

Review

Promoting Physical Activity Among Young People with Epilepsy: Are We Making the Most of Behavioural Science? A Scoping Review

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Abstract

Physical activity can help people manage their epilepsy, yet young people with epilepsy are less active than their peers. Behaviour change interventions are needed. Behavioural science offers a range of theories, concepts and tools that increase the likelihood that such interventions will be effective. This scoping review assessed the extent to which physical activity behaviour change interventions for young people with epilepsy have been designed and evaluated using behavioural science tools. Systematic electronic database searches (last updated 3 December 2025) identified seven publications, reporting six distinct intervention trials. Intervention reports were coded to identify how behaviour change science had been drawn on. Interventions were also coded for evidence of effectiveness. None were identified as showing convergent evidence of effectiveness. For three interventions, there was limited evidence of effectiveness based on within-group increases in physical activity or quality of life, and for three, there was no evidence of effectiveness for physical activity or quality of life. Interventions using goal-setting, guidance on performance or information on health consequences were more commonly found in interventions showing some evidence of effectiveness than those showing no such evidence. Limited evidence was found of explicit behavioural science use in published reports of physical activity promotion interventions for young people with epilepsy. We recommend ways in which intervention developers can draw more on behavioural science theory, evidence and tools when developing, evaluating and reporting interventions, and therefore increase realisation of the benefits of physical activity interventions for this population.

Keywords: epilepsy; physical activity; psychology; behaviour; behaviour change; behavioural science



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1. Introduction

Regular physical activity (PA) is associated with a decreased risk of obesity, type 2 diabetes and cardiovascular disease and can reduce the risk of anxiety and depression [1–3]. For people living with epilepsy, regular PA is also helpful for symptom management. PA can reduce seizure frequency, and individuals with epilepsy who engage in PA typically experience fewer symptoms of depression and anxiety, have increased opportunity for socialising, and have an overall improved quality of life (QoL) [4–6]. While historically, people with epilepsy were encouraged to avoid PA due to fears over injury or seizure [7], this stance began to shift in the 1970s when the American Medical Association permitted contact sports [8]. In 2016, the International League Against Epilepsy began advocating for low-risk PA and sport to manage epilepsy symptoms [9].

People living with epilepsy are significantly less likely to engage in PA than those without a health condition [10]. Only 5.6% of young people with epilepsy (YPWE) achieve the guideline of 60+ mins of moderate to vigorous PA recommended for children and adolescents, compared to 20% of young people in the general population [11,12]. Effective PA promotion among YPWE would likely improve both short-term and long-term outcomes, because PA behaviours established during childhood tend to persist into adulthood [13]. Yet, studies indicate that concerns about seizures and safety, low perceived capability, epilepsy-related stigma, and limited awareness of the benefits of PA hinder engagement with PA among YPWE [14–16]. Behaviour change interventions are needed to support PA among young people with epilepsy.

Broadly speaking, behaviour change interventions are developed in one of two ways. One approach involves developing interventions ad hoc, seemingly based on intuition regarding how best to foster behaviour change. This ‘evidence-lite’ strategy has been termed the ‘ISLAGIATT’ approach; i.e., ‘it seemed like a good idea at the time’ (see, e.g., [17]). As the ‘ISLAGIATT’ label implies, this strategy is apparently neither systematically developed nor explicitly evidence-based, such that if the resultant intervention fails, the developer may have minimal insight into reasons for failure, or may simply be unable to recollect the thought process underlying the design of the intervention. The other approach involves following a systematic, best-practice development process, drawing on available theory and evidence, to maximise the likelihood of intervention effectiveness [18]. Multiple intervention development frameworks are available for negotiating this process, such as the UK Medical Research Council’s guidance for designing complex interventions [19], the Intervention Mapping approach [20], and the Behaviour Change Wheel approach [17]. These frameworks converge on the idea that three key steps must be followed: specifying the target behaviour and target population, identifying the determinants of engagement (or non-engagement) in the target behaviour, and selecting strategies suitable for targeting those determinants so as to change the target behaviour [17,20]. For example, promoting PA (target behaviour) among YPWE (target population) will require acknowledging that many YPWE (and their caregivers) are concerned about the risk of injury [14,21], such that providing guidance on low-impact or non-injurious activities may be an appropriate strategy, tailored to barriers. Crucially, theory and evidence should be consulted at all three stages, because drawing on prior knowledge regarding which target behaviours will be most feasible to change or most impactful, barriers to change and effective strategies will maximise the likelihood that the intervention will successfully change behaviour [17]. Interventions developed in accordance with these frameworks tend to be more effective than those that are not [17,22].

A multitude of behavioural science tools are available to navigate through the process of systematically designing evidence-based interventions. Theories of behaviour and behaviour change can provide insight into which determinants of a behaviour to target, how and why [23]. For example, the Theory of Planned Behaviour (TPB) portrays action as the result of intentions, which in turn summarise the influence of attitudes (i.e., positive or negative appraisals of the expected outcomes of action), subjective norms (i.e., perceptions of others’ positive or negative appraisals of the action), and perceived behavioural control (i.e., perceptions of how easy or difficult it is to engage in the action [24]). The TPB thus proposes that, to change behaviour, attempts must be made to understand and modify the specific attitudinal, normative or control beliefs that can be shown to influence intentions [25], and that behaviour change will only arise if intentions are successfully modified. Similarly, the COM-B Model proposes that for a behaviour to occur, a person must have sufficient capability, opportunity, and motivation to act, such that change requires a focus on whichever of the three determinants is identified as a barrier to changing a target behaviour [26]. Theory

can aid intervention development in many ways, including identifying which determinants to target (e.g., whether to target attitudinal or normative beliefs), which change strategies to use based on the known determinants (e.g., using persuasive communication to change attitudes, or providing information to correct misperceptions of subjective norms), and which psychological mechanisms to measure to establish the pathways through which the intervention changed behaviour (e.g., whether to assess changes in attitudes, norms, or another theory-derived construct [27]).

