Technology-supported physical activity and its potential as a tool to promote young women's physical activity and physical literacy: A systematic review.

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Abstract

Background: Despite the known benefits of physical activity (PA), globally, rates of engagement in PA remain low. The low engagement of PA among young women has the potential to impact their health. Technology-supported PA may be able to increase PA and physical literacy (skills that can support PA) among young women.

Objective: This systematic review aimed to investigate the: i) associations between technology-supported PA and PA levels, ii) associations between technology-supported PA and physical literacy levels and iii) the types of technology-supported PA that are associated with higher levels of PA engagement among women aged 13-24 years.

Methods: Eligible studies were original research, published in English between 2010 and 2023 from six databases; Medline Complete, SPORTDiscus, Global Health, Education Source, Applied Science, and EMBASE. The studies focused on young women between 13-24 years-old, were either technology-supported PA interventions or research exploring correlation between technology and PA and/or physical literacy. Quality was assessed using the Joanna Briggs Institute Critical Appraisal checklists for randomised control trials (RCT), cross-sectional and quasi-experimental study designs.

Results: Eligible studies were original research, published in English between 2010 and 2023 from six databases; Medline Complete, SPORTDiscus, Global Health, Education Source, Applied Science, and EMBASE. The studies focused on young women between 13-24 years-old, were either technology-supported PA interventions or research exploring correlation between technology and PA and/or physical literacy. Quality was assessed using the Joanna Briggs Institute Critical Appraisal checklists for randomised control trials (RCT), cross-sectional and quasi-experimental study designs.

Conclusions: This is the first review to investigate the literature exploring the use of technology-supported PA in young women. This review found limited evidence that technology-supported PA can improve young women’s PA or physical literacy. Given that technology-supported PA is still in its infancy, and technology is continuing to rapidly advance, further studies are needed to demonstrate the value and impact of technology-supported PA in improving PA and physical literacy among young women. Clinical Trial: PROSPERO International Prospective Register of Systematic Reviews CRD42022382471; https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42022382471

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Review

Technology-supported physical activity and its potential as a tool to promote young women's physical activity and physical literacy: A Systematic review.

Introduction

Background

Physical activity (PA) is considered one of the most effective ways to maintain good health across the lifespan [1, 2]. The World Health Organization (WHO) PA guidelines recommend at least 60 minutes of PA per day for those aged 5-17 years and 150-300 minutes per week for those aged 18-64 years [3]. Meeting the WHO PA guidelines helps individuals maintain a healthy weight, reduces the risk of developing non-communicable diseases such as type 2 diabetes and obesity [1, 2, 4], may improve mental wellbeing and increase academic performance [5, 6]. Despite the known benefits, global rates of PA engagement are low (36.8% failing to meet guidelines) [7]. **Women are significantly less likely to meet PA guidelines than men (32% vs. 23%) [7]. T**he lowest level of PA **is** seen in adolescent girls aged 11-17 years **with** 85% failing to meet guidelines, **compared to 78% of adolescent boys** [7].

Adolescence is the transitional period from childhood to adulthood, characterised by rapid growth and changing social expectations [8, 9]. The period of adolescence is generally considered to be between the ages of 13-17 years; health interventions seeking to improve adolescent health often focus on this age range [3, 8, 9]. Conversely, the United Nations (UN) defines adolescence as those aged 10-19 years-old, [10] with recent research suggesting that the period of adolescence should be widened further to include those aged 10-24 years [9]. Sawyer et al [9] suggests that a focus on 'young people,' which would include traditional adolescents (13-17 years-old) and young adults (18-24 years-old) would account for varying growth patterns and changes in the timing of social role transitions across different countries. Another consideration is the development of lifelong PA habits. Young people move through two transitional periods, starting secondary school and then higher education [1, 11, 12]. It is during this period that individuals become responsible for their own health and develop their PA beliefs and behaviours which generally remain consistent across the rest of their lifespan [1, 11-13]. Although adolescents and young adults have different experiences, focusing on both age groups targets the transitional periods in which PA engagement decreases. For these reasons, this review is focused on young women aged 13-24.

Given the known benefits of PA and the importance of developing healthy habits during adolescence, there have been numerous interventions seeking to increase PA engagement during this life stage [14-18]. These interventions are primarily aimed at those <18 years, with none examining those aged 13-24 years-old specifically [14, 16-18]. They also generally focus on both males and females within the target age range [14, 16-18]. One review [16] of school-based PA interventions identified a small increase in PA. While another review of 39 reviews of child and adolescent PA interventions reported a small positive effect [14], however, the review noted that the positive impact of the interventions was small.

As previous PA interventions seeking to improve young women's PA have had limited success, a different approach may be required [2, 14, 16, 17, 19-21]. One area of interest is the use of technology-supported PA as a strategy to increase PA [22-26]. Technology has been used as a tool for health promotion since the first mobile fitness applications (apps) were released in 2010 and its use increased during COVID-19 lockdowns [24, 27-30]. Technology-supported PA can be defined as the use of some form of interactive technology or digitally accessed information to promote PA either through; 1) demonstration of PA (e.g., pre-recorded, or live-streamed fitness classes), 2) interaction with a device that provides feedback (e.g., smartphones, fitness trackers), and/or 3) interaction with fitness professionals (e.g., online personal training) or other users of technology-supported PA (e.g., through a fitness app or social media platform) [24, 27, 29, 30]. Technology-supported PA is either self-led, when individuals use them in their own time (e.g., apps, fitness trackers), or facilitated, which are run by fitness professionals (e.g., personal trainers or yoga instructors) in real time which allows the trainer to interact with their client directly [24, 27, 29, 30].

Recent systematic reviews focusing on the general population, have suggested that technology-supported PA use is associated with increased PA and that the most successful types used behaviour change techniques, were easy to use, and included gamification, such as offering some competition or challenge [8, 18, 22, 25, 31]. These reviews have generally focused only on a single form of technology (e.g., apps, fitness trackers). The level of effectiveness of technology-supported PA on increasing PA varies, with some reporting an overall significant improvement in PA for intervention groups compared to comparison groups [32, 33] and others reporting no change in PA [34]. Reviews that did report improvements in PA, such as Champion et al., [35] (22 publications including 18,873 participants) and Lee et al., [33] (16 interventions) noted that only a few of the included studies had a post-intervention follow-up and when they were included it appeared improvements were not maintained [32, 33].

In addition to the potential benefits on young women's PA engagement, technology-supported PA could also improve young women's physical literacy [36-38]. **Physical literacy is a holistic approach to health that goes beyond simply engaging in PA, rather it is focused on developing the skills, behaviours, and confidence needed to lead an active life [37, 40, 41].** Physical literacy is complex in nature, and it is defined and conceptualised in various ways across the globe [36-39]. One of the most comprehensive understandings of physical literacy is conceptualised in the 'Australian Physical Literacy Framework' [40]. This framework groups the elements needed to improve physical literacy into four domains: physical (e.g., strength and movement skills), psychological (e.g., confidence and motivation), social (e.g., relationships and collaboration), and cognitive (e.g., content knowledge and reasoning) [40]. **Emerging research suggests that the development of PA habits is tied to the development of physical literacy [18, 36, 40, 41]. Studies seeking to improve physical literacy have focused primarily on school-aged children, with none examining young women specifically [36, 42, 43]. No review has examined whether technology-supported PA could impact each domain of physical literacy [8, 18, 22, 25].**

There is a need for further investigation of the effectiveness of technology-supported PA use by young women, and which types of technology may facilitate increased PA engagement and improve physical literacy. The purpose of this systematic review was to investigate, in young women aged 13-24: **the associations between different types of technology-supported PA and i) PA engagement, and ii) physical literacy.**

Method

The selection, analysis, and reporting of study results were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [44]. The search strategy was registered online with PROSPERO in December 2022 (CRD42022382471) **and there were no deviations from this protocol.**

Search strategy

A systematic search of six data bases was conducted (Medline Complete, SPORTDiscus, Global Health, Education Source, Applied Science, and EMBASE). **These databases were selected with advice from the University librarian due to their alignment with the review objectives.** The search **focused on articles published between 01/01/2010 and 24/04/2024.** The strategy combined synonyms for "young women," "technology-supported physical activity," and "physical activity" (see multimedia appendix 1 for a full list of terms used in the search) with truncation used to maximise search results.

