

# The Benefits of Physical Activity in Children and Adolescents with Epilepsy: A Systematic Review

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## Abstract

The aim of this study was to review the literature about the effect of physical activity intervention in children and adolescents with epilepsy. Articles were searched in the central electronic databases of MEDLINE, Embase, PsycArticles, and CINAHL for the following keywords: “epilepsy,” “seizure,” “physical activity,” “physical exercise,” “exercise therapy,” “sport,” using the Boolean operator “AND” and “OR.” The quality of the selected articles was evaluated by the Physiotherapy Evidence Database scale. Out of the 22 articles selected, 18 did not involve intervention or did not have pre- and postresults and therefore were excluded from the study. The remaining four were studies from Canada and Korea which comprised two long-period interventions and were included in the analysis. Both programs demonstrated a positive effect of physical activity on variables related to psychological well-being and cognitive function. All the four articles demonstrated a lower score of quality. In conclusion, reviewed studies suggest that physical exercise program induces some benefits in children and adolescents with epilepsy. However, the noncontrolled trials and the varied analyses (quantitative vs. qualitative) make it difficult to establish a consensus about benefits of physical activity in epilepsy.

## Keywords

- ▶ adolescents
- ▶ children
- ▶ epilepsy
- ▶ exercise
- ▶ physical activity

## Introduction

Epilepsy is a chronic neurological condition characterized by the recurrence of unprovoked seizures, as a result of abnormal and excessive electrical discharges from neurons of the central nervous system.<sup>1</sup> It can be caused by a genetic disorder, acquired brain injury (e.g., trauma or stroke),<sup>1,2</sup> or in the first year of life due to immaturity of the brain.<sup>3</sup> Epileptic seizures can be classified as focal or generalized, which can result in changes in the neural networks.<sup>4</sup>

Prevalence of epilepsy in children and adolescents in the developed world is ~3.2 to 5.5 per 1,000.<sup>5</sup> In children 3 to 10 years of age, the most common epilepsy type was generalized, while in those 10 to 18 years of age, it was focal, similar to the epileptic adult population.<sup>4</sup> For fear of occur-

rence of epileptic seizures, children and adolescents with epilepsy tend to reduce their participation in the sports program and exercise activities. They are consequently classified as inactive or less physically active,<sup>3</sup> thereby having lower cardiorespiratory fitness levels<sup>6</sup> compared with people without it. However, studies showed that seizures during exercise are uncommon.<sup>7,8</sup> Participation in sports and physical activities is encouraged, especially at young ages, as they can act as a protective factor against seizures<sup>7</sup> and psychosocial aspects such as increased self-esteem, socialization, and decreased comorbidities related to epilepsy.<sup>9</sup>

The recommendations reported in the literature for sports practice for people with epilepsy classify sports as high risk, moderate risk, low risk, and no risk of seizure occurrence during the event.<sup>7</sup> However, this classification takes into

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account the sports' specific individual characteristics or circumstances for practice based on data evaluation, speculation of previous studies, and common sense.<sup>7</sup> A systematic review described the recommendations for physical exercise protocols based on animal studies. As the main finding, the authors pointed out that resistance training proved to be more effective in treating epilepsy in rats, and protocols of long duration and moderate to high intensity were demonstrated to be more effective when compared with their counterparts.<sup>10</sup>

A previous study reported that only 2 of the 400 adults (less than 0.5%) had seizures during physical activity.<sup>11</sup> Another study concluded that exercise and sports may not trigger seizures in children and adolescents with epilepsy during physical activity at school.<sup>12</sup> Due to the lack of knowledge of the disease, fear, overprotection, and other reasons, people with epilepsy are less inclined to exercise.<sup>12</sup>

This study was undertaken to review the literature about the impact of physical activity intervention in children and adolescents with epilepsy. Moreover, we aimed to describe design characteristics (e.g., type of exercise, duration, and intensity) and the effectiveness of these interventions. The results of this review may help support future interventional studies and assist physical education professionals in the prescription and guidance of exercises in children and adolescents with epilepsy.

