Promoting physical activity in patients with rheumatoid arthritis

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Chapter 6

Internet-based physical activity interventions: a systematic review of the literature

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Submitted

Abstract

Objective. To systematically describe the effectiveness of interventions designed to promote physical activity by means of the Internet.

Methods. A literature search was conducted up to July 2006 using the databases PubMed, Web of Science, EMBASE, PsycINFO and Cochrane Library. Only randomised controlled trials describing the effectiveness of an Internet-based intervention with the promotion of physical activity among adults being one of its major goals were included. Data extracted included source and year of publication, country of origin, targeted health behaviours, participants' characteristics, characteristics of the intervention, and effectiveness data. In addition, methodological quality was assessed.

Results. The literature search resulted in ten eligible studies of which five studies met at least nine out of thirteen methodological criteria. In four studies an Internet-based physical activity intervention was compared with a print-based version of the intervention (n=1) or a waiting list group (n=3). Of these four studies, two studies reported a significantly greater improvement of physical activity levels in the Internet-based physical activity intervention than in the control group. In six studies different types of an Internet-based physical activity intervention were compared among each other, with the difference between the interventions mainly pertaining to the degree of tailoring or personalization. In one of these studies a significant effect in favour of an intervention with personalised supervision was seen.

Conclusions. Internet-based physical activity interventions appear more effective than a waiting list strategy. Regarding the active components of Internet-based physical activity interventions, the added value of individual tailoring remains to be established. As Internet-based physical activity interventions can reach large numbers of people at relatively low costs, more research into their optimal content and mode of delivery is justified.

Introduction

Regular physical activity is associated with lower morbidity and mortality rates from cardiovascular diseases (1-4), diabetes mellitus (5), cancer (6), and osteoporosis (7). Despite these proven health benefits, the majority of the adult population in Western nations does not meet the public health recommendations for physical activity (8-12). Therefore, there is a need for the delivery of effective interventions aimed at positively influencing physical activity behaviour.

Traditionally, most physical activity interventions use face-to-face modes of delivery (e.g. individual consultations or group meetings). Their effectiveness has been extensively documented, demonstrating (mainly the short-term) effectiveness (13-17). However, there are a number of barriers associated with administering face-to-face interventions in health care settings, such as time constraints, high costs and limited access. Therefore, researchers have been investigating alternative methods for delivering physical activity interventions, such as delivery by means of the Internet.

The number of people having access to and using the Internet is increasing rapidly (18). As a consequence, the Internet has been advocated as a promising mode for delivering physical activity interventions (19;20). The strength of Internet-based interventions is that these can reach large numbers of individuals at lower costs than those associated with face-to-face interventions (19;21). Moreover, by using the Internet, participants in these interventions can access large amounts of information and they can choose the timing of when they would like to interact and receive information (22). However, little research has been conducted investigating to which extent Internet-based physical activity interventions are effective.

The purpose of this review is to systematically assess the effectiveness of interventions designed to promote physical activity by means of the Internet, among healthy persons and patients with chronic conditions.

Materials and Methods

Definitions

Physical activity and exercise represent different concepts: physical activity is defined as any bodily movement resulting in energy expenditure; exercise is a subset of physical activity that is

planned, structured, repetitive, and aimed at improving or maintaining physical fitness (23). Since exercise falls under the broader concept of physical activity, in this manuscript we will only use the term physical activity.

In addition, since e-mail communication is based on Internet technology, both the use of websites and the use of e-mails will be designated as Internet-based interventions.

Search strategy

In cooperation with a trained librarian (JS) a search strategy was composed. The following databases were searched: PubMed (1949 up to July 2006), Web of Science (1945 up to July 2006), EMBASE [OVID-version] (1980 up to July 2006), PsycINFO (1887 up to July 2006), and Cochrane Library (1990 up to July 2006). The search strategy consisted of the AND-combination of three main concepts: internet, physical activity, and intervention. For these three concepts, all relevant keyword variations were used, not only keyword variations in the controlled vocabularies of the various databases, but the free text word variations of these concepts as well. In general, the search consisted of the combination of the following terms: (internet or worldwideweb or world wide web or information technology or cyber* or web or website* or interactive or email or e-mail or e mail or emails or e-mails or e mails or emailing or e-mailing or e mailing or electronic mail) and (physical education and training or exercise therapy or physical fitness or exercise or motor activity or physical training or physical education or fitness or exercise* or physical activity or physical activities or physical inactivity) and (intervention or interventions or intervention* or treatment outcome or intervention studies or epidemiologic study characteristics or study characteristics or epidemiologic methods or program or programs or programme or programmes or programmed or program evaluation). This search strategy was optimised for all consulted databases, taking into account the differences of the various controlled vocabularies as well as the differences of database-specific technical variations (e.g. different truncations symbols). Details of the database searches can be obtained from the author.

