

The use of eHealth to promote physical activity in thoracic malignancies survivors: a systematic review and meta-analysis.

Janet Rodríguez-Torres

University of Granada: Universidad de Granada

Andrés Calvache-Mateo

University of Granada: Universidad de Granada

Araceli Ortíz-Rubio

University of Granada: Universidad de Granada

Natalia Muñoz-Vigueras

University of Granada: Universidad de Granada

Laura López-López

University of Granada: Universidad de Granada

Javier Martín-Núñez

University of Granada: Universidad de Granada

Marie Carmen Valenza (✉ cvalenza@ugr.es)

Universidad de Granada <https://orcid.org/0000-0003-2368-1307>

Research Article

Keywords: eHealth, physical activity, thoracic malignancies, survivors

Posted Date: May 7th, 2021

DOI: <https://doi.org/10.21203/rs.3.rs-427148/v1>

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Abstract

Purpose

Survival rates for many forms of thoracic malignancies have improved over the past few decades, however, many survivors are coping with the side effects of cancer treatment for longer. Physical activity has been proposed as a therapeutic strategy to act across multiple organ systems and improve clinical outcomes and eHealth could be a good way to encourage patients. The aim of this systematic review was to explore the effects of eHealth in the promotion of PA among thoracic malignancies.

Methods

Suitable articles were searched using PubMed, Web of Science and Scopus databases using a combination of medical subject headings. Articles were screened by two independent reviewers and were included if they presented an eHealth intervention to improve PA in thoracic malignancies.

Results

In total, 4781 articles were identified, of which ten met eligibility criteria. Different eHealth interventions were described in these studies: mobile application (app) (n=3), website (n=2), email (n=2), web and mobile application (n=1), telephone counseling (n=1) and online sheet (n=1). All studies reported improvements in PA, with 8/10 studies reporting statistically significant changes.

Conclusion

Meta-analysis revealed eHealth is a good way to improve PA in thoracic malignancies survivors, compared to no intervention, conventional treatment or a diet approach. Future studies are needed to clarify the specific intervention to improve these patients' recovery.

Introduction

Thoracic malignancies (TM) are amongst the most lethal of all cancers and include non-small cell lung cancer (NSCLC), small cell lung cancer (SCLC), breast cancer, lymphoma and malignant pleural mesothelioma (MPM) [1]. The prevalence of TM is increasing worldwide in the last years [2–5]. For both sexes combined, lung cancer is the most commonly diagnosed cancer (11.6% of the total cases) and the leading cause of cancer death (18.4% of the total cancer deaths), closely followed by female breast cancer (11.6%) [6].

Surgical resection remains the only potentially curative option for a wide variety of these diseases [7, 8]. However, as with any oncological surgery, complications are a significant cause of morbidity [9]. Despite significant advancements in surgical techniques and postoperative care, complications from resection are considerable and largely depend on the extent, the cardiopulmonary reserve of the patient, and the presence of comorbid disease [10, 11]. It can produce negative short and long-term physiologic and or psychological effects, including pain, decreased cardiorespiratory capacity, cancer related fatigue, reduced quality of life, and suppressed immune function [12].

Given that survival rates for many forms of thoracic malignancy have improved over the past few decades, many people are coping with the side effects of cancer treatment for longer [13]. Physical activity (PA) has been proposed as a nonpharmacologic intervention to combat these effects of treatment in cancer survivors [14, 15]. It is a pleiotropic therapeutic strategy with the capacity to act across multiple organ systems to facilitate attenuation and/or prevention of cancer therapy-associated morbidity as well as improve clinical outcomes in cancer survivors so, it has been the focus of many studies [16, 17].

Electronical health (eHealth) is an emerging concept in healthcare which may present opportunities to improve PA in cancer survivors [13, 18]. eHealth has the potential for improving access to and enhancing the quality of healthcare [19], decreasing

healthcare costs [20], supporting self-management for chronic diseases, reducing patients' visit to healthcare centers, and enhancing the capability of providing individual, regional, and on-demand services [21, 22]. A number of systematic reviews have been published which primarily focused on eHealth-based PA interventions in community dwelling adults or in general populations from paediatric to older age groups [23–26]. Results consistently supported the effectiveness of eHealth interventions for promoting PA in those populations.

eHealth interventions may be an effective strategy for improving PA for thoracic malignancies survivors. To our knowledge, no systematic review has synthesized the literature on eHealth interventions to increase PA in this population. So, the present systematic review and meta-analysis aimed to find and evaluate studies related to PA designed for TM and implemented through eHealth.

