolly et al., 2009; Silva et al., 2011, 2008, 2010, 2010; Van Hoecke, Delecluse, Bogaerts, & Boen, 2014; Van Hoecke et al., 2013). In general these studies show that SDT/MI-based PA interventions can be effective in increasing PA.

SDT and MI in web-based computer tailored PA interventions

Web-based computer tailored PA interventions grounded in SDT and using the communication style and principles from MI, may be promising for large-scale PA promotion. Compared to traditional web-based computer tailored interventions, web-based computer tailored interventions grounded in SDT and MI may enhance intervention effects because of the focus on promoting autonomous motivation. Web-based computer tailored PA interventions based on traditional health behaviour theories such as SCT, SRT, TTM and TPB have a strong focus on providing participants with persuasive messages and tips on how to become more physically active (Davies et al., 2012). An SDT/MI-based approach would pay attention to supporting the participant's basic psychological needs. This approach could allow autonomous motivation to increase that in turn would lead to heightened PA levels and its maintenance over time (Patrick et al., 2013; Teixeira et al., 2012). In addition, because of the participant-centred approach, a web-based computer tailored PA intervention based on MI and SDT might lead to better user appreciation, compared to a traditional intervention. The current study aimed to test these premises by comparing a MI/SDT-based PA intervention to a traditional one.

Although SDT postulates that all humans have the same basic psychological needs, previous studies on tailored PA interventions have shown that participant characteristics such as age, gender, BMI, intention to be physically active at baseline and PA at baseline can influence the effects of tailored PA interventions (Peels et al., 2013, 2014; Spittaels & De Bourdeaudhuij, 2007; Van 't Riet, Crutzen, & De Vries, 2010; van Stralen, de Vries, Bolman, Mudde, & Lechner, 2010). This is relevant in the context of our study, since the impact of both our interventions might be more pronounced in subgroups of participants with specific characteristics. Therefore, the present study also aimed to identify participant characteristics that modify the intervention effects, by conducting moderator analyses. These analyses will include variables that moderated the effects of tailored interventions in earlier studies such as age, gender, BMI, intention to be physically active at baseline and PA at baseline (Peels et al., 2013, 2014; Spittaels & De Bourdeaudhuij, 2007; Van 't Riet et al., 2010; van Stralen et al., 2010). The moderator analyses will identify in which participant subgroups the SDT/MI-based and the traditional intervention exert the greatest effects, enabling a more in-depth view on the impact of both interventions. The results of these analyses will potentially yield recommendations for future intervention development (van Stralen et al., 2010). Based on earlier literature, it was hypothesised that the effects of both interventions would be higher in female participants (since women tend to be more actively involved in interventions than men) older participants (since they usually participate more actively than younger participants), participants with high education (since they have more advanced self-regulatory skills than lowly educated participants), participants with high intention

to be physically active (since these participants will be most willing to increase their PA) and participants who were relatively inactive at baseline and had high BMI (because much progression can be gained among these participants) (Peels et al., 2013, 2014; Spittaels & De Bourdeaudhuij, 2007; Van 't Riet et al., 2010; van Stralen et al., 2010).

Method

A randomized controlled trial was conducted, which was approved by the Medical Ethics Committee of Atrium-Orbis-Zuyd and was registered with the Dutch Trial Register (NTR 4129).

Participants and procedure

Individuals were eligible for participation in this trial when they were between 18 and 70 years old, did not have a condition that seriously hinders their ability to be physically active, did not take part in one of the pilot studies (Friederichs, Bolman, Oenema, Guyaux, & Lechner, 2014; Friederichs et al., 2013), and when they were less physically active than 5 days per week for 60 min per day (Friederichs et al., 2014). Based on a power calculation (ES = .25; power = .80), it was estimated that data of 600 participants would be needed for this study. Based on an expected drop-out of 40–70% (Elfeddali, Bolman, Candel, Wiers, & de Vries, 2012; Peels et al., 2013), it was estimated that a minimum of 2000 respondents would be needed to enrol in the study.

The study procedure and flow of participants is shown in Figure 1. In September-December 2013, participants were recruited by means of advertisements (containing a link to the study website) in national newspapers, social media and via an online panel. At the study website, individuals were given the option to participate in the study by clicking on the '*I want to participate*' button. After passing through the inclusion questions and granting informed consent, participants were randomized into one of the three research conditions (1:1:1) by means of a digital randomizer built into the website, and were asked to fill in the baseline questionnaire. The three research conditions in this study are: (1) the I Move condition; participants in this condition receive I Move, which is a web-based computer tailored PA intervention based on MI and SDT (Friederichs et al., 2014), (2) the Active Plus condition; participants in this condition receive Active Plus, which is a traditional web-based computer tailored PA intervention, based on theories such as TPB, SCT, SRT and TTM (Peels et al., 2012; van Stralen et al., 2008) and (3) the control condition, which is a waiting list control group.

Measurements were taken at baseline, and at 3 and 6 months from baseline. All measurements were taken by web-based questionnaires via the study website. Participants from the two intervention conditions were also asked to fill in a questionnaire at 6 weeks from baseline. This questionnaire contains questions that are used to tailor the intervention content, as well as questions on process evaluations. In order to decrease attrition, 10 prizes of €50 were raffled among those participants who have completed each questionnaire (Robroek, van Lenthe, van Empelen, & Burdorf, 2009). Among those participants who completed all questionnaires, two tablet computers were raffled.