Selection of articles

To be included, articles had to describe an intervention in which one of the primary goals was the promotion of physical activity among adults (18 years or older). Furthermore, the intervention had to be delivered predominantly by means of Internet in one of the following ways: (i) exchange of information via the World Wide Web between a health care setting and an individual (e.g. between

a clinic and a patient's home or workplace); (ii) use of e-mail for communication between a therapist or health care professional and a patient (group). Internet-based physical activity interventions that promote physical activity in order to achieve a secondary goal, such as weight reduction, were also included.

Only randomised controlled trails with pretest and posttest outcome data of both the control as well as the intervention group were considered for inclusion in this review. No restrictions were defined regarding the type and contents of the control group: this could be assignment to a waiting list, a non Internet-based intervention or a different type of Internet-based intervention. At least one of the outcomes had to be described in terms of change in physical activity levels (e.g. change in amount or quantity of physical activity). Furthermore, because of limited resources for translation, this review was restricted to publications in English, Dutch, and German.

The reference lists of the selected articles were checked for additional eligible articles, using the same inclusion criteria. Review articles itself could not be included in the review; however, the reference lists of relevant review articles were also checked for additional eligible articles. The articles were independently selected and assessed by two reviewers (MvdB and TVV).

Assessment of methodological quality

The methodological quality of the included articles was rated using a list recommended by Van Tulder et al (24), containing 19 methodological criteria. The criteria 'care provider blinded', 'patient blinded', 'co-interventions avoided' and 'description of adverse effects' were not regarded as being suitable or relevant by the reviewers, because of the character of the interventions, and were removed from the list. The criteria 'relevant outcome measures' and 'short-term follow-up outcome' were already used as inclusion criteria for inclusion of articles in this review; therefore these criteria were not used for assessing methodological quality. Finally, the criterion 'acceptable compliance' was reformulated as 'description of compliance' and 'description of and acceptable drop-out rate' was reformulated as 'description drop-out rate plus comparison drop-outs with completers'. The final amount of criteria used to assess methodological quality was 13 (see Appendix 1). All criteria were scored as 'yes', 'no', or 'unclear'. Equal weight was applied on all criteria resulting in a methodological summary score ranging from 0 to 13. The literature provides no guidelines for choosing cut-off points in order to rate the methodological quality (25). In this review we rated the studies as having good

methodological quality if two-thirds or more of the criteria were met (i.e. a summary score of 9 or higher).

Data extraction

This review is a qualitative systematic review, as the extracted data of the selected studies are summarised, but not statistically combined. In our review, aggregating findings across studies rather than pooling them was a more useful method for describing synthesis, as the outcome measures varied widely. The results of the selected studies in this review were broken down, thoroughly analyzed, and then combined into a whole via a listing of themes. This method has proven to be a suitable method in systematic reviews (26).

The following information was systematically extracted by the two reviewers: source and year of publication, country of origin, targeted health behaviours (physical activity, weight loss, nutrition behaviour or other), characteristics of the study population (number and type of participants, age, sex), characteristics of the intervention (duration, theoretical foundation, description of contents), and pretest and posttest physical activity outcomes of both intervention groups. Only the posttest results measured directly after finishing the physical activity intervention were included in this review. When more than two types of physical activity outcomes were reported in the studies, we only mentioned the two most important outcome measures in Table 3, in order to keep this table orderly. Information about the other outcomes is presented in the text of this review.

Reviewers were blinded to authorship, journal title and other study-related information. Furthermore, screening for eligible articles as well as data extraction from the selected articles was done independently. Any discrepancies between the two reviewers were settled by consensus.

Results

Selection of articles

Figure 1 illustrates the search and selection process. The initial database search yielded 1220 citations. After eliminating duplicates this was reduced to 957 citations, of which 117 were review articles. Screening titles and abstracts of the 840 non-review articles resulted in 66 citations potentially meeting eligibility criteria.