Eligibility Criteria

Eligible studies included randomised control trials (RCTs) or non-randomised interventions investigating the effectiveness of technology-supported PA, as well as longitudinal and cross-sectional studies investigating the potential correlation between technology-supported PA use and PA engagement. Articles that were peer-reviewed, contained original research, were published in English, and published after 2010, were considered. The period from 2010 was selected as this was the year the first PA apps were released [45]. Studies that focused on women between the ages of 13 and 24 were the primary target. Reference lists of included articles were also searched for any studies that may have been missed in the initial literature search.

Study selection and screening

Studies were imported into the Covidence [46] online platform for screening. Qualitative studies, duplicates, articles not available in English, opinion articles, conference abstracts, systematic reviews and study protocols were excluded. **These study types were excluded as they either did not provide original data on the effectiveness of technology-supported PA or in the case of conference abstracts/non-English articles did not provide sufficient detail to undertake data analysis.** A full text inclusion/exclusion criterion (see multimedia appendix 2) was used by the research team to identify which articles should be included for data extraction. **Search terms related to physical literacy were not included in the database search, as the review focused on interventions that increased PA as the primary outcome of interest, in the analysis authors investigated if these interventions included elements of physical literacy.** Studies were excluded if they did not provide data on the target population, did not focus on increasing PA and if the technology was used to target specialised populations or those with chronic conditions, except for interventions focused on decreasing obesity. This is because preliminary searches indicated one of the main aims of obesity interventions was increasing PA, while interventions on other chronic conditions did not typically have PA as a key focus. In instances when a sample was the target age and included both males and females, studies were excluded if the results of young women were not reported separately.

Data extraction and synthesis

Extraction was conducted using Covidence and Microsoft Excel**. Generative AI was not used in any capacity.** Extracted data included author, country, intervention setting, study design, theoretical framework, participant characteristics and demographic information, study aims, how PA was measured, and the data collection tool(s) used. For the intervention studies, information on the length of the intervention and if any follow-up was conducted was also extracted. Details of the intervention and any control group was included as was the method of data analysis. Finally, information was provided on the effectiveness of the intervention and the effect size of any changes (if these were reported). **Title and abstract screening and data collection was conducted by at least two authors independently. Disagreements on inclusion were discussed with a third author as**

needed. Prior to the full data extraction process, the authorship team extracted data from a sample of the studies and compared their findings to ensure consistency with data extraction. Disagreements on inclusion between the two authors was discussed with a third author as needed.

To assess the effectiveness of interventions and the reported associations between the use of technology-supported PA and PA in the cross-sectional studies, the reviewers divided the studies into three categories of technology-supported PA: interactive website/social media, PA tracking mobile apps, and wearable fitness trackers. Analyses was then conducted based on the effectiveness of each of these categories of technology on PA (improvement/positive association, decline/negative association, null effect). Analysis of the effect the interventions had on the category of PA measured (accelerometry, PA intensity, guideline adherence, energy expenditure, step count, time spent walking, sessions of PA and increased exercise) was also conducted. The effectiveness of the interventions was assessed using a scale adapted from work conducted by Page et al., [47]. If less than 30% of the studies reported a positive effect on PA or physical literacy, then the impact was coded as no likely effect: '0'. If 30-59% of the studies reported improvements these were coded as uncertain '?' as there was a potential for a positive effect, but not enough data to confirm it [47]. While in instances where 60% or more of the studies reported improvements the results were coded as positive: '+'.

Included studies were assessed according to their alignment to any of the thirty elements of the 'Australian Physical Literacy Framework' [40]. Physical literacy is a newer concept and definitions on what it is and is not vary depending on the framework used [48]. Additionally, many studies explore outcomes that can be considered physical literacy without defining it as physical literacy [49]. The team agreed that outcomes related to changes in social support and self-efficacy would not be included as physical literacy outcomes. Though some aspects of social support could relate to elements within the social domain and self-efficacy could be related to the psychological domain of the 'Australian Physical Literacy Framework,' they are not included as part of this particular framework [40].

In addition to the effectiveness of the interventions on the PA of all young women 13-24 years-old the research team divided the sample into two subgroups, adolescents <19 years and young adults >19 years. This was to account for the potentially significant physical, physiological, social, and environmental differences between these subgroups as well as the different PA guidelines each age group needs to engage in to be considered physically active.

Quality assessment

Two authors independently assessed each publication for quality and risk of bias using the Joanna Briggs Institute (JBI) Critical Appraisal tools [44]. Three checklists were used to account for the different study designs used in the included articles: RCTs, cross-sectional, and quasi-experimental study designs. **To ensure consistency between the quality assessments and the reliability of quality analysis, the research team met to discuss how they would ensure consistency across all the checklists and the different study designs included in the review.** For example, questions in the cross-sectional and quasi-experimental checklists were adapted slightly to be more consistent with the RCT checklist. Originally, only the RCT checklist required exploration of both validity and reliability of the tools used, while the other checklists only required investigation of reliability; however, this was added to the cross-sectional and quasi-experimental checklists. Further, validity and reliability of the data collection methods was considered in reference to the target population of young women. Within the RCT checklist, some questions explored the blinding of both participants and assessors. The research team decided that participant blinding to treatment assignment only occurred in instances where the study explicitly stated blinding occurred or if each group received some form of intervention. The rationale being that blinding would be likely in this scenario as there would be no reason for the researchers to inform participants whether they were in the intervention or control group. When it came to assessor blinding, this was only considered if data collection was done in-person, not collected via online self-report. Each study was assessed following the relevant JBI checklist. **If agreement on study quality could not be reached, a third author resolved the discrepancy by undertaking an independent assessment of the publication and a final decision was made between the three authors.**

Results

Description of studies

The combined database searches yielded **23,609** results **(Applied Science = 1408, Education Source = 6292, EMBASE = 5432, Global Health = 2336, Medline Complete = 5724 and SPORTDiscus = 2417)**, **4716** were duplicates and removed, and **18,893** were screened by two authors via title/abstract. **At this stage there were 23 disagreements that were resolved via discussion with the two authors who screened the papers. After title/abstract screening was completed, 219 articles (seven resolved disagreements) were included in the full-text analysis.** Manual searches of the reference lists of these articles were conducted, but no additional relevant articles were found (see Figure 1).

Figure 1. PRISMA flow chart

Study Characteristics

In total, **23** articles **comprising 10,233 participants** were included in the final review. Of these, **18** were interventions (nine RCTs, **nine** non-randomised), **12** included a control group **(Multimedia Appendix 3)** [39, 50-60] and six had a single sample **(Multimedia Appendix 4** [61-66]. The remaining five studies were cross-sectional and investigated correlation between technology-supported PA and PA engagement **(Multimedia Appendix 5)** [67-71]. Five of the studies explored variables that can be classified as elements of physical literacy, though none mentioned physical literacy specifically **(Multimedia Appendix 6)** [39, 61, 63, 64, 70]. The studies included five elements within the psychological [39, 63, 64, 70] and physical [61] domains of the 'Australian Physical Literacy Framework' [40].

