NOWAK, Wojciech, SAWICKI, Mirosław, MIKOŁAJCZYK, Jagoda, KRZEMIŃSKA, Paulina, GOŁĘBSKI, Maciej, KUKLA, Zuzanna, MUSIALIK, Sebastian, MIERUSZYŃSKA, Stella, WŁOSIAŃSKI, Jakub and SADOWSKA, Izabela. Unsteady ground: understanding the problem of BPPV in the world of sports. Quality in Sport. 2025;38:58239. eISSN 2450-3118.
https://doi.org/10.12775/QS.2025.38.58239
https://apcz.umk.pl/QS/article/view/58239

The journal has been 20 points in the Ministry of Higher Education and Science of Poland parametric evaluation. Annex to the announcement of the Minister of Higher Education and Science of 05.01.2024. No. 32553.
Has a Journal's Unique Identifier: 201398. Scientific disciplines assigned: Economics and finance (Field of social sciences); Management and Quality Sciences (Field of social sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 r. Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398.
Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 26.01.2025. Revised: 10.02.2025. Accepted: 10.02.2025 Published: 10.02.2025.

Unsteady ground: understanding the problem of BPPV in the world of sports

Wojciech Nowak [WN]
Heliodor Swiecicki Clinical Hospital, Przybyszewskiego 49, Poznań, 60-355
ORCID: 0009-0000-1259-3067
nowakwojciech52@gmail.com

Mirosław Sawicki [MS]
District hospital in Nysa, ul. Bohaterów Warszawy 34, 48-300 Nysa
ORCID: 0009-0007-1740-5046
miroslaw.sawicki93@gmail.com

Jagoda Mikołajczyk [JM]
Collegium Medicum, Nicolaus Copernicus University, Bydgoszcz, Poland, Jagiellońska 13/15, 85-067 Bydgoszcz
ORCID: 0009-0009-1745-5339
300093@stud.umk.pl

Paulina Krzemińska [PK]
Non-public Health Care Facility „Radziwie Clinic", Popłacińska 42, 09-401 Płock
ORCID: 0009-0003-6071-4320
krzeminskapaula15@gmail.com

Maciej Gołębski [MG]
Zaglebiow Clinical Hospital, Szpitalna 40, 41-250 Czeladz
ORCID: 0009-0005-3065-814X
theawesomesquare@gmail.com

Zuzanna Kukla [ZK]
Heliodor Swiecicki CLinical Hospital, Przybyszewskiego 49, Poznań, 60-355
ORCID: 0009-0005-2652-6988|
zuzannakukla9@gmail.com

Sebastian Musialik [SM]
SALUS Outpatient Medical Care Center, Wrocławska 8, 55-095 Siedlec, Poland
ORCID: 0009-0006-6237-9820
sebastian.musialik@gmail.com

Stella Mieruszyńska [SM]
Collegium Medicum, Nicolaus Copernicus University, Bydgoszcz, Poland, Jagiellońska 13/15, 85-067 Bydgoszcz
ORCID: 0009-0004-3483-5660
mieruszynskas@gmail.com

Jakub Włosiański [JW]
Poznań University of Medical Sciences, ul. Fredry 10, 61-701 Poznań
ORCID: 0009-0005-6985-4076
jakub.włosiński@gmail.com

Izabela Sadowska [IS]
Provincial Polyclinical Hospital in Płock of Marcina Kacprzaka, Medyczna 19, 09-400 Płock
ORCID: 0000-0003-3441-1636
I.sztybor@gmail.com

Abstract:

Introduction: Dizzyness and Vertigo are one of the most common symptoms presented by patients, often the symptoms are caused by BPPV. BPPV may by provoked by certain types of impacts, head motion and other various factors including sport practice. In modern world, sport has become a part of everyday life, both in professional in amateur matter. Different sports, may lead to different types of injuries and related complications, one of them is dizzyness and vertigo. We investigated the existing data about the prevalence of BPPV related to certain types of physical activity. Different sports vary in the movement profile, amount and frequency of impacts. Furthermore, the injuries resulting from physical activity are not always associated with direct hits. Presenting all at once: the data, diagnostic and treatement strategy, we resume the existing knowledge on the phenomenon of BPPV in physical activity.