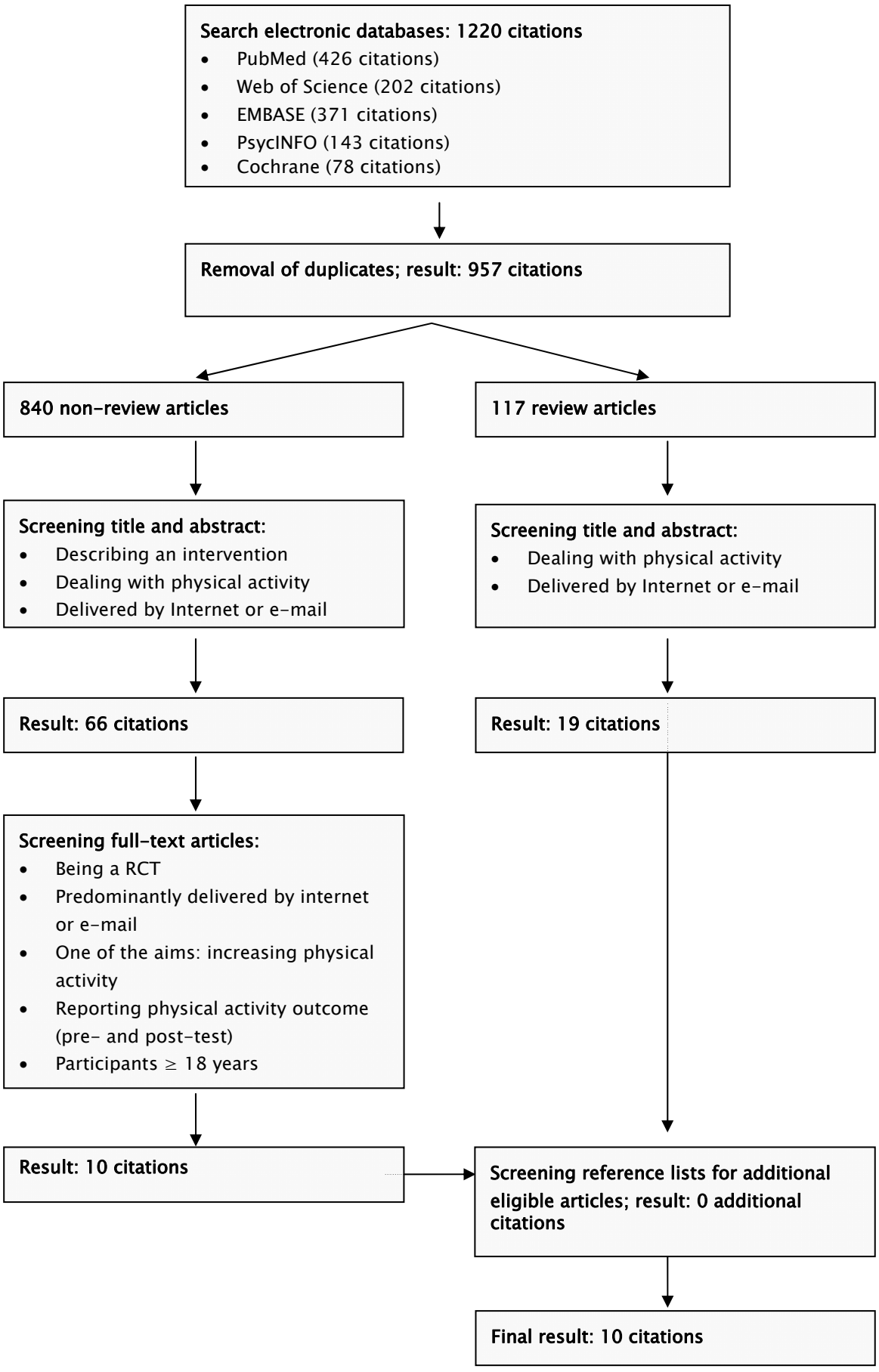

Figure 1. Search and selection process.

After completely reviewing the corresponding full-text articles of these citations, the total number of articles was reduced to 10. Reasons for exclusion of the 56 citations were: not reporting pre- and posttest physical activity outcomes (n=25), not predominantly delivered by the Internet (n=16), not being a RCT (n=13), and participants being younger than 18 years (n=2). Screening the titles and abstracts of the 117 review articles resulted in 19 relevant reviews. Screening both the reference list of these reviews, as well as the reference lists of the 10 selected articles, did not bring up any additional articles. As a result, 10 articles were included.

Assessing methodological quality

Results of the methodological assessments are described in Table 1. Five studies met nine or more criteria (27-31), implying a good methodological quality. One study described the method of random assignment and stated that this assignment was performed by an independent person (31). Information about the blinding of the outcome assessor was given in two studies (28;31). None of the studies performed a full intention-to-treat analysis according to the definition of intention-to-treat given by Hollis and Campbell (32), stating that 'a full application of intention-to-treat is possible only when complete outcome data are available for all randomised subjects'. All studies reported a drop-out rate, with six out of the ten studies comparing the characteristics of these drop-outs with the subjects that completed all outcome measurements (27;29;30;33-35). In two studies (35;36) the study sample included only those participants who completed both the baseline as well as the follow-up measurements, excluding drop-outs from the analysis.

Data extraction

Characteristics of selected studies. Study characteristics are described in Table 2. Seven of the ten selected studies were performed in the United States, one in Canada, one in Australia and one in The Netherlands. All studies were published between 2001 and 2006. Three studies addressed interventions targeted at both physical activity as well as nutrition behaviour; the other seven studies focused on interventions aimed at physical activity behaviour only. The duration of the interventions varied from 1 to 12 months, with three studies describing interventions of 6 months or longer.

