REVIEW DERLEME

DOI: 10.5336/pediatr.2024-104909

Factors Shaping Physical Activity Levels in Children with Epilepsy-A Rehabilitation Perspective: Traditional Review

Epilepsili Çocuklarda Fiziksel Aktivite Düzeylerini Şekillendiren Faktörler-Bir Rehabilitasyon Perspektifi: Geleneksel Derleme

Merve KURT AYDIN[a,b], Dilan SAVAŞ KALENDER[c], Tülay TARSUSLU[d]

[a]İzmir Kâtip Çelebi University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, İzmir, Türkiye
[b]İzmir Kâtip Çelebi University Physiotherapy and Rehabilitation Research and Application Center, İzmir, Türkiye
[c]Dokuz Eylül University Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, İzmir, Türkiye
[d]Dokuz Eylül University Faculty of Physical Therapy and Rehabilitation, Department of Neurological Physiotherapy-Rehabilitation, İzmir, Türkiye

ABSTRACT From past to present, epilepsy, a long-term neurological condition marked by recurrent unprovoked seizures, has been linked to limitations in physical activity. Despite the proven benefits of exercise or physical activity in children with epilepsy, unfounded beliefs and misinformation, such as the idea that physical activity can trigger seizures or is dangerous for children with epilepsy, can influence attitudes of families and children about it, potentially leading to reduced participation in physical activities. The International League Against Epilepsy recommends physical activity for individuals diagnosed with epilepsy, highlighting that the benefits outweigh the risks. In 2016, the International League Against Epilepsy supported safe participation in sports for individuals with epilepsy, categorizing sports by their potential risk of injury or death during a seizure: minimal, moderate, or high risk. Swimming, water skiing, and sailing should be approached with caution and preferably conducted under supervision. For sports like bicycle racing, horseback riding, and gymnastics should be considered according to individual characteristics. Aerobic exercise is generally recommended for nearly all individuals with epilepsy. When recommending physical activity, it is important to consider the benefit/risk ratio, personal characteristics, seizure characteristics, and the nature of the physical activity. Physical activity can potentially reduce seizure frequency, improve mood and cognitive function, enhance overall physical health, and mitigate comorbidities which might result from epilepsy or its treatment, such as obesity and decreased bone quality. Therefore, children and adolescents should be encouraged to participate in sports activities at school or in recreational settings, while taking into account the associated risk classifications.

Keywords: Epilepsy; aerobic exercise; seizure; physical activity

ÖZET Geçmişten bu yana, tekrarlayan provoke edilmemiş nöbetlerle kendini gösteren uzun süreli nörolojik bir durum olan epilepsi, fiziksel aktivite sınırlamalarıyla ilişkilendirilmiştir. Epilepsili çocuklarda egzersiz veya fiziksel aktivitenin kanıtlanmış faydalarına rağmen fiziksel aktivitenin nöbetleri tetikleyebileceği veya epilepsili çocuklar için tehlikeli olduğu fikri gibi asılsız inançlar ve yanlış bilgiler, ailelerin ve çocukların bu konuya yaklaşımını etkileyerek fiziksel aktivitelere katılımın azalmasına neden olabilmektedir. Uluslararası Epilepsi ile Savaş Ligi, epilepsi teşhisi konmuş bireyler için fiziksel aktiviteyi tavsiye etmekte ve faydalarının risklerinden daha ağır bastığını vurgulamaktadır. Uluslararası Epilepsi ile Savaş Ligi, 2016 yılında epilepsili bireylerin spora güvenli bir şekilde katılımını desteklemiş ve sporları nöbet sırasında yaralanma veya ölüm riskine göre kategorize etmiştir: minimal, orta veya yüksek risk. Yüzme, su kayağı ve yelken gibi aktivitelere dikkatle yaklaşılmalı ve tercihen gözetim altında yapılmalıdır. Bisiklet yarışı, ata binme ve jimnastik gibi sporlar için bireysel özellikler dikkate alınmalıdır. Aerobik egzersiz genellikle epilepsisi olan neredeyse tüm bireyler için önerilmektedir. Fiziksel aktivite önerirken fayda/risk oranını, kişisel özellikleri, nöbet özelliklerini ve fiziksel aktivitenin doğasını göz önünde bulundurmak önemlidir. Fiziksel aktivite potansiyel olarak nöbet sıklığını azaltabilir, ruh hâlini ve bilişsel işlevi iyileştirebilir, genel fiziksel sağlığı geliştirebilir ve obezite ve azalmış kemik kalitesi gibi epilepsi ile ilişkili komorbiditeleri hafifletebilir. Bu nedenle, çocuklar ve ergenler, ilgili risk sınıflandırmaları dikkate alınarak, okulda veya eğlence ortamlarında spor faaliyetlerine katılmaya teşvik edilmelidir.