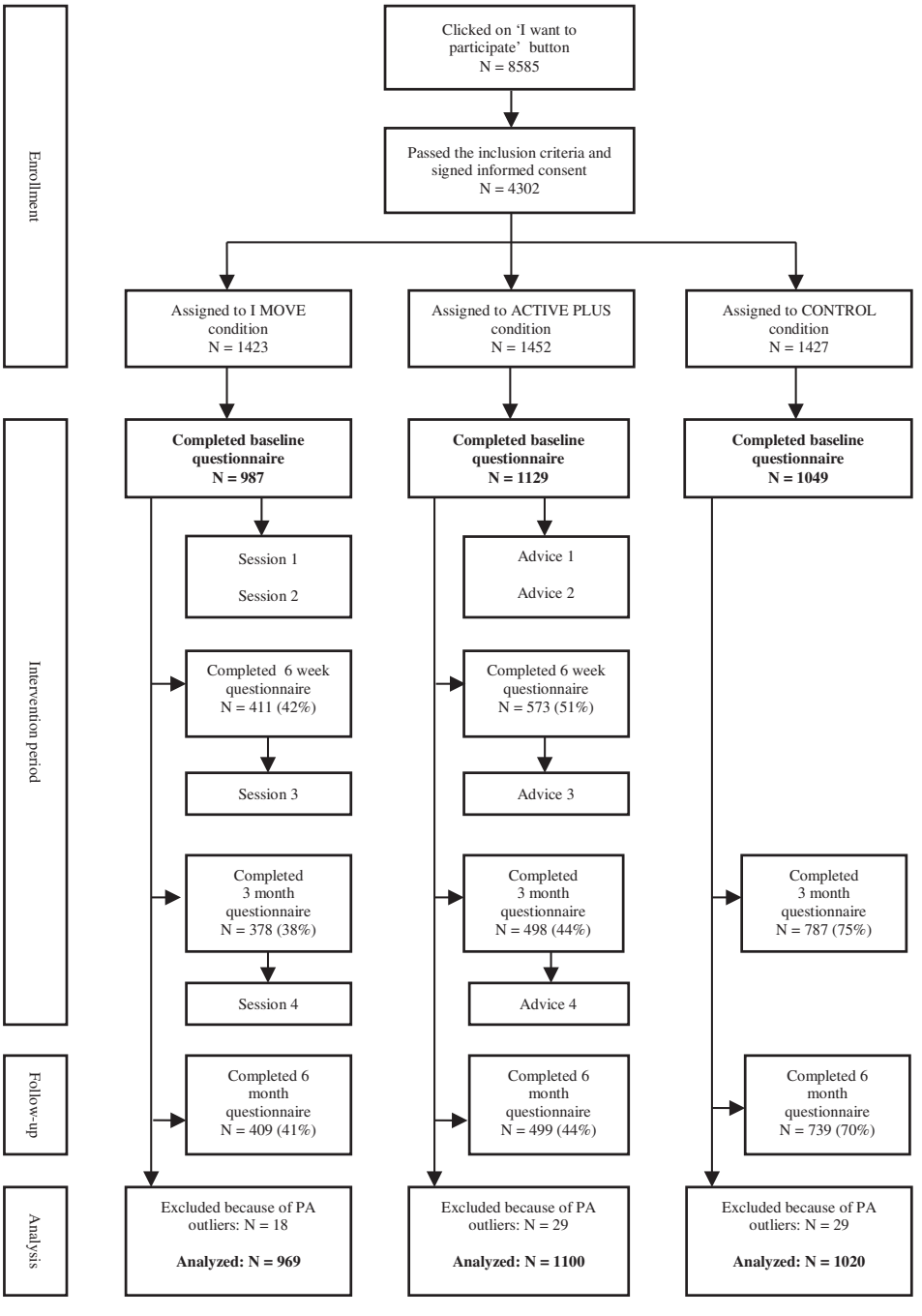

Figure 1. Flow of participants.

Interventions

I Move is a web-based computer tailored PA intervention, aimed at increasing and maintaining PA among adults (Friederichs et al., 2014). The intervention is based on the theoretical insights of SDT and the practical applications of MI. Since developing interventions in a systemically planned way increases the likelihood of effectiveness (Brug, Oenema, & Ferreira, 2005), we used the Intervention Mapping protocol (Bartholomew, Parcel, Kok, Gottlieb, & Fernandez, 2011) to develop I Move. In I Move several practical applications derived from MI have been implemented. In order to do so, we converted the skills, processes and spirit of MI into web-based CT (Miller & Rollnick, 2013). Throughout this process, SDT was used as the underlying theoretical framework (Markland et al., 2005).