Table 1. Methodological quality of the studies included in the review

	Kosma et al (35)	Plotnikoff et al (36)	Napolitano et al (33)	Marshall et al (28)	Van den Berg et al (31)	Hageman et al (37)	Rovniak et al (27)	Tate et al (30)	McKay et al (34)	Tate et al (29)
Specification of eligibility criteria	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Description of randomization method	no	no	no	yes	yes	no	yes	yes	no	no
Random assignment performed by independent person	unclear	unclear	unclear	unclear	yes	unclear	unclear	unclear	unclear	unclear
Groups similar at baseline	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Sufficient description of interventions	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Description of compliance with interventions	no	no	yes	yes	yes	yes	yes	yes	yes	yes
Blinding of outcome assessor	unclear	unclear	unclear	yes	yes	unclear	no	unclear	unclear	unclear
Description drop-out rate plus comparison drop-outs & completes	yes	no	yes	no	no	no	yes	yes	yes	yes
Outcome assessment ≥ 6 months after randomization	no	no	no	no	yes	no	yes	yes	no	yes
Timing of assessments comparable	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Description of sample size calculation	no	no	no	yes	yes	yes	no	no	no	yes
Intention-to-treat analysis	no	no	no	no	no	no	no	no	no	no
Presentation of point estimates and variability measures	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
Total number of criteria fulfilled	**6**	**5**	**7**	**9**	**11**	**7**	**9**	**9**	**7**	**9**

Characteristics of study population. Table 2 shows that the total population size varied from 31 to 2598 participants. The study populations all consisted of healthy (overweight) adults, except for the studies of Kosma et al (35), McKay et al (34) and Van den Berg et al (31) where physically disabled patients, diabetic patients and patients with rheumatoid arthritis were included, respectively. Six of the ten studies were specifically targeted at adults who were sedentary at baseline (27;31;33-35;37); the other four studies did not employ any inclusion criteria regarding baseline physical activity levels (28-30;36). In two studies (28;34) the proportions of males and female participants were almost equal; in the other studies the large majority of participants was female. Furthermore, mean age varied from 39 to 56 years.

Characteristics of intervention. Table 3 describes the characteristics of the Internet-based physical activity interventions and control conditions. Section A of this table describes the four studies in which an Internet-based physical activity intervention was compared with a non-Internet-based intervention, i.e. a print-based version of the intervention (28), or a waiting list group (33;35;36). In three of these four studies (28;33;35), the participants in the Internet-based intervention got access to a website and received e-mails; in the other study the intervention group received e-mails only (36).

Section B of Table 3 describes the six studies in which two different types of Internet-based physical activity interventions were being compared among each other (27;29-31;34;37). These studies were designed to determine the key components of Internet-based physical activity interventions. In all of these studies, the most important difference between the intervention and control group was the degree of tailoring or personalization: participants from the intervention group received tailored or personalised web-based information, whereas the control group received more general or standard information. In three of these six studies (29;31;34), participants from the intervention group got access to a website and received e-mails, whereas the control group received website-access only. One study (30) offered website access and e-mail communication to both the participants from the intervention group as well as the control group, in the other two studies both groups were offered website-access only (37) or e-mail communication only (27).

Table 2. Characteristics of studies and participants participating in Internet-based physical activity interventions #

Study	Targeted health behaviour(s)	Duration of intervention (months)	Sample description				
			No. of participants randomised	No. of participants with complete data	Type of participants	Sex (% male)	Age (mean ± SD; years)
Kosma et al (35), 2005, USA	PA	1	151 (I: 101 C: 50)	75 (I: 46, C: 29)	Inactive adults with physical disabilities with Internet access	21	38.7 ± 8.9
Plotnikoff et al (36), 2005, Canada	PA and nutrition behaviour	3	2598 (I: ?, C: ?)	2121 (I: 1566, C: 555)	Employees of large workplaces with Internet and e-mail access	26	44.9 ± 6.3
Napolitano et al (33), 2003, USA	PA	3	65 (I: 30, C: 35)	52 (I: 21, C: 31)	Hospital employees participating in ≤ 120 min. of moderate PA/week or ≤ 60 min. of vigorous PA/week with Internet and e-mail access	14	42.8 ± 10.0
Marshall et al (28), 2003, Australia	PA	2	655 (I: 327, C: 328	512 (I: 250, C: 262)	University employees with e-mail access	49	43 ± 11
Van den Berg et al (31), 2006, The Netherlands	PA	12	160 (I: 82, C: 78)	152 (I: 77, C: 75)	Patients with rheumatoid arthritis not participating in 30 min. of moderate PA on ≥ 5 days/week with Internet and e-mail access	24	49.6 ± 10.3
Hageman et al (37), 2005, USA	PA	2	31 (I: 15, C: 16)	30 (I:?, C: ?)	Healthy women not participating in 30 min. of moderate PA on ≥ 5 days/week with Internet access	0	56.1 ± 4.9
Rovniak et al (27), 2005, USA	PA	3	61 (I: 30, C: 31)	50 (I: 25, C: 25)	Sedentary adult women participating in < 90 min. of PA/ week with e-mail access	0	40.2 ± 9.1
Tate et al (30), 2003, USA	Weight loss (PA and nutrition)	12	92 (I: 46, C: 46)	77 (I: 38, C: 39)	Overweight (BMI 27-40 kg/m^2) adults at risk of type 2 diabetes with Internet and e-mail access	10	48.5 ± 9.4
McKay et al (34), 2001, USA	PA	2	78 (I: 38, C: 40)	68 (I: 35, C: 33)	Type 2 diabetic patients not participating in 30 min. of moderate PA on ≥ 5 days/week with Internet and e-mail access	47	52.3 ± ?
Tate et al (29), 2001, USA	Weight loss (PA and nutrition)	6	91 (I: 46, C: 45)	71 (I: 36, C: 35)	Overweight (BMI 25-36 kg/m^2) adult hospital employees with Internet and e-mail access	11	40.9 ± 10.6

