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| **CRITICALLY APPRAISED TOPIC** |

**FOCUSED CLINICAL QUESTION**

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| In adults (18 to 65 years) with mild TBI, are vestibular rehabilitation exercises effective in improving symptoms of dizziness (no comparison intervention)?  |

**AUTHOR**

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| **Prepared by** | Elizabeth Nixon | **Date** | 11/11/15 |
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**CLINICAL SCENARIO**

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| My last clinical at Veterans Affairs involved a patient case load with a high number of Veterans who had experienced a traumatic brain injury (TBI). Although I was treating many of them for musculoskeletal conditions, they had concurrent symptoms that could be attributed to their previous TBI. One patient came in to the clinic with a referral for low back pain but was unable to complete the examination because all testing positions (besides short sitting) caused intense vertigo. The physical therapist treating this patient referred the patient to another health care provider because they were unsure how to treat this combination of conditions. Treating patients with both brain injury and dizziness can be challenging. Typical treatment strategies for dizziness might not be appropriate for a patient who also has experienced a TBI. Physical therapists could benefit from information about how to best treat patients with these two simultaneous and complex conditions.  |

**SUMMARY OF SEARCH**

[Best evidence appraised and key findings]

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| * 5 electronic databases were searched, 10 articles were identified.
	+ 1 randomized controlled trial, 4 case series studies, and 5 case control studies
* Key findings from the three studies with highest evidence related to the clinical questions indicates that:
	+ In individuals with concurrent concussion and symptoms of dizziness (whose symptoms aren’t resolved with rest) vestibular rehabilitation could be beneficial in resolving these symptoms.
	+ Vestibular rehabilitation can be beneficial for individuals with BPPV after TBI but might require more treatment visits to resolve symptoms of dizziness compared to individuals with idiopathic BPPV.
	+ In individuals with sport related concussion, a combination of vestibular rehabilitation and cervical spine treatments might be beneficial in decreasing persistent dizziness (as well as neck pain and/or headaches) and could decrease the amount of time before medical clearance for return to sport is given.
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**CLINICAL BOTTOM LINE**

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| Current best evidence suggests that vestibular rehabilitation can be beneficial in reducing symptoms of dizziness in individuals who have experienced a traumatic brain injury (TBI). Although the evidence is varied in terms of which specific interventions are best practice, some that have been shown to be beneficial include: static and dynamic balance activities, canalith repositioning manoeuvres, gaze stabilization exercises, and adaptation exercises. A physical therapist should be certain to address symptoms of dizziness in individuals with TBI in order to help individuals return to their optimal functioning as swiftly as possible.  |

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| ***This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor*** |

**SEARCH STRATEGY**

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| **Terms used to guide the search strategy** |
| **P**atient/Client Group | **I**ntervention (or Assessment) | **C**omparison | **O**utcome(s) |
| adult\*menwomenmiddle-agedyoungTBItraumatic brain injurybrain injury\*head injury\*skull fractureconcussionhead contusion | vestibularrehabrehabilitationtreatmentexercis\*interventionphysical therapyphysiotherapytrain\* | (N/A) | dizzydizzinessvertigonystagmusspin\* |

**Final search strategy:**

PubMed:

1. Adult\* OR men OR women OR middle-aged OR young
2. TBI OR traumatic brain injury OR brain injury\* OR head injury\* OR skull fracture OR concussion or head contusion
3. Vestibular OR rehab OR rehabilitation OR treatment OR exercise\* OR exercis\* OR intervention OR physical therapy OR physiotherapy OR train\*
4. dizzy OR dizziness OR vertigo OR nystagmus OR spin\*
5. #1 AND #2 AND #3 AND #4