Anahtar Kelimeler: Epilepsi; aerobik egzersiz; nöbet; fiziksel aktivite

TO CITE THIS ARTICLE:
Kurt Aydın M, Savaş Kalender D, Tarsuslu T. Factors shaping physical activity levels in children with epilepsy-A rehabilitation perspective: Traditional review. Turkiye Klinikleri J Pediatr. 2025;34(1):27-34.

Correspondence: Merve KURT AYDIN
İzmir Kâtip Çelebi University Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, İzmir, Türkiye
E-mail: merveekurtt93@gmail.com

Peer review under responsibility of Turkiye Klinikleri Journal of Pediatrics.

Received: 17 Jul 2024 ***Received in revised form:*** 05 Nov 2024 ***Accepted:*** 05 Nov 2024 ***Available online:*** 16 Dec 2024

Epilepsy is a condition caused by sudden, excessive and abnormal electrical discharges in neurons in the central nervous system and is characterized by unprovoked seizures.[1] Epilepsy is one of the most frequent neurological disorders in children and adolescents.[2] In 2022, International League Against Epilepsy (ILAE) categorized epilepsy syndromes into 4 main groups based on age of onset. These are categorized as onset in the newborn and infancy, onset in childhood, onset at variable ages, and idiopathic generalized epilepsy syndromes.[3] Epileptic activity in the brain can lead profound impact on patients' behavior, mood, and cognitive functions. Furthermore, these effects are further shaped by others' attitudes towards them. As a result, individuals with epilepsy often face significant psychosocial challenges that affect their quality of life, including social isolation, family pressure, anxiety, depression, peer rejection, and decreased self-confidence due to stigma.[4,5]

For children with epilepsy (CwE), these challenges are compounded by barriers to participating in physical and sports activities. Social isolation, adverse effects of anti-seizure medications on performance, and other epilepsy-related obstacles contribute to their reduced engagement in physical activities (PA). Additionally, parental reluctance to allow their children to participate in exercise further diminishes their activity levels.[4-6]

Studies have shown that physical activity levels are lower in individuals with epilepsy compared to the general population. There are also studies demonstrating that exercise in this population improves mood, cognitive functions, muscle strength, cardiorespiratory health, and overall quality of life, while reducing the risks of obesity, high blood pressure, diabetes, and coronary heart disease, as well as decreasing the frequency of seizures.[4,7-13] Additionally, physical activity positively affects brain health by increasing blood flow, promoting new neuron formation, and enhancing cognitive capacity.[14,15]

In the literature, it is observed that studies have been conducted, and guidelines published on topics such as the effects of physical activity and participation in physical activity in individuals diagnosed with epilepsy.[4,8,9,11-13,16] Despite epilepsy being more prevalent in childhood, there are notably fewer studies examining the effects of physical activity in children diagnosed with epilepsy.[17,18] This traditional review aims to examine the existing literature on physical activity in children diagnosed with epilepsy, focusing on factors determining physical activity levels, the effects of physical activity, and compiling recommendations from the available literature.

COMPARISON OF PHYSICAL ACTIVITY LEVELS BETWEEN GENERAL POPULATION AND INDIVIDUALS WITH EPILEPSY

People diagnosed with epilepsy tend to be physically inactive and have limited participation in activities compared to the general population. Green et al. reported that although they are predominantly young and middle-aged adults, individuals diagnosed with epilepsy are commonly reported to have sedentary lifestyles.[19] A meta-analysis involving 1,599 individuals with epilepsy revealed a notable disparity in PA levels between adults with epilepsy and 137,803 control subjects, showing that adults with epilepsy were considerably less likely to adhere to global PA guidelines.[20] However, when examining studies from the childhood period, it is noteworthy that the number of studies including this population is quite low.