## Methods

### Protocol

The systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement guidelines<sup>13</sup> and the PICOS model for the definition of the inclusion criteria: P (Population): "children and adolescents"; I (Intervention): "physical activity, sports or therapeutic exercises interventions"; C (Comparators): "variable results presented pre- and postinterventions"; O (Outcome): "effect or not on variables evaluated"; S (Study design): "interventional."<sup>14</sup>

### Search Strategy

Searching included four relevant electronic databases: MEDLINE (accessed by PubMed), Embase, Psycarticles, and CINAHL. Medical Subject Heading terms, if available in PubMed, were used. The following keywords were applied: "epilepsy," "seizure," "physical activity," "physical exercise," "exercise therapy," "sport," using the Boolean operator "AND" and "OR."

### Eligibility Criteria

Only studies performed in children and adolescents, with exercise intervention and with pre- and postintervention assessments were included, with no restriction of sex, physical fitness, or level. Review, meta-analysis, and case study were excluded.

### Screening and Selection

The search for articles was conducted between April and May 2020 by one independent evaluator. The studies were

selected by title, abstract, and relevance. Duplicate studies, manuscript published as notes, case studies, reviews, and books, and those studies that did not meet the inclusion criteria were excluded. All publications, regardless of the year of publication, were considered for initial analysis.

### Quality and Risk of Bias Assessment

One investigator evaluated the methodological quality of the included studies. The PEDro scale was used to assess the risk of bias which evaluates the quality of trials, especially in physical therapy and rehabilitation studies. PEDro scale contains 11 criteria: eligibility criteria, random allocation, concealed allocation, similarity at baseline, participants blinding, therapist blinding, assessor blinding, adequate follow-up (> 85% follow-up for at least one key outcome), intention-to-treat analysis, between-group statistical comparison for at least one key outcome, and point and variability measures for at least one key work. Each item, except the first criterion, corresponds to one point and a study is graded as: 9 to 10 excellent, 6 to 8 good, 4 to 5 fair, and <3 poor quality.<sup>15</sup>

## Results

### Search Results

The first step consisted of conducting the search in four databases, in which 480 studies were found; the second step consisted of identifying the articles based on the title and abstract, which excluded 250 works that did not contain the inclusion criteria and 208 articles with repeated titles. The third step was the eligibility stage, in which 22 articles were read in full, and the final selection identified four studies which were included in the present review (→ Fig. 1).

### Characteristics of Included Studies

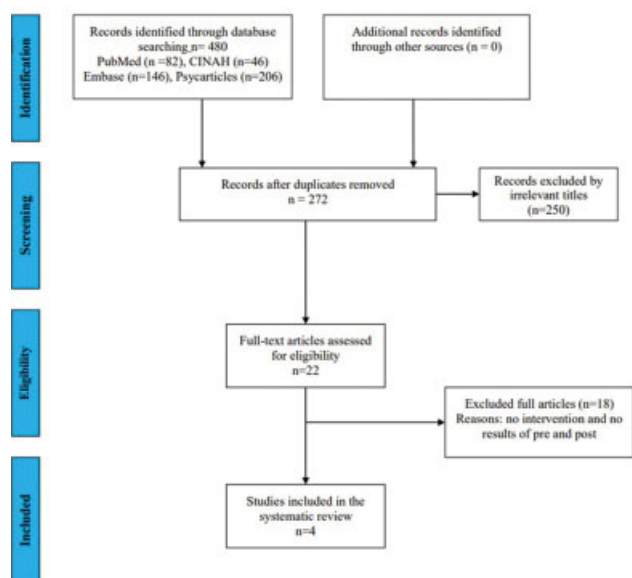
All four interventional studies identified (two each from Canada and Korea) included baseline and postintervention results, and had short-period and long-period intervention arms. The Korean study intervention lasted 35 weeks, separated into two phases: 5 weeks<sup>16</sup> and 30 weeks.<sup>17</sup> The Canadian study intervention lasted 12 months, also divided into the two-phase investigation: 6 months of intervention and 6 months of no intervention, with both qualitative<sup>18</sup> and quantitative results<sup>19</sup> (→ Table 1).