Behavioural science methodologists have also proposed a comprehensive list of nine intervention types, which denote the different functions that an intervention may play in order to change behaviour [26]. For example, an intervention may attempt to *educate* a young person with epilepsy about the importance of PA, *persuade* them to engage in PA based on inducing positive feelings towards PA, or *train* them in the skills needed to engage in PA in a way that will minimise adverse health reactions [26]. Behaviour change technique (BCT) taxonomies provide another useful tool for intervention development [28,29]. These taxonomies provide categorised lists of components that can be used in an intervention so as to bring about behaviour change, such as setting behavioural goals, providing information on the consequences of behaviour, and restructuring the physical environment [29]. BCTs represent the discrete and irreducible units of intervention content that may contribute to its effectiveness; i.e., the smallest ‘active ingredients’ of the intervention [28]. Within the intervention development process, identification of the determinants of behaviour can inform the selection of appropriate intervention types and BCTs from these lists. For example, from a COM-B perspective, concern among YPWE around PA inducing seizures indicates a lack of perceived physical capability [14,21], which in turn suggests that interventions should seek to educate and train YPWE in how to engage in PA safely. BCTs known to be suitable for education and training intervention types include instructing on how to perform the behaviour, behavioural practice, and graded tasks (i.e., gradually building up the intensity or duration of activity [17]).

Behavioural science tools are useful not only when developing new interventions, but also for post hoc evaluation and interpretation of prior interventions. Coding intervention descriptions to identify which theories, intervention types and BCTs have been used can reveal important assumptions made by the intervention developer regarding why the target behaviour occurs and the mechanisms through which the intervention changed (or failed to change) behaviour. For example, an intervention based on the TPB is necessarily founded on the assumption that, to change behaviour, YPWE must be better supported to want (i.e., intend) to engage in PA. Similarly, an intervention observed to offer only skills training to YPWE indicates the assumption that YPWE fail to engage in PA not because of a lack of motivation, but rather because they lack the physical or psychological capability necessary to do so [17]. Likewise, an intervention based on encouraging consistent behavioural repetition, practice, and performance in certain settings (e.g., exercising at the same time each week) suggests the assumption that YPWE can be encouraged to form PA habits, which will support long-term maintenance [30]. Retrospectively applying behavioural science tools to past interventions in this way can provide useful evidence regarding ‘what works’—and what does not—for encouraging PA among YPWE, which can in turn further develop the evidence base needed to refine existing PA interventions or design new interventions. For example, if interventions centring on providing YPWE (or their caregivers) with information on the importance of PA were found to have no effect on PA among YPWE, this would indicate that increasing awareness of PA benefits is not a viable mechanism for promoting PA, and that efforts should switch to alternative mechanisms [31]. More broadly, coding interventions for the use of behavioural science tools—that is, to establish *whether* and *which* theory, intervention types, BCTs or psychological mechanisms

have been explicitly drawn upon—can help to identify the extent to which interventions in a given behavioural domain are making the most of behavioural science technologies.

This study reports a scoping review, undertaken to identify whether and how behavioural science tools have been used in the development and assessment of PA promotion interventions for YPWE. Our purpose was to conduct a behavioural science audit of the PA-promotion intervention literature, to establish whether and how interventions and intervention trials have reported applying behavioural science concepts, while also extracting information regarding the characteristics of effective interventions. Our primary aim was to describe how theories and methods from behavioural science have been drawn on. Specifically, we sought to extract information from intervention evaluation reports regarding whether theory was used in the design of the intervention; which intervention types and BCTs were used; and whether and which psychological determinants were tested as mediators of effects of interventions on behaviour change. Our secondary aim was to investigate the frequency with which specific intervention types and BCTs were used in effective versus ineffective interventions, to develop an understanding of which intervention content may be more promising for increasing PA. PA interventions for YPWE have previously been reviewed, but only to assess the extent to which they appear to benefit health and quality of life [5]. No review has yet sought to understand the content of such interventions or what makes them effective. Such knowledge will help to inform the development of optimally effective PA behaviour change interventions for YPWE [32].

Our focus was on interventions designed to increase uptake of PA. However, our review included interventions evaluated for effects on either PA or QoL. QoL is central to life satisfaction and wellbeing, yet is typically lower in YPWE than the general public [33,34]. QoL is therefore the ultimate outcome of interest in many health-related interventions for YPWE. PA promotion interventions, for example, encourage PA as a means of enhancing QoL, and increased PA has been shown to boost QoL [5]. QoL among YPWE can be influenced by clinical characteristics such as seizure frequency and medication use, psychological factors such as seizure worry and perceived social support, and demographic factors such as socioeconomic status and gender [35–37]. Nonetheless, QoL offers a crude yet clinically significant, downstream proxy effectiveness indicator for PA interventions.

Our research questions were:

1. Have behavioural science theories, concepts and methods been reported in descriptions of the development and evaluation of PA promotion interventions for YPWE—and if so, how have they been used to develop and evaluate such interventions?
2. Are some intervention types and BCTs more commonly seen in interventions that are effective in increasing PA or QoL than in non-effective interventions?

2. Materials and Methods

We report our review in accordance with the PRISMA extension for scoping reviews (PRISMA-ScR [38]). This review was undertaken as graduate coursework by the first author and, due to time pressure, was not pre-registered. A retrospective registration document is available at <https://doi.org/10.17605/OSF.IO/EZAFS> (accessed on 25 June 2026).