I Move entails four automated text-based sessions. During these sessions, participants answer several questions (either by typing in their answer or choosing their answer from a list). In between those questions they receive tailored feedback text messages. As such, a motivational dialogue is simulated between the intervention and the participant. Alongside the text-based sections, at regular times during the intervention, participants are offered the option to watch short videos (starring a programme host, a PA-expert and four allegedly former intervention participants). Session 1 starts with an introduction, and after that several topics are discussed such as the participant's current PA, how important he/she thinks it is to increase his/her PA level, and how confident he/she is with regards to becoming more physically active. Participants can choose to make an action plan to become more active. Three weeks and six weeks later, participants receive an invitation email for session 2 and 3, respectively. Session 2 and 3 go into further detail on importance and confidence of becoming more physically active. Participants are given the opportunity to evaluate and adjust their plans, and to formulate coping plans. During session 3, participants receive ipsative feedback on their PA level. Three months after session 1, participants receive an invitation email for session 4. In this session, participants are given the option to choose themselves which parts of the session they want to go through (ipsative feedback on PA, long-term motivation and confidence). The day after having completed an intervention session, participants receive a PDF file by email, containing a summary of the session. Table 1 shows how the principles and strategies from SDT and MI were implemented in I Move. For more detailed information on the content and basis of I Move, please see the separate study protocol paper (Friederichs et al., 2014).

Active Plus is a traditional web-based computer tailored PA intervention (Peels et al., 2012; van Stralen et al., 2008). This systematically developed, theory- and evidence-based intervention is predominantly founded on traditional health behaviour change theories such as TPB, SCT, SRT and TTM. Active Plus, aimed at PA increase and maintenance, entails three times a tailored advice, (Peels et al., 2012; van Stralen et al., 2008). The format of the tailored advice is mostly text-based, supplemented by pictures and short videos. The content of each tailored advice is adjusted on the basis of several psychosocial constructs such as awareness, knowledge, attitude, self-efficacy, modelling and action planning (Peels et al., 2012; van Stralen et al., 2008). The main structure of each tailored advice depends on the participant's motivational stage of change (Prochaska & Velicer, 1997). For instance, the first tailored advice for precontemplators and contemplators mainly addresses attitude and modelling, whereas

Table 1. Integration of SDT and MI in I Move.

SDT	MI	Integration in I Move
Autonomy support	Skills: asking open questions and reflective listening	The intervention contains a combination of open and multiple choice questions with unique feedback messages for specific combinations
	Skills: summarising	At regular times during the intervention, participants receive feedback messages summarising their own answers. One day after each of the four sessions, they receive a summary by email
	Processes: focusing	Throughout the intervention, participants are encouraged to come up with their own themes and ideas (within the context of PA)
	Processes: evoking (I)	Throughout the intervention, several methods are used to elicit the participants' self-determined motivation (for example the importance ruler and value clarification)
	Processes: planning	Participants are offered the opportunity to create a specific action and coping plans that suit well to their needs and wishes
	Spirit: evocation	The intervention contains many evocative elements (see processes: evoking I & II)
Competence support	Skills: affirming	Feedback messages specifically address and comment on the participants' strengths and efforts. Messages were written in an empathetic style
	Skills: informing and advising	Participants are offered information through several short expert videos. They can choose themselves which videos they want to see
	Processes: evoking (II)	Throughout the intervention, several methods are used to help the participants increase their perceived confidence (for example, the confidence ruler and reviewing past successes)
Relatedness support	Processes: engaging	At the start of the intervention it is stated that participants are experts about themselves. Each of the four sessions contains a video coach; a series of video messages in which a coach welcomes the participant, and briefly introduces new questions and exercises. Furthermore, at several moments throughout all four sessions, participants can watch short videos with narratives of four allegedly former participants of I Move. These narratives provide the opportunity for the participants to feel connected with other people who go through similar experiences as themselves
	Spirit: partnership	The intervention uses the participants' input as the starting point for each session, in order to create a collaborative conversation
	Spirit: acceptance and compassion	The intervention contains highly specific feedback messages that suit well to the participants' needs and wishes. All messages are written in an empathetic style, without coercion or blame

preparators, actors and maintainers receive more information on post-motivational constructs such as action planning. Since Active Plus was originally designed for individuals over 50 years, we adapted the intervention in such a way that it is appropriate for the general adult population; messages that were clearly aimed at elderly people were adapted or removed. Furthermore, the original Active Plus contains only three times a tailored advice. Therefore, one additional tailored advice was added, in order to make it optimally comparable to I Move. Participants in Active Plus receive the tailored advice in two ways: (1) they are invited to read the advice and watch the related videos online, at the study website, and (2) one day after a new tailored advice has become available, they receive a PDF file by email, containing the tailored advice (videos replaced by pictures).

As emerges from the above, I Move and Active Plus are both systemically developed web-based computer tailored PA interventions. Both of these interventions entail four 'intervention moments' and in both interventions participants receive PDF files by email, containing the content of the previous session/advice. Nonetheless there are also several important differences between the interventions, one of which concerns the degree of interactivity. In Active Plus, participants are first asked to fill in a questionnaire on all the relevant psychological constructs, and they then receive the complete advice at once. I Move was designed to simulate a conversation with the participant by means of an interactive question-feedback approach. Hence, the participant is asked to actively participate in the intervention by responding to the questions, and reading the feedback messages. In addition, several other differences between both interventions exist, many of which stem from the differing theoretical foundations. Many differences are related to the fact that I Move provides more autonomy support. For example, right at the start of I Move, the collaborative character of the intervention is explicated by stating that the participant is his or her own expert, which is not the case in Active Plus. Similarly, before being provided with information on PA, participants in I Move are first asked whether they would like to read some more about the beneficial effects of PA, while in Active Plus no permission is asked and information is simply provided. In Table 2 the most important similarities and differences between both interventions are summarised.