Sample sizes ranged from 16 [61] to 4128 [69]. Twelve of the studies only included the target population [39, 51-53, 55, 56, 58, 61-63, 65, 67] while the remaining ten also included other populations such as males, and individuals outside the target population age range [50, 54, 57, 59, 60, 64, 66, 68-71]. **Nine of the studies included only adolescents [50, 53, 57-60, 64, 65, 69], twelve focused on young adults [39, 51, 54-56, 61-63, 67, 68, 70, 71] and two looked at both groups [52, 66].** Six studies consisted of a sample that were overweight/obese [39, 53, 55, 56, 62, 63], and three focused on participants who were insufficiently active [52, 59, 65].

The types of technology-supported PA varied. Four interventions used fitness trackers [55, 57, 59, 64], ten used an interactive website/social media [39, 50-52, 54, 60-63, 65], and four used mobile apps [53, 56, 58, 66]. **When looking at fitness tracker interventions, three were conducted with adolescents [57, 59, 64] and one was conducted with young adults [55].**

Two interventions using mobile apps were conducted with adolescents [53, 58], one was focused on young adults [56] and the other on the whole sample [66]. Three of the website/social media interventions targeted adolescents [50, 60, 65], six focused on young adults [39, 51, 54, 61-63] and one focused on the whole sample [52]. Seven interventions used forms of technology-supported PA that had been designed specifically for the study either as a standalone intervention or combined with a commercially available form of technology [50-54, 59, 62, 63].

The cross-sectional studies compared various types of technology-supported PA including mobile apps, wearable devices, and fitness trackers [67-71]. **One of these focused on adolescents [69] and**

the other four on young adults [67, 68, 70, 71].

The most common intervention setting was universities [39, 51, 52, 54-56, 62, 63, 67, 70, 71], followed by high schools [50, 53, 57-60, 64], while five were conducted on the general population [61, 65, 66, 68, 69]. Half of the studies took place in the USA [52, 54, 55, 60, 62, 63, 65-68, 70], two were conducted in Australia [57, 61], while one study was conducted in Saudi Arabia [39], United Arab Emirates [51], **Israel [50],** China [71], Pakistan [56], Poland [53], Singapore [58], The Netherlands [59] and the UK [64]. Additionally, one study compared data between Finland and Ireland [69].

Nine studies reported being theory-based [51, 54, 55, 59, 62-65, 67], although Kattelmann et al., [54] and Melton et al., [55] did not specify which theory their intervention was based on. Social Cognitive Theory was the most common theory used [51, 62, 63, 65, 67] with McFadden [67] combining it with **the Transtheoretical Model of Behaviour Change**. The remaining two studies were based on Self-Determination Theory [59, 64]. **Three of the theory-based studies focused on adolescents [59, 64, 65] and six involved young adults [51, 54, 55, 62, 63, 67].**

The most common method of data collection was self-report surveys, with **12** studies using this method [39, 50, 53, 54, 59-61, 67-71], **five of these were studies of adolescents [50, 53, 59, 60, 69] and seven focused on young adults [39, 54, 61, 67, 68, 70, 71].** Device-based types of data were collected in five studies either with an accelerometer [64, 65], commercial fitness tracker [55] or step tracking commercial mobile app [56, 66]. **Both accelerometer studies were conducted with adolescents [64, 65], whilst tracking apps were used in two studies with young adults [55, 56] and one study across both age groups [66].** Six studies used a combination of subjective and device-based measures [51, 52, 57, 58, 62, 63], **two with adolescents [57, 58], three with young adults [51, 62, 63] and the other investigated the whole sample [52].**

Levels of PA were recorded as **time spent in PA (days and/or minutes per week) in eight of the adolescent studies [50, 53, 57, 59, 60, 64, 65, 69], five of the studies with young adults [51, 61, 67, 70, 71] and one study that investigated all young women [52]**. Both studies conducted on young adults by Joesph et al [62, 63] combined days/minutes of weekly PA with website engagement. Of the four studies that measured PA as total reported steps, **two were conducted on young adults [55, 56],** one with **adolescents [58], and the other with both age groups [66]. The final tools of PA measurement,** attendance to in-person PA sessions [39], total metabolic equivalent of task (MET) [54] and level of exercise engagement [68] were all use in interventions focused on young adults.

Just over half of the studies that included a control/comparison group reported a positive effect on PA (58% 7/12), four of these were RCTs [52, 53, 55, 59] and the other three were non-randomised studies (Multimedia Appendix 3) [39, 50, 51]. Of the six single-sample studies included in the review, three reported a positive outcome [62, 65, 66], two had no impact [61, 63] and one reported a decrease in PA post-intervention (Multimedia Appendix 4) [64]. All the cross-sectional studies included in the review reported a positive association between technology-supported PA use and PA engagement (Multimedia Appendix 5) [67-71].

Results of the quality assessment

The quality of the studies (summarised in figure 2) varied, with eight found to be of high quality [52, 55, 59, 62, 66, 68, 69, 71], **seven** of medium quality [50, 53, 54, 57, 60, 61, 63] and eight of low quality [39, 51, 56, 58, 64, 65, 67, 70].

All RCTs (figure 3) reported that true randomisation was used to assign participants to the intervention and control, that the groups were treated identically and that the outcome measurements used were the same for both groups [52-60]. However, many of the studies did not provide information on participant or assessor blinding, only two studies reported that allocation to treatment groups was concealed [56, 59], and only three used participant blinding [52, 53, 55]. No study reported if those delivering the intervention were blind to the treatment group, though half of these were due to the intervention being self-led, so the question was not applicable [52-56]. Additionally, no study stated if assessors measuring the outcomes of the intervention were blind to the treatment group. Five of these used self-report as the data collection so the question was not considered applicable [52, 54, 55, 58, 59] but the remaining four did use outcome assessors and either reported the assessors were not blinded [57] or did not report on it at all [53, 56, 60].

The studies assessed via the quasi-experimental checklist (figure 3) were found to be of lower quality, but this was in part due to the variation in study designs. As such, questions related to the use of comparison or control groups only related to Al-Eisa et al. [39], Ali et al. [51] and **Glaser et al. [50]. Al-Eisa et al. [39] and Ali et al. [51]** reported using a control and assessing the intervention and control groups in the same way but failed to provide information on similarities between the intervention and control. **Glaser et al. [50] reported assessing the intervention and control groups in the same way but also provided information on similarities between groups at baseline, which was why it was considered medium quality (56%).**

All studies outlined the independent and dependent variable under investigation, but none reported why the chosen method of data analysis was used [39, 50, 51, 61-65]. Only two studies collected data at multiple points during the intervention period [61, 62] and an intervention follow-up was only conducted by Joseph et al., [62] and Larsen et al., [65]. Only one of the studies assessed with the quasi-experimental checklist was found to be of high quality [62], while half of the studies included in this systematic review that were considered low quality were from this group [39, 51, 64, 65].

Six studies were assessed with the JBI cross-sectional checklist (figure 3), four of these were considered high quality [66, 68, 69, 71] while the remaining two were considered low quality [67, 70]. All studies provided details on the study subjects and setting, how the outcomes were measured in a valid and reliable way and the appropriateness of the statistical analysis method used [66-71]. However, only half of the studies clearly defined the participant inclusion criteria and reported if objective standard criteria were used for the measurement of the condition under investigation [66, 69, 71]. While only three identified potential confounding factors and how these factors were addressed [68, 69, 71]. Once quality assessment had been conducted, the research team found that only Ng et al., [69] and Wang et al., [71] provided enough information to positively answer all of the checklist questions.