2.1. Identifying Papers for Review

2.1.1. Eligibility Criteria

Study eligibility criteria were determined using the PICO framework (Participant, Intervention, Comparator, Outcome [39]). *Participants* were required to be aged under 18 years with a diagnosis of epilepsy. Studies which included participants with other disorders (e.g., cerebral palsy) were excluded. *Interventions* were eligible where they were designed to increase the frequency, duration or intensity of PA. Multi-behaviour

interventions—for example, those that sought to modify PA and aspects of diet—were included. A control group was not an eligibility requirement; we included uncontrolled, pre-post studies in which *comparator* data were taken only from a pre-intervention baseline, allowing within-group comparisons among intervention recipients only, and trials featuring a control group, which generated both between-group (intervention vs control group values) and within-group (pre-post values) comparisons. Eligible studies had to report one of two *outcomes*, i.e., PA (frequency, duration, or intensity), or QoL. We focused on both PA and QoL because a previous review showed that many PA interventions for YPWE did not measure PA behaviour, instead using QoL as an effectiveness outcome [5]. QoL can provide a crude proxy indicator of changes in PA, so it allowed us to retain studies in which PA outcomes were not measured, where removing such studies would likely have reduced the available evidence to the extent that our review would not be meaningful. Only quantitative studies, reporting analyses of the statistical significance of comparisons, were eligible.

2.1.2. Search Procedure

Two databases (PsychINFO, Medline) were systematically searched in July 2025, and searches were updated on 3 December 2025. In each database, the Title and Abstract fields were searched for synonyms for *children*, *epilepsy*, *physical activity*, and *intervention*. No date limits were set. Searches and screening were undertaken by the first author (LW), a graduate student trained in database searching, under the supervision of the second author (BG), who has extensive behaviour change intervention review experience. Search terms and results are provided in Supplementary Table S1.

2.1.3. Search Results and Screening

Across the two databases, 233 papers were identified, with 190 remaining after duplicates were removed (see Figure 1). Title and abstract screening removed 137 irrelevant papers. Of the remaining 53 papers, 46 were removed during full-text screening, most commonly due to interventions not focusing on PA ($n = 21$) or because participants were not people living with epilepsy ($n = 18$). Of the remaining papers, two appeared to feature the same group of participants [40,41], so they were treated as a single study for analyses except where indicated otherwise. Thus, a total of seven papers, reporting six distinct studies, were entered into review [40–46].

2.2. Data Extraction

All data were extracted to Microsoft Excel spreadsheets and tabulated for analysis purposes.

2.2.1. Study Characteristics

Methodological characteristics extracted from each study included author, country, study design, number of conditions, time to follow-up(s), and epilepsy criteria. *Sample characteristics* extracted included total and per-condition sample size in total and per condition (at baseline and follow-up), demographics (e.g., mean age at study baseline; mean age at epilepsy onset), and epilepsy criteria. Of the six studies, four had a single follow-up point, and two had two follow-ups: Brown et al. [42] employed both a 6- and 12-month follow-up, and Ibañez-Micó et al. [45] used 3- and 6-month follow-ups. The two studies reported zero attrition between follow-up points, such that the follow-up sample size represents both the first and final follow-up sample for all studies.

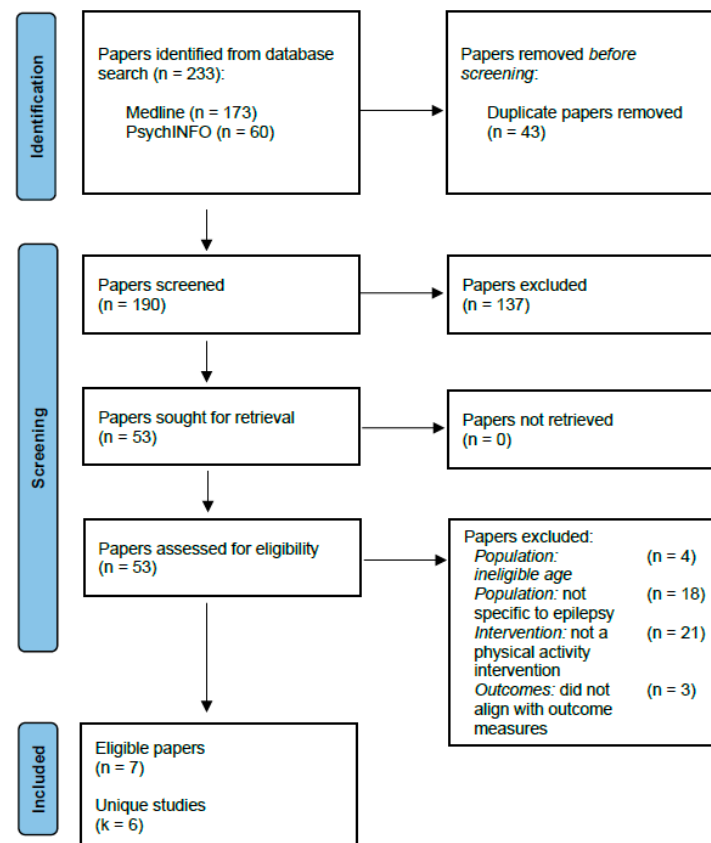


Figure 1. Study search and selection procedure.

Outcome characteristics and data extracted related to how intervention effectiveness outcomes—i.e., PA and quality of life—were measured and, for each condition (i.e., intervention and control group[s]), whether there were statistically significant within- or between-group changes in any PA or quality of life indicator, between pre-intervention baseline and at the earliest post-intervention follow-up timepoint. Two outcome measures were used because, while some studies did not report PA outcomes, all studies reported quality of life, which has been shown to increase following increased engagement in PA [5]. When extracting data on intervention effectiveness from the two studies with multiple follow-ups [42,45], we selected the earlier follow-up point because behaviour change interventions tend to have the greatest impact on behavioural outcomes in the short-term [47], though in both studies the same pattern of effects was found at both first and final follow-up. In one study, post-intervention PA and quality of life data were reported at different timepoints [40,41], so we extracted post-intervention data for each outcome at the earliest timepoint at which it was measured.

2.2.2. Intervention Characteristics

We extracted information on the intervention target behaviour, including the type(s) of PA targeted and the frequency, duration and intensity with which PA was engaged in. Each intervention report was also coded for theory use, component BCTs and intervention types.