Methods

This review has been written in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement [27]. It was registered at the International Prospective Register of Systematic Review (PROSPERO) with registration number: CRD42021215251. The search took place between November and February 2021. An electronic search was conducted using three electronic databases: PudMed, Web of Science and Scopus. The search strategy was created for MEDLINE and amended for each database using the following Medical Subject Head-ings (MeSH) terms and keywords (Appendix I). Relevant publications were included from inception until 1 February 2021. Two independent reviewers, who consulted a third one if there was any disagreement regarding the inclusion or exclusion of a paper, conducted the screening process. To define the research question, the PICOS model was applied:

- (P) Population: Adults ≥ 18 years of age, who were non-small cell lung cancer, small cell lung cancer, breast cancer, lymphoma or malignant pleural mesothelioma survivors.
- (I) Interventions: Studies in which physical activity interventions were given as a single intervention or integrated with any other interventions. Type, dose and frequency of PA were not limited.
- (C) Comparison: A standardized conventional program or any other intervention not focused on physical activity.
- (O) Outcome: Trials also had to include an outcome report on at least one measure of physical activity (eg. accelerometer, International Physical Activity Questionnaire)
- (T) Timing: at any time after the cancer treatment.
- (S) Setting: no restriction of setting.

The systematic review was limited to randomized and nonrandomized controlled trials written in English, French, and Spanish languages. Exclusion criteria were reviews and meta-analyses, books, practice guidelines, conference papers, theses or dissertations, letters, and abstracts.

After the records were obtained from the different databases, duplicates were removed. Then, two reviewers performed independent evaluations of the titles and abstracts of all obtained papers and further reviewed the studies to ensure eligibility. All disagreement or differences in criteria were resolved by a third reviewer. After the studies selection, data was extracted and a quality assessment was performed. The methodological quality of the included studies was assessed by two independent researchers using the Downs and Black quality assessment method [28]. It contains 27 items divided into 5 sections: study quality, external validity, study bias, confounding and selections bias, and study power. It is considered excellent when it reaches a score between 26 and 28 points, good between 20 and 25, fair between 15 and 19, and poor when it is less or equal to 14. This scale has been ranked as one of the six best quality assessment scales suitable for use in systematic reviews because of its high validity and reliability [29,30].

The risk of bias was assessed using the Cochrane Risk of Bias Tool for Randomized Controlled Trials method [31]. It consists of seven elements with six subscales (selection bias, performance bias, detection bias, attrition bias, reporting bias and other bias). It is considered that a study is of high quality when there is low risk for each domain. Fair quality when one criterion does not meet (i.e. high risk of bias for one domain) or two criteria are unclear, and there is no known important limitation that could invalidate the results. Poor quality, when one criterion does not meet or two criteria are unclear, and there are important limitations that could invalidate the results; and when two or more criteria are listed as high or unclear risk of bias.

When possible, study results were pooled and a meta-analysis was undertaken using Review Manager Software (RevMan version 5.1, updated March 2011). We performed the meta-analysis on all studies which presented self-reported or objectively measured physical activity post-intervention means and standard deviations. When data for physical activity were insufficient for meta-analyses purposes, we contacted trial authors where possible. The I^2 statistic was utilized to determine the degree of heterogeneity, where the percentages quantified the magnitude of heterogeneity [32]: 25%=low, 50%=medium, and 75%=high heterogeneity. A random effects model was used when I^2 was 50%. With the aim of illustrating the overall effect of interventions, forest plots were generated to.

Results

A total of 7906 records were initially identified through database searching. After deleting duplicates, a total of 4781 studies were selected. Finally, a total of 10 studies were included in the review, with a total of 1835 participants analyzed. The PRISMA flowchart is depicted in Figure 1.

The characteristics of the studies included are presented in Table 1.

All included studies were published between 2011 and 2020. Mean ages of participants ranged from 44.6 [37] to 59.18 years [40]. The percentage of women were higher in all studies (79.2-100%), even including only women some of them [34,36,37,40]. In regard to the cancer etiology, most studies included only patients with breast cancer [34-42]. The cancer treatment included surgery, radiotherapy, chemotherapy, hormone therapy or a combination thereof. Table 1 also shows the modified Downs and Black scale scores. The mean score of the studies included was 20.1. Based on the cut points suggested to categorize studies according to their quality, three articles were evaluated as "fair" (15–19 points) and seven were classified as "good".