Figure 2. Overall quality of the included studies
Figure 3. Quality assessment for each study design

Summary of the findings.

Associations with physical activity outcomes

A summary of the study results according to the three types of technology-supported PA (interactive website/social media, physical activity tracking mobile app, wearable fitness tracker) and the type of PA measures assessed is provided in Table 1.

The included studies explored 53 different PA measures which were grouped into eight types: accelerometry, PA intensity and duration, PA guideline adherence, energy expenditure, step count, walking, PA sessions and increased exercise. Most of the studies explored more than one type.

The most common PA outcome was self-reported intensity (**15** studies with 26 different analyses) which included both the type of PA such as light, moderate, or vigorous as well as the duration measured as minutes or days per week. Across the **15** studies that reported PA intensity [50, 51, 53, 54, 57-65, 70, 71] a positive effect or association was reported in **41% (11/27 analyses),** so it was rated as uncertain of effect '?.'

Energy expenditure was the next most common outcome (four studies using seven analyses) that included MET and number of calories expended per PA type. Of the studies that included this measure, three measured min/week of MET [54, 58, 61] while Cavallo et al., [52] measured PA as amount of kcal. The results of these interventions reported that technology-supported PA had no likely effect on participant PA [52, 54, 58, 61], and thus was rated as ‘0’.

Walking was measured as self-reported days/minutes per week or minutes per day of PA in three interventions [51, 54, 61] and one cross-sectional study [71]. Only one intervention reported that the use of technology-supported PA had a positive effect [51] while the rest reported a null result [54, 61, 71], thus rated as having no effect, ‘0’.

Adherence to PA guidelines (four analyses) was used as a measure in three cross-sectional studies [39, 69, 71]. The guidelines used were those provided by the WHO [69, 71] and the ACSM [67]. All forms of technology-supported PA measured were associated with greater adherence to PA guidelines [67, 69, 71], and therefore rated as having a positive effect, ‘+’.

The overall positive impact of technology-supported PA was uncertain as only **36% (19/53 analyses)** reported a positive effect.

Table 1. Summary of physical activity results in the expected direction classified by type of PA measurement.

	Interactive website/social media			Physical activity tracking mobile app			Wearable fitness tracker			Summaries
	Positive [a]	**Negative**[a]	**Null** [a]	**Positive** [a]	**Negative**[a]	**Null** [a]	**Positive** [a]	**Negative**[a]	**Null** [a]	
Accelerometry										
Accelerometry Counts		Larsen et al 2018[f]	Joseph et al 2016[f]						Melton et al 2016[e] Ridgers et al 2021[e]	0/4
SUMMARY	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**2**	**0/4 (0%)** **Code: 0**
Intensity										
Light Physical Activity										
Min/week									Slootmaker et al 2010[e]	0/1
Moderate Physical Activity										
Day/week	Ali et al 2021[e]		Whittemore et al 2013[e]							1/2
Mins/day			Ali et al 2021[e]						Ridgers et al 2021[e]	0/2
Min/week			Curtis et al 2020[f] Kattelmann et al 2014[e] Papalia et al 2018[d]	Wang et al 2019[d]		Seah and Koh 2021[ce]	Slootmaker et al 2010[e]			2/6
Vigorous Physical activity										
Day/week	Ali et al 2021[e]		Whittemore et al 2013[e]							1/2

Min/day	Ali et al 2021[e]									1/1
Min/week	Kattelmann et al 2014[e] Papalia et al 2018[d]		Curtis et al 2020[f]	Wang et al 2019[d]		Seah and Koh 2021[c]			Slootmaker et al 2010[e]	3/6
Moderate to vigorous physical activity										
Days/week	**Glaser et al 2024[e]**			Dzielska et al 2020[be]						**2/2**
Min/day								Kerner et al 2019[f]		0/1
Min/week	Larsen et al 2018[f]		Joseph et al 2015[f] Joseph et al 2016[f]						Slootmaker et al 2010[e]	1/4
SUMMARY	**7**	**0**	**9**	**3**	**0**	**2**	**1**	**1**	**4**	**11/27 (41%)** **Code: ?**
Guideline adherence										
Meeting American College of Sports Medicine physical activity guidelines							McFadden 2021[d]			1/1
Meeting World Health Organization physical activity guidelines				Ng et al 2021[d] Wang et al 2019[d]			Ng et al 2021[d]			3/3
SUMMARY	**0**	**0**	**0**	**2**	**0**	**0**	**2**	**0**	**0**	**4/4 (100%)** **Code: +**
Energy expenditure										
Min/week of total Metabolic equivalent of task			Curtis et al 2020[f] Kattelmann et al 2014[e]			Seah and Koh 2021[ce]				0/3
Physical activity (heavy kcal)			Cavallo et al 2012[e]							0/1
Physical activity (light kcal)			Cavallo et al 2012[e]							0/1
Physical activity (moderate kcal)			Cavallo et al 2012[e]							0/1
Physical activity (total kcal)			Cavallo et al 2012[e]							0/1
SUMMARY	**0**	**0**	**6**	**0**	**0**	**1**	**0**	**0**	**0**	**0/7 (0%)** **Code: 0**
Step count										
Total step count				Xian et al 2017[f]	Memon et al 2016[e]	Seah and Koh 2021[ce]		Melton et al 2016[e]		1/4
SUMMARY	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**0**	**1/4 (25%)** **Code: 0**
Walking										

Day/week			Ali et al 2021[e]			Wang et al 2019[d]				0/2
Min/day	Ali et al 2021[e]		Curtis et al 2020[f]							1/2
Min/week			Kattelmann et al 2014[e]							0/1
SUMMARY	**1**	**0**	**3**	**0**	**0**	**1**	**0**	**0**	**0**	**1/5 (20%) Code: 0**
Physical activity session										
Number of at home exercise sessions	Al-Eisa et al 2016[e]									1/1
SUMMARY	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1/1 (100%) Code: +**
Increased exercise										
Increased exercise over the last year				Nagata et al 2021[d]						1/1
SUMMARY	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**1/1 (100%) Code: +**
Overall impact on physical activity										**19/53 (36%) Code: ?**

a Impact/association of study in the hypothesised direction
b Overweight/Obese participants only.
c Only looked at PA engagement on weekends.
d Cross-sectional – shows correlation between technology and PA.
e Intervention study with comparison groups
f Intervention study with a single sample
Note: The impact of interventions was marked as.
0 = no likely effect reported when less than 30% of the studies found an improvement
? = uncertain effect reported in 31-60% of the studies found an improvement
+ = positive effect reported when 61%-100% of the studies reported an improvement

***Adapted from Page et al., 2017 [47]**

Associations by type of technology-supported physical activity

When comparing different types of technology-supported PA, data synthesis suggests that interactive websites/social media (**30%; 8/27** PA measurements) and wearable fitness trackers (18%; 2/11 PA measures) have no likely effect on PA. The effect of mobile apps was more promising, but the full impact was uncertain (60%; 9/15 study PA measures). Summary of these findings is reported in Table 2.

Table 2. Summary of physical activity results in the expected direction classified by type of intervention.