Questionnaire

Demographics

Age, gender, weight, height, relational status and highest completed educational level were assessed. Educational level was categorised into high (higher vocational school or university level) and low (elementary education, medium general secondary education, preparatory vocational school, lower vocational school, higher general secondary education, preparatory academic education, medium vocational school), according to the Dutch educational system.

PA intention

At baseline, intention to become sufficiently active was measured, since this can be an important predictor of dropout in web-based PA interventions (Peels et al., 2013). Intention to become sufficiently active was measured with three items (e.g. 'Are you planning to be sufficiently physically active?' Definitely not (1) – Yes, definitely (10)).

Table 2. General similarities and differences between both interventions.

	I Move	Active Plus
Theoretical framework	SDT/MI	TPB, SCT, SRT, TTM
Determinants addressed	Autonomous motivation, basic psychological needs for autonomy, competence, relatedness	Awareness, knowledge, self-efficacy, modelling, attitude, planning
Examples of intervention strategies	Asking evocative open questions to elicit self-determined motivational statements; providing empathically formulated reflections; importance and confidence rulers; reviewing past successes; providing the option for the participants to formulate action and coping plans	Providing normative feedback on behaviour; encouraging monitoring of own behaviour; providing feedback and arguments about pros and cons; providing personal feedback and new arguments on self-efficacy; providing role model stories about action planning; inviting to formulate action and coping plans
Degree of interactivity	+ (interactive dialogue with intervention software)	– (unidirectional advice is provided)
Degree of directivity	– (permission is asked before advising; minimal normative information is provided)	+ (advice is simply provided; relatively much information on the importance of complying to PA guidelines)
Number of intervention moments	4 (at baseline, and 3 weeks, 6 weeks and 3 months from baseline)	4 (at baseline, and 3 weeks, 6 weeks and 3 months from baseline)
Summary of tailored intervention	One day after each of the intervention moments, participants receive a pdf file with a summary	One day after each of the intervention moments, participants receive a pdf file with a summary

PA level

At baseline, 3 and 6 months, PA behaviour was measured using the validated self-administered Dutch Short Questionnaire to Assess Health Enhancing PA (SQUASH) (Wendel-Vos, Schuit, Saris, & Kromhout, 2003).

Total weekly minutes of moderate to vigorous physical activity (MVPA) was calculated by multiplying the frequency (how many days per week), and duration (how many hours and minutes per day) of leisure and transport walking, leisure and transport cycling, sports, gardening, household chores and odd jobs performed with moderate or vigorous intensity. The relative validity ($r_{spearman}$ = .45; 95% CI = .17–.66) and reproducibility ($r_{spearman}$ = .58; 95% CI = .36–.74) of the SQUASH are reasonable for the general adult population (Wendel-Vos et al., 2003).

Total weekly days with more than 30 min PA was measured by a single item: 'How many days per week are you, in total, moderately physically active by undertaking, for example, brisk walking, cycling, chores, gardening, sports, or other physical activities for at least 30 min?'. Prior research provided support for the validity and reliability of

single-item self-reports of PA (Milton, Bull, & Bauman, 2011; Milton, Clemes, & Bull, 2013) and several studies found the single item PA measure to be among the most accurate PA questionnaires, when compared to accelerometer output (van Poppel, Chinapaw, Mokkink, van Mechelen, & Terwee, 2010).

Process evaluation measures

At 6 weeks and 6 months from baseline, appreciation for the interventions was evaluated. Participants were asked to indicate on a seven-point scale how useful, understandable, trustworthy, personally relevant and motivating they perceived the content of the sessions/tailored advice to be. Furthermore, participants were asked to provide an overall appreciation score (minimum 1; maximum 10) for each session / advice. These questions were derived from another PA CT intervention study (van Stralen, de Vries, Mudde, Bolman, & Lechner, 2009a, 2009b).

SDT measures

At 6 weeks and at 6 months from baseline, perceived basic psychological need support was measured, using nine especially developed items. At baseline and at 3 months from baseline several SDT variables (e.g. intrinsic motivation, perceived choice, perceived competence) were measured using the Exercise Self-Regulation Questionnaire (Ryan & Connell, 1989) and the Intrinsic Motivation Inventory (McAuley, Duncan, & Tammen, 1989). These SDT measures are reported on in a separate paper on the mediated effects or processes of change of the I Move intervention (Friederichs, Bolman, Oenema, Verboon, & Lechner, 2016), and are therefore not featured in the current paper.

Statistical analysis

All analyses were conducted using SPSS for Windows (Version 22). According to the guidelines of the SQUASH, participants who reported over 6720 min PA per week were excluded from all analyses (Wendel-Vos et al., 2003).

Chi-square tests and one-way analyses of variance (ANOVAs) were conducted to identify potential baseline differences among the research conditions. Logistic regression analyses were performed to assess predictors of dropout at the 6 month measurement.

Measurement moments (at 3 months and at 6 months) were nested within participants, resulting in the likelihood of interdependence. Therefore, multilevel linear regression analyses were conducted with random intercepts for two levels (time and participant). To account for possible selective drop-out, analyses were conducted using the whole data-set, including missing data. Applying multilevel analyses to an incomplete data-set has been shown to give better estimations than using multiple imputation (Twisk, 2013).