Though the number of studies involving children and adolescents with epilepsy is relatively low, the available research highlights a concerning trend. Ogwumike et al. found that CwE exhibited considerably lower PA levels compared to their peers without epilepsy.[21] Wong and Wirrell similarly found that although there was no history of seizure activity related to physical exercise in CwE, these children had lower levels of PA compared to their typically developing peers.[22] Sırtbaş et al. found that CwE exhibits significantly lower levels of PA, poorer performance, and reduced quality of life.[23] Another study found that only 11% of CwE reached the recommended level of physical activity.[24] The presence of epilepsy appears to negatively affect various aspects of physical fitness and activity during childhood, with CwE often leading more inactive lifestyles than their typically devoloping peers. These findings underscore the importance of raising awareness among health profes-

sionals and families, promoting greater PA participation for CwE.[23]

In the past, concerns about PA and its use in the epilepsy population, lack of understanding and excessive caution have discouraged people with epilepsy from engaging in PA and exercise. However, the literature suggests a change in this perspective.[20] Individuals who live with epilepsy should be encouraged to increase their level of PA and exercise participation. This shift in advice is supported by the data, underscoring the importance of promoting an active lifestyle for individuals managing epilepsy.[20]

RISKS AND CHALLENGES TO ENGAGING IN PHYSICAL ACTIVITY IN PEDIATRIC EPILEPSY

In the past, concerns about PA within the epilepsy population, combined with a lack of understanding and excessive caution, have discouraged individuals with epilepsy from engaging in exercise. Despite the well-documented benefits of exercise and PA in CwE, unfounded beliefs and misinformation, such as the notion that PA can trigger seizures or is inherently dangerous for CwE, can shape how families and children approach it, often resulting in reduced participation in PA.[22,25-27]

RISKS

Until the mid-seventies, discouraging PA in people with epilepsy was the norm. However, in general, seizures are rarely triggered by PA. In a study of patients with epilepsy, only in two out of 400 subjects, PA was identified as a trigger.[28] Another study reported exercise-induced seizures in only 2% of 204 individuals with epilepsy, usually during strenuous activity.[29]

It has been noted that CwE do not experience more injuries in daily life or during PA compared to children without seizures.[30,31] However, despite these findings, families and children often avoid PA due to concerns that it may trigger seizures or result in injuries during a seizure.[30,32]

Both studies and the ILAE Task Force on Sports and Epilepsy assert that PA is recommended for individuals diagnosed with epilepsy.[16,30,32,33] In 2016, the ILAE Task Force on Sports and Epilepsy recommended safe sports participation for individuals diagnosed with epilepsy. Sports can be classified into three categories based on the potential risk of injury or death in the event of a seizure: sports with minimal additional risk, sports with a moderate level of risk, and sports with a high level of risk.[16] It should be cautioned during activities such as swimming, water skiing, and sailing, preferably performed under observation if possible. Personal characteristics should be considered for sports like bicycle racing, horseback riding, and gymnastics.[25,30] Aerobic exercise is reported to be recommended for almost all individuals diagnosed with epilepsy.[32] In light of the information in the literature, the benefit/risk ratio, personal characteristics, seizure characteristics, and the nature of PA should be taken into consideration when recommending PA for CwE.

When recommending PA for CwE, it is essential to consider the benefit/risk ratio, individual characteristics, seizure patterns, and the nature of the activity. Based on the literature and ILAE guidelines, CwE should generally be encouraged to participate in PA, as it is typically not expected to provoke or contribute to the occurrence of seizures.

CHALLENGES

Upon reviewing the literature, it becomes evident that the PA levels of CwE are lower compared to children with typical development.[34] When exploring the factors that restrict or make it difficult for CwE to participate in PA, it is noteworthy that the fear of exercise triggering seizures is a significant limitation.[27,35] However, contrary to popular belief, exercise has been found to decrease epileptiform activity.[8,11,30,36,37]

Lack of social support, deficiencies in PA guidance, insufficient time, poor general health, decreased endurance, coordination problems, the need for family observation in some sports activities, lack of motivation, poor mood, and families' reluctance for their children to participate in PA have been found to be other factors that make it difficult for individuals diagnosed with epilepsy to engage in PA.[4,35,38,39] Therefore, clinicians or researchers planning PA and/or exercise interventions in CwE should be informed

about these factors that hinder exercise participation. Planning should take into consideration personal factors, which are important determinants affecting participation in exercise/PA.

WHICH FACTORS ARE ASSOCIATED WITH PHYSICAL ACTIVITY LEVEL IN PEDIATRIC EPILEPSY?