Theory use was coded in two ways. First, we coded for whether a named theory (e.g., the TPB) was mentioned in the Abstract, Introduction or Method of the paper reporting trial results. Second, we coded for whether one or more theory-derived psychological variables (e.g., attitudes) were investigated as mechanisms of intervention effectiveness; that is, as a potential mediator of the impact of the intervention on behaviour change (e.g., testing whether changes in behaviour can be statistically attributed to changes in attitudes), or as a standalone effectiveness outcome (e.g., testing whether attitudes changed as a result of

the intervention). A more extensive ‘theory-basedness’ coding frame is available that sets out multiple ways in which theory can be used, such as targeting interventions to people based on their scores on theory-derived measures (e.g., delivering an intervention only to people with positive attitudes [27]). However, typically, few studies use theory other than as inspiration for intervention content (e.g., targeting TPB constructs), which can be revealed by mentions of specific theories in the paper, and use of theory-derived variables as mechanisms or mediators of change, or as an effectiveness outcome [32,48].

Each intervention was coded as aligning with one or more of nine possible *intervention types*: education, which focuses on increasing knowledge or understanding; persuasion, which involves using communication to induce positive or negative emotions and thereby spur action; incentivisation, which creates expectations of rewards for performing the behaviour; coercion, which involves creating expectations of punishments or costs for not performing the behaviour; training, i.e., imparting skills; restriction, which for PA involves reducing the opportunity to engage in competing behaviours; environmental restructuring, i.e., modifying the physical or social context; modelling, which involves providing an example for people to aspire to or imitate; or enablement, which entails increasing means or reducing barriers to PA, by increasing capability or opportunity [26].

BCTs were coded for using the BCT Taxonomy v1 [29], which sets out 93 discrete BCTs. In one study, BCTs were explicitly described using BCT Taxonomy labels, so we used the authors’ original BCT descriptions [42]. BCTs in all other papers were coded by LW via interpretation of intervention descriptions provided in the original papers. Prior to coding, LW completed an online training in identifying BCTs by the authors of the BCT Taxonomy v1 (<https://www.bct-taxonomy.com/>; accessed on 13 July 2025). BCTs were only coded where the coder was highly confident that a BCT had been used.

The trial that was reported across two papers evaluated an intervention that included two components: a supervised sport intervention delivered over five weeks, and a home-based intervention delivered over 35 weeks [40,41]. These were assessed at two immediate post-intervention timepoints immediately after delivery (i.e., five and 35 weeks post-baseline, respectively). For coding purposes, we treated this as a single intervention. One intervention, which promoted both diet and PA behaviour change, was coded for its PA content only [46].

To ensure coding reliability, a senior author (BG) experienced in BCT and intervention type coding independently coded all studies. Reliability was indexed using percentage agreement and kappa statistics, the latter of which was calculated based only on BCTs and types that at least one of the two coders coded as present, to minimise bias due to many BCTs not being coded as present by either coder. Initially, imperfect agreement across all reviewed studies (BCTs: 90% agreement, kappa = 0.80; intervention types: 88% agreement, kappa = 0.76) prompted a round of discussions to resolve discrepancies. Final coding was achieved through consensus.

2.3. Analysis

Sample, intervention and methodological characteristics were descriptively analysed. While meta-regression would ideally have been used to establish links between intervention characteristics and effectiveness, it was deemed unsuitable given the small number of studies in the review. Instead, we adopted a pragmatic two-step method to explore whether certain BCTs or intervention types were more often observed in effective than non-effective interventions [32]. At the first step, we categorised the effectiveness of each *intervention* according to patterns of within- and between-group change, using three category labels. Interventions were deemed to show ‘convergent evidence of effectiveness’ where using a controlled trial design, intervention recipients experienced positive change in at least one measure of PA or QoL (i.e., positive within-group PA or QoL change), and the intervention group experienced greater increases in PA or QoL than did the control group (i.e., positive

between-group PA or QoL change). Interventions were deemed to show ‘limited evidence of effectiveness’ where either positive within-group or positive between-group change was recorded for at least one PA or QoL measure; this allowed for interventions assessed in uncontrolled trials, for which only within-group change could be estimated, to be treated as promising. Interventions that produced neither positive within-group change nor positive between-group change on any PA (or QoL) measure were deemed to show ‘no evidence of effectiveness’. In sum, an intervention was judged as showing at least some evidence of effectiveness if post-intervention change was observed in either at least one PA or at least one QoL measure, and no evidence of effectiveness if post-intervention change was not observed in any PA or any QoL measure.

At the second step, to document which intervention types and BCTs were most commonly present in interventions showing evidence of effectiveness—and therefore, appeared to show promise—we computed a statistic representing the proportion of all interventions incorporating the technique or type that showed at least some evidence of effectiveness. This was calculated by dividing the number of interventions showing ‘convergent’ or ‘limited’ evidence of effectiveness in which the type (or BCT) featured, by the total number of interventions in which that type (or BCT) featured. Where the resultant proportion statistic was above 0.50, this indicated that the type (or BCT) was more commonly used in interventions with at least some evidence of effectiveness than in interventions showing no evidence of effectiveness. Where the proportion was below 0.50, this indicates that the type (or BCT) was more commonly used in interventions showing no evidence of effectiveness. Proportions were not calculated in two instances. Where intervention types (or BCTs) were identified only in interventions showing no evidence of effectiveness, proportions could not be calculated because there was no variation in effectiveness. Additionally, where an intervention type (or BCT) was present in only one intervention overall, proportions were not calculated due to insufficient data to yield an interpretable estimate.

Both intervention-level and technique-level analyses were intended to be exploratory only, and to guide hypotheses and decisions around which interventions and components may most warrant further development or evaluation. The crude, preliminary nature of the analyses precludes conclusions regarding which interventions or components were most or least effective.

We intended to explore whether theory use (i.e., whether and which specific theory was mentioned, and whether and which psychological mediators of intervention effectiveness were measured) varied with intervention effectiveness. However, this was not possible because no study used theory in either capacity.

In the trial that featured two consecutively delivered interventions, reported across two papers [40,41], the intervention types and BCTs used in the second and more comprehensive treatment were used for analyses of associations with evidence of intervention effectiveness.