For the main outcome analyses, both PA outcomes (weekly days with ≥30 min PA and weekly minutes of MVPA) were regressed on two dummies (one for both of the intervention conditions, using the control group as the reference). The following variables were included as covariates: baseline PA value (minutes and days), time, gender, age, educational level, relational status, BMI and intention to be sufficiently physically active. Cohen's *d* effect sizes (ESs) were computed for both intervention conditions on

the basis of the unstandardised regression coefficients and the pooled standard deviation of the outcome measure (Lipsey & Wilson, 2000). Effect sizes of .15, .20 and .25, respectively, were considered small, medium and large (Rossi, 2003).

To gain more insight into the intervention effects among those participants who were exposed to the total intervention, separate multilevel linear regression analyses were conducted for both PA outcomes. These analyses included (1) those participants from the I Move condition who completed all four sessions, (2) those participants from the Active Plus condition who went through all four rounds of advice and (3) all participants from the control condition.

Moderators

In order to assess whether the intervention effects on both PA outcomes were moderated by participant characteristics, a second series of multilevel regression analyses was conducted. This time, interaction terms between the intervention dummies and gender, age, educational level, relational status, BMI and intention to be sufficiently physically active were added to the model. Separate moderation analyses were performed for each of the user characteristics. If an interaction term had a P-value $< .1$ this interaction was decomposed (using a median split in case of a continuous variable) and subgroup analyses were performed (Groeneveld, Proper, van der Beek, Hildebrandt, & van Mechelen, 2011; Rodenburg, Kremers, Oenema, & van de Mheen, 2014; Rodenburg, Oenema, Kremers, & van de Mheen, 2012; Rosnow & Rosenthal, 1989; van der Horst et al., 2007).

Process evaluation

First, in order to get an indication of the intervention exposure, it was assessed how many participants in the Active Plus condition clicked through at least one web-based advice, and how many participants in the I Move condition completed at least one web-based session. Also, it was assessed how many participants (from the I Move and the Active Plus condition) went through all four sessions/rounds of advice. Potential group differences within the process evaluation scores were assessed by means of multivariate and univariate analyses of variance (MANOVAs and ANOVAs). The first MANOVA assessed potential group differences in the extent to which participants perceived the content of session / advice 1 and 2 as useful, understandable, trustworthy, personally relevant and motivating. A second MANOVA evaluated potential group differences within the same variables, but this time for session / advice 3 and 4. These two MANOVAs only included those participants who completed at least one out of two of the intervention moments of interest (either session / advice 1 and 2 or 3 and 4). Both MANOVAs were followed by univariate ANOVAs to check for group differences in the individual variables. Finally, four ANOVAs were conducted to identify potential group differences on the overall appreciation scores for the four intervention moments. These four ANOVAs only included those participants who did complete the intervention moment of interest (either session / advice 1, 2, 3 or 4).

Results

In Figure 1, an overview of the flow of participants in the study is presented. As shown in Table 3, no baseline differences on key characteristics were found between the three study conditions. Dropout analysis showed that the lower their age ($B = .019 \pm .003$; $P < .001$), the higher their BMI ($B = .023 \pm .008$; $p = .005$) and the lower their intention to be sufficiently physically active ($B = .076 \pm .022$; $P < .001$), the less likely participants were to fill in the 6-month PA questionnaire. In addition, the more weekly minutes of MVPA they reported at baseline ($B < .001 \pm .000$; $P < .001$) and the less weekly days with > 30 min PA they reported at baseline ($B = .090 \pm .024$; $P < .001$) the less likely participants were to fill in the 6 month PA questionnaire. Finally, participants were less likely to fill in the 6 month PA questionnaire if they were married or living together (OR = 1.19; 95% CI = 1.00–1.42), if they were lowly educated (OR = 1.34; 95% CI = 1.15–1.57; $P < .001$) and if they were randomized in one of the intervention conditions ($OR_{IMove} = 3.49$; 95% CI = 2.89–4.22; $P < .001$; $OR_{ActivePlus} = 3.17$; 95% CI = 2.64–3.81; $P < .001$). These predictors of dropout were included in the effect analyses as covariates.

Table 4 shows the actual PA values for the three research conditions at baseline and at 6 months from baseline. In Table 5, the intervention effects on the one item measure of weekly days with ≥30 min PA and weekly minutes of MVPA, in comparison to the control condition, are shown. I Move realised a small, but significant, effect in weekly minutes of MVPA ($B = 54.55$; $p = .027$; ES = .09). Active Plus did not effectuate a significant effect regarding minutes of PA ($B = 40.86$; $p = .073$; ES = .07). Regarding days with ≥30 min PA, I Move realised a medium sized effect ($B = .40$; $p < .001$; ES = .21). Active Plus realised a large effect on this outcome ($B = .65$; $p < .001$; ES = .35).

The analyses including only those participants who were exposed to the total intervention yielded comparable results. In these analyses, the I Move intervention induced a significant effect on weekly minutes of MVPA ($B = 72.150$; $p = .013$; ES = .12) while the Active Plus intervention did not effectuate a significant effect on this outcome

Table 3. Baseline characteristics.