When the factors related to PA levels in children were examined, it was reported that male gender, the desire to be physically active, achievement orientation, perceived competence, access to facilities and programs, time spent outdoors, and the PA level of siblings were positively correlated with the PA levels of children and adolescents. On the other hand, perceived obstacles to PA were found to be negatively associated with PA levels.[40]

A positive correlation was found between age, sports club membership, and PA level.[41] Low maternal education level and the need for three or more antiepileptic drug (AED) treatments were found to be associated with a lower PA level.[41] The duration of epilepsy, type or etiology of epilepsy, seizure type and seizure frequency were not found to be associated with the PA level.[42,43] On the other hand, an increased PA level was found to be associated with better cognitive performance, higher quality of life, lower depression, less anxiety, and lower seizure frequency in this population.[19,22,23,41,43-45]

THE EFFECT OF PHYSICAL ACTIVITY AND POSSIBLE MECHANISMS IN PEDIATRIC EPILEPSY

Anti-seizure drugs are the primary treatment for epilepsy; however, due to differences in their effect mechanism, they may not effectively control all types of seizures.[46,47] In conclusion, non-pharmacologic approaches targeting to management of seizures are regarded as supportive for patients with epilepsy. In this context, PA and/or exercise practices can fortify the effectiveness of traditional drug therapy.[46]

SEIZURES/SYMPTOMS

Considering the effectiveness of PA and/or exercise practices in this population, there are studies showing that PA practices provide a decrease in seizure frequency, but there are also studies indicating that no significant improvement was obtained, but there was no increase in seizure frequency.[11,43,48,49] A study conducted on the pediatric population reported that supervised moderate-intensity aerobic exercise combined with a low glycemic diet resulted in a reduction in seizure frequency in children.[11] It should be kept in mind that the initial seizure frequency of the participants, whether they were seizure-free before the intervention, epilepsy types, types of exercise performed, and pre-intervention PA levels may have played a role in obtaining different results. When examining the mechanisms of exercise on seizure control, it becomes apparent that various mechanisms have been suggested:

When examining the mechanisms of exercise on seizure control, it becomes apparent that various mechanisms have been suggested: It has been reported that intense exercise causes metabolic acidosis by increasing blood lactate. It has been proposed that the decrease in seizure-prone EEG activity following intense physical exertion may be related to the increase in gamma-aminobutyric acid (GABA) levels due to metabolic acidosis.[8] It has been suggested that exercise may lead to the release of β-endorphins, which might play a role in modulating seizure activity.[36,50] It has been reported that the increased alertness and attention required during PA may reduce seizure frequency.[36] Based on substantial evidence of the effect of regular exercise in reducing stress sensitization, neurosteroids appear to play a beneficial role in regulating susceptibility to seizures.[8] The endogenous galanin produced through exercise might contribute to mitigating the severity of seizures.[51] Engaging in an aerobic program might reduce hyperreactivity of CA1 cells and induce structural changes within the hippocampus, which could potentially inhibit the occurrence of abnormal electrical discharges.[8,36] Melatonin levels rise following acute exercise or physical training, and it has been suggested that the elevated melatonin concentration may be effective in reducing seizure frequency.[8,36]

PA triggers a cascade of responses within the body, including alterations in neurotransmitter levels such as GABA, serotonin, and dopamine, which are

known to influence seizure activity.[8] Additionally, exercise promotes neuroplasticity, the release of endorphins, regulation of stress sensitivity, and modulation of hormonal balance, all of which may contribute to seizure control.[8,36] Understanding the interplay of these physiological adaptations is essential to elucidate the mechanisms by which PA exerts its therapeutic effects in epilepsy management. The possible role of physical exercise as a supplementary measure to prevent epilepsy has been documented in animal models, but its preventive effect on humans is still uncertain, primarily due to the lack of epidemiological and longitudinal studies on the topic.[8]

EPILEPSY COMORBIDITIES

Epilepsy often correlates with a heightened risk of both psychiatric and medical comorbidities, which can significantly affect the quality of life for those living with the condition. Mental health disorders are more prevalent in people with epilepsy than in the general population, with depression being the most common psychiatric comorbidity. Individuals frequently report experiencing other psychological concerns including anxiety and stress.[32]

From a neurobiological perspective, both epilepsy and mood disorders may exhibit dysfunctions in neurotransmitter systems such as glutamate, serotonin, dopamine, noradrenaline, and GABA.[32] Regular exercise impacts the production and secretion of noradrenaline, serotonin, and dopamine, while upregulating neurotrophins and diminishing hypothalamic-pituitary-adrenal activity.[8] Engaging in exercise may contribute to enhanced mood, diminished depression, anxiety, and stress, and reduced susceptibility to seizures, ultimately leading to fewer comorbidities associated with epilepsy.[7-10]