### Variables Measured and Main Results

In both studies, physical activity and variables related to psychological, well-being, and cognitive function were measured. Positive effects in both programs were present.<sup>16–18</sup> In the Canadian study, the physical activity did not increase to levels above those found in the control group<sup>19</sup> (→ Table 2). In the Korean studies, the authors reported the results in values with pre- and postinterventions, displayed in → Fig. 2.

### Quality and Risk of Bias

Scores on the PEDro scale ranged from 2 to 9 of a maximum 10 points (→ Table 3). The Eom et al's studies<sup>16,17</sup> presented lower scores of quality and bias. Although the eligibility,



**Fig. 1** Preferred Reporting Items for Systematic Reviews and Meta-Analyses diagram.

adequate follow-up, and intention-to-treat analysis criteria were met, the studies did not present comparisons between-group and some blinded criteria. Willis et al<sup>18</sup> presented a similar weakness and presented the results quantitatively; however, the long-period project demonstrated in Brown et al<sup>19</sup> fulfilled most of the quality criteria and showed excellent quality.

## Discussion

This study aimed to review the scientific literature regarding the effect of physical activity intervention in children and adolescents with epilepsy. We found only four studies that presented physical activity intervention, comprising two big projects, a Korean and a Canadian, with a presentational sports program, and long-term and home-based exercises recommendation protocols. The exercise improved neurocognitive function, psychological domain, and social interaction in both projects, but not the physical resistance and physical activity levels in this specific population.

In the study of Eom et al from Korea,<sup>16,17</sup> the program started with 5 weeks of supervised exercise/sports practice in children ( $9.7 \pm 1.42$  years), conducted by exercise experts and assisted by nurses, and continued with 30 more weeks of home-based activities and meetings about exercise instructions. The researchers recommended the parents to encourage their children with epilepsy to perform resistance exercises using body weight and 20 to 30 minutes of aerobic exercise. Similarly, in the Canadian study,<sup>18,19</sup> the program for children and adolescents (8–14 years) with epilepsy consisted of 6 months of counseling about increased step count, with a goal of 12,000 steps per day, and then 6 more months of only monitoring.

Both study protocols comprised recommendations of physical activity for children and adolescents to encourage them to be more active, but without specific exercise, or

protocol controlling type and intensity (e.g., volume and duration), and without professional supervision. Maybe this explains the lack of improvement in the Korean study's physical components<sup>15</sup> and the failure to increase the physical activity levels in the Canadian study.<sup>18,19</sup> On the contrary, both protocols improved different parameters such as neurocognitive function, psychological domain, general health and quality of life, and social interaction, highlighting the far-reaching benefits of the practice of physical activity, regardless of the type, in children and adolescents with epilepsy.

There was a noticeable lack of information regarding recommendations about appropriate exercises for children and adolescents with epilepsy. In the sport's settings, the literature pointed out that some mechanisms might trigger seizures during athletics, such as sports causing hypoxia which may occur in climbing or skiing at high altitude and sports involving recurring head trauma (e.g., boxing, hockey, diving, soccer, rugby). Moreover, sports with high risk of dangerous falls (e.g., mountain climbing, parachuting) and those who require supervision underwater should be avoided.<sup>7</sup> Also, Capovilla et al<sup>8</sup> categorized the sports based on the risk of injury or death that should a seizure occur during the event: no significant additional risk, moderate risk, and high risk (see detailed in Table 1 of the Capovilla et al's article); nonetheless, the categorization was made based on the judgment of the physician, with no experimental support. On the contrary, the literature also recommends that patients with epilepsy should not be discouraged from practicing any recreational or competitive sport, and they can enjoy the physical and psychological benefits of the sport and exercise as anyone else.<sup>7,8</sup> Therefore, we highlight the importance of professional teaching, guiding, and monitoring children and adolescents with epilepsy during practice.