The risk of bias assessment using the Cochrane Risk of Bias Tool for randomized trials is presented in Table 2.

The main characteristics of the studies included are shown in Table 3.

Table 3 includes the intervention type, the approach of the comparator group, the eHealth system used, the duration, the physical variables included and the main results.

Comparator group approach

Six studies compared the eHealth intervention with a comparator group who did not received any intervention [33,37,38,40-42]. Three studies compared the eHealth physical activity intervention with a conventional treatment (information [34], brochure [39], traditional physical activity [36]) and one study compared the eHealth physical intervention with a diet intervention [35].

eHealth system

Most studies included used a mobile app to carry out the physical activity intervention [34,36,39]. Two studies performed the physical activity intervention using interactive emails [35,38]. Two studies used a website to instruct and provides personalized feedback to patients [33,42]. One study carried out the physical activity intervention using the Fitbit app or website, and adding regular emails and phone calls [41]. One study used an online sheet to increase physical activity and other study carried out telephone counseling sessions to guide the physical activity intervention [37]. Feedback during physical activity intervention was used in seven of the included studies [33,34,37,39-42].

Duration of the intervention

Details of the intervention duration for each study are also presented in Table 3. Median intervention length was 3.2 months (range 1–6 months). The majority of the studies performed a three months intervention [35,37-41], two studies carried out an intervention during 6 months [33,34] and two studies performed a 4 weeks treatment [36,42]. No specific prescriptions about physical activity frequency were provided in most studies.

Physical activity variables

The included studies evaluated PA using different tools, e.g. using the International Physical Activity Questionnaire (IPAQ) [37,39,42], the Short Questionnaire to Assess Health Enhancing Physical Activity (SQUASH) [33], the Godin-Shepard Leisure-Time Physical Activity questionnaire [34,40], the Physical Activity Questionnaire (PAQ) [35], the Behavioral Risk Factor Surveillance System (BRFSS) [37], the ActiGraph wGT3X-BT [36,41] or the FitBit One [41]. The most reported outcome was the IPAQ, followed by the Godin-Shepard Questionnaire and the ActiGraph wGT3X-BT.

Results obtained in meta-analysis

Data from 9 RCTs were included [33-40,42]. Excluded studies did not provide (sufficient) physical activity data (either baseline and/or post intervention means and standard deviations) and attempts to contact trial authors were unsuccessful. The analysis was based on 1314 patients (658 for intervention and 656 for control).

For the physical activity level, the pooled mean difference (MD) showed significant overall effect when compared the eHealth intervention to no intervention (MD=1.14; 95% CI=0.18, 2.10; $p=0.02$; five studies [33,37,38,40,42]), to a conventional treatment (MD=0.20; 95% CI=0.02; 0.38; $p=0.03$; three studies [34,36,39]) or to a diet intervention (MD=0.19; 95% CI=0.68; 1.70; $p<0.001$, one study [35]). Heterogeneity was high in the comparison with no intervention and conventional treatment ($I^2=96%$; $I^2=93%$), respectively.

These interventions resulted in an overall effect of 0.83 (95% CI 0.35–1.31), which was significant ($Z = 3.38$, $p<0.001$). There was significant ($\text{Chi}^2 = 15.78$; $p<0.001$) and high heterogeneity ($I^2 = 87.3%$) across the included comparisons.

Discussion

This systematic review and meta-analysis support the idea that eHealth interventions are effective to improve physical activity in thoracic malignancies survivors. Results revealed that the included interventions can increase the level of PA in these patients, compared to no intervention, conventional treatment or a dietary approach.

The use of novel technologies for evaluating PA is an objective, validated and reliable measure, which includes accelerometers, pedometers and multi-sensor systems transferring data to a website or a mobile application. In our review, 18% of articles used these tools for measuring PA [36, 41].

Most included studies increase the level of PA in malignant thoracic survivors regardless of its duration, which varies from 1 month [36, 42] to six months [32, 34] with follow-up periods until 12 months [32, 34]. The frequency and type of intervention may be a point which could affect the significance of results. Kuijpers et al. [42] presented results favorable to control group, which could be due to the differences found in the physical activity levels at baseline between both groups.