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| **Databases and Sites Searched** | **Number of results** | **Limits applied, revised number of results (if applicable)** |
| **PubMed** | **67** | **60:** Revised number after filtering dates from 2000 to the present and to articles only in English. |
| **CINAHL** | **43** | No results until search was revised to look at “tbi or traumatic brain injury or concussion” and “dizziness or vertigo or nystagmus” AND “rehabilitation or physical therapy or physiotherapy”  |
| **PEDro** | **142** | No results until search was revised to look only at results for “brain injury” and “TBI” |
| **APTA Hooked on Evidence** | **173** | No results until search was revised to look at results for key terms “traumatic brain injury”, “brain injury”, “vertigo” and “dizziness” separately. (Number is the combined total of each) |
| **Cochrane Library** | **72** |  |

## INCLUSION and EXCLUSION CRITERIA

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| **Inclusion Criteria** |
| - Published in English- Studied a population of adults (age 18 to 65)- Studied individuals who experienced a traumatic brain injury- A protocol that includes a vestibular rehabilitation intervention |
| **Exclusion Criteria** |
| - Studies done prior to 2000- Abstracts, conference proceedings, letters to the editor, dissertations, narrative review articles |

**RESULTS OF SEARCH**

**Summary of articles retrieved that met inclusion and exclusion criteria**

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| **Author (Year)** | **Study quality score** | **Level of Evidence** | **Study design** |
| Agostini V, Chiaramello E, Bredariol C, Cavallini C, and Knaflitz M (20111 | **8/29** **(Downs and Black)** | **3b** | **Case control study** |
| Ahn, SK, Jeon SY, Kim JP, Park JJ, Hur DG, Kim DW, Woo SH, Kwon OJ, and Kim JY (2011)2 | **16/29****(Downs and Black)** | **3b** | **Case control study** |
| Alsalaheen BA, Whitney SL, Mucha A,Morris LO, Furman JM, and Sparto PJ (2012)3 | **11/29****(Downs and Black)** | **4** | **Case series study** |
| Alsalaheen BA, Mucha A, Morris LO, Whitney SL, Furman JM, Camiolo-Reddy CE, Collins MW, Lovell MR, and Sparto PJ (2010)4 | **19/29****(Downs and Black)** | **4** | **Case series study** |
| Alvarez TL, Kim EH, Vicci VR, Dhar SK, Biswal BB, and Barrett AM (2012)5 | **11/29****(Downs and Black)** | **4** | **Case series study** |
| Basford JR, Chou LS, Kaufman KR, Brey RH, Walker A, Malec JF, Moessner AM, Brown AW (2003)6 | **14/29****(Downs and Black)** | **3b** | **Case control study** |
| Laborey M, Masson F, Ribéreau-Gayon R, Zongo D, Salmi LR, and Lagarde E (2014)7 | **18/29****(Downs and Black)** | **3b** | **Case control study** |
| Motin M, Keren O, Groswasser Z, Gordon CR (2005)8 | **11/29****(Downs and Black)** | **4** | **Case series study** |
| Nacci A, Ferrazzi M, Berrettini S, Panicucci E, Matteucci J, Bruschini L, Ursino F, Fattori B (2011)9 | **11/29****(Downs and Black)** | **3b** | **Case control study** |
| Schneider KJ, Meeuwisse WH, Nettel-Aguirre A, Barlow K, Boyd L, Kang J, and Emery CA (2014)10 | **9/11** **(PEDro)** | **1b** | **Randomized controlled trial** |

**BEST EVIDENCE**

The following 3 studies were identified as the ‘best’ evidence and selected for critical appraisal. Reasons for selecting these studies were:

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| * **Alsalaheen et al (2010):** Although this is only a case series, it scored higher than the many of the other studies in terms of study quality score and it met all the inclusion criteria as well as matched closely with the PICO question. It also had a bigger sample size than many of the case control studies.
* **Ahn et al (2011):** Although this study scored lower in terms of evidence than others listed above this study met all the inclusion criteria and directly related to the PICO question. This was particularly important in terms of utilizing vestibular rehabilitation as an intervention which many of the other studies did not.
* **Schneider et al (2014):** This is the only RCT in the group which rates it as the highest level of evidence of the group of 10 studies. After scoring on the PEDro scale it scored 9/11 which is rather high. The clinical significance might not be the best due to the small effect size; however, because of the level of evidence combined with the study objectives it best fit the PICO question.
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**SUMMARY OF BEST EVIDENCE**