PA = physical activity, I = intervention group, C = control group

Of the ten selected studies, six used one or more theoretical models to compose the contents delivered to the intervention group only (33-36), or to both the intervention as well as the control group (27;28). These models were: the Transtheoretical Model (28;33;35;36), Protection Motivation Theory (36), Theory of Planned Behaviour (36), Social Cognitive Theory (27;33;36) and a social-ecological model (34).

Most studies were aimed at increasing any type of physical activity. However, two studies were targeted at one specific activity. In these two studies, both comparing two different types of Internet-based physical activity interventions, one study promoted walking among the participants from both the intervention as well as the control group (27), whereas in the other study cycling on a bicycle ergometer was one of the main activities within the intervention group only (31).

Effectiveness of intervention. The physical activity outcome measures of both the intervention group as well as the control group are expressed as pretest and posttest results and are described in Table 3. In general, of the ten selected studies, four studies reported one physical activity outcome parameter (27;29;30;35); five studies reported two physical activity parameters (28;33;34;36;37), and one study reported more than two physical activity parameters (31).

Regarding the four studies described in section A of Table 3, which compared an Internet-based with a non-Internet-based intervention, two studies reported significant differences between the intervention and control groups (33;36). These two studies both had a waiting list control group. One study in section A had a good methodological quality (28).

With respect to the six studies described in section B of Table 3, in which two different types of Internet-based physical activity interventions were compared, one study reported significant between groups differences between the intervention and the control group with respect to change in physical activity levels (31). Moreover, four studies described in this section of Table 3, had a good methodological quality, including the study with the significant results (27;29;30).

In general, lack of effectiveness within the studies was explained by lack of long-term follow-up data, too small sample sizes, lack of adherence to the program, and difficulty in accurately measuring physical activity behaviour.

Table 3. Characteristics and results of Internet-based physical activity interventions

Study	Description intervention group	Description control group	Physical activity outcome measure			
			Outcome variable	Pre-test results (mean ± SD)	Post-test results (mean ± SD) #	Conclusion
Section A: Comparison of an Internet-based physical activity intervention with a non-Internet-based physical activity intervention						
Kosma et al (35), 2005	• Weekly e-mails containing a web link to motivational PA lesson plans + for half of intervention group: opportunity to participate in web-based discussion board	• Weekly e-mails containing messages not related to PA	• Leisure time PA (MET-hours/day)	• I: 6.1 ± 7.4 • C: 9.3 ± 7.7	• I: 8.2 ± 6.8 • C: 6.9 ± 7.8	No significant between-groups differences for leisure time PA
Plotnikoff et al (36), 2005	• Weekly e-mails containing PA information operationalizing social-cognitive items and beliefs predicting PA behaviour and links to other websites about PA and healthy eating	• No weekly e-mails (nothing)	• Moderate and vigorous PA (MET min/week) • Workplace activity status (range 1 = sedentary to 4 = very active)	• PA: • I: 664.1 ± 726.1 • C: 668.6 ± 752.6 • Workplace status: • I: 1.3 ± 0.6 • C: 1.3 ± 0.5	• PA: • I: 683.7 ± 702.3 • C: 592.7 ± 652.8 • Workplace status: • I: 1.4 ± 0.6 • C: 1.4 ± 0.6	Significant between-group differences for moderate and vigorous PA, not for workplace status
Napolitano et al (33), 2003	• Access to stage-based PA website containing the following sections: activity quiz, safety tips, becoming active, PA and health, overcoming barriers, planning PA, and benefits of PA • Weekly tip sheets sent by e-mail containing PA-related information about getting started, monitoring progress, setting goals, rewarding, and support • Opportunity to contact helpline by e-mail or telephone inc case of questions, concerns, or problems	• Waiting list	• Moderate intensity PA (min/week) • Walking (min/week)	• Moderate PA: • I: 68.8 ± 58.1 • C: 80.9 ± 77.8 • Walking: • I: 57.2 ± 56.9 • C: 87.6 ± 177.4	• Moderate PA: • I: 112.0 ± 75.7 • C: 82.0 ± 87.3 • Walking: • I: 99.8 ± 68.3 • C: 68.4 ± 85.2	Significant between-groups differences for moderate intensity PA and walking.