Our findings are in line with previous systematic reviews performed in cancer survivors population. Dorri et al. [43] performed a systematic review analyzing the effectiveness of eHealth interventions to improve physical activity in breast cancer. They reported eHealth systems are useful to improve physical activity levels and highlighted the need of developing tailored interventions for these patients. Haberlin et al. [13] carried out a systematic review about eHealth to promote physical activity in the general population of cancer survivors, also reporting its benefits. However, we have not found specific studies about the use of eHealth in thoracic malignancies survivors. So, this paper is relevant and needed to update and provide high quality level of evidence in this population.

When analyzing the results obtained comparing eHealth PA interventions to no treatment or other treatments, a significant difference was found in favour of physical activity group treated with eHealth. Previous meta-analyses have examined the effects of PA on cancer, several focused on breast cancer [44, 45] and general cancer [46, 47], showing similar results to our study.

Health interventions are presumed to have great potential to increase access to interventions, increase compliance, lessen the burden on healthcare staff, and are highly scalable [48]. Therefore, the results of the present review aim to improve health resources and quality of life in these patients.

Some limitations need to be reported. Firstly, the lack of consistency in the PA outcomes included across the different studies, with most studies including only self-reported outcomes. However, self-reported measures are validated tools to give information about the different outcomes [49]. Secondly, the small sample size of the reviewed studies. Researches on this topic must expand and increase in number. Thirdly, the majority of studies are scarce in the description of the dosage, intensity and individualization of the treatment which difficult the external validity of the data and the reproducibility of the protocols. Finally, the heterogeneity of included studies in the meta-analysis could have affected the analysis and the conclusions.

Our review has important clinical implications for rehabilitation practice, which need to be reported. eHealth interventions are useful tools which could be used to improve recovery after thoracic malignancies hospitalization due to their enormous potential to improve healthcare cost, effectiveness, and quality of care. eHealth interventions have demonstrated specific results in physical activity level, previously related to an improvement in psychological, physical and emotional quality of life parameters for cancer survivors. Future research with larger samples should focus on specific parameters of eHealth interventions to determine how and when they are effective in the treatment of thoracic malignancies survivors. Moreover, future research may also investigate the optimal eHealth medium to increase PA among these survivors.

Conclusion

This systematic review and meta-analysis provide a comprehensive assessment of the effects of eHealth interventions on PA in thoracic malignancies survivors, which can be used as a supportive opportunity for these patients. Results revealed that the included eHealth interventions can increase the level of PA in these patients, however, no clear specific parameters and duration are reported.

Declarations

Funding

This work was supported by the Spanish Ministry of Education [grant numbers, FPU:16/01531 and FPU:17/00408].

Conflicts of interest/Competing interests

Nothing to declare.

Availability of data and material

Not applicable.

Code availability

Not applicable.

Authors' contributions

Janet Rodríguez-Torres: methodology, data curation, writing-original draft.

Andrés Calvache-Mateo: data curation, formal analysis, supervision.

Araceli Ortíz-Rubio: supervisión, visualization.

Natalia Muñoz-Vigueras: conceptualization, methodology, supervision.

Laura López-López: data curation, visualization.

Javier Martín-Núñez: methodology, data curation.

Marie C Valenza: conceptualization, methodology, formal analysis.

Ethics approval

The study protocol was reviewed and approved by the University of Granada Ethics Committee (Granada, Spain). This study was performed in accordance with the Declaration of Helsinki (General Assembly of the World Medical Association, 2014).

Consent for publication

All authors give their consent for publication.

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Tables

Table 1. Characteristics of the studies included.

Author, year	No. of participants enrolled (EG/CG)	Mean age (years) (EG/CG)	Women (%) (EG/CG)	Cancer type	Quality assessment
et al. [33]	462	EG: 55.6 CG: 56.2	EG: 79.2 CG: 80.5	Breast cancer and other types	21
al. (2020)	127	EG: 51.4 CG: 56.7	EG: 100 CG: 100	Breast cancer	16
et al. [35]	71	EG : 52.7 CG : 51.8	-	Breast cancer	21
et al. [36]	21	EG: 52.8 CG: 51.44	EG: 100 CG: 100	Breast cancer	20
. (2011)	45	EG: 44.6 CG: 47.1	EG: 100 CG: 100	Breast cancer	21
et al. [38]	74	-	-	Breast cancer	20
et al. [39]	256	EG: 49.3 CG: 51.3	-	Breast cancer	23
et al. [40]	101	EG: 59.18 CG: 58.98	EG: 100 CG: 100	Breast cancer	22
et al. [41]	87	EG: 57.9	-	Breast cancer	19
et al. [42]	83	49.5	-	Breast cancer	18

EG: experimental group; CG: control group.