3. Results

3.1. Study Characteristics

Table 1 summarises study characteristics, and Supplementary Table S2 provides further detail. The seven papers, which were published between 2008 and 2024, reported six discrete intervention evaluation studies. Most were undertaken in North America (two in Canada, one in the US), with two conducted in Asia (one in China, one in South Korea) and one in Europe (Spain). Most studies used single-group cohort designs ($k = 4$), with two studies using (two-arm) RCT designs. Time to final follow-up ranged from 5 weeks to 12 months. The total baseline sample size across all studies was 221, with sample sizes ranging from 9 to 115. Three studies required participants to have had an epilepsy diagnosis for at least one year prior to study entry, one required a diagnosis of drug-resistant epilepsy, and two studies did not state epilepsy criteria.

Table 1. Summary of study and intervention characteristics.

Characteristics	Categories & Frequencies
Methodological characteristics	
Setting	Total k = 6 North America k = 3 Asia k = 2 Europe k = 1
Study design	Total k = 6 RCTs k = 2 Cohort k = 4
Time to first follow-up	Total k = 7 * Range: 5 weeks–35 weeks; median 15 weeks
Time to final follow-up	Total k = 7 * Range: 5 weeks–12 months; median 26 weeks
Sample characteristics	
Sample size	Total k = 6 Combined total N = 221; N range 9–115; median N = 26
Epilepsy criteria	Total k = 6 Epilepsy diagnosis k = 3 Drug-resistant epilepsy k = 1 Not reported k = 2
Average participant age at baseline	Total k = 6 Range of averages: 9.70–13.10 y; median of averages: 10.80 y
Average participant age at epilepsy onset	Total k = 5 ** Range of averages: 4.14 y; median of averages: 7.50 y
Outcome measurement characteristics	
PA measures	Total k = 4 (not measured k = 2) Monitor-assessed k = 2 Independently observed k = 1 Parent-reported k = 1
Quality of life measures	Total k = 6 Parent-reported k = 3 Self-reported k = 2 Unclear how reported k = 1
Intervention characteristics	
Number of intervention types used per intervention	Total k = 7 * Range 1–3; mean 1.86 types
Number of BCTs used per intervention	Total k = 7 * Range 1–14; mean 5.71 BCTs
Theory use: theory mentioned	Total k = 7 * Theory mentioned k = 0 Theory not mentioned k = 7
Theory use: theory-derived mechanisms tested in a trial	Total k = 7 * Theory-derived mechanisms tested k = 0 Theory-derived mechanisms not tested k = 7
Effectiveness: PA as outcome	Total k = 4 Convergent evidence of effectiveness k = 0 Limited evidence of effectiveness k = 2 No evidence of effectiveness k = 2
Effectiveness: QoL as outcome	Total k = 6 Convergent evidence of effectiveness k = 0 Limited evidence of effectiveness k = 3 No evidence of effectiveness k = 3
Overall effectiveness (i.e., PA or QoL as outcome)	Total k = 6 Convergent evidence of effectiveness k = 0 Limited evidence of effectiveness k = 3 No evidence of effectiveness k = 3

k = number of studies. * One study was reported across two papers [40,41], each with a different follow-up point, both of which are counted separately on specified rows. ** One study did not report average age at epilepsy onset [45].

All studies specified a gender breakdown, which ranged from 38% to 77% female. Average participant age at baseline ranged from 9.70 to 13.10 years, and average age at epilepsy onset was 7.5 years. Only four of the six studies reported PA outcomes; two of the four studies used monitor-assessed data, one used independent observation of fitness tests, and one used parent-reported PA. QoL was reported in all six studies, via parent-report ($k = 3$) or self-report ($k = 2$), with one study not specifying who reported QoL. None of the six studies mentioned a specific theory, nor did they measure theory-derived variables as potential outcomes, mediators or mechanisms of effectiveness.

3.2. Intervention Characteristics

Table 2 summarises characteristics of intervention content, and more detailed descriptions are provided in Supplementary Table S3. Of the four interventions assessed for effectiveness in modifying PA behaviour outcomes, none showed convergent evidence of effectiveness, two showed limited evidence of effectiveness (that is, within-group increases in PA were observed among the intervention group), and two showed no evidence of effectiveness (that is, no within- or between-group changes favouring the intervention group). Assessments of effectiveness for increasing QoL showed that none of the six interventions showed convergent evidence of effectiveness, three showed limited evidence of effectiveness, and three showed no evidence of effectiveness. Considering overall evidence of effectiveness, based on evidence of effectiveness for PA or QoL outcomes, three interventions overall showed limited evidence of effectiveness, and three showed no evidence of effectiveness, with no changes seen in any PA or QoL outcome.

Table 2. Intervention content, according to the overall evidence of intervention effectiveness.

Content	Total Number of Studies (k)	Evidence of Intervention Effectiveness *			Proportion of Appearances in Interventions Showing Some Effectiveness **
		Convergent Evidence (k)	Limited Evidence (k)	No Evidence (k)	
Intervention types					
Enablement	4	0	1	3	0.25
Education	3	0	2	1	0.67
Training	3	0	1	2	0.33
Modelling	1	0	0	1	N/A (insufficient data)
Behaviour change techniques					
Goal setting (behaviour)	5	0	3	2	0.60
Self-monitoring of behaviour	3	0	1	2	0.33
Social support (unspecified)	3	0	0	3	N/A (no evidence of effectiveness)
Instructions on how to perform behaviour	3	0	2	1	0.67
Information about health consequences	3	0	2	1	0.67
Demonstration of behaviour	3	0	2	1	0.67
Behavioural practice/rehearsal	3	0	2	1	0.67

Table 2. Cont.