Another common problem observed in epilepsy is cognitive impairment, affecting approximately 70% of individuals diagnosed with epilepsy, leading to difficulties in cognitive functions such as attention, executive function, and memory.[52] A systematic review in 2023 found a close relationship between PA levels and cognitive functions in individuals diagnosed with epilepsy.[45] Interventions involving exercise and/or PA have been shown to improve cognitive functions in this population.[46,53,54]

The risk of obesity and decreased bone quality increases in individuals diagnosed with epilepsy due to lower PA levels compared to healthy peers and the side effects of AEDs.[8,12,55] In addition to reducing weight and body fat, exercise and/or PA interventions in epilepsy can be utilized to mitigate risk factors for high blood pressure, obesity, diabetes, and coronary heart disease.[30,32] Although it is not clear whether exercise improves bone quality in epilepsy, it is recommended for patients of all ages.[32]

It has been reported that exercise and/or PA interventions improve muscle strength and cardiorespiratory functions in individuals diagnosed with epilepsy.[13,49,54] Additionally, these interventions have been shown to enhance the quality of life for individuals diagnosed with epilepsy.[46,49,54]

PHYSICAL ACTIVITY RECOMMENDATION FOR CHILDREN WITH PEDIATRIC EPILEPSY

PA and exercise offer numerous benefits for both epilepsy symptoms and comorbidities.[4,7-11,16,32] However, exercise has been avoided in this population for many years, and concerns persist.[32,56] It would be beneficial for CwE to be guided towards PA and exercise by specialists who understand the individual's specific clinical features of epilepsy.[16,32] However, when selecting appropriate activities, the available literature and the child's clinical characteristics should be taken into consideration. Swimming and in-water sports are recommended to be performed with a trained supervisor and a life vest. Skydiving, scuba diving, water skiing, climbing, hang gliding, or boxing and other contact sports are not recommended in both controlled and uncontrolled epilepsy, although a clear consensus is still lacking. Aerobic exercises are recommended without any restriction after taking necessary safety precautions.[8,16,32]

While studies indicate lower levels of PA among individuals diagnosed with epilepsy compared to healthy individuals, there exists a positive correlation between PA and quality of life in this population, supporting the beneficial effects of PA. The lack of a clear association between reported PA levels and seizure frequency can provide reassurance to patients.

However, it's important for healthcare providers to conduct a thorough clinical assessment of each individual's risk-benefit profile. Tailored structured PA specific to the individual, taking into consideration epilepsy type, seizure severity, and seizure control, is believed to be beneficial in this population. However, the heterogeneous nature of epilepsy in the current literature, inadequate studies specific to different age groups, low study quality, and the use of self-reported methods necessitate more comprehensive and better-designed studies.

CONCLUSION

In conclusion, CwE should be encouraged to participate in sports activities at school or in recreational settings, while taking into account the associated risk classifications. It is crucial to know when to limit sports practice. To address this, there is a need for randomized controlled trials examining the interaction of exercise and seizures in CwE, using robust evidence-based measurements. The findings from these studies will ensure that PA recommendations and training provided by healthcare professionals are based on more solid foundations.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Merve Kurt Aydin, Dilan Savaş Kalender, Tülay Tarsuslu;* ***Design:*** *Merve Kurt Aydin, Dilan Savaş Kalender, Tülay Tarsuslu;* ***Control/Supervision:*** *Merve Kurt Aydin, Dilan Savaş Kalender, Tülay Tarsuslu;* ***Data Collection and/or Processing:*** *Merve Kurt Aydin, Dilan Savaş Kalender, Tülay Tarsuslu;* ***Analysis and/or Interpretation:*** *Merve Kurt Aydin, Dilan Savaş Kalender, Tülay Tarsuslu;* ***Literature Review:*** *Merve Kurt Aydin, Dilan Savaş Kalender;* ***Writing the Article:*** *Merve Kurt Aydin, Dilan Savaş Kalender;* ***Critical Review:*** *Merve Kurt Aydin, Dilan Savaş Kalender, Tülay Tarsuslu;* ***References and Fundings:*** *Merve Kurt Aydin, Dilan Savaş Kalender, Tülay Tarsuslu.*