	Improvement or positive association reported in physical activity	Decline negative association reported in physical activity	Null result in physical activity	Summary of results in the expected direction	Code
Interactive website/ social media	Intervention study with comparison groups Al-Eisa et al 2016[a] Ali et al 2021[bcd] Kattelmann et al 2014[c] **Glaser et al 2014[j]**	Intervention study with a single sample Larsen et al 2018[f]	Intervention study with comparison groups Ali et al 2021[bd] Cavallo et al 2012[gbh] Kattelmann et al 2014[bid] Whittemore et al 2013[bc]	**8/27 (30%)**	0

	Intervention study with a single sample Larsen et al 2018[j]		Intervention study with a single sample Curtis et al 2020[cbid] Joseph et al 2015[j] Joseph et al 2016[fj]		
	Cross-sectional study Papalia et al 2018[c]		Cross-sectional study Papalia et al 2018[b]		
Physical activity tracking mobile app	Intervention study with comparison groups Dzielska et al 2020[io]	Intervention study with comparison groups Memon et al 2016[k]	Intervention study with comparison groups Seah and Koh 2021[bcik]	9/15 (60%)	?
	Intervention study with a single sample Xian et al 2017[k]		Cross-sectional study Wang et al 2019[d]		
	Cross-sectional study Ng et al 2021[pl] Nagata et al 2021[m] Wang et al 2019[bcl]				
Wearable fitness tracker	Intervention study with comparison groups Slootmaker et al 2010[b]	Intervention study with comparison groups Melton et al 2016[k]	Intervention study with comparison groups Melton et al 2016[f] Ridgers et al 2021 [bf] Slootmaker et al 2010[gcj]	2/11 (18%)	0
	Cross-sectional study McFadden 2021[n]	Intervention study with a single sample Kerner et al 2019[j]	Cross-sectional study Ng et al 2021[l]		
Overall impact				**19/53 (36%)**	**?**

a number of home exercise sessions
b moderate physical activity
c vigorous physical activity
d walking
f accelerometry counts
g light physical activity
h heavy physical activity
i metabolic equivalent of task
j moderate to vigorous physical activity
k total step counts
l meeting World Health Organization physical activity guidelines
m increased exercise in the previous year
n meeting American College of Sports Medicine physical activity guidelines
o improvement only seen in overweight/obese participants
p investigated multiple forms of technology-supported physical activity
Note: The impact of interventions was marked as.
0 = no likely effect reported when less than 30% of the studies found an improvement
? = uncertain effect reported in 31-60% of the studies found an improvement
+ = positive effect reported when 61%-100% of the studies reported an improvement

***Adapted from Page et al., 2017 [47]**

Associations with physical literacy outcomes

Elements of physical literacy were explored in four of the interactive website/social media studies [39, 61, 63, 70] and one study on wearable fitness trackers (Multimedia Appendix 6) [64]. Improvements were reported in two of the studies [39, 70] for motivation [39] and engagement/enjoyment [70], while the other three reported the intervention had no effect [61, 63, 64]. Overall, there was no effect on physical literacy (29%; 2/7 analyses) (Multimedia Appendix 6).

Differences in effectiveness of technology-supported PA between

adolescents and young adults subgroups.

Of the 15 studies that reported a positive impact or association between the use of technology-supported PA and PA engagement, half (8/15 52%) were with young adults [39, 51, 55, 62, 67, 68, 70, 71]. By comparison, only 33% (5/15) of the effective interventions focused on adolescents, while both interventions that looked at the whole sample reported a positive result [52, 66].

Mobile apps were only associated with positive PA outcomes when used by adolescents or across both age groups [66]. Both age groups reported positive PA outcomes when using interactive website/social media (two with adolescents, three with young adults) [39, 50, 51, 62, 65]. While the adolescent [59] and young adults [55] subgroup each had one fitness tracker intervention that reported a positive outcome. Overall, 56% (5/9) of adolescent and 67% (8/12) of young adult interventions reported a positive outcome.

Effectiveness of technology-supported physical activity according to study quality and theoretical framework.

Nine studies included in this review reported being underpinned by a theoretical design [51, 54, 55, 59, 62-65, 67] and of these, 66% (6/9) reported a positive outcome or association [51, 55, 59, 62, 65, 67]. Of the effective theory-based studies, social cognitive theory was the most used, with four interventions drawing from this theory [51, 62, 63, 65] and one cross-sectional study combining it with the Transtheoretical Model of Behaviour Change. However, only one of these studies was considered high quality [62], with the other three considered poor quality [51, 65, 67]. The other two effective theory-based studies were considered high quality [55, 59]; Slootmaker et al [59] used Self-Determination Theory, while Melton et al [55] did not provide information on what theory they used (figure 2 and 3).

Analysis of the non-theory-based interventions reported that 64% (9/14) had positive outcomes or association between technology-supported PA use and PA engagement [39, 50, 52, 53, 66, 68-71]. Half of these were cross-sectional studies [68-71], so only a positive association between technology-supported PA and PA use could be reported. Five of the effective non-theory-based interventions were considered high quality [39, 52, 66, 68, 69, 71], two considered medium [50, 53] and two poor quality [39, 70] (figure 2 and 3).

Discussion

Main findings

The primary aim of this review was to investigate the effectiveness of various types of technology-supported PA on increasing young women's PA engagement. The secondary aim was to assess if any of these interventions explored elements of physical literacy and if the interventions led to improvements in physical literacy. There were three main types of technology-supported PA investigated in these studies: mobile apps, fitness trackers and interactive websites/social media. Analysis of the study findings did not indicate that technology-supported PA is an effective method of increasing young women's PA. Although, when breaking the findings down by age group, **technology-supported PA may have a greater impact on PA engagement for young adults compared to adolescents.** There was no evidence that technology-supported PA is an effective way of increasing young women's physical literacy.

Effectiveness of mobile applications

Whilst the overall impact of technology-supported PA on young women's PA was uncertain, mobile apps may hold some promise, with positive results reported in two studies [53, 66] and 60% of the measured PA outcomes. Currently, over 80% of the global population own a mobile device and these rates are continuing to increase [72]. **Phone use is especially prevalent in adolescents, with data indicating that in some countries up to 95% of those aged 13-19 years have a mobile device and individuals in this age range report higher levels of daily usage than other age groups [73]. This higher rate of ownership and use may make mobile apps seeking to improve levels of PA engagement more effective in those <19 years, although, only four of the studies in this review focused on mobile apps, highlighting how little research has been conducted on this form of technology-supported PA [53, 56, 58, 66].** Another consideration when investigating the effectiveness of mobile apps is the use of various forms of 'gamification' [22, 31-33]. Gamification, such as offering some competition or challenge has been linked to improved intrinsic motivation and higher levels of app engagement [22, 31-33]. Both mobile app studies included in this review that reported improvements in PA used gamification [53, 66]. This result is in line with previously conducted studies, with several systematic reviews reporting gamified apps led to higher levels of PA engagement than apps without elements of gamification [22, 31-33]. However, just because mobile apps are popular, does not necessarily mean they are effective [22, 34, 74-76]. A common limitation of PA mobile apps is a lack of evidence and theory-based design, which has been reported in several systematic reviews [22, 34, 74-76]. This limitation can be seen in the interventions included in this review, as both of the mobile app interventions that did not improve PA, used commercial fitness apps without providing evidence of reliability or a theoretical framework [56, 58].

Effectiveness of websites and/or social media

Interventions based on websites and/or social media were not found to be an effective way of improving young women's PA. Only **30%** of the measured PA outcomes assessed in interventions using an interactive website and/or social media reported a positive effect. Social media is reported to be well-liked by young women and considered an effective way of improving PA facilitators such as motivation or social support [23, 77-80]. Yet these findings suggest that while social media is popular, it does not necessarily mean it is effective. This disconnect between engagement and effectiveness has been explored in previous research [77, 79]. A study conducted by Duplaga et al., [79] reported that only 33% of young adults following fitness influences on social media engaged in regular PA. While a survey by Camacho-Miñano et al., [77] (37 13-17 year-olds) reported that Instagram fitness groups were associated with negative outcomes such as body dissatisfaction [39, 61, 77, 79].