Purpose of work: The article was completed to analyze the available data on the prevalence of BPPV in sports practitioners. This aims to facilitate the prompt resolution of vertigo symptoms in affected individuals and to identify potential, less obvious risk factors that may predispose athletes to this condition.

State of Knowledge: Even though the knowledge about the etiology and risk factors of BPPV has significantly advanced in the last decade, more than half of all cases is are still classified as idiopathic. While data on possible new risk factors is growing, it often consists of case

reports or orginal studies with small sample sizes, limiting its generalizability. It is widely believed though that certain types of movement may play a role in triggering BPPV.

Material and methods: This article is based on a comprehensive review of the literature, conducted using PubMed and Google Scholar. The research focused on studies concerning the prevalence, etiology and risk factors of BPPV, particularly in sports practitioners.

Keywords: BPPV; Vertigo; Sports;

Introduction

Dizzyness and vertigo are conditions frequently approached in medical care. Some studies show that over 30% of the general public will experience at least one episode in their lifetime.[1] Patiens often describe their symptoms as loss of balance with a subjective sensation of movement of the environement around them. It is estimated that up to 25% of patients treated because of vertigo are diagnosed as benign paroxysmal positional vertigo (BPPV).[2] BPPV results from calcium carbonate crystals being dislocated into semicircular canals, provoking the subjective feeling of head motion. The majority of cases are of idiopatic origin, however, several risk factors have been identified. Evidence suggest a possible correlation between physical activity and the prevalence of BPPV, showing that the condition is not always directly linked to impacts or head trauma.[3] Due to specific types of mechanical stress, movements, and physical impacts associated with certain sports, the likehood of developping BPPV appears to vary and is elevated in certain groups. Having selected a few sports with varying characteristics, we investigated the possible reasons for the increased prevalence of this type of vertigo. This review aims to summarize the current evidence on this topic.

Pathomechanism of BPPV

The vestibular system of the inner ear consists of the semicircular cannals, utricle, saccule and vestibular nerve. The semicircular canals are responsible for detecting angular head movements. The utricle contains otoconia, calcium carbonate crystals that play a crucial role in sensing linear acceleration.[4] Sometimes, due to various reasons, these otoconia can move

into semicircular canals, causing episodes of vertigo accompanied by nystagmus, the symptoms are typically triggered by head position changes. This phenomenon, called BPPV, impacts significantly quality of life if left untreated.[5] The posterior semicircular canal is the most common site for otoconia displacement, it's because of it's anatomical orientation. The hotizontal semicircular canal is the second most frequenty affected site (HC-BPPV), while the least common is the BPPV originating from the anterior semicircular canal.[6] The severity of experienced vertigo is influenced by the specific mechanism and extent of the migration.

According to widely accepted theory behind the patophysiology of BPPV, the otoconia can either "free-float" in an semicircular canal (canalolithiasis) or adhere to the cupula (cupulolithiasis).[6] In both cases the receptors become overstimulated, leading to episodes of vertigo and nystagmus, however the cupulolithiasis adhesion seems to results in higher persistence of symptoms.[7]

Diagnosis

The Barany society established criteria for BPPV diagnostics.[8] According to the criteria, a vertigo episode can be classified as BPPV if the recurrent attacks of vertigo are provoked by positional shifts, with positional nystagmus induced by maneuver relevant for BPPV subtype and affected site. The nystagmus however is not always evident. Practicians find Frenzel goggles and video oculography useful in nystagmus observation and classification. Accurate classification of BPPV is critical because missclassification may cause the repositioning maneuvers to be ineffective and in some cases exacerbate the condition.[8] Furthermore, symptoms of dizzyness and vertigo can have various underlying causes that must be carefully differenciated. Relyling solely on an initial diagnosis may lead to overlooking alternative explanations. For these reasons, a careful assessment and classification are essential to ensure proper management.