REFERENCES

1. Beghi E, Giussani G, Sander JW. The natural history and prognosis of epilepsy. Epileptic Disord. 2015;17(3):243-53. [Crossref] [PubMed]
2. Häfele CA, Freitas MP, Gervini BL, de Carvalho RM, Rombaldi AJ. Who are the individuals diagnosed with epilepsy using the Public Health System in the city of Pelotas, southern Brazil? Epilepsy Behav. 2018;78:84-90. [Crossref] [PubMed]
3. Zuberi SM, Wirrell E, Yozawitz E, Wilmshurst JM, Specchio N, Riney K, et al. ILAE classification and definition of epilepsy syndromes with onset in neonates and infants: position statement by the ILAE Task Force on Nosology and Definitions. Epilepsia. 2022;63(6):1349-97. [Crossref] [PubMed]
4. Arida RM, Teixeira-Machado L. Physical exercise for children and adolescents with epilepsy: what have we learned? Seizure. 2023;111:1-8. [Crossref] [PubMed]
5. Ahmad Shehata G. A review of epilepsy stigma in egypt. acta psychopathologica. OMICS Publishing Group. 2016;02(02):1-7. [Crossref]
6. Yeni K, Tülek Z, Bebek N. Epilepsi Özyönetim Ölçeği geçerlik ve güvenirlik çalışması [Validity and reliability study of Epilepsy Self-Management Scale]. Epilepsi: Journal of the Turkish Epilepsi Society. 2020;26(1):12-9. [Crossref]
7. Roth DL, Goode KT, Williams VL, Faught E. Physical exercise, stressful life experience, and depression in adults with epilepsy. Epilepsia. 1994;35(6):1248-55. [Crossref] [PubMed]
8. Arida RM. Physical exercise and seizure activity. Biochim Biophys Acta Mol Basis Dis. 2021;1867(1):165979. [Crossref] [PubMed]
9. Dustin IH, Resnick B, Galik E, Klinedinst NJ, Michael K, Wiggs E, et al. The feasibility and impact of the EMOVE intervention on self-efficacy and outcome expectations for exercise in epilepsy. J Neurosci Nurs. 2019;51(2):95-100. [Crossref] [PubMed] [PMC]
10. McAuley JW, Long L, Heise J, Kirby T, Buckworth J, Pitt C, et al. A prospective evaluation of the effects of a 12-week outpatient exercise program on clinical and behavioral outcomes in patients with epilepsy. Epilepsy Behav. 2001;2(6):592-600. [Crossref] [PubMed]
11. Zhang H, Yu L, Li H, Liu Y. Effect of low glycaemic diet and structured exercise on quality of life and psychosocial functions in children with epilepsy. J Int Med Res. 2020;48(4):300060519893855. [Crossref] [PubMed] [PMC]
12. Elliott JO, Jacobson MP. Bone loss in epilepsy: barriers to prevention, diagnosis, and treatment. Epilepsy Behav. 2006;8(1):169-75. [Crossref] [PubMed]
13. Vooturi S, Lakshmi ANR, Jayalakshmi S. Adherence to exercise in people with epilepsy. Eur J Physiother. 2023;25(3):162-7. [Crossref]
14. Sharma AA, Mackensie Terry D, Popp JL, Szaflarski JP, Martin RC, Nenert R, et al. Neuromorphometric associations with mood, cognition, and self-reported exercise levels in epilepsy and healthy individuals. Epilepsy Behav Rep. 2023;25:100643. [Crossref] [PubMed] [PMC]

15. Feter N, Alt R, Dias MG, Rombaldi AJ. How do different physical exercise parameters modulate brain-derived neurotrophic factor in healthy and non-healthy adults? A systematic review, meta-analysis and meta-regression. Sci Sports. 2019;34(5):293-304. [Crossref]

16. Capovilla G, Kaufman KR, Perucca E, Moshé SL, Arida RM. Epilepsy, seizures, physical exercise, and sports: a report from the ILAE Task Force on Sports and Epilepsy. Epilepsia. 2016;57(1):6-12. [Crossref] [PubMed]

17. Syeda A, Karim MR. The mean age of petit mal epilepsy. J Pediatr Neurosci. 2016;11(2):112-4. [Crossref] [PubMed] [PMC]

18. Sheth RD. Adolescent issues in epilepsy. J Child Neurol. 2002;17 Suppl 2:2S23-2S27. [Crossref] [PubMed]

19. Green R, Abe C, Denney DA, Zhang R, Doyle A, Gadelmola K, et al. Physical activity status and quality of life in patients with epilepsy - Survey from level four epilepsy monitoring units. Epilepsy Res. 2021;173:106639. [Crossref] [PubMed]