	I Move $n = 969$	Active Plus $n = 1100$	No intervention $n = 1020$	F / χ^2 (df = 2)
Gender: % male	30.0%	31.5%	31.2%	.59
Age	44.99 ± 13.11	45.28 ± 12.70	44.49 ± 12.98	1.00
Relational status: % married / living together	74.3%	74.2%	73.9%	.04
Education: % high education	63.1%	61.3%	61.0%	1.06
BMI	26.16 ± 4.80	26.07 ± 5.23	25.80 ± 4.47	1.50
Physical activity, weekly minutes	512 ± 577	482 ± 548	502 ± 555	.75
Physical activity, weekly days	3.09 ± 1.71	3.09 ± 1.65	3.13 ± 1.70	.16
Intention to be sufficiently physically active	7.07 ± 1.89	7.16 ± 1.81	7.15 ± 1.88	.63

Table 4. Absolute PA levels at baseline and 6 months.

	Baseline	6 months
Weekly minutes of MVPA		
I Move	512 ± 577	640 ± 650
Active Plus	482 ± 548	636 ± 661
Control	502 ± 555	562 ± 583
Weekly days with ≥ 30 min PA		
I Move	3.09 ± 1.71	4.07 ± 1.87
Active Plus	3.09 ± 1.65	4.34 ± 1.81
Control	3.13 ± 1.70	3.75 ± 1.90

(B = 34.73; p = .338; ES = .07). The I Move intervention realised a significant effect on days with ≥30 min PA (B = .46; p < .001; ES = .26). Active Plus also induced a significant effect on this outcome (B = .73; p < .001; ES = .40).

Moderators

Age moderated the effect of I Move on weekly minutes of MVPA (p = .015) and on weekly days with ≥30 min PA (p = .067). Gender also moderated the effect of I Move on weekly minutes of MVPA (p = .081) and on weekly days with ≥30 min PA (p = .032). Furthermore, the effect of I Move on weekly minutes of MVPA was moderated by relational status (p = .074). Finally, the effect of Active Plus on weekly days with ≥30 min PA was moderated by BMI (p = .021). PA (days and minutes) and intention at baseline did not moderate the intervention effects nor did educational level. Table 6 shows the intervention effects on both PA outcomes for the different subgroups.

Regarding weekly minutes of MVPA, I Move was effective in producing a significant effect in male participants (B = 117.52; p = .011; ES = .20), participants aged 47–70 (B = 86.08; p = .026; ES = .15), and participants who were single (B = 125.61; p = .011; ES = .22), but not in female participants (B = 25.73; p = .374; ES = .04), participants aged 18–46 (B = 23.83; p = .791; p = .04) and participants who were married or living together (B = 27.31; p = .338; ES = .05). Active Plus did not produce significant effects on weekly minutes of MVPA in any of these subgroups.

Regarding weekly days with ≥30 min PA, I Move produced greater effects in male participants (B = .64; p < .001; ES = .35), compared to female participants (B = .29; p = .004; ES = .15). The effect of I Move on weekly days with ≥30 min PA was more

Table 5. Intervention effects on PA outcomes.

	B	SE	*p*	95% CI	ES
Effect on minutes PA					
I Move vs. Control	54.55	24.58	.027	6.42 – 102.85	.09
Active Plus vs. Control	40.86	22.77	.073	−3.83 – 85.48	.07
Effect on days PA					
I Move vs. Control	.40	.09	<.001	.25 – .60	.21
Active Plus vs. Control	.65	.08	<.001	.47 – .79	.35

Table 6. Intervention effects on PA outcomes in subgroups.

	I Move vs Control			Active Plus vs. Control		
	B	*p*	ES	*B*	*p*	ES
Weekly minutes of MVPA						
Male	117.52	.011	.20	26.19	.534	.05
Female	25.73	.374	.04	46.19	.083	.08
Age 18–46	23.83	.791	.04	9.69	.346	.02
Age 47–70	86.08	.026	.15	68.76	.054	.12
Single	125.61	.011	.22	41.32	.366	.07
Married/living together	27.31	.338	.05	39.06	.137	.07
Weekly days with > 30 min PA						
Male	.64	< .001	.35	.73	< .001	.40
Female	.29	.004	.15	.61	< .001	.33
Age 18–46	.31	.007	.17	.60	< .001	.32
Age 47–70	.48	< .001	.26	.71	< .001	.38
BMI ≤ 25	.40	.001	.21	.57	< .001	.31
BMI > 25	.40	< .001	.21	.73	< .001	.40

pronounced in participants aged 47–70 ($B = .48$; $p = .001$; ES = .26) than in participants aged 18–46 ($B = .31$; $p = .007$; ES = .17). Active Plus produced larger effects on weekly days with ≥30 min PA in participants with BMI > 25 ($B = .73$; $p < .001$; ES = .40) than in participants with BMI ≤ 25 ($B = .57$; $p < .001$; ES = .31).

Process evaluation

In total, 73.5% of the I Move participants completed at least one web-based session, while 89.4% of the Active Plus participants fully clicked through at least one web-based advice (χ^2 (1, $N = 2069$) = 87.79, $p < .001$). Furthermore, 24.6% of the I Move participants completed all four sessions, while 12.6% of the Active Plus participants clicked through all four rounds of advice ($\chi 2$ (1, $N = 2069$) = 49.17, $p < .001$). On average, 88% (I Move) and 83% (Active Plus) gave the intervention materials a rating of 6/10 or higher. As is shown in Table 7, session 2 of I Move was better appreciated than advice 2 of Active Plus ($F = 5.80$; $p = .016$). Furthermore, session 1 and 2 of I Move were perceived as less trustworthy ($F = 4.24$; $p = .040$) and as more motivating ($F = 5.26$; $p = .022$) than session 1 and 2 of Active Plus. Finally, session 3 & 4 of I Move were experienced as more understandable than advice 3 and 4 of the Active Plus condition ($F = 4.80$; $p = .029$).