Content	Total Number of Studies (k)	Evidence of Intervention Effectiveness *			Proportion of Appearances in Interventions Showing Some Effectiveness **
		Convergent Evidence (k)	Limited Evidence (k)	No Evidence (k)	
Problem solving	2	0	0	2	N/A (no evidence of effectiveness)
Review behavioural goals	2	0	0	2	N/A (no evidence of effectiveness)
Feedback on behaviour	2	0	1	1	0.50
Graded tasks	2	0	0	2	N/A (no evidence of effectiveness)
Goal setting (outcome)	1	0	0	1	N/A (insufficient data)
Action planning	1	0	0	1	N/A (insufficient data)
Discrepancy between current behaviour and goal	1	0	0	1	N/A (insufficient data)
Review outcome goal(s)	1	0	0	1	N/A (insufficient data)
Monitoring of behaviour by others without feedback	1	0	1	0	N/A (insufficient data)
Social support (practical)	1	0	0	1	N/A (insufficient data)
Social support (emotional)	1	0	0	1	N/A (insufficient data)
Information about social and environmental consequences	2	0	1	1	0.50

k = number of studies. * Overall evidence of intervention effectiveness categories are based on whether the intervention showed 'convergent', 'limited' or no evidence of effectiveness in changing either at least one PA or at least one QoL outcome. ** The proportion of appearances in interventions showing some evidence of effectiveness denotes the number of interventions in which the BCT or type featured, as divided by the total number of interventions using the technique. Proportions are not reported for BCTs and intervention types used only in interventions with no evidence of effectiveness, or where the total number of interventions was less than two.

Four intervention types and 19 BCTs were identified in at least one intervention. The most common intervention types were enablement (k = 4), education (k = 3) and training (k = 3). The most commonly used BCTs were setting behavioural goals, used in five studies, self-monitoring behaviour (k = 3), providing (unspecified forms of) social support (k = 3), giving instructions on how to perform the behaviour (k = 3), providing information on health consequences (k = 3), demonstrating the behaviour (k = 3), and engaging behavioural practice or rehearsal (k = 3).

Education was used twice as many 'limited evidence' as 'no evidence' interventions (i.e., proportion appearances in interventions with some evidence of effectiveness = 0.67), whereas enablement and training were more often observed in interventions showing no evidence of effectiveness than interventions showing limited evidence of effectiveness (proportions 0.25 and 0.33, respectively).

Four BCTs were found to be used in twice as many 'limited evidence' as 'no evidence' interventions (i.e., proportions = 0.67): instruction on how to perform behaviour, information about health consequences, demonstration of behaviour, and behavioural practice or

rehearsal. Where proportions could be calculated, only one other BCT was more commonly found in interventions showing some evidence of effectiveness (setting behavioural goals; proportion = 0.60), with three BCTs (feedback on behaviour, graded tasks, information on social and environmental consequences) being used in the same number of 'limited evidence' as 'no evidence' interventions (i.e., proportion = 0.50). One BCT (self-monitoring behaviour) featured in twice as many 'no evidence' as 'limited evidence' interventions (proportion = 0.33). Proportions were not computed for four BCTs due to their use in only interventions with no evidence of effectiveness, nor for the one intervention type or seven BCTs that were each used in only one intervention.

4. Discussion

Among people living with epilepsy, physical activity (PA) can help symptom management, yet few young people with epilepsy (YPWE) meet PA targets, so behaviour change interventions are needed. Behavioural science offers multiple theories, concepts and methods that are rooted in prior knowledge around how best to change behaviour and when used to develop and evaluate such interventions, will typically enhance intervention effectiveness in PA promotion attempts [31]. We undertook a scoping review of PA interventions for YPWE to provide an 'audit' of whether and how behavioural science tools have been used in interventions in this domain. The few PA interventions identified were shown to have limited effectiveness, with three interventions showing no impact on PA or quality of life (QoL), and three showing weak evidence of effectiveness, with increases in PA observed in intervention groups, but no superior change reported in the intervention group compared to control groups. Moreover, findings provided little indication of explicit behavioural science use in developing or assessing PA interventions for YPWE. Theory was not mentioned, and a narrow range of behaviour change techniques (BCTs) and intervention types appears to have been used. While we found some evidence to suggest that interventions involving setting behavioural goals, providing instruction, demonstration or behavioural practice, or giving information about health consequences tend to be more effective, the small number of studies limits the reliability of these findings. To maximise the benefits of PA promotion attempts for YPWE, intervention designers should draw on intervention development frameworks that offer guidance on how to build interventions in a way that draws on known barriers to engagement in PA among YPWE and their caregivers, and strategies tailored to addressing those barriers.

Our systematic search found only six PA behaviour change interventions that have been trialled among YPWE to date, and little evidence to suggest that they were effective. Behaviour change outcomes were not consistently considered; while QoL outcomes were measured in all six studies, behaviour change outcomes (i.e., changes in PA duration, intensity or frequency) were only assessed in four of the six studies. This is understandable, given that PA promotion among YPWE is typically a means of increasing QoL [5], but nonetheless problematic, because assessing the effectiveness of PA promotion interventions relies on determining whether PA has changed. Our findings suggested that behavioural science has not been adequately considered or consulted—or, at very least, reported—in the development or evaluation of these interventions. For example, none of the six interventions appeared to have been designed on the basis of a named theory of behaviour or behaviour change, nor were any theory-derived constructs used to understand whether or why PA changed. This is an important omission, because theories provide structured summaries of accrued prior evidence around the discrete reasons why people do or do not engage in PA, and accounts of the pathways through which behaviour change might occur [49]. For example, the Theory of Planned Behaviour (TPB [24]) proposes that four key concepts shape behaviour; specifically, attitudes, subjective norms and perceived