The World Health Organization's recent recommendations for physical activity in children and youth aged 5 to 17 years, unless contraindicated due to specific medical conditions, include at least 60 minutes of moderate- to vigorous-intensity exercise daily. Additionally, most of the daily physical activity should be aerobic, strengthen muscle and bone, and should be incorporated at least three times per week.<sup>20</sup> However, this recommendation has been hard to follow. A recent study demonstrated that globally, more than 80% of adolescents aged 11 to 17 years did not meet daily physical activity.<sup>20</sup>

Inactive or insufficient active children and youth should be encouraged to a progressive increase in their physical activity levels to eventually achieve the target recommendations and participate in a variety of physical activities to improve their development, and at the same time, these activities should be enjoyable and safe.<sup>21</sup> For children and adolescents with epilepsy, a supervised and monitored exercise program with their health care and physical education professional should be emphasized to increase physical parameters and physical activity levels, besides the cognitive, psychological, and social benefits. Parents' role is essential to maintain the physical activity levels and other lifestyle factors, as children and adolescents are dependent on them in several aspects.

To date, this is the first systematic review that presents and discusses the protocols and benefits of physical activity

**Table 1** Characteristics of the included studies

Author (y)	Country	n/age (median ± SD)	Epilepsy type	Duration/exercise type	Exercise intervention
Eom et al (2014) <sup>16</sup>	Korea	Boys = 4, girls = 6 9.7 ± 1.42 y	Benign epilepsy centrotemporal spikes	10 presentational sessions (twice per week, 5 wk). Exercise session duration: 3 h. Home-based exercise recommendation	Activities consisted of playing basketball, soccer, table tennis, badminton, or jump rope, and line dancing. Recommendation to perform home-based exercises, 15–20 min of resistance exercises using their own body weight (e.g., sit-ups and push-ups)
Eom et al (2016) <sup>17</sup>	Korea	Boys = 4, girls = 6 9.7 ± 1.42 y	Benign epilepsy centrotemporal spikes	5 wk of presentational activities 30 wk of home-based program recommendation, duration: 20–30 min	Home-based exercise instruction for children to perform an exercise program on their own with their parents' encouragement at home. Recommendation consisted of resistance exercises using their body weight such as sit-ups and push-ups and 20–30 min of aerobic exercise
Willis et al (2018) <sup>18</sup>	Canada	Intervention = 56; control = 59 8–14 y	Active epilepsy, with seizure within the previous 12 mo	12 mo of monitoring. 6 mo of counseling: weekly for weeks 1–4, biweekly for weeks 6–12, and monthly for weeks 13–24. A total of 11 calls counseling	Intervention based on achieving a goal of 12,000 steps per day. First 6 mo with personal coaching recommendation regarding increasing step count via phone calls (intervention group). The second phase, more 6 mo, aimed to maintain the step goal independently, without counseling (both groups)
Brown et al (2019) <sup>19</sup>	Canada	Intervention = 56; control = 59 8–14 y	Active epilepsy, with seizure within the previous 12 mo	12 mo of monitoring. 6 mo of counseling: weekly for weeks 1–4, biweekly for weeks 6–12, and monthly for weeks 13–24. A total of 11 calls counseling	Intervention based on achieving a goal of 12,000 steps per day. First 6 mo with personal coaching recommendation regarding increasing step count via phone calls (intervention group). The second phase, more 6 mo, aimed to maintain the step goal independently, without counseling (both groups)

Abbreviation: SD, standard deviation.