Discussion

This study evaluated the effectiveness of I Move, a web-based computer tailored PA intervention, based on SDT and MI. I Move was compared to a proven effective traditional web-based PA intervention (Active Plus) and to a waiting list control group. In addition, potential moderating factors of the intervention effects were explored. Finally, by conducting a process evaluation, user appreciation for both interventions was investigated.

I Move achieved a small, but significant increase in weekly minutes of MVPA, while Active Plus did not have a significant impact on this outcome. In contrast to our hypothesis, however, the difference in effect sizes between both interventions on this outcome (I Move ES = .09 vs Active Plus ES = .07) was negligible. This may be related to the rather limited intervention exposure in the I Move condition. Indeed, the percentage of Active Plus participants who fully clicked through at least one web-based advice was higher than the percentage of I Move participants who completed at least one web-based session. One possible explanation for this finding is that engagement with the intervention was lower among I Move participants than among Active Plus participants (O'Brien & Toms, 2008). Due to its collaborative, interactive nature, I Move could be experienced as more intensive and lengthy compared Active Plus, which may have had an negative impact on intervention use (Brouwer et al., 2011; Ritterband, Thorndike, Cox, Kovatchev, & Gonder-Frederick, 2009). However, reasoning from the tenets of SDT and MI, a directive and advice-giving intervention such as Active Plus should instead cause less engagement (Ryan et al., 2008). This line of thought is in line with our finding that the percentage of I Move participants who completed all four sessions was significantly higher than the percentage of Active Plus participants who clicked through all four rounds of advice. An alternative explanation for this, however, could be that the rounds of advice from Active Plus were also emailed to each Active

Table 7. Process evaluation of I Move and Active Plus.

	I Move		Active Plus			
	Mean	SD	Mean	SD	Pillai's trace	*F*-value
Overall appreciation score: session / advice 1 (n = 895)	6.68	1.25	6.71	1.28	NA	.145
Overall appreciation score: session / advice 2 (n =515)	6.71	1.32	6.41	1.48	NA	5.80*
Overall appreciation score: session / advice 3 (n = 663)	6.72	1.32	6.72	1.40	NA	.000
Overall appreciation score: session / advice 4 (n = 682)	6.81	1.29	6.68	1.41	NA	1.52
Useful: session / advice 1 & 2 (n = 907)	4.95	1.31	4.94	1.29	.024**	.014
Understandable: session / advice 1 & 2 (n = 907)	5.88	1.14	5.90	1.10	.024**	.042
Trustworthy: session / advice 1 & 2 (n = 907)	5.38	1.23	5.54	1.15	.024**	4.24*
Personally relevant: session / advice 1 & 2 (n = 907)	4.60	1.44	4.67	1.44	.024**	.483
Motivating: session / advice 1 & 2 (n = 907)	4.40	1.68	4.15	1.53	.024**	5.26*
Useful: session / advice 3 & 4 (n = 767)	4.94	1.21	4.86	1.28	.018*	2.15
Understandable: session / advice 3 & 4 (n = 767)	5.88	1.03	5.70	1.26	.018*	4.80*
Trustworthy: session / advice 3 & 4 (n = 767)	5.47	1.18	5.38	1.31	.018*	.813
Personally relevant: session / advice 3 & 4 (n = 767)	4.58	1.40	4.65	1.45	.018*	.440
Motivating: session / advice 3 & 4 (n = 767)	4.34	1.58	4.26	1.53	.018*	.549

*$P < .05$. **$P < .01$.

Plus participant, as PDF files. Therefore, these participants had the option to not click through their advice on the website, but to read the PDF file instead.

While overall, the effect of I Move on weekly minutes of MVPA was rather small (ES = .09), in some subgroups (participants with higher age, male participants, participants who were single) the effect sizes for this outcome were more pronounced (ES ranging from .15 to .22). The larger effect sizes in these particular groups probably have several causes. For instance, participants with higher age are generally more inclined to take an active part in web-based interventions, compared to younger participants (Schneider, van Osch, Schulz, Kremers, & de Vries, 2012; Van 't Riet et al., 2010). The fact that I Move was capable of achieving significant small to medium effects on weekly minutes of MVPA (in some subgroups of participants), suggests that combining SDT and MI within a web-based PA interventions has the potential to effectively increase daily PA behaviour. Nonetheless, it is possible that I Move should be further adapted in order to better fulfil the needs and wishes of certain subgroups such as participants who are married or living together, and female participants. Indeed, future studies on web-based interventions altogether should examine how to design interventions in such a way that the tailored content optimises engagement and impact in all participant subgroups (Chen, Reid, Parker, & Pillemer, 2013; Morrison, Yardley, Powell, & Michie, 2012; Neville, O'Hara, & Milat, 2009).

Both I Move and Active Plus were effective in increasing weekly days with ≥30 min PA, whereas Active Plus yielded a greater effect size on this outcome (I Move .21 vs Active Plus .35). Among other factors (such as the limited intervention exposure in the I Move condition) these results may be related to the normative approach as operationalised by Active Plus. During Active Plus, participants are continuously informed about the importance of complying to the (inter)national PA guidelines (being physically active for 30 min or more during at least 5 days per week) (Garber et al., 2011; Peels et al., 2012; van Stralen et al., 2008). In I Move, the PA guidelines are hardly mentioned and participants are stimulated to set their own PA norms/goals (which are not necessarily in line with the PA guidelines). Therefore, when compared to the Active Plus participants, the I Move participants possibly concentrated their PA behaviour on fewer days in the week.