**(1) Description and appraisal of *Vestibular Rehabilitation for Dizziness and Balance Disorders after Concussion* by Alsalaheen et al (2010)**

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| **Aim/Objective of the Study/Systematic Review:** |
| The objective of this study was to examine how vestibular rehabilitation can both improve functional gait and balance as well as reduce symptoms of dizziness in individuals who have experienced a concussion. In addition, the aim was to examine if the recovery time varied for children versus adults who underwent vestibular rehabilitation.  |
| **Study Design** |
| * Retrospective cohort study design
* Retrospective chart review of patients from a single clinic who presented with diagnosis of concussion and concurrent vestibular symptoms.
* Outcome measures were obtained during the initial evaluation and at discharge.
* Due to the retrospective study design there was no blinding of researchers
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| **Setting** |
| University of Pittsburgh Medical Center (UPMC) Centers for Rehab Services Vestibular Rehabilitation Clinic. A tertiary balance center for vestibular rehabilitation located in Pittsburgh, Pennsylvania, United States.  |
| **Participants** |
| * N = 114 total charts reviewed
* Individuals diagnosed with concussion and referred to the clinic between 2006 and 2008.
* Time from concussion to clinic visit: Median of 61 days and range of 6-2566 days.
* Children (age 18 or younger): 45 females and 22 males. Median age of 16 and range of 8-18 years old.
* Adults (older than 18): 25 females and 22 males. Median age of 41 with a range of 19-73 years old.
* Dizziness symptoms described as off-balance, light-headedness, spinning, nausea and sensation of motion with off-balance being the most common descriptor.
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| **Intervention Investigated** |
| *Intervention* |
| * Individual, customized program for each participant related to their impairments
* Vestibular rehab performed by 8 therapists with 2 of the therapists treating 71% of patients.
* Exercises to treat dizziness, ocular motor function and gait and balance activities both in the clinic and home exercise programs. These included: Canalith repositioning manoeuvres, gaze stabilization exercises, standing balance (eyes open and closed), and walking with balance challenges (such as obstacle courses or walking with head turns).
* Exercises were to be done daily either in the clinic or at home.
* Visits: 84 participants had more than one visit. 30 participants had only one visit.
* The reasons for no return visit include: no physical therapy was indicated, patient distance to clinic and non-compliance.
* Duration: Median of 33 days and range of 7-181 days
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| **Outcome Measures** (Primary and Secondary) |
| * Dizziness severity ranking: Subjects self-reported their severity of dizziness on a scale from 0-100 (0 = no dizziness, 100 = max dizziness). Subjects were provided with additional numbers that allowed them to rank their symptom severity between the 0 and 100 in terms of slight, mild, moderate or severe. They were also asked to use other terms to describe the dizziness with options such as “nausea, spinning, off-balance” and more.
* Activities-specific Balance Confidence (ABC): Questionnaire where subjects list how confidently they are able to maintain their balance during 16 functional activities (0 = no confidence, 100 = max confidence)
* Dizziness Handicap Inventory (DHI): Participants ranks their dizziness on 25 items related to physical, emotional and functional health. (0 = no disability and 100 = greatest level of disability from dizziness)
* Dynamic Gait Index (DGI): 8 item test with various gait and balance activities scaled 0-3 (0 = severely impaired, 3 = normal) with a max score of 24.
* Functional Gait Assessment (FGA): 10 item test of functional balance activities. (0 = worst score, 30 = max score with higher scores indicating less impairment.)
* Gait speed: Gait speed timed while subjects walk at a comfortable pace on a 4 meter course.
* Timed Up and Go (TUG): Subject stands from a chair, walks 3 meters are their self-selected walking speed, returns to the chair and sits down, all while being timed. (The less the time the participant takes, the better.)
* 5 Times Sit to Stand (FTSTS): Patients cross their arms across their chest and stand up and sit down 5 times as quickly as possible while being timed. (The less the time the participant takes, the better.)
* Sensory Organization Test (SOT): 6 sensory conditions utilized including – eyes open, fixed support; eyes closed, fixed support; sway-referenced vision, fixed support; eyes open, sway-referenced support; eyes closed, sway-referenced support; sway-referenced vision and support. 3 trials of 20 seconds each for each condition. (loss of balance = 0 and no sway = 100). Average scores were calculated with a single score from the combined average scores.