Marshall et al (28), 2003	• Access to a stage-targeted PA website containing stage-based quizzes with feedback, personalised sections on goal setting, activity planning, targeted heart rates and a PA readiness questionnaire • Personalised reinforcement e-mails sent every 2 weeks containing stage-targeted PA information and links to study website	• Stage-targeted printed booklets sent by postal mail containing PA information based on Transtheoretical model of behaviour change • Additional printed reinforcement letters sent by postal mail every 2 weeks containing stage-targeted PA information	• Total amount of PA (MET min/week) • Total amount of sitting (MET min/week)	• PA*: • I: 2425 ± 113 • C: 2413 ± 115 • Sitting time*: • I: 2263 ± 57 • C: 2221 ± 56	• PA*: • I: 2433 ± 121 • C: 2518 ± 115 • Sitting time*: • I: 2158 ± 48 • C: 2150 ± 49	No significant between-groups differences for PA and sitting time
Section B: Comparison of two different types of Internet-based physical activity interventions						
Van den Berg et al (31), 2006	• Access to website containing a personalised PA program consisting of weekly personalised physical activity schedules with weekly personalised feedback provided by physical therapist • Access to online discussion forum to contact other participants • Access to face-to-face group meetings very 3 months • A bicycle ergometer was given on loan during intervention period	• Access to website containing general PA information which was up-dated once a month • Opportunity to order free copy of PA-related CD-ROM	• Moderate PA (% patients meeting moderate PA recommendations) • Vigorous PA (% patients meeting vigorous PA recommendations)	• Moderate proportions: • I: 0 • C: 0 • Vigorous proportions: • I: 6 • C: 1	• Moderate %: • I: 26 • C: 15 • Vigorous %: • I: 34 • C: 10	Significant between-groups differences for vigorous PA, not for moderate PA
Hageman et al (37), 2005	• One initial face-to-face assessment of behavioural markers and biomarkers • Three online newsletters containing individually tailored information about PA goals, benefits and barriers to PA and self-efficacy delivered by Internet every month.	• One initial face-to-face assessment of behavioural markers and biomarkers • Three online newsletters containing general information about PA goals, benefits and barriers to PA and self-efficacy delivered by Internet every month.	• Moderate or vigorous PA (min/week) • Energy expenditure (kcal/kg/day)	• PA: • I: 937.6 ± 616.5 • C: 1228.1 ± 119.7 • E expenditure: • I: 28.7 ± 5.0 • C: 28.9 ± 5.7	• PA**: • I: 672.5 ± 643.9 • C: 906.0 ± 775.8 • E expenditure**: • I: 26.5 ± 5.0 • C: 27.3 ± 4.6	No significant between-groups differences for moderate or vigorous PA and energy expenditure

Rovniak et al (27), 2005	• One 30 min. face-to-face session providing information about walking plus modelling of 3 walking skills • Specific and tailored email-based walking prescription by supervisor • Immediate and precise self-monitoring of walking information by participants by means of online walking logs • Weekly specific feedback by supervisor about walking performance relative to past accomplishments and normative standards sent by e-mail	• One 30 min. face-to-face session only providing information about walking • General email-based walking prescription by supervisor • General self-monitoring of walking information by participants by means of online walking logs • Weekly general feedback sent by supervisor about walking performance	• Walking (min/week)	• I: 17.5 ± 20.9 • C: 16.4 ± 24.8	• I: 74.5 ± 49.9 • C: 61.2 ± 38.8	No significant between-groups differences for walking time
Tate et al (30), 2003	• One introductory face-to-face group weight loss session (1 hour) in which instructions regarding weight loss and increasing PA levels were given by clinical therapist • Access to educational website containing information about weight loss including tips, links and other Internet resources • Instructions to report dietary and PA self-monitoring information weekly by means of website diary. • 5 e-mails per week sent by therapist in the 1st month, weekly e-mails for remaining 11 months. E-mails contained personalised feedback, recommendations, reinforcements, answers to participants' questions, and general support	• One introductory face-to-face group weight loss session (1 hour) in which instructions regarding weight loss and increasing PA levels were given by clinical therapist • Access to educational website containing information about weight loss including tips, links and other Internet resources • Encouragements to use online dietary and PA self-monitoring tools • Weekly e-mail reminders sent by therapist to submit self-monitoring data	• Exercise energy expenditure (kcal/week)	• I: 886 ± 832 • C: 803 ± 1015	• I: 342 ± 945*** • C: 63 ± 1211***	No significant between-groups differences for exercise energy expenditure