Effectiveness of wearable fitness trackers

The least effective form of technology-supported PA was wearable fitness trackers, with only 18% of measured PA outcomes reporting a positive effect. Only two of the four fitness tracker interventions reported a positive result [55, 59] and one decreased participant PA [64]. The authors theorised this decrease may be due to fitness trackers only increasing external motivation rather than autonomous motivation, which promotes long-term behaviour change [81]. The limited effectiveness of wearable fitness trackers could be due to the design of the devices used in the interventions. Three of the four fitness tracker interventions used commercial devices [55, 57, 64] which are often not theory or evidenced-based [75]. This may mean that the fitness tracker might not produce significant improvements in PA, even if the intervention is otherwise well designed. A lack of compliance with the devices and insufficient wear time could have also been a factor. Three of the studies reported issues with fitness tracker compliance and previous research has reported this is a common issue with fitness tracker interventions [82, 83]. **Another consideration is the age group the fitness tracker interventions were conducted with. Three of the interventions focused on adolescents [57, 59, 64], but a recent study by Shandhi et al [84] reported that young adults were the age group most likely to own and use a fitness tracker. So, it is possible that the limited**

effectiveness of wearable fitness trackers reported in this review is due to them being conducted primarily on adolescents [55, 57, 59, 64, 84].

Variation between study designs

The results may not only be attributed to the type of technology-supported PA. The different characteristics of the studies, including study designs, PA outcomes and measurement tools should be considered. For example, theory-based interventions are reported to result in better outcomes and have more generalisable findings than those that are not [85, 86]. **This was evident in the review findings, as of the 14 studies that were effective, only six had a theoretical framework (43%) [51, 55, 59, 62, 65, 67]. In comparison, only three (38%) of the eight studies that were not effective, reported being theory-based [54, 63, 64]. Though it is important to remember, that a study being based on a theoretical framework does not automatically make it well-designed. This can be seen in the findings of this review; it was noted that only three of the effective theory-based interventions were high quality [55, 59, 62]. Our findings also noted that studies in the review were more likely to report a positive outcome or association between technology-supported PA use and PA engagement if they were high quality, regardless of the study design [52, 55, 59, 62, 66, 68, 69, 71]. This is in line with recent reviews of health research, which note that studies that report higher quality are more likely to report positive outcomes [87, 88].**
Another consideration is the method of data collection. In PA research, data is primarily collected via self-report or device-based measures (e.g., pedometers, accelerometers) and both methods have benefits and limitations [82, 83]. Self-report methods are low-cost and easy to administer but are prone to recall bias and over-reporting of PA [82, 83]. While device-based methods reduce the risk of bias, they are limited by cost, reduced generalisability, incorrect use and devices not being suitable for all types of PA [82]. An example of this can be seen in Larsen et al., [65], who reported an increase in self-reported MVPA (24.7 vs 79.4 minutes), but a decrease in device measured MVPA (21.4 vs 10.4 minutes), attributed to changes in the type of PA the sample was engaging in post-intervention that were not effectively measured by accelerometers [65].

Impact on physical literacy

There was little evidence that technology-supported PA could improve young women's physical literacy, with only 29% of the physical literacy elements assessed reporting a positive effect. Only two of the included studies reported positive changes in physical literacy [39, 70]. The remaining three interventions reported no likely effect in physical literacy [61, 63, 64]. This is not surprising given that these three interventions also failed to increase PA engagement [61, 63, 64]. **Only one of the physical literacy interventions focused on adolescents [64].** The primary domain explored in these interventions was the psychological domain. This focus on the psychological domain makes sense given that these elements are known facilitators to PA for young women [31, 89-91]. It should be noted that though these studies were found to explore aspects of physical literacy, none of them mentioned the term physical literacy specifically [39, 61, 63, 64, 70]. However, this was expected as physical literacy is a newer concept and the 'Australian Physical Literacy Framework' was only published in 2019 [40]. Only two of the physical literacy studies were published after this date [61, 64].

Strengths and limitations

To the research team's knowledge, this review is the first synthesis of the impact various types of technology-supported PA could have on young women's (13-24 years-old) PA. This is a critical period for health promotion, as this age range is when young women's PA begins to decrease and lifelong PA habits are formed [1, 2]. This review also investigated and compared different types of technology-supported PA, while other reviews have focused on a single form of technology such as mHealth or mobile apps [22, 33, 34]. Focusing on a single form of technology ignores the fast-paced changes in technology advancement, especially in a post COVID-19 world. This is also the first review to investigate the potential impact technology-supported PA could have on physical literacy. The review was further strengthened by the use of a comprehensive quality assessment. Despite these strengths there are also some limitations. The first is the inclusion of several single sample studies, as these do not have the same high quality found in RCTs. Additionally, several cross-sectional studies were included, these cannot provide a causal link between technology-supported PA use and PA engagement. However, given the limited data available on the use of technology-supported PA by the target population, valuable insights would have been missed if the review had only included RCT studies. **The variety of study designs included in this review also made assessing the quality of the studies more complex. Three different quality checklists were used in this review. The risk of this impacting the results was mitigated by the research team agreeing on ways to make the different checklists more consistent. The analysis of the results of the included interventions could also have been hindered by the number of different PA measurements. There were 53 different ways of PA outcomes were measured, so the authors sought to address this by combining the different measurements into subgroups. The reported positive impact of mobile apps must be considered with caution due to the small number of studies that focused on this form of technology-supported PA. It is possible that mobile apps may only appear more effective than interactive websites/social media and fitness trackers because the limited outcomes measured skewed the results. Another consideration is the poor quality of the included studies and a lack of theory-based design. The authors cannot be certain that the findings reported in this review are due to the limited effectiveness of technology-supported PA. It may instead be related to the quality of the studies and the types of technology-supported PA used. The findings of this review would have been strengthened if a meta-analysis of the findings could have been conducted. But the variation between study designs, measurement of PA outcomes and study quality did not make this viable.**

The findings of this review suggest two areas for future research. First, more research focused on young women's use of technology-supported PA is needed. Only 12 of the studies in this review examined young women specifically [39, 51-53, 55, 56, 58, 61-63, 65, 67]. Previous research reports that young women experience unique barriers to PA that may not be targeted in interventions of wider populations [61, 90-92]. The second area that requires investigation is the potential of facilitated technology-supported PA. This review was unable to investigate the effectiveness of facilitated technology-supported PA as it was not used in any of the included studies. This finding was not surprising, as facilitated technology-supported PA was not common prior to the COVID-19 pandemic. However, its use increased significantly during the pandemic and has continued to remain popular [27, 30, 93]. Emerging research indicates that facilitated technology-supported PA is most popular with young women and fitness professionals see it as an effective method of client engagement [27, 93]. **Another consideration when addressing these areas is how researchers choose to measure PA. Greater consistency in the type of PA measured when investigating technology-supported PA would make comparison between interventions more effective.**

Conclusions

This is the first systematic review exploring the use of various types of technology-supported PA and highlighted there is not yet evidence for the benefits of technology-supported PA for young women. The review highlights how little research has been conducted in this area. Many of the studies included in this review were of poor quality, not grounded in theory, and none investigated facilitated technology-supported PA. **Nevertheless, some of our findings indicate areas of promise for the future. Future interventions could focus on mobile apps as they may be more effective than website/social media and commercial fitness trackers. Additionally, interventions that combine multiple forms of support, such as mentors or in-person instruction may be more effective than**

a single form of technology-supported PA. Adolescents and young adults may experience different barriers and facilitators to PA and the use of technology-supported PA. This must be considered when conducting research on this age group, as it may be that different forms of technology are needed for each subgroup of young women. The review findings noted that interventions that were theory-based may be more effective than those that were not. Researchers should consider developing interventions underpinned by behavioural change theory, with follow-ups post-intervention to see if improvements in PA and use of technology-supported PA is maintained. Additionally, more research is needed on the impact technology-supported PA could have on adolescents, as the review findings of the impact on this age group are very limited. Not only will this improve the health outcomes of young women in the short-term, but it will also help them develop the skills and confidence needed to engage in PA across the lifespan. As technology-supported PA continues to improve and become more common, there is a greater need for well-designed evidence-based research exploring the impact these new types of technology could have on young women's PA and physical literacy.