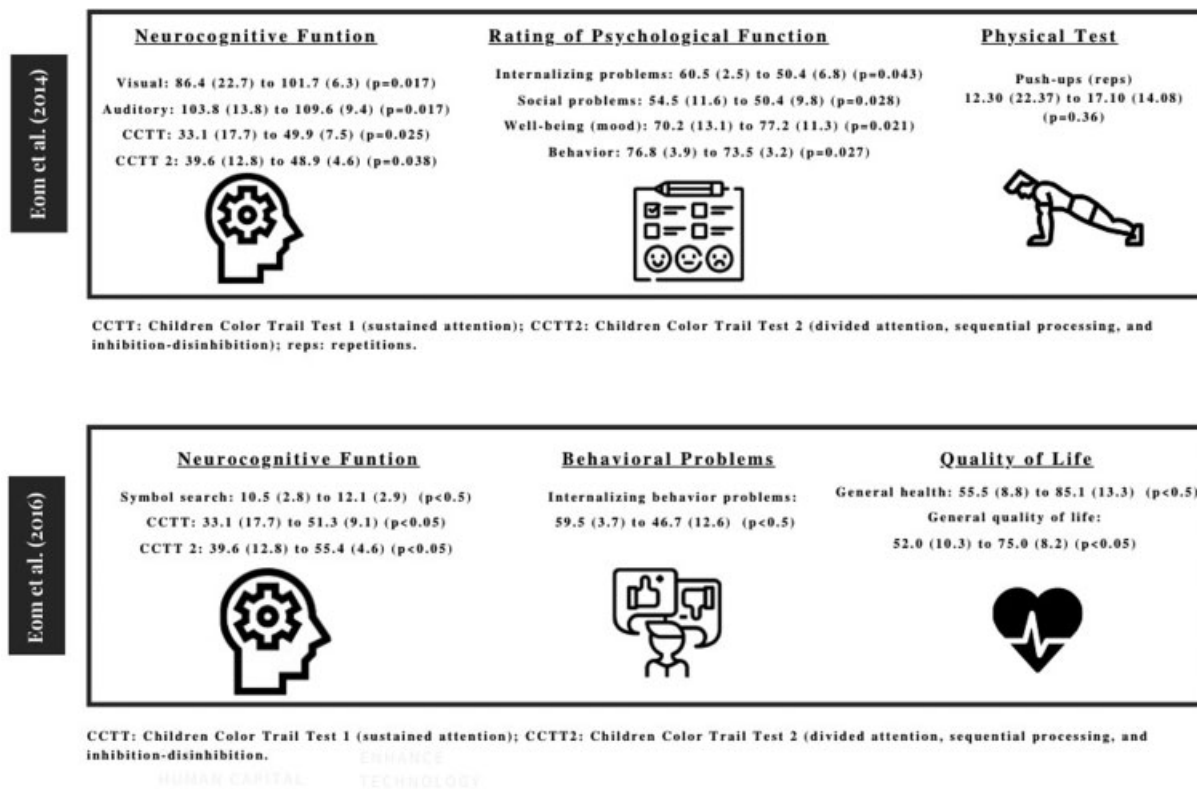
**Table 2** Variables measured and main results

Study	Measurement	Main results
Eom et al (2014) <sup>16</sup>	Resistance physical tests; attention, executive function, depression, anxiety, behavior problems, and quality of life	Exercise programs show increases from baseline to postintervention on indices of neurocognitive function involving visual, auditory, sustained, and divided attention; psychomotor speed; sequential processing; and inhibition–disinhibition. Ratings of psychological functions also showed improvement in the realms of emotional and psychosocial adjustment. Physical tests did not differ from baseline to postintervention, only the push-ups test
Eom et al (2016) <sup>17</sup>	Competence, behavioral problems, physical function, well-being, cognition, social function, general health, and quality of life	Long-term home-based exercise recommendation presented significant improvements in neurocognitive domains such as psychomotor speed, sustained attention, divided attention, and inhibition–disinhibition ability, and in psychological domains including internalizing behavior problems, general health, and general quality of life