The posterior canal (PC-BPPV) is typically involved (over 80% of cases), with minor incidence of horizontal and anterior canal BPPV.[5] PC-BPPV is normally diagnosed through Dix-Hallpike test.[9] During the test, patient initially sits upright on an examination couch, head is turned 45° to the tested side, then the patient is quickly moved to lying down with the head hanging 20-30° off the table. The eyes are then closely observes for signs of nystagmus, simultaneously the patient is asked if they experience any sensation of vertigo. The horizontal

canal BPPV is approached less often. It is diagnosed through supine roll test and demands different treatement strategy. In supine roll test, the eyes are observed in search of nystagmus in supine position with head 30° elevated. During the test, the head is turned 90° to the sides.[6] The abnormal eye movements typically beat stronger towards the affected side. This intensity helps indentify which ear is involved. Moreover, the type of nystagmus observed during the tests can indicate the specific variant of BPPV. [6]

Risk factors

As noted earlier the BPPV is most often classified as idiopathic.[6] Efforts are focused on indentifying risk factors and situations that may increase susceptibility to BPPV. Over the years several risk factors have been indentified and described. The syndrome is most often asociated with Aging ,Meniers's disease, Migraine, Trauma, Vitamin D deficiency, and more less pronounced.[10]

The phenomenon of thauma- related BPPV is multifaceted, as the origin of traumatic injuries is diverse and encompasses a wide spectrum of contributing factors. Earlier research has reported traffic accidents, head trauma, dental or temporal bone surgery to be significant for BPPV prevalence. [10,11] Some recent analyses suggest that trauma related BPPV may account for up to one- fifth of cases and compared to BPPV of other origins, it's presentation is more severe. The treatement of trauma related BPPV is considered to be more complex, symptoms tend to be recurrent and demand repetitive maneuvers to resolve. Trauma not only displaces the ocotonia, it may also have significant influence of surrounding dissues, increasing the likehood of developing the syndrome.[11]

Physical actvites, especially in the context of professional sport practice are often correlated with an increased predisposition to trauma related incidents. Because of repetitive strain, high impact forces in competitive sports, the risk of head injuries and the possible inner ear abnormalities is amplified. Not only have we considered activities involving direct impacts, we also decided to investigate sports that don't necessairly involve abrupt strains. Instead, these sports involve specific types of movement or constant vibrations, which may cause the otoconia to dislodge and result in symptoms of BPPV.

American Football and Football (Soccer)

Soccer is widely regarded as the most popular sport globally, with nearly 130 000 active professional players around the world, according to FIFA's Professional Football Report. [12] This figure does not account for the vast number of people playing casually. In contrast, American Football, as reported by National Football Foundation, involves over one million active participants both professional and amateur, within the United States.[13]

American Football and Soccer are both sports characterized by a high incidence of repetitive collisions, though the nature of these impacts varies between the two. In american football, the mechanism of head injuries is defined by high frequency of high-energy collisions. On the other hand, in soccer along with direct impacts between the players, the practice of repetitive ball heading introduces an additional risk factor. [14] While we recognize the differences in injury mechanisms between these sports, for the purposes of classification, they have been grouped together due to shared characteristics such as frequent direct head impacts and rapid acceleration-deceleration movement patterns.

Recurrent BPPV has already been reported in connection with soccer and american football practice. Although direct studies focusing specifically on these sports are limited, the available research provides significant insights. Kerrigan et al. presented that alhletes involved in football and soccer represent a substantial proportion of young adults diagnosed and treated for BPPV. Of the 200 individuals observed, football players accounted for 36% and soccer players for 22%.[15]

Gökler et al. reviewed a group of 63 american footballers and discovered a increased prevalence of BPPV in this group. They defined the weekly training hours and years of practice as risk factors for BPPV.[16]

Regarding soccer, we identified two case reports in the literature. Burrows et al. and Warming et al. described two patients, soccer players, diagnosed with BPPV. [17,18] Both cases suggest, that while various risk factors may play a role, though the repetitive heading, and rapid head angular movements possibly contribue to BPPV developement. Both individuals were sucessfully treated with repositioning meneuvers. One of the individuals demonstrated a particularly quick recovery, returning to their standard training regimen within just 24 hours.