McKay et al (34), 2001	• Access to website containing a personalised PA program based on baseline online assessment of PA level. PA program consisted of personalised goal setting, activity selection, scheduling PA, overcoming barriers • Access to personal PA database containing additional PA-related information, and PA logs with graphs of progress • Provision of personalised counselling and support provided by a personal coach by means of online messages • Access to peer-to-peer support groups	• Access to website containing diabetes specific articles plus real-time blood glucose tracking with graphic feedback	• Moderate-to-vigorous intensity exercise (min/day) • Walking (min/day)	• Exercise: • I: 5.6 ± 6.2 • C: 7.3 ± 6.2 • Walking: • I: 6.4 ± 6.2 • C: 8.4 ± 8.4	• Exercise: • I: 17.6 ± 15.3 • C: 18.0 ± 17.3 • Walking: • I: 12.5 ± 9.5 • C: 16.8 ± 22.8	No significant between-groups differences for moderate-to-vigorous intensity exercise or walking
Tate et al (29), 2001	• One introductory face-to-face group weight loss session (1 hour) with instructions regarding weight loss and increasing PA levels given by clinical therapist • Access to educational website containing information about weight loss such as diet, exercise, self-monitoring, social support, stimulus control, managing stress • A brief 15 min. face-to-face check in with therapist every 3 months • Instructions to report dietary and PA self-monitoring information weekly by means of website diary • Weekly e-mails sent by therapist containing behavioural weight loss lesson, personalized feedback, recommendations, reinforcements, and general support • Access to electronic bulletin board	• One introductory face-to-face group weight loss session (1 hour) in which instructions regarding weight loss and increasing PA levels were given by clinical therapist • Access to educational website containing information about weight loss such as diet, exercise, self-monitoring, social support, stimulus control, and managing stress • A brief 15 min. face-to-face check in with therapist every 3 months • Encouragements to use online dietary and PA self-monitoring tools	• Exercise energy expenditure (kcal/week)	• I: 1360 ± 1415 • C: 1031 ± 981	• I: 1289 ± 919 • C: 1125 ± 1320	No significant between-groups differences for exercise energy expenditure

I = intervention group, C = control group, PA = physical activity

Post-test results = results measured directly after end of total intervention period

* Values of pre- and post-test data represent mean ± SE

** Post-test data measured not directly after intervention (1 month after sending last newsletter)

*** Values of post-test data represent change scores (mean ± SD)

For the study of Van den Berg et al (31) only the primary outcomes are presented (i.e. the proportions of patients meeting moderate and vigorous physical activity recommendations). The secondary physical activity outcome measures, assessing the total number of days per week of moderate and vigorous activity, showed similar results, producing significant between-group differences for vigorous physical activity, not for moderate activity. In addition, in this study physical activity was also measured by an activity monitor. These data did not bring on any significant between-group differences.

Discussion

The number of randomised controlled trials on the effectiveness of Internet-based physical activity interventions is limited. This review represents the best available evidence so far. Two investigators independently assessed all articles and abstracts, and consensus was reached concerning both the inclusion of the studies as well as the data extracted.

Four studies were identified in which it was investigated whether an Internet-based physical activity intervention is more effective than a non-Internet-based intervention. In one of these studies the Internet-based physical activity intervention was compared with a print-based version of the intervention. In the other three studies the Internet-based intervention was compared with a waiting list control group, two of which reported significantly greater increase in physical activity in the Internet-based intervention than in the waiting list group. However, the effect sizes which were reported in only one of these two studies were small, indicating that the clinical relevance remains questionable.

Six studies were identified in which two different types of an Internet-based physical activity intervention were compared among each other, in order to identify the key or critical component(s) of an Internet-based physical activity intervention. In these studies, the most important difference between the intervention and control group was the degree of personalization: participants from the intervention group received tailored or personalised web-based information, whereas the control group received more general or standard information. Of these six studies, one study reported significant differences between the two interventions with respect to change in physical activity levels. However, in this study the provision of personalised supervision was not the only difference between the intervention and control group. As opposed to the participants from the control group, participants from the intervention group did also

receive a bicycle ergometer and were offered peer-to-peer group contacts. Therefore, it could not be established which of these components caused the increase in effectiveness compared to the Internet-based intervention with the general information.

Based on the above-mentioned results of this review, we conclude that there is indicative evidence that Internet-based physical activity interventions are more effective than a waiting list group. With respect to the active components, for example adding individual tailoring, the evidence is scanty. Several factors may have contributed to the limited evidence of effectiveness.

Firstly, the number of eligible studies was limited. The Internet is a relatively new tool for delivering physical activity interventions. Moreover, many of the interventions that did use the Internet for program delivery, did not report their outcomes in terms of changes in physical activity levels, but used indirect measures such as changes in weight, heart rate, maximal oxygen uptake, or stages of motivational readiness.