**Table 2** (Continued)

Study	Measurement	Main results
Willis et al (2018) <sup>18</sup>	Semistructured interviews with questions pertaining enhancing PA and how various elements play a role in facilitation or hindering exercise, in viewpoints of participants and their parents PA monitored daily using the Fitbit Ultra Wireless Activity Tracker	Participant’s perspective: weight loss, increased muscle strength, increased family time, changes of attitude toward activity, increased insight, positive feelings associated with achieving goals, emotional release, change of habits, increased confidence, changes in time management, improved perception of activity benefits and decreased seizure activity. <i>Parents’ perspective:</i> an improved experience of self, strength benefits, improved sleep, increased family time, changes in a dialog among families regarding epilepsy, happier family environment, social benefits, improved attitude toward PA, change of habits, changes in perception of benefits of activity, improved mood, increased confidence, decreased seizure activity, increased parents awareness of own PA, improvement of entire family’s attitude toward activity
Brown et al (2019) <sup>19</sup>	Anthropometric measures, quality of life, and health-related PA monitored daily using the Fitbit Ultra Wireless Activity Tracker	The counseling program was unsuccessful in increasing PA to levels above those found in the control group. Measures of mental health and quality of life also showed no differences between conditions over the 1-year period. In fact, PA levels decreased among both groups following the 6-mo intervention period; however, reductions in PA were not associated with declines in depressive symptoms and quality of life

Abbreviation: PA, physical activity.



**Fig. 2** Descriptive results of significant variables improved postexercise intervention in children and adolescents from Korean studies.

**Table 3** Quality and eligibility bias of selected studies

	Eom et al (2014)	Eom et al (2016)	Willis et al (2018)	Brown et al (2019)	Studies meeting criterion n (%)
Eligibility criteria	Yes	Yes	Yes	Yes	4 (100)
Randomized allocation	No	No	No	Yes	1 (25)
Concealed allocation	No	No	No	No	0 (0)
Comparable at baseline	No	No	No	Yes	1 (25)
Blinded participants	No	No	No	Yes	1 (25)
Blinded therapists	No	No	No	Yes	1 (25)
Blinded assessors	No	No	No	Yes	1 (25)
Adequate follow-up	Yes	Yes	Yes	Yes	4 (100)
Intention-to-treat analysis	Yes	Yes	Yes	Yes	4 (100)
Between-group comparisons	No	No	No	Yes	1 (25)
Point estimates and variability	Yes	Yes	No	Yes	3 (75)
Total score	3	3	2	9	

in children and adolescents with epilepsy. However, despite the originality and robustness of the current study, some limitations should be highlighted. The small number of studies with only two intervention programs included in this review is the most critical limitations. Moreover, the variables evaluated are different as well as methods (e.g., qualitative vs. quantitative). Also, considering the risk of bias, three out of four included studies present poor quality,<sup>16–18</sup> reported the effects of intervention in the same group (experimental), and thus, these nonrandomized controlled trials compromise the quality of the results. Only one study was considered excellent quality, in which no differences were found in depressive symptoms and quality of life.<sup>18</sup>

Nonetheless, even though the PEDro scale is frequently used in systematic reviews, the interpretation of bias risk requires caution, once the tool is not specific to qualitative studies. Moreover, the selected studies did not report if the physical activity interventions effectively controlled epileptic seizures. Thus, there is a lack of evidence-based literature regarding positive effect of physical exercise in children and adolescents with epilepsy.

## Conclusion

In conclusion, reviewed studies suggest that physical exercise program induces some benefits in children and adolescents with epilepsy. The studies demonstrated positive impact on neurocognitive function, psychological domain, and social interaction, but not on the physical resistance and physical activity levels in this specific population. However, due to low number, poor quality of publications, noncontrolled trials, and varied analyses made (quantitative vs. qualitative) make it difficult to establish consensus about the dose–response of physical activity in epileptics in children and adolescents.

### Conflict of Interest

None declared.

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