Given the importance of these sports to many athletes, both at amateur and professional levels, identyfying the condition and applying effective strategies is crucial. However, further research is essential to better understand this association and develop appropriate preventive measures.

Combat sports

The matter becomes even more compelling in high-impact sports, where the force of substantial momentum is predominantly focused on the head, often and repeatedly targeting the temporal regions. The mean punch force delivered in a professional boxing match was measured to account for around 1000N, however, depending on the technique, weight class and various other factors it may account for over 5000N. [19,20] During a match multiple punches are landed, in a match of 12 rounds it is estimated that around 50- 80 punches are thrown per round.[21]

Combat sports have already been proven to affect the body in many ways. The central nervous system is just one among other systems influenced, the competitors suffer from acute skeletal and vascular trauma: among others, cases of carotid artery dissection have been described.[22]

Within the central nervous system, damage can be both acute and chronic. Acutely, due to direct hits and falls, the incidence of concussion and subdural hematoma is increased. Chronically the repeating brain trauma leads to chronic traumatic encephalopathy (CTE). Symptoms of CTE include difficulty with memory, irritability, depression, problems with self-control, Parkinsonism, all accompanied by progressive dementia. [23]

Concussion is a mild brain traumatic injury, arising from the brain jolting between skull walls after hits. It's higher incidence leads to increased prevalence of post-concussive dizziness (PCD), a syndrome observed after head injuries, characterized by balance

disturbances and persistent dizzyness. [24] The BPPV was described as the most frequent et persistent reason for PCD. Depending on the study, it may be a reason for up to 57% of dizzyness cases following head injuries. [25] A recent study investigating vestibular and oculomotor functions impairement in combat sport athletes shows that more than half of the athletes participating in the study showed some abnormalities in tested functions. However, there was no difference between the experimental and the control group concerning the presence of BPPV.[26] The complexity of the phenomenon in this group highlights the need for a more comprehensive approach. Given the increased prevalence of vertigo, it remains clear that the BPPV should be prioritized as a primary diagnostic consideration when evaluating the symptoms.

Swimming

The involvement of BPPV in sports carrying a high risk of trauma appears more intuitive compared to its association with swimming. The existing research primarily consists of case reports and limited data, still in swimming the movement pattern remains extremaly repetitive within certain styles – seeming plausible to cause the BPPV. Songül et al. designed a study to determine wheather regular swimming training increases the risk of BPPV.

The initial hypothesis suggested that crawl is likely to cause BPPV due to it's biomechanical characterictics – the rapid rotational head movements around the body's longitudinal axis. Thirty swimmers participated in the study, four of them presented vertigo later diagnosed as BPPV.[27]

All of them developped PC-BPPV and were sucessfully treated with Epley meneuver. The phenomenon of vertigo in swimmers presents a multifaceted challenge. In another case study about a swimmer expiriencing BPPV, authors point out that the etiology is not always evident. [28] Swimming exposes the body to significant thermal fluctuations, which may contribute to the onset of vertigo. Additionally, the literature has documented a case where vertigo in swimmer was attributed to a cereberall stroke. [29] As with combat sports, multiple factors must be taken into account. It is challenging to draw conclusions about the effects of other swimming styles on the onset or exacerbation of BPPV. However, we hypothesize that the relatively stable positioning of the head during these techniques may result in a reduced

likelihood of provoking the condition. This is based on the reduced frequency of rapid angular head movements.

Mountain biking

Off- road biking is characterized by a high frequency of acceterations, jumps, landings and the potential for falls, all of which contribute to its intense physical demands. What is noteworthy, however, is the continuous exposure to vibrations, which can have a significant impact on the vestibular system. The matter was described latter in relation to military training related activities and surprisingly, whole body vibration training plate use.[30]

Acordding to the article of Vibert et al., this sport may be associated with a higher susceptibility to BPPV. Authors presented four cases of bikers experiencing episodes of vertigo after intensive off-road bike rides, all of them were later diagnosed and treated as BPPV.[31]

In this instance, the authors describe a potential mechanism for the displacement of otoconia, which occurs due to both rapid vertical accelerations and decelerations during jumps and landings, in combination with simultaneous head protraction-retraction movements. The impact generated during landing itself can result in vertical acceleration exceeding 2g, and is further compounded by rapid forward and backward movements of the neck.