* 8 physical therapists provided treatment with one of the therapists treating 44% of the caseload and another treating 27% of the cases. No standardization of measures was mentioned in the study.
* Outcome measures (both self-report and performance measures) were administered at the initial evaluation, as well as weekly and monthly intervals. If an outcome measure was not administered at the initial visit or discharge, data was used from the outcome measure recorded closest to those dates.
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| **Main Findings** |
| * Median 4 visits and 33 days per subject which was less time than similar studies done at the same clinic.
* Outcome measures that demonstrated average larger than minimally clinically important differences changes included the DHI (18 points), gait speed (0.1 m/s) and SOT composite scores (10 points).
* Outcome measures that did not have established minimally clinically important differences include but demonstrated likely clinically significant changes included the ABC scale (20 points), DGI (3 points) and FGA (6 points). These changes were statistically significant as well.
* For outcome measures related to symptoms of dizziness specifically, both the dizziness severity and DHI had P values <.001.
* For the dizziness severity decreased from a mean (SD) of 21 (22) to 12 (18) for pre and posttreatment and the DHI mean (SD) decreased from 49 (21) to 30 (22).
* The biggest age difference occurred with the dizziness severity ranking and first two SOT conditions. Dizziness severity in children mean standard deviation (SD) from 26 (22) to 7 (11) from pre to post treatment with adults only averaging 21 (20) to 20 (25) from pre to post treatment. For SOT condition #1 the children’s mean (SD) was 79 to 92 (pre to post treatment) with adults 91 to 91 (pre to post treatment). For SOT condition #2 the children’s mean (SD) was 72 (21) to 89 (5) from pre to post treatment, and the adults was 83 (11) to 83 (13) from pre to post treatment.
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| **Original Authors’ Conclusions** |
| For both adults and children who have experienced concussion and concurrent resultant vestibular symptoms, vestibular rehabilitation could be beneficial in helping to improve the symptoms of dizziness, as well as gait and balance disturbances, if those symptoms aren’t resolved with rest. |
| **Critical Appraisal** |
| **Validity**[Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.] |
| * Downs and Black checklist score: 19/29
* Strengths include: the large number of outcome measures utilized as well as data indicating that vestibular rehabilitation might be beneficial for individuals who have experienced a concussion.
* Limitations include: observational study design which limited blinding, no control or experimental group, inability to assess immediate concussion symptoms at time of injury, no standardized battery of vestibular tests or standardized vestibular evaluation which made it hard to compare data across groups.
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| **Interpretation of Results**[This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.] |
| The results are positive for the use of vestibular rehabilitation in treating individuals who have symptoms of dizziness after concussion or mild TBI. The results suggest that vestibular rehabilitation could lead to an improvement in symptoms of dizziness. The study looked at a large group of subjects and utilized a large number of outcome measures. In every patient who was seen for more than one visit improvements were shown in the self-report outcome measures, as well as gait and balance measures. However, the observational nature of the study design was a major limitation of the study and the lack of standardization makes it difficult to ensure the data could be replicated in other individuals with similar impairments.The results didn’t demonstrate much of a difference between age groups except for a couple of the self-report outcome measures as well as the 5 time sit to stand. This could be due to children’s self-awareness of their symptoms and how much they think the dizziness impacts their life. The differences in FTSTS scores could be due to the overall physical activity differences between adults and children.Although it’s impressive that every patient improved this could be due to the individualized treatment for every patient and the number of outcome measures utilized. With that many outcome measures the sample size is relatively low to ensure the results could be replicated in other clinical situations. If some controls were applied either to the participants or by limiting the number of outcome measures it could likely change the results quite a bit. |