Table 2. Risk of bias of the Studies Included in the Systematic Review.

Article author, reference, year	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Other sources of bias
Kanera et al. (2017) [33]	Low	Low	High	High	Low	Low	-
Cairo et al. (2020) [34]	-	-	-	-	-	-	-
Paxton et al. (2017) [35]	Low	Unclear	High	High	Low	Low	-
Allicock et al. (2017) [36]	Low	Unclear	High	High	High	Low	-
Lee et al. (2011) [37]	Low	Low	High	High	Low	Low	-
Hatchett et al. (2012) [38]	Low	High	Low	High	Unclear	Unclear	-
Eun Uhm et al. (2016) [39]	Low	Low	High	High	Low	Low	-
Chapman et al. (2018) [40]	Low	Unclear	Low	High	Unclear	Low	-
Hartman	Low	High	Low	High	Unclear	Low	-

et al. (2018) [41]							
Kuijpers et al. (2016) [42]	Unclear	High	High	High	Low	Low	-

Table 3. Characteristics of the intervention, postural control measures, and main results of the studies included.

	Experimental group	Comparator group	eHealth system	Frequency (min. per session / sessions per week) and duration	Physical activity variables	Main results
e	Web-based self-management program with personalized feedback.	Usual care waiting list control condition.	Web-based intervention	Duration: 6 months.	SQUASH	- Between group significant differences in moderate PA after 12 months, in the intervention group.
	Vida app, a certified wellness coach oriented and provided regular feedback and motivation.	Guided "toolkit" with information and exercise material.	Mobile app	Daily feedback. Duration: 6 months.	Godin-Shephard Leisure-Time Physical Activity Questionnaire	- The Vida group demonstrated statistically significant improvements in "strenuous activity".
t	"A Lifestyle Intervention via Email" (ALIVE), individualized website and interactive emails. This group followed the PA track.	ALIVE, with the dietary intake track.	Email	Weekly feedback. Duration: 3 months.	PAQ	- The improvements in the physical activity track were greater than that of the dietary track. - The improvements in minutes of moderate physical activity per week were more than twice than that of the dietary track in the completers.
	"Creating Healthy Actions through Technology (CHAT)", a mobile app to promote PA and provide feedback.	The same intervention without tailored messages as feedback to the responses provided.	Mobile app	30 min/day (assessment) Twice/day (Random sampling Assessments) Duration: 4 weeks	BRFSS ActiGraph wGT3X-BT	- The mean daily PA was greater for the CHAT group, however, no significant differences were found. - Findings show feasibility and acceptability and potential of the intervention to positively impact PA.
.	Simultaneous	No	Telephone	30 min/week	IPAQ	- No significant

	Stage-Matched Exercise and Diet Intervention with individualized prescription.	intervention.	counseling sessions	Duration: 12 weeks		group-by-time interaction on physical activity existed between the two groups. - Women in the intervention group reported a greater increase in PA than the control group.
	Email messages to enhance participants' PA.	No intervention.	Email	Once per week (5 weeks) Twice per week (6 weeks) Duration: 12 weeks	A 7-day physical activity recall. Days per week achieving ≥ 30 moderate and/or vigorous PA.	- At 6 and 12 weeks, the intervention group reported significantly more days of PA. - The intervention group were more regularly engaged in PA and reported more days of exercise at weeks 6 and 12.
1	Aerobic and resistance exercise with a pedometer and a newly developed smartphone application to provide information and monitor the prescribed exercises.	Conventional programme using brochure to promote physical activity and exercise.	Mobile app	Duration: 12 weeks.	IPAQ (short form)	- Weekly physical activity was significantly increased in both groups and the increment was greater in the mHealth group, but was not statistically significant.
1	Online volitional help sheet to increase leisure time PA.	Implementation intention intervention.	Online sheet	Duration: 3 months	Godin-Shephard Leisure-Time Physical Activity Questionnaire.	- At 3 months a significant within-group increase in PA from baseline was demonstrated in the intervention group but not the implementation intention group. - The between group difference at 3 months was also significant.