These combines forces create a movement pattern similar to that of whiplash injuries, which have already been described as a factor increasing the potential for BPPV development.[32]

Treatment

The BPPV can remit naturally, however the repositioning meneuvers have been established as a standard way of treatement.[2] Over years many maneuvers of different rate of success were described, these are Epley, Semont, Lempert (Barbecue Roll Maneuver) and Gufoni maneuvers.[6] Different terapeutic strategies are applied depending on the specific type of BPPV, which has to be diagnosed as outlined in one of the previous sections. The

repositioning maneuvers aim to guide the displaced particles back into their correct location within the inner ear. The Epley maneuver, recognized as the gold standard, was first described in early 1990 and has demonstrated high efficacy in relieving symptoms of PC-BPPV.[33]

The procedure begins with the patient seated upright on the examination couch. The physician then turns the patient's head towards the affected site, before lying them back, with the head extended 20-30° beyond the edge of the table. Next, the head is carefully rotated 90°to the unaffected side. In the following position, the patient rolled onto their side, with the head rotated further toward the ground. Finally, the individual is brought back to an upright sitting position.

The approach for the HC-BPPV differs, as the semicircular canal plate is differently oriented. The methods of choice are Gufoni and Lempert's maneuvers.

All the repositioning sequences are designed to guide the dislodged particles to the utricle using gravitational forces. To perform meneuvers effectively, time intervals between position changes should account for around 20-30 seconds. The efficacity increases as the maneuvers are repeated, relieving symptoms in over 80% of the affected individuals.[34] We would like to highlight the fact that the current evidence regarding the effectiveness and outcomes of the HC-BPPV remains limited, especially compared to PC-BPPV. As acknowledged by the authors, further comprehensive research is necessary to strengthen the existing data and provide more definitive conclusions.[35]

Historicaly, certain post-repositioning instruntions were believed to increase the effectiveness of BPPV treatement. These included specific postural guidelines for patients to follow after the procedure, recommendations regarding sleeping positions, and other movement restrictions.[36] Additionally, some researchers suggested the application of vibration to the mastoid process during the maneuvers as a potential method to improve outcomes.[35,36] However, these approaches have not beed proven to significantly improve treatment efficacy. Authors reviewing various managment strategies have emphasized that the repositioning meneuvers themselves, when performed correctly, constitue a sufficient and effective treatment for BPPV.[36] Nevertheless, they acknowledge the need for further research to validate these findings.

Conclusions

Vertigo is a condition commonly encountered by physicians with one of the most the frequent, and relatively treatable causes being BPPV. Among the various factors contributing to its occurence, certain sports practices appear to notably increase its prevalence. However, despite its clinical relevance, the evidence remains limited. Nevertheless, existing analyses, have identified specific types of physical activities that may elevate the risk, and it is advised that every sport professional suffering from vertigo undergoes thorough evaluation and diagnosis, with particular consideration for potential BPPV. [11] The BPPV significantly declines the quality of life if left untreated.

For athletes, whose performance heavily depends of balance, BPPV can have even more profound consequences, potentially disrupting training routines and competitive capabilities. Identifying the hightened prevalence of BPPV in these groups is therefore critical for ensuring timely diagnosis and effective treatment, guarding both their health and athletic potential.

Disclosures

Authors Contributions

Conceptualization: WN

Methodology: WN

Formal analysis: WN

Investigation: MG, JM, ZK, WN

Resources: JM, SM, WN, PK

Writing- rough preparation: PK, JM, JW, WN

Writing- review and editing: IS, SM, JW

Visualization: WN, ZK, MG

Supervision: WN, IS, JW

Project administration: WN, MG

All authors have read and agreed with the published version of the manuscript.

Financial disclosure

The study dit not receive any funding.

Institutional Review Board Statement

Not applicable.

Informed Consent Statement

Not applicable.

Data Availability Statement

Not applicable.

Conflict of interest

The authors report no conflict of interest.