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Author contributions

KWM, LMB, NL, FHM and LA conceived the idea for this review and developed the search strategy. KWM conducted the literature search and screened all the articles at both the title/abstract and full text stage. LMB, NL, FHM, LA, AJ and FV assisted with the screening and worked with KWM to select the articles to be included in the review. Preliminary data extraction of these articles was conducted by KWM and checked by LMB, NL, LA, AJ and FV. KWM, LMB and AJ assessed the included PA articles to see if they included aspects of physical literacy and worked together to extract the physical literacy data. Quality assessment of all the included articles was conducted by KWM, LMB, FHM and FV and the quality of the study elements related to physical literacy was conducted by KWM, LMB and AJ. The summary and results tables included in the review were developed by KWM, LMB, LA, AJ and FV. KWM wrote the first and second draft of the review and initial feedback was provided by LMB, NL, LA and FHM. Prior to submission all authors read and approved the final version of the manuscript.

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Conflicts of interest

None declared.

Abbreviations

ACSM: American College of Sports Medicine
C group: control group
MET: metabolic equivalent of task
MPA: moderate physical activity
MVPA: moderate to vigorous physical activity
PA: physical activity
RCT: randomised control trial
VPA: vigorous physical activity
WHO: World Health Organization

Multimedia Appendix 1

Technology-supported physical activity and its potential as a tool to promote young women's physical activity and physical literacy: Systematic review search strategy.

Multimedia Appendix 2

Inclusion - Exclusion criteria: Technology-supported physical activity and its potential as a tool to promote young women's (13-24 years-old) physical activity and physical literacy: Systematic review.

Multimedia Appendix 3

Intervention and result details from comparison group studies

Multimedia Appendix 4

Intervention and result details from single sample studies

Multimedia Appendix 5

Results details from cross-sectional studies

Multimedia Appendix 6

Summary of results in the expected direction by domain and element of physical literacy.

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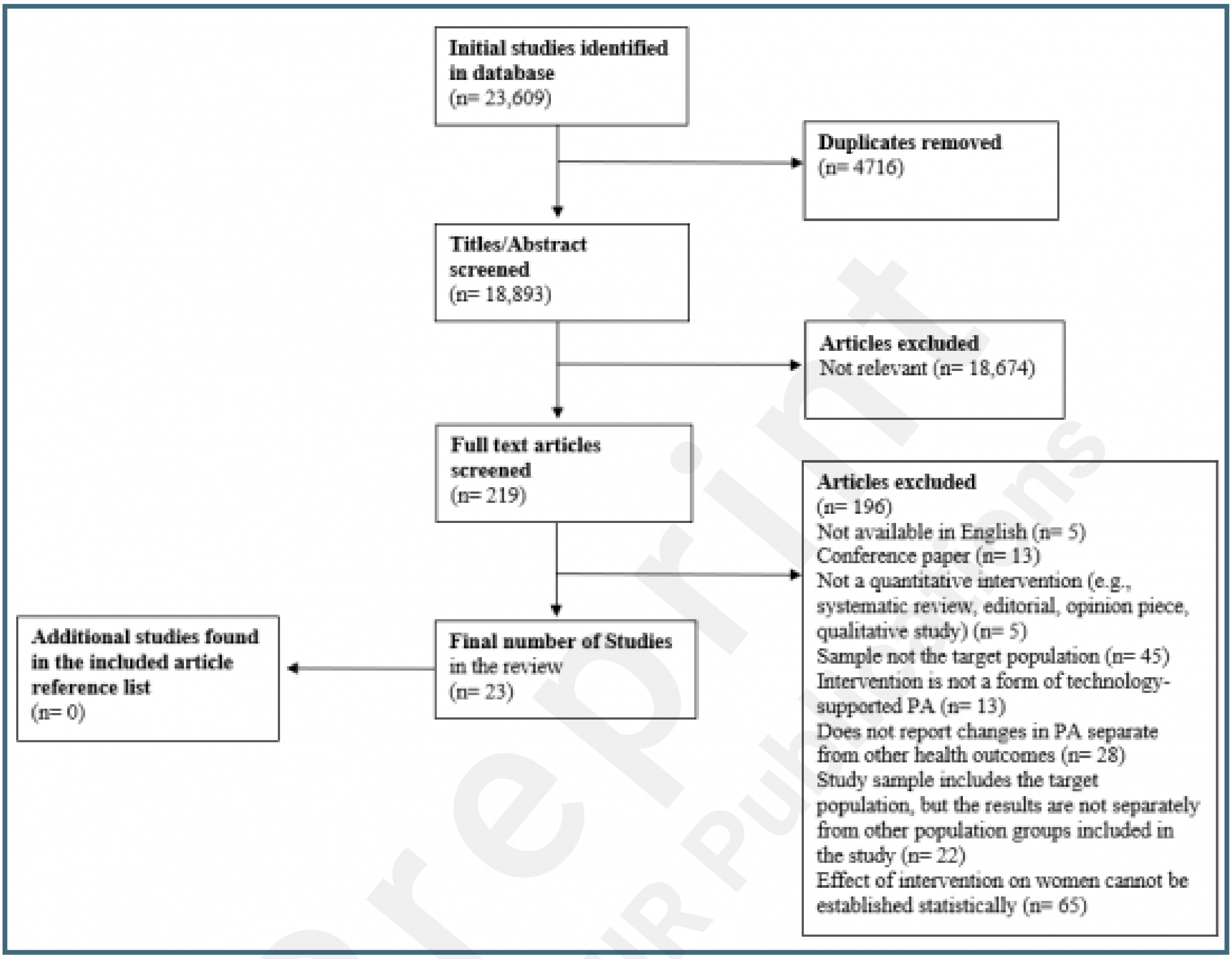
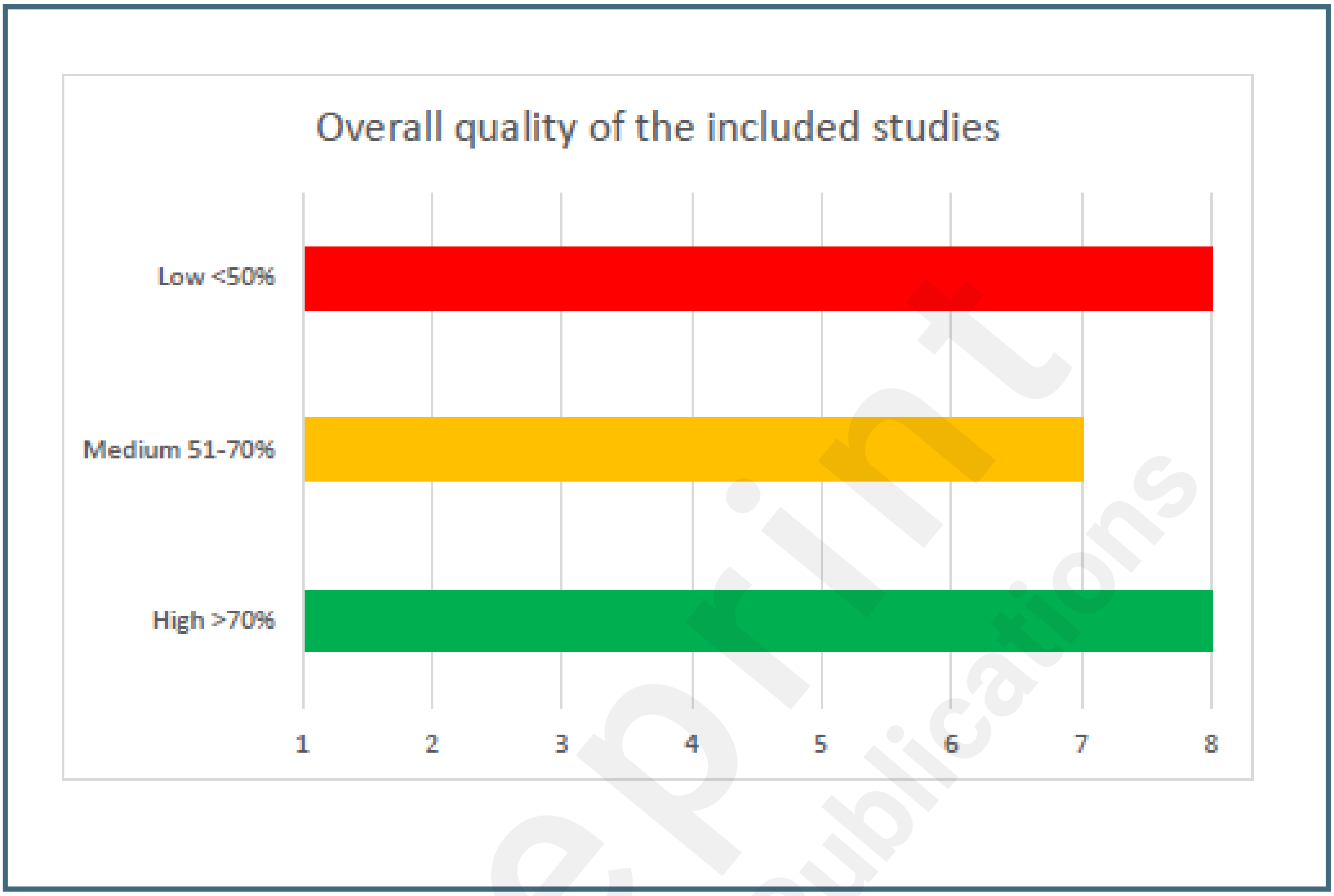
Supplementary Files