Fitbit One app and ActiGraph.	No intervention.	Fitbit website or app.	Duration: 12 weeks	Fitbit One. ActiGraph GT3X+.	- Minutes of PA per week significantly differed over the 12 weeks. - Greater adherence to wearing the Fitbit was associated with greater increases in ActiGraph-measured PA.
Interactive portal including patient education, personalized material and PA support.	No intervention.	Website.	Duration: 4 weeks	IPAQ	- Median vigorous physical activity increased significantly from 0.0 to 360.0 MET-minutes per week for the total group but this effect was not apparent in the subgroup analyses.

PA: physical activity; SQUASH: Short Questionnaire to Assess Health Enhancing Physical Activity; PAQ: Physical Activity Questionnaire; IPAQ: International Physical Activity Questionnaire; BRFSS: Behavioral Risk Factor Surveillance System.

Figures

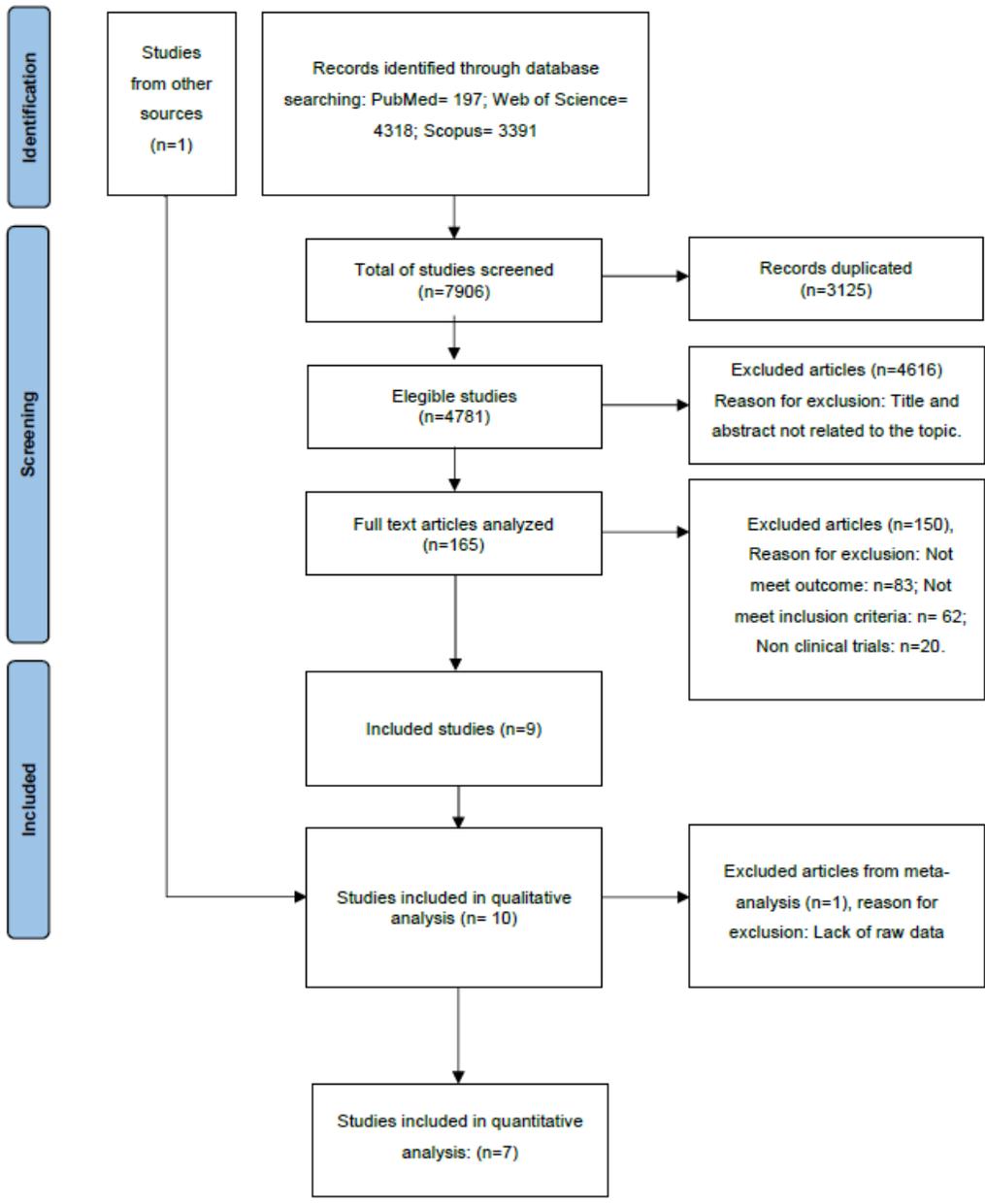


Figure 1

Flowchart of the literature search and studies included based on the PRISMA guidelines

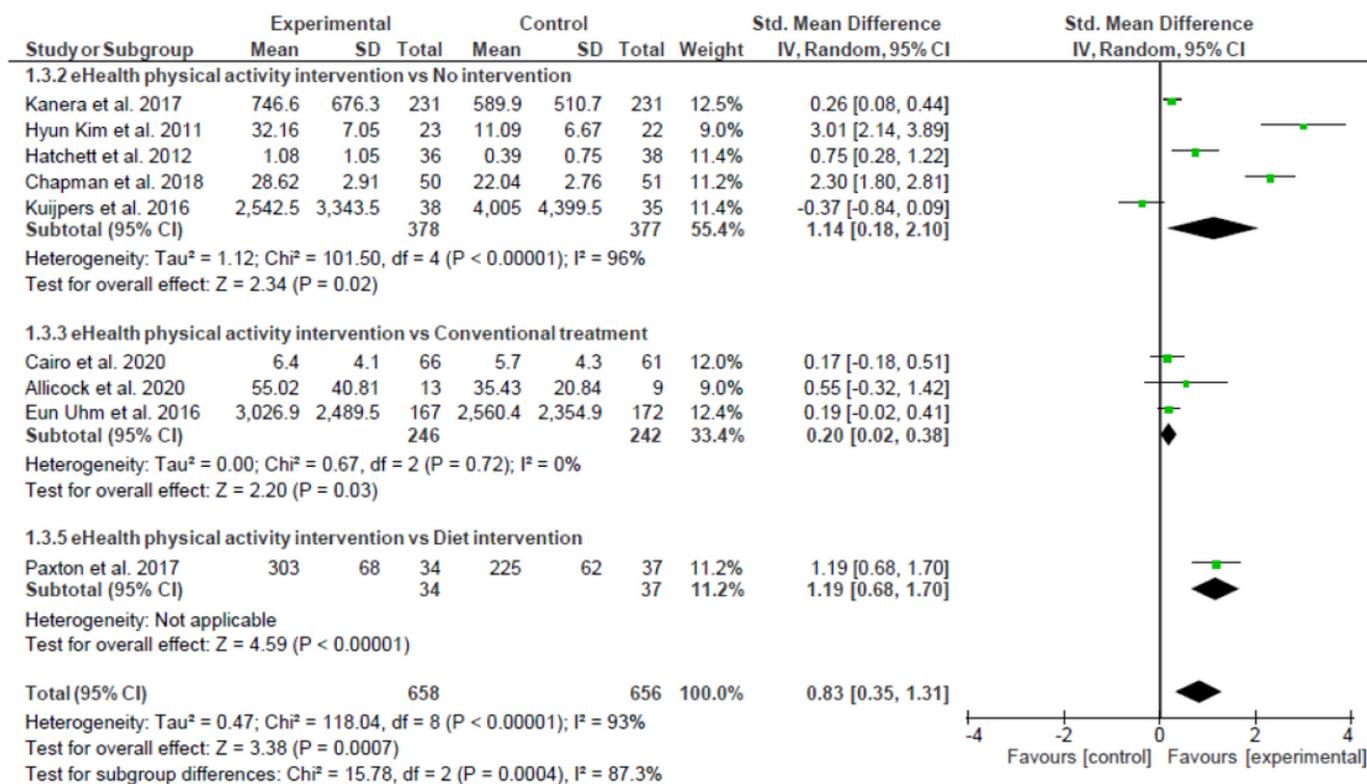


Figure 2

Forest plot of intervention effects on physical activity expressed as standardized mean differences.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Appendix1.docx](#)