References

1. Neuhauser HK. The epidemiology of dizziness and vertigo. *Handb Clin Neurol*. 2016;137:67-82. doi:10.1016/B978-0-444-63437-5.00005-4
2. Kim HJ, Park JH, Kim JS. Update on benign paroxysmal positional vertigo. *J Neurol*. 2021;268(5):1995-2000. doi:10.1007/S00415-020-10314-7
3. Warming N, Andersen SB, Hougaard DD. Soccer and Benign Paroxysmal Positional Vertigo. *Case Rep Otolaryngol*. 2023;2023:1-6. doi:10.1155/2023/3744863
4. Bruss DM, Shohet JA. Neuroanatomy, Ear. *StatPearls*. Published online April 3, 2023. Accessed January 14, 2025. https://www.ncbi.nlm.nih.gov/books/NBK551658/

5. Kim HJ, Park JH, Kim JS. Update on benign paroxysmal positional vertigo. *J Neurol*. 2021;268(5):1995-2000. doi:10.1007/S00415-020-10314-7
6. Bhattacharyya N, Gubbels SP, Schwartz SR, et al. Clinical Practice Guideline: Benign Paroxysmal Positional Vertigo (Update). *Otolaryngol Head Neck Surg*. 2017;156(3_suppl):S1-S47. doi:10.1177/0194599816689667
7. Kalmanson O, Foster CA. Cupulolithiasis: A Critical Reappraisal. *OTO Open*. 2023;7(1). doi:10.1002/OTO2.38
8. Von Brevern M, Bertholon P, Brandt T, et al. Benign paroxysmal positional vertigo: Diagnostic criteria. *J Vestib Res*. 2015;25(3-4):105-117. doi:10.3233/VES-150553
9. Chen X, Mao J, Ye H, et al. The effectiveness of the modified Epley maneuver for the treatment of posterior semicircular canal benign paroxysmal positional vertigo. *Front Neurol*. 2023;14:1328896. doi:10.3389/FNEUR.2023.1328896
10. Yetiser S. Review of the pathology underlying benign paroxysmal positional vertigo. *J Int Med Res*. 2020;48(4). doi:10.1177/0300060519892370
11. Gordon CR, Levite R, Joffe V, Gadoth N. Is posttraumatic benign paroxysmal positional vertigo different from the idiopathic form? *Arch Neurol*. 2004;61(10):1590-1593. doi:10.1001/ARCHNEUR.61.10.1590
12. FIFA publishes Professional Football Report 2023. Accessed December 18, 2024. https://inside.fifa.com/legal/news/fifa-publishes-professional-football-report-2023
13. Football by the Numbers - National Football Foundation. Accessed December 18, 2024. https://footballfoundation.org/news/2023/7/25/football-by-the-numbers.aspx
14. Langdon S, Goedhart E, Oosterlaan J, Königs M. Heading Exposure in Elite Football (Soccer): A Study in Adolescent, Young Adult, and Adult Male and Female Players. *Med Sci Sports Exerc*. 2022;54(9):1459. doi:10.1249/MSS.0000000000002945
15. Kerrigan MA, Costigan MF, Blatt KJ, Mathiason MA, Domroese ME. Prevalence of benign paroxysmal positional vertigo in the young adult population. *PM R*. 2013;5(9):778-785. doi:10.1016/J.PMRJ.2013.05.010
16. Gökler O, Koçak İ, Aydoğan E, Karanfil I, Baş C. Evaluation of Benign Paroxysmal Positional Vertigo in American Football Players. *J Int Adv Otol*. 2018;14(2):295. doi:10.5152/IAO.2018.4384
17. Burrows L, Price R. Benign paroxysmal positional vertigo (BPPV) diagnosis and treatment in an elite professional football (soccer) player. *BMJ Case Rep*. 2017;2017. doi:10.1136/BCR-2017-220000
18. Warming N, Andersen SB, Hougaard DD. Soccer and Benign Paroxysmal Positional Vertigo. *Case Rep Otolaryngol*. 2023;2023:1-6. doi:10.1155/2023/3744863
19. Pierce JD, Reinbold KA, Lyngard BC, Goldman RJ, Pastore CM. Direct Measurement of Punch Force During Six Professional Boxing Matches. *J Quant Anal Sports*. 2006;2(2). doi:10.2202/1559-0410.1004
20. Walilko TJ, Viano DC, Bir CA. Biomechanics of the head for Olympic boxer punches to the face. *Br J Sports Med*. 2005;39(10):710. doi:10.1136/BJSM.2004.014126
21. Finlay MJ. World Heavyweight Championship boxing: The past 30+ years of the male division. *PLoS One*. 2022;17(1):e0263038. doi:10.1371/JOURNAL.PONE.0263038
22. Zazryn TR, McCrory PR, Cameron PA. Neurologic injuries in boxing and other combat sports. *Phys Med Rehabil Clin N Am*. 2009;20(1):227-239. doi:10.1016/J.PMR.2008.10.004
23. McCrory P, Zazryn T, Cameron P. The evidence for chronic traumatic encephalopathy in boxing. *Sports Med*. 2007;37(6):467-476. doi:10.2165/00007256-200737060-00001