behavioural control influence intentions and intentions are the most proximal determinant of behaviour. The TPB offers suggestions as to why YPWE fail to engage more in PA; specifically, YPWE (or, especially for younger people with epilepsy, their caregivers) must not sufficiently intend to do so, due to some combination of insufficiently positive attitudes, perceptions of unsupportive social norms, or they must feel it is prohibitively difficult to do so. Additionally, the TPB proposes that, to change PA, an intervention must address the salient attitudinal, normative or control beliefs that preclude positive PA intentions and that doing so will change motivation, which in turn will spur action [50]. These recommendations can be used to direct intervention efforts towards the main barriers to behaviour change. Conversely, if an intervention has failed to increase PA, the TPB suggests that it must not have sufficiently changed the core attitudinal, normative or control beliefs that act as barriers to PA. It is therefore important to measure not only behaviour change, but also changes in expected theoretical mechanisms through which an intervention is expected to work—for example, assessing attitudes, when evaluating an intervention designed to change behaviour via attitude change. Using theory in this way can provide important insights into why an intervention has been successful or not, which in turn can help intervention developers to focus on effective mechanisms for change and avoid targeting ineffective mechanisms [49]. More broadly, the apparent lack of explicit theory use observed in our review suggests that intervention developers may not be following a systematic process of considering theory and evidence when designing interventions. Interventions developed based on intuition alone tend to be less effective than those designed with consideration of appropriate theory and evidence [17]. Trials among clinical populations are resource- and cost-intensive, and interventions that are not clearly based on evidence or theory risk costly failure. Recruiting YPWE to potentially burdensome tests of potentially suboptimal interventions also raises ethical concerns [51]. Multiple frameworks are available that provide step-by-step guidance for considering theory and evidence when developing behaviour change interventions [17,19,20]. The Behaviour Change Wheel framework is particularly notable because it is designed to support people with no formal behavioural science training to negotiate the intervention development process [17].

Intervention content can be understood according to its component behaviour change techniques (BCTs), and we found that only 19 of a possible 93 BCTs were reportedly used in PA promotion interventions for YPWE. This is a significant finding because it suggests that interventions have been overly reliant on a small number of BCTs. We do not recommend that all interventions should use more BCTs per se; simply increasing the number of BCTs used does not typically enhance intervention effectiveness [52]. However, the use of only a minority of available BCTs is notable because it indicates a narrowness of thinking around how to increase PA in YPWE. Observing which BCTs—and intervention types—have been used most often can reveal intervention developers' assumptions regarding how to modify PA in this population. Techniques such as setting behavioural goals and providing information on health consequences, and a focus on education, all of which were commonly observed in these interventions, may suggest that intervention developers have assumed that YPWE are unable to effectively plan how to engage in PA, or do not recognise the benefits of doing so. These assumptions may be well-founded; indeed, all these approaches were more prevalent in interventions for which there was at least some evidence of effectiveness relative to those showing no evidence of effectiveness, suggesting that they may contribute to successful PA promotion. However, these BCTs may not be sufficient to tackle all barriers to PA engagement, such as worry about injury or health risks [21,22]. These barriers perhaps call for more social support for engaging in PA safely, and instruction on how to self-monitor the outcomes of PA on their health

and wellbeing; yet, social support BCTs were used only inconsistently in the reviewed interventions, and self-monitoring PA outcomes was not encouraged in any intervention. BCT taxonomies also offer multiple other clusters of techniques that could potentially be useful for supporting PA uptake among YPWE. These include context-consistent repetition, which aims to encourage the formation of habits, such that PA episodes are triggered automatically [30]; reflecting on past successes, to enhance self-belief and confidence [53]; and creating or tapping into salient social identities that prescribe PA, such as seeing oneself as a health-conscious person [54]. We do not endorse the adoption of underused BCTs per se. Rather, we recommend that a broader range of BCTs be considered, based on prior analyses of barriers to engaging in PA among YPWE, and existing knowledge regarding which BCTs are best suited to target which barriers (see [26]).

Our analysis identified BCTs and intervention types that were more prevalent in interventions for which there was at least some evidence of effectiveness relative to those for which there was no such evidence. These included providing instruction on how to do PA, information on health consequences, demonstration of behaviour, behavioural practice, goal-setting techniques, and education-based approaches. While these findings cannot be interpreted as evidence of whether techniques were 'effective' or 'ineffective', they nonetheless more broadly suggest that guiding YPWE or their caregivers in how—and why—to engage in PA safely could potentially have a positive impact on PA uptake. In this respect, our findings largely align with previous reviews, which suggest that self-regulatory support—that is, using techniques that help people to act on their motivation, such as goal-setting and self-monitoring behaviour—is beneficial for PA promotion [47,55,56]. Goal-setting is thought to be particularly valuable for YPWE as it helps people to break down PA goals into realistic and manageable steps, so overcoming difficulties of coordination, motor control and fatigue that can arise from epilepsy and the side effects of anti-seizure medication and which are thought to inhibit bouts of PA [14]. Self-monitoring behaviour or outcomes, or encouraging such monitoring among caregivers, is also well suited to YPWE, because features such as heart rate monitoring and temperature tracking can support individuals to understand seizure triggers, assisting in self-management of seizure frequency, and thereby tackling a significant barrier to PA in YPWE [21]. Our analyses regarding which intervention components were more commonly found in interventions with some evidence of effectiveness are crude and do not reveal true effectiveness. Given also the small sample of interventions reviewed, these findings must be interpreted with considerable caution. Additionally, our operationalisation of evidence of intervention effectiveness was crude and based on whether any changes were observed, rather than extracting data on effect size magnitude. We also defined 'evidence of effectiveness' liberally, deeming an intervention to have shown some evidence of effectiveness, albeit limited evidence, if any within- or between-group change was observed for either PA or quality of life. This resulted in one intervention being treated as showing (limited) evidence of effectiveness for changing PA based on a within-group increase in just one of six physical fitness tests [40]. Additionally, one intervention classified as showing (limited) effectiveness in improving QoL targeted both PA and dietary changes [46], such that observed effects cannot be confidently attributed to PA-focused components. Our classification system may thus have overstated the evidence of the effectiveness of PA interventions and their components. More sophisticated techniques are available for estimating the contribution of discrete intervention components to variation in effect sizes [49], but these were not feasible for use in our review due to the small sample. Relatedly, the small samples used in the reviewed studies mean that we cannot rule out the effectiveness of interventions and intervention components, for which there was no evidence of effectiveness in our review. Five of the six reviewed studies used samples of 29 participants or fewer, including

two studies with just nine and 10 participants, respectively. This highlights the problem of dichotomising intervention effectiveness evidence based on statistical significance alone. Interventions deemed to have shown ‘no evidence of effectiveness’ in our review could feasibly be found to be effective in future research using adequately statistically powered samples.