**(2) Description and appraisal of *Clinical Characteristics and Treatment of Benign Paroxysmal***

***Positional Vertigo After Traumatic Brain Injury* by Ahn et al (2011)**

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| **Aim/Objective of the Study/Systematic Review:** |
| The aim of this study was to examine the clinical features of benign paroxysmal positional vertigo (BPPV) after traumatic brain injury (TBI). The authors also examined differences clinically between individuals with idiopathic BPPV versus those who experienced BPPV traumatically.  |
| **Study Design** |
| * Retrospective cohort study design
* Inclusion criteria: Head injury mechanism not due to surgical procedures or whiplash; nystagmus either recorded by video or observed by an experienced clinician; vertigo that occurred within 72 hours of their head injury; and no prior history of BPPV before TBI.
* Exclusion criteria: Prior BPPV and/or head trauma, history of ear disease, migraine, brain tumor, cerebrovascular disease. Subjects with idiopathic BPPV were cleared for head injury.
* Allocated into groups based on diagnoses of either idiopathic BPPV or BPPV after TBI.
* Due to retrospective nature, no blinding occurred of subjects or clinicians. Assessor blinding was not stated in this study.
* No objective self-report or performance outcome measures were utilized. Success was determined by lack of positional vertigo and observable nystagmus.
* Patients were re-examined at both 3 and 6 months after symptoms of dizziness dissipated. Subjects were also followed up with on the telephone by two physicians.
* Clinical differences between groups were measured by Pearson’s x2 test and for p values <0.05 statistical significant was established.
 |
| **Setting** |
| Tertiary referral neurotology and dizziness clinic in Jinju, South Korea. |
| **Participants** |
| * 533 total charts reviewed (341 with idiopathic BPPV and 192 with positional vertigo after head injury)
* Subjects were selected from the medical records of a single neurotology and dizziness clinic from January 1st, 2003 to January 31st, 2009.
* N = 144 (32 with BPPV after TBI and 112 with idiopathic BPPV)
* TBI mechanism of injury was due to motor vehicle crash (20 subjects), fall (8 subjects), and a blow to the head (4 subjects).
* BPPV was diagnosed based on patient report of recurrent positional vertigo as well as results of clinical tests (Dix-Hallpike and supine head-turning). Subjects were further classified by type of BPPV, either posterior semicircular canal (PSC) or horizontal semicircular canal (HSC).
* PSC-BPPV was diagnosed by positive Dix-Hallpike Test. A positive occurs when the patient gets nystagmus in the testing position (affected ear down results in geotropic torsional nystagmus with up-beating component) and is reversed upon return to upright sitting.
* HSC-BPPV was diagnosed by occurrence of “confirmed by horizontal direction-changing positional nystagmus concurrent with vertigo precipitated by the supine head-turning test”. HSC-BPPV was further categorized by canalolithiasis or cupulolithiasis depending on the direction of the subject’s nystagmus.
* BPPV after TBI group:
	+ Gender: 18 men and 14 women
	+ Age: Ranged from 30 to 74 years with a mean age of 52.9 years.
* Idiopathic BPPV group:
	+ Gender: 44 men and 68 women
	+ Age: Ranged from 11 to 83 years with average age of 55.3 years.
* Due to the retrospective nature there were no dropouts or lost to follow up statistics.
 |
| **Intervention Investigated** |
| *Treatment* |
| * Subjects were treated with the type of repositioning maneuver appropriate for their type of BPPV.
* PSC-BPPV was treated with the Epley maneuver.
* HSC-BPPV was treated with the 360 degree barbeque rotation maneuver (with or without prolonged positioning), head shaking, and/or the fourth step of the Semont maneuver.