24. Gianoli GJ. Post-concussive Dizziness: A Review and Clinical Approach to the Patient. *Front Neurol*. 2022;12. doi:10.3389/FNEUR.2021.718318
25. Akin FW, Murnane OD, Hall CD, Riska KM. Vestibular consequences of mild traumatic brain injury and blast exposure: a review. *Brain Inj*. 2017;31(9):1188-1194. doi:10.1080/02699052.2017.1288928
26. Brown DA, Leung FT, Evans K, Grant G, Hides JA. Vestibular and oculomotor function in male combat sport athletes. *J Sci Med Sport*. 2022;25(6):524-528. doi:10.1016/j.jsams.2022.02.004
27. Levent S, Songül A. Yüzücülerde benign paroksismal pozisyonel vertigo. *The Turkish Journal of Ear Nose and Throat*. 2007;17(6):307-310. doi:https://dx.doi.org/null
28. Selcuk OT, Eraslan A, Osma U, Eren E, Eyigor H, Yilmaz MD. Benign paroxysmal positional vertigo caused by swimming. *Asian J Sports Med*. 2014;5(1):71-72. doi:10.5812/ASJSM.34237
29. Jude Tramo M, Hainline B, Petito F, Lee B, Caronna J. Vertebral artery injury and cerebellar stroke while swimming: case report. *Stroke*. 1985;16(6):1039-1042. doi:10.1161/01.STR.16.6.1039
30. Amir I, Young E, Belloso A. Self-limiting benign paroxysmal positional vertigo following use of whole-body vibration training plate. *J Laryngol Otol*. 2010;124(7):796-798. doi:10.1017/S0022215109992441
31. Hancı D, Altun H. Prevalence of benign paroxysmal positional vertigo among motocross racers: a case-control study. *Kulak Burun Bogaz Ihtis Derg*. 2015;25(5):279-283. doi:10.5606/KBBIHTISAS.2015.90922
32. Dispenza F, De Stefano A, Mathur N, Croce A, Gallina S. Benign paroxysmal positional vertigo following whiplash injury: a myth or a reality? *Am J Otolaryngol*. 2011;32(5):376-380. doi:10.1016/J.AMJOTO.2010.07.009
33. Epley JM. The canalith repositioning procedure: for treatment of benign paroxysmal positional vertigo. *Otolaryngol Head Neck Surg*. 1992;107(3):399-404. doi:10.1177/019459989210700310
34. Almohiza MA. Effects of Epley procedure on BPPV patients: a systematic review of randomized controlled trails. *Eur Rev Med Pharmacol Sci*. 2023;27(16):7409-7415. doi:10.26355/EURREV_202308_33392
35. Herdman SJ. Vestibular rehabilitation. *Curr Opin Neurol*. 2013;26(1):96-101. doi:10.1097/WCO.0B013E32835C5EC4
36. Hunt WT, Zimmermann EF, Hilton MP. Modifications of the Epley (canalith repositioning) manoeuvre for posterior canal benign paroxysmal positional vertigo (BPPV). *Cochrane Database Syst Rev*. 2012;2012(4):CD008675. doi:10.1002/14651858.CD008675.PUB2