20. Vancampfort D, Ward PB, Stubbs B. Physical activity and sedentary levels among people living with epilepsy: a systematic review and meta-analysis. Epilepsy Behav. 2019;99:106390. [Crossref] [PubMed]

21. Ogwumike O, Agboke M, Adeniyi A. Association between physical activity level and health-related quality of life of children with and without epilepsy. Journal of Pediatric Neurology. 2016;14(03):095-101. [Crossref]

22. Wong J, Wirrell E. Physical activity in children/teens with epilepsy compared with that in their siblings without epilepsy. Epilepsia. 2006;47(3):631-9. [Crossref] [PubMed]

23. Sırtbaş G, Yalnızoğlu D, Livanelioğlu A. Comparison of physical fitness, activity, and quality of life of the children with epilepsy and their healthy peers. Epilepsy Res. 2021;178:106795. [Crossref] [PubMed]

24. Pohl D, Alpous A, Hamer S, Longmuir PE. Higher screen time, lower muscular endurance, and decreased agility limit the physical literacy of children with epilepsy. Epilepsy Behav. 2019;90:260-5. [Crossref] [PubMed]

25. Dimitri P, Joshi K, Jones N; Moving Medicine for Children Working Group. Moving more: physical activity and its positive effects on long term conditions in children and young people. Arch Dis Child. 2020;105(11):1035-40. [Crossref] [PubMed]

26. Brna PM, Gordon KE, Woolridge E, Dooley JM, Wood E. Perceived need for restrictions on activity for children with epilepsy. Epilepsy Behav. 2017;73:236-9. [Crossref] [PubMed]

27. Wilfred AM, Humphreys C, Patterson S, Brown DM, Pohl D, Moyes C, et al. Being physically active with epilepsy: Insights from young people and their parents. Epilepsy Res. 2022;188:107035. [Crossref] [PubMed]

28. Arida RM, Scorza FA, Terra VC, Scorza CA, de Almeida AC, Cavalheiro EA. Physical exercise in epilepsy: what kind of stressor is it? Epilepsy Behav. 2009;16(3):381-7. [Crossref] [PubMed]

29. Nakken KO. Physical exercise in outpatients with epilepsy. Epilepsia. 1999;40(5):643-51. [Crossref] [PubMed]

30. Arida RM, Cavalheiro EA, da Silva AC, Scorza FA. Physical activity and epilepsy: proven and predicted benefits. Sports Med. 2008;38(7):607-15. [Crossref] [PubMed]

31. Téllez-Zenteno JF, Hunter G, Wiebe S. Injuries in people with self-reported epilepsy: a population-based study. Epilepsia. 2008;49(6):954-61. [Crossref] [PubMed]

32. Pimentel J, Tojal R, Morgado J. Epilepsy and physical exercise. Seizure. 2015;25:87-94. [Crossref] [PubMed]

33. Arida RM, Scorza FA, Gomes da Silva S, Schachter SC, Cavalheiro EA. The potential role of physical exercise in the treatment of epilepsy. Epilepsy Behav. 2010;17(4):432-5. [Crossref] [PubMed]

34. Ronen GM, Janssen I. Patterns of daily activity among young people with epilepsy. Dev Med Child Neurol. 2019;61(12):1386-91. [Crossref] [PubMed]

35. Alexander HB, Arnel M, O'Connell N, Munger Clary HM, Fanning J, Brubaker P, et al. A single-center survey on physical activity barriers, behaviors and preferences in adults with epilepsy. Epilepsy Behav. 2023;149:109491. [Crossref] [PubMed] [PMC]

36. Carrizosa-Moog J, Ladino LD, Benjumea-Cuartas V, Orozco-Hernández JP, Castrillón-Velilla DM, Rizvi S, et al. Epilepsy, physical activity and sports: a narrative review. Can J Neurol Sci. 2018;45(6):624-32. [Crossref] [PubMed]

37. Lin XY, Cui Y, Wang L, Chen W. Chronic exercise buffers the cognitive dysfunction and decreases the susceptibility to seizures in PTZ-treated rats. Epilepsy Behav. 2019;98(Pt A):173-87. [Crossref] [PubMed]