* Subjects were re-evaluated for nystagmus or positional vertigo either 3 or 5 days after initial treatment.
* Maneuvers were repeated until both nystagmus and positional vertigo symptoms were resolved.
* Subjects were asked to return if vertigo symptoms reoccurred. Otherwise they were re-examined at both 3 and 6 months after testing negatively for vertigo and contacted by telephone by two physicians.
 |
| **Outcome Measures** (Primary and Secondary) |
| * No objective self-report or performance outcome measures were utilized.
* Authors defined success as absence of nystagmus and positional vertigo but no further details were described.
* Patients were re-examined at 3 and 6 months after symptoms of dizziness dissipated. Patients also spoke with physicians via telephone for further information.
 |
| **Main Findings** |
| * The mean number of treatment sessions was significantly higher statistically for those with post-traumatic BPPV versus idiopathic BPPV in both in individuals with PSC-BPPV (p = 0.006) and HSC-BPPV (p= 0.024).
* While subjects with BPPV after TBI were more likely to have recurrent BPPV than the idiopathic BPPV group, the results were not statistically significant (p=0.685).
* Diagnosis of HSC-BPPV versus PSC-BPPV (p=0.16), bilateral involvement of BPPV (p=0.89), and multiple canal involvement (p=0.50) was similar between groups but none were statistically significant.
* The prevalence between men and women within groups was statistically significant (p = 0.04).
 |
| **Original Authors’ Conclusions** |
| BPPV after TBI was more likely to require more treatment sessions to resolve compared to idiopathic BPPV. However, there was no statistical difference between BPPV after TBI versus idiopathic BPPV in terms of reoccurrence.  |
| **Critical Appraisal** |
| **Validity**[Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.] |
| * Downs and Black checklist score: 16/29
* Strengths include: Reviewed charts were selected from consecutive records with the target diagnosis at a single clinic in a specified time range. Inclusion criteria for intervention group focused on limiting exposure misclassification bias due to previous diagnoses (e.g. Prior BPPV and head injury from distinct mechanisms).
* Limitations include: observational study design which limited blinding in all involved parties; no specifics on which or how many subjects were lost to follow up; lack of control or experimental group; lack of information about treating clinicians; inability to assess immediate concussion symptoms at time of injury; and no standardized vestibular evaluation, battery of tests, or treatment utilized to assist in comparing data across groups.
* This paper also didn’t include any self-reported limitations, sources of bias, or competing interests of the authors.
 |
| **Interpretation of Results** |
| The results indicate that individuals with post-traumatic BPPV could require more treatment visits to resolve symptoms of dizziness compared to individuals with idiopathic BPPV. The results were statistically significant for individuals with both PSC and HSC BPPV after TBI. Despite this, the reoccurrence rate for both groups was similar (though not statistically significant), suggesting that after the resolution of the initial symptoms, the recovery process is similar between the post-traumatic and idiopathic groups. Despite the statistically significant results found in the study, there were multiple sources of bias and quite a few limitations to the study as a whole. The retrospective, observational nature, lack of controls, lack of blinding and lack of randomization, and lack of standardized controls are all problematic. The final results should be considered when working with this patient population; however, more rigorous research is required in order to be confident that the results can be realistically replicated in similar groups of patients.  |