Secondly, this review comprised mainly short-term physical activity interventions. Only three studies incorporated interventions of 6 months or longer. The literature suggests that long-term changes in physical activity behaviour can only by accomplished by studies with long-term follow-up (38). However, no guidelines exist regarding the optimal duration of interventions. Therefore, more research should be done evaluating the minimal duration of physical activity interventions in order to produce long-term physical activity behaviour changes.

Thirdly, the methodological quality of the selected studies varied. Only half of the ten selected studies were rated as having a good methodological quality. Lack of information about blinding of the outcome assessor, no description of sample size calculation, no intention-to-treat analysis and insufficient description of the randomization and concealment method were the most important reasons for low scores on methodological quality. This may have influenced the results found in these studies, since it has been showed that inadequate methodological approaches in controlled trials, particularly those representing poor allocation concealment, are associated with bias (39).

Furthermore, the baseline physical activity levels of the persons participating in the interventions differed, making it difficult to report on the overall effectiveness of these interventions. Moreover, four studies in this review did not report any baseline physical activity levels. Since physically active persons in general are better able to comply with physical activity interventions and maintain a healthy lifestyle than sedentary persons (40-42), incomplete or inconsistent information about baseline physical activity levels may have influenced the results found.

Another limitation is the fact that the contents of the control intervention differed widely. In some studies participants from the control group received more general or standard versions of an Internet-based physical activity intervention, in other studies these participants received a print-based version of the intervention or were assigned to a waiting list. The exact surplus value of adding personalised supervision to an Internet-based physical activity intervention could not be established because in most studies besides this supervision, other components were added as well. The two studies that compared the Internet-based physical activity intervention with a waiting list both reported significant differences between the intervention and control group. This may indicate that, when trying to increase people's physical activity levels, providing an Internet-based physical activity intervention is more effective than doing little or nothing. However, more studies are needed to establish this conclusion. With respect to determining the effectiveness of different components of an Internet-based physical activity intervention, more studies are needed using appropriate research designs, i.e. designs in which the only difference between the intervention and the control group is the addition of a specific component, such as providing personalised supervision.

The lack of uniform physical activity outcome measures in the reviewed studies, introduces another limitation. Some studies report their outcomes in time (e.g. minutes or hours per day/ per week), energy expenditure (e.g. kcal or METs per day/ per week), or categorical variables such as proportions of persons meeting physical activity recommendations. Moreover, all physical activity outcomes were based on self-reported measures. Although most of these measures were validated instruments, additional objective measures of physical activity would have strengthened the value of the selected studies.

In this review, in six studies the researchers have used one or more theoretical models to compose the interventions. The Transtheoretical Model and the Social Cognitive Theory were the two most frequently used theories. This review could not demonstrate that theory-based physical activity interventions conducted through the Internet are more effective than non-theory-based interventions. Although there is some evidence that interventions in which these models are incorporated are effective in increasing physical activity levels (43-45), other researchers still question this effectiveness (46). Further research on the surplus value of these models in promoting complex health behaviour such as physical activity is needed.

In conclusion, there are limited numbers of randomised controlled trials demonstrating that Internet-based physical activity interventions are more effective when compared to non-Internet-

based interventions. Although this review could not provide indisputable evidence that Internet-based physical activity interventions are effective with respect to improving participants' physical activity levels, nor which components of an Internet-based physical activity intervention can be identified as the key components within these interventions, we would like to conclude that delivering physical activity interventions by means of the Internet or e-mail is a promising intervention strategy to promote physical activity. An important advantage of Internet-based interventions is that it can reach large numbers of people at relatively low costs. However, more cost-effectiveness studies should be done in order to establish the exact surplus value of this delivery method when compared with more traditional methods, such as face-to-face sessions. Moreover, future research should properly define the control groups and incorporate both long-term as well uniform physical activity outcome measures.

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Appendix 1: Criteria of methodological quality

1. Were the eligibility criteria specified?
2. Was the method of randomization described?
3. Was the random allocation concealed? (i.e. was the assignment generated by an independent parson not responsible for determining the eligibility of the patients?)
4. Were the groups similar at baseline regarding important prognostic indicators?
5. Were both the index as well as the control interventions explicitly described?
6. Was the compliance or adherence with the interventions described?
7. Was the outcome assessor blinded to the interventions?
8. Was the drop-out rate described and were the characteristics of the drop-outs compared with the completers of the study?
9. Was a long-term follow-up measurement performed (outcomes measured ≥ 6 months after randomization)?
10. Was the timing of the outcome measurements in both groups comparable?
11. Was the sample size for each group described by means of a power calculation?
12. Did the analysis include an intention-to-treat analysis?
13. Were point estimates and measures of variability presented for the primary outcome measures?