Other limitations of our review must be acknowledged. We searched only two databases, focusing on psychology and health (i.e., PsychInfo, Medline). Given the interdisciplinary nature of this topic, it remains possible that we may have overlooked other relevant studies that may have been identified via, for example, sports or rehabilitation databases. However, the credibility of our search is validated by a recent literature review focusing on the effects of PA on epilepsy outcomes, rather than behaviour change outcomes [5], which located the same studies as included in our review—except a study ineligible for our review [56], and a more recently published paper [45]. We are therefore confident that our search, while not exhaustive, identified key, representative studies in this domain.

We did not code for who was targeted by the intervention, using which techniques. Among younger children with epilepsy, caregivers and family members may have a greater influence on PA engagement, such that PA uptake might be most effectively encouraged by targeting the attitudes, beliefs or values of family members and other caregivers, rather than YPWE themselves [5,16]. However, this reflects a limitation of the reviewed interventions; several interventions were delivered to YPWE of broad age ranges (e.g., 8–14 year olds [42]; 11–17 year olds [46]), and authors did not report age-specific or recipient-specific effects. It was therefore unclear whether changes occurred primarily among YPWE or their caregivers.

The appropriateness of our coding might be questioned. Our findings suggest that behavioural science has rarely been explicitly used in PA promotion interventions for YPWE. Yet, intervention content coding is constrained by the clarity of intervention descriptions, such that BCTs and intervention types are more difficult to extract from interventions that are described unclearly or in minimal detail. Notably, the intervention for which most BCTs were coded was explicitly described by the study authors using the BCT Taxonomy v1 [42]. The number of BCTs coded in each intervention may therefore reflect the clarity of intervention descriptions, rather than truly reflecting the BCTs used [57]. Similarly, while no named theories were found to have been mentioned in any of the reviewed studies, this may reflect that the reports were published in journals in which providing such details is unconventional or not required. We were unable to distinguish between suboptimal use of behavioural science in intervention design and evaluation, and in reporting interventions and their effects. Yet, it is important to separate these limitations. A lack of engagement with behavioural science in intervention design limits conclusions about intervention effectiveness, whereas reporting problems focus on incomplete or unclear descriptions of intervention content and mechanisms, including insufficient specification of behaviour change techniques and theoretical underpinnings. Reporting limitations, however, obstruct evidence synthesis and replication, and may obscure actual use of behavioural science and the true nature of intervention effects. Although these are distinct concerns, addressing both sets of limitations is essential for advancing the field.

We encourage intervention developers to make explicit use of behavioural science in the development, evaluation, and reporting of PA promotion interventions for YPWE. We propose a ‘checklist’ of tools to aid these efforts. When developing interventions, we encourage the use of behaviour change intervention development frameworks, as these offer step-by-step practical guidance on how to harness theory and evidence to increase the likelihood of intervention effectiveness. While several such frameworks exist [17,19,20],

we recommend the Behaviour Change Wheel framework for its accessibility for those less familiar with behavioural science [17]. The Behaviour Change Wheel proposes a series of steps in intervention design. First, intervention developers should consult available theory and evidence to identify which specific behaviour(s) to target, among whom, to encourage PA uptake among YPWE. Second, a 'behavioural diagnosis' should be conducted, whereby theory and evidence are reviewed and synthesised to identify the most pertinent barriers to changing the focal behaviour(s). Lastly, developers should select BCTs and intervention types likely to most effectively target the identified barriers (see [17] for guidance). When evaluating interventions, intervention developers should seek to assess changes not only in prioritised outcomes of behaviour (e.g., QoL), but also in behaviour itself, and ideally, in the identified determinants of behaviour. For example, attempts to boost QoL through PA uptake, promoted via educating caregivers about how YPWE can safely engage in PA as a means to enhance caregivers' motivation, should seek to measure changes in QoL and PA among YPWE, and changes in knowledge and motivation among caregivers. Evaluating these indicators in an RCT, in both intervention and control recipients, would reveal whether QoL changed, whether increases in PA were responsible for the change, and whether PA modification could be attributed to changes in caregivers' knowledge and motivation. Such information is important for understanding not only whether but also *why* the intervention was effective; that is, through which psychological and behavioural mechanisms the intervention affected outcomes. To enhance the robustness of behavioural data, we encourage the use of monitor-based PA assessments where possible, such as wearable activity trackers. When reporting interventions, we encourage intervention developers to specify whether, which and how theory was used (for guidance, see [27]), and which intervention types and BCTs were used. BCTs should be described using the standardised terminology prescribed by the BCT Taxonomy v1 [29], or its successor, the BCT Ontology [28]. For comprehensiveness and optimal clarity, authors should not only describe intervention content according to component BCTs, but also report other intervention elements (e.g., mode and source of delivery) using the Template for Intervention Description and Replication (TIDieR) checklist [58]. These efforts would greatly enhance the usefulness of intervention reports for future syntheses of PA promotion interventions. To maximise the usefulness of published reports of behaviour change interventions for enhancing PA uptake among YPWE, journal editors should require the provision of such information as standard.

5. Conclusions

Behavioural science offers tools and insights that can help intervention developers to systematically identify barriers and facilitators of engagement in PA among YPWE, and appropriate methods for addressing these barriers. Yet, this review showed that these tools are rarely reported in descriptions of the design or evaluation of PA promotion interventions. We encourage researchers to make explicit use of behaviour change tools when developing, evaluating and reporting findings from attempts to promote PA among YPWE. This will increase the likelihood that resultant interventions are effective, and will enhance understanding of the mechanisms through which such interventions have such effects.

Supplementary Materials: The following supporting information can be downloaded at <https://www.mdpi.com/article/10.3390/app16136539/s1>. Table S1: Search terms and output; Table S2: Study characteristics; Table S3: Intervention content and theory use.

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Abbreviations

The following abbreviations are used in this manuscript:

BCT	behaviour change technique
PA	physical activity
QoL	quality of life
RCT	randomised controlled trial
YPWE	young people with epilepsy

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