38. Collard SS, Ellis-Hill C. How do you exercise with epilepsy? Insights into the barriers and adaptations to successfully exercise with epilepsy. Epilepsy Behav. 2017;70(Pt A):66-71. [Crossref] [PubMed]

39. Willis J, Hophing L, Mahlberg N, Ronen GM. Youth with epilepsy: their insight into participating in enhanced physical activity study. Epilepsy Behav. 2018;89:63-9. [Crossref] [PubMed]

40. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Med Sci Sports Exerc. 2000;32(5):963-75. [Crossref] [PubMed]

41. Vancampfort D, Ward PB. Physical activity correlates across the lifespan in people with epilepsy: a systematic review. Disabil Rehabil. 2021;43(10):1359-66. [Crossref] [PubMed]

42. Tedrus GMAS, Sterca GS, Pereira RB. Physical activity, stigma, and quality of life in patients with epilepsy. Epilepsy Behav. 2017;77:96-8. [Crossref] [PubMed]

43. Johnson EC, Helen Cross J, Reilly C. Physical activity in people with epilepsy: a systematic review. Epilepsia. 2020;61(6):1062-81. [Crossref] [PubMed]

44. Popp JL, Szaflarski JP, Kaur M, Martin RC, Brokamp GA, Terry DM, et al. Relationships between cognitive function, seizure control, and self-reported leisure-time exercise in epilepsy. Epilepsy Behav. 2021;118:107900. [Crossref] [PubMed]

45. Alexander HB, Allendorfer JB. The relationship between physical activity and cognitive function in people with epilepsy: a systematic review. Epilepsy Behav. 2023;142:109170. [Crossref] [PubMed] [PMC]

46. Duñabeitia I, Bidaurrazaga-Letona I, Diz JC, Colon-Leira S, García-Fresneda A, Ayán C. Effects of physical exercise in people with epilepsy: a systematic review and meta-analysis. Epilepsy Behav. 2022;137(Pt A):108959. [Crossref] [PubMed]

47. Löscher W, Klein P. The pharmacology and clinical efficacy of antiseizure medications: from bromide salts to cenobamate and beyond. CNS Drugs. 2021;35(9):935-63. Erratum in: CNS Drugs. 2021;35(9):1033-4. [Crossref] [PubMed] [PMC]

48. Kumar M, Ramanujam B, Barki S, Dwivedi R, Vibha D, Singh RK, et al. Impact of exercise as a complementary management strategy in people with epilepsy: a randomized controlled trial. Epilepsy Behav. 2022;129:108616. [Crossref] [PubMed]

49. Häfele CA, Rombaldi AJ, Feter N, Häfele V, Gervini BL, Domingues MR, et al. Effects of an exercise program on health of people with epilepsy: a randomized clinical trial. Epilepsy Behav. 2021;117:107904. [Crossref] [PubMed]

50. Burtscher J, Schwarzer C. The opioid system in temporal lobe epilepsy: functional role and therapeutic potential. Front Mol Neurosci. 2017;10:245. [Crossref] [PubMed] [PMC]

51. Holmes PV, Reiss JI, Murray PS, Dishman RK, Spradley JM. Chronic exercise dampens hippocampal glutamate overflow induced by kainic acid in rats. Behav Brain Res. 2015;284:19-23. [Crossref] [PubMed]

52. Witt JA, Helmstaedter C. Should cognition be screened in new-onset epilepsies? A study in 247 untreated patients. J Neurol. 2012;259(8):1727-31 [Crossref] [PubMed]

53. Feter N, Alt R, Häfele CA, da Silva MC, Rombaldi AJ. Effect of combined physical training on cognitive function in people with epilepsy: Results from a randomized controlled trial. Epilepsia. 2020;61(8):1649-58. [Crossref] [PubMed]

54. Eom S, Lee MK, Park JH, Jeon JY, Kang HC, Lee JS, et al. The impact of an exercise therapy on psychosocial health of children with benign epilepsy: a pilot study. Epilepsy Behav. 2014;37:151-6. [Crossref] [PubMed]

55. Hinnell C, Williams J, Metcalfe A, Patten SB, Parker R, Wiebe S, et al. Health status and health-related behaviors in epilepsy compared to other chronic conditions—a national population-based study. Epilepsia. 2010;51(5):853-61. [Crossref] [PubMed]

56. Corbitt RW, Cooper DL, Erickson DJ, Kriss FC, Thornton ML, Craig TT. Editorial: epileptics and contact sports. JAMA. 1974;229(7):820-1. [Crossref] [PubMed]