Figures

Prisma flow chart.



Overall quality of the included studies.



Quality assessment for each study design.

RCT study design	Carvalho et al 2012	Dzielska et al 2020	Katzelmann et al 2014	Melton et al 2016	Munan et al 2017	Ridgers et al 2021	Seah and Koh 2021	Slootmaker et al 2010	Whittemore et al 2013
Was true randomisation used for assignment of participants to treatment groups?	✓	✓	✓	✓	✓	✓	✓	✓	✓
Was allocation to treatment groups concealed?	NR	NR	NR	NR	✓	NR	NR	✓	NR
Were treatment groups similar at the baseline?	X	✓	✓	✓	X	✓	NR	✓	✓
Were participants blind to treatment assignment?	✓	✓	X	✓	NR	NR	NR	NR	NR
Were those delivering treatment blind to treatment assignment?	N/A	N/A	N/A	N/A	N/A	X	X	NR	NR
Were outcomes assessors blind to treatment assignment?	N/A	NR	N/A	N/A	NR	X	N/A	N/A	NR
Were treatment groups treated identically other than the intervention of interest?	✓	✓	✓	✓	✓	✓	✓	✓	✓
Was follow up complete and if not, were differences between	✓	X	X	X	NR	✓	X	✓	✓
Were participants analysed in the groups to which they were randomised?	✓	✓	✓	NR	✓	✓	✓	✓	✓
Were outcomes measured in the same way for treatment groups?	✓	✓	✓	✓	✓	✓	✓	✓	✓
Were outcomes measured in a reliable way?	NR	X	✓	✓	X	✓	✓	X	X
Was appropriate statistical analysis used?	✓	X	X	✓	X	✓	✓	✓	✓
Was the trial design appropriate, and any deviations from the	✓	✓	✓	✓	✓	✓	X	✓	✓

Quasi-experimental	Al-Eisa et al 2016	Ali et al 2021	Curtis et al 2020	Glaser et al 2024	Joseph et al 2015	Joseph et al 2016	Kerner, Burrows and McGrane 2019	Larsen et al 2018
Is it clear in the study what is the 'cause' and what is the 'effect' (i.e. there is no confusion about which variable comes first)?	✓	✓	✓	✓	✓	✓	✓	✓
Were the participants included in any comparisons similar?	NR	NR	N/A	✓	N/A	N/A	N/A	N/A
Were the participants included in any comparisons receiving similar treatment/care, other than the exposure or intervention of interest?	NR	✓	NR	NR	✓	✓	NR	NR
Was there a control group?	✓	✓	N/A	✓	N/A	N/A	N/A	N/A
Were there multiple measurements of the outcome both pre and post the intervention/exposure?	X	X	✓	✓	✓	X	X	X
groups in terms of their follow up adequately described and analysed?	X	X	NR	X	✓	X	X	✓
Were the outcomes of participants included in any comparisons measured in the same way?	✓	✓	N/A	✓	N/A	N/A	N/A	N/A
Were outcomes measured in a reliable way?	X	X	✓	X	✓	✓	✓	X
Was appropriate statistical analysis used?	X	X	X	X	X	X	X	X

Cross-sectional	McFadden 2021	Nagata et al 2021	Ng et al 2020	Papalia et al 2018	Wang et al 2019	Xian et al 2017
Were the criteria for inclusion in the sample clearly defined?	NR	X	✓	X	✓	✓
Were the study subjects and the setting described in detail?	✓	✓	✓	✓	✓	✓
Was the exposure measured in a valid and reliable way?	✓	✓	✓	✓	✓	X
Were objective, standard criteria used for measurement of the condition?	NR	NR	✓	NR	✓	✓
Were confounding factors identified?	NR	✓	✓	NR	✓	NR
Were strategies to deal with confounding factors stated?	NR	✓	✓	NR	✓	NR
Were the outcomes measured in a valid and reliable way?	✓	✓	✓	✓	✓	✓
Was appropriate statistical analysis used?	✓	✓	✓	✓	✓	✓

✓	Positive response to question
X	Negative response to question
NR	Not reported (which was considered a negative response)
N/A	NA = not applicable (which was not considered on the percentage calculation)

Multimedia Appendixes

Technology-supported physical activity and its potential as a tool to promote young women's physical activity and physical.
URL: http://asset.jmir.pub/assets/7beba7f5c8f2dd8d128c033745bd8224.pdf

Inclusion - Exclusion criteria: Technology-supported physical activity and its potential as a tool to promote young women's (13-24 years-old) physical activity and physical literacy - Systematic review.
URL: http://asset.jmir.pub/assets/9f49c1f106b7abb6bbf9e1c348143450.pdf

Intervention and result details from comparison group studies.
URL: http://asset.jmir.pub/assets/1da51be04bbbac436390fce88a294ba2.pdf

Intervention and result details from single sample studies.
URL: http://asset.jmir.pub/assets/883cbd139422e913c8cbebcd8c4006c3.pdf

Results details from cross-sectional studies.
URL: http://asset.jmir.pub/assets/753ae3df27f039859029cf89eeb7d9f6.pdf

Summary of results in the expected direction by domain and element of physical literacy.
URL: http://asset.jmir.pub/assets/23a1173c2f793b14174ad91c7e40257b.pdf