Active Plus was especially effective in increasing days with ≥30 min PA in overweight people. This phenomenon was also observed in an earlier study on a print-delivered version of Active Plus (van Stralen et al., 2010). The higher effect of Active Plus on days with ≥30 min PA in participants with BMI > 25 could indicate that people with overweight are more receptive to the normative health-related messages as provided by Active Plus (Elliott, Baxter, Davies, & Truby, 2014; McMurray et al., 2008; Troiano, Pettee Gabriel, Welk, Owen, & Sternfeld, 2012).

The results of the separate outcome analyses (including only those participants who went through all intervention components), were comparable to the results of the original outcome analyses (with all participants, including those who skipped one or more intervention components). The effect sizes in the completer-only analyses are very much alike the effect sizes in the intention-to-treat analyses. This shows that, apparently, in the context of interactive PA interventions like I Move, it is not of utmost importance that all participants take part in all intervention sessions. For future intervention developers, it would be relevant to find out whether there is a certain number of sessions is optimal and whether this might vary between subpopulations.

Overall, I Move and Active Plus were both fairly appreciated. Session 2 of I Move was better appreciated than advice 2 of Active Plus. Possibly, this has to do with the fact that session 2 of I Move uses a partnership approach, and actively involves the participant by continuing the conversation of session 1 and adapting the feedback messages to participant's current needs and wishes. Session 1 and 2 of I Move were perceived as more motivating than advice 1 and 2 of Active Plus, which is in favour of the autonomy-supportive approach as adopted by I Move. However, session 1 and 2 of I Move were perceived as less trustworthy than advice 1 and 2 of Active Plus. This may indicate that, for some participants (e.g. participants who just wanted to receive guidelines and tips about PA), the approach of I Move was too cumbersome, too little self-explanatory, and consequently perceived as less trustworthy (Patrick et al., 2013). Also, reasoning from a SDT context, this result may imply that there was too little structure in the I Move intervention which may have thwarted the participants' basic need for competence (Ryan et al., 2008). Finally, the I Move participants scoring higher on the motivation variable but lower on the trust variable seems contradictory. This finding can be explained by the fact that the correlation between the motivation and trust variable was slightly different among participants from the I Move vs. the Active Plus condition.

Strengths and limitations

As far as is known to us, I Move is the first web-based PA intervention based on SDT and MI. In this intervention, new and innovative ways of motivating individuals to become physically active have been integrated. The innovative nature of I Move therefore is an important strength of this study. Furthermore, this study had a strong randomized controlled design, with a large sample size, and no baseline differences between the study conditions. Also, self-reported PA was measured using a validated measurement instrument (Wendel-Vos et al., 2003).

Despite these strengths, the current study is not without limitations. First, the study was subject to a considerable amount of attrition. Unfortunately, attrition is very common in studies on eHealth and web-based interventions (Eysenbach, 2005). In this study, we aimed to handle the missing data in the most accurate way possible by conducting multilevel analyses (Twisk, 2013). Indeed, applying multilevel analyses to an incomplete data-set has been shown to give better estimations than using multiple imputations (Twisk, 2013). Second, although the reproducibility and relative validity of the measurement instrument in this study are reasonable (Wendel-Vos et al., 2003), the fact that it is self-report leads to the probability of bias, for example via over reporting or via socially desirable responses (Brouwer et al., 2011; Prince et al., 2008). Over reporting of PA behaviour is likely in this study since the mean BMI of the participants (26.0) is quite high compared with their self-reported PA level. The use of self-report as the only outcome measure should therefore regarded as an important limitation of this study. Future studies on web-based PA interventions should include a more objective measure of PA behaviour (Lyons, Lewis, Mayrsohn, & Rowland, 2014; Trost & O'Neil, 2014). Third, eligibility criteria of this study included the requirement that participants be physically active for less than 5 days per week for 60 min per day. Therefore, relatively active individuals were still allowed to take part in the study which could have led to a ceiling effect (predominantly in subparts of the sample with lots of active

individuals) and could partly explain the rather moderate observed intervention effects. However, moderator analyses showed that baseline PA level did not significantly moderate the intervention effects, arguing against a ceiling effect. Fourth, the results of this study may be influenced by selective drop-out (e.g. participants with lower age dropped out more frequently). By including all drop-out predictors in the regression analyses as covariates, and by analysing the total data-set including missing values, we aimed to account for selective drop-out as much as possible (Twisk, 2013). Finally, caution is needed when generalising the main outcomes of this study to the general population, because of the overrepresentation of female and highly educated participants in the research population. By conducting the moderation analyses, however, we aimed to provide insight into the differential effectiveness of the interventions in specific subgroups of participants.

Conclusions

In this study, I Move (a web-based computer tailored PA intervention based on MI and SDT), did not outperform Active Plus (a web-based computer tailored PA intervention based on traditional health behavioural theories). Further research should reveal whether MI/SDT-based interventions are profitable for long-term maintenance of PA levels. For future studies in this domain, it is recommended to invest in prevention of disengagement and attrition, and to include objective measures of PA.

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