**(3) Description and appraisal of *Cervicovestibular rehabilitation in sport-related***

***concussion: a randomised controlled trial* by Schneider et al (2014)**

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| **Aim/Objective of the Study/Systematic Review:** |
| The aim of this study was to examine how vestibular rehabilitation and cervical spine physical therapy impacts the time before return to play, medical clearance is given to individuals who experience persistent post-concussion symptoms.  |
| **Study Design** |
| * Randomized controlled trial
* Random allocation to the treatment or control group via a “computer-generated randomisation sequence in permuted blocks with sizes of four, six and eight”. This was done by a biostatistician not related to the study to ensure similar groups at baseline.
* The primary outcome measure (medical clearance for return to play) was determined by a physician blinded to the treatment groups.
* One physiotherapist with 13 years of clinical experience including knowledge in musculoskeletal and vestibular rehabilitation performed all the treatments for both groups.
* A second physiotherapist blinded to the treatment groupings performed the secondary outcome measure assessments.
* A linear regression was planned to evaluate the difference in number of days to medical clearance but not all subjects were cleared to play at 8 weeks so a Kaplan-Meier survival analysis was used instead.
* Authors performed an intention to treat analysis and descriptive and non-parametric statistics were used to assess baseline and follow up value differences.
* A priori α-level of 0.05 was used for statistical tests.
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| **Setting** |
| University of Calgary Sport Medicine Centre in Calgary, Canada |
| **Participants** |
| * N = 31 participants (58 recruited with 14 non-responders, 1 with lack of transportation, and 12 that did not meet the inclusion criteria).
* From November 2010 to October 2011 all subjects at the University of Calgary Sport Medicine Center diagnosed with sport-related concussion (utilizing guidelines from the Third International Consensus Conference on Concussion in Sport) and symptoms greater than 10 days of dizziness, neck pain and/or headaches were considered for the study.
* Exclusion criteria included: “fracture, other neurological conditions, musculoskeletal injuries (other than the cervical spine) that restrict activity and medications that affect neural adaptation.”
* Subjects were randomly allocated to the treatment or control group.
* Age: 12 to 30 years of age
* Gender: 11 male and 4 female (treatment group) and 7 male and 9 female (control group)
* For symptoms of dizziness (a key variable) the groups were relatively similar with the treatment group having dizziness in 86.33% of subjects and the control group having 82.75%.
* For the DHI subjects in the treatment group had a median score of 46 with those in the control having a median score of 42.
* Vestibular findings were found in 80% of the treatment group and 87.5% of the control group.
* Two subjects in the control group (with similar baseline characteristics to study participants) dropped out.
 |
| **Intervention Investigated** |
| *Control* |
| * Subjects were seen 1x week for 8 weeks by the treating physiotherapist or until medical clearance for return to sport was achieved. No specific treatment times were specified.
* Participants were asked to rest (cognitively and physically) until symptom free and then add in graded exertion activity which followed a post-concussion standard of care.
* Range of motion, stretching, and postural education in non-provocative manner.\*
* Subjects kept an exercise journal to track home exercise program adherence.\*

*\* Exercise specifics not explained in detail in study* |
| *Experimental* |
| * Subjects were seen 1x week for 8 weeks by the treating physiotherapist or until medical clearance for return to sport was achieved. No specific treatment times were specified.
* Participants were asked to rest (cognitively and physically) until symptom free and then add in graded exertion activity which followed a post-concussion standard of care.
* Range of motion, stretching, and postural education in non-provocative manner.\*
* Subjects kept an exercise journal to track home exercise program adherence.\*
* In addition to exercises above, subjects were given an individualized program incorporating some or all of the exercises listed below based on the findings (which were reassessed each visit) by the treating physiotherapist.
* Cervical spine therapy including: joint mobilizations of the cervical and thoracic spine; therapeutic exercises with a neuromuscular retaining component (flexion and extension exercises in the craniovertebral region); and sensorimotor exercises.
* All symptoms of headache were to be controlled before initiating vestibular rehabilitation exercises.
* Vestibular rehabilitation consisting of: “habituation, gaze stabilisation, adaptation exercises, standing balance exercises, dynamic balance exercises and canalith repositioning manoeuvres.”

*\* Exercise specifics not explained in detail in study* |
| **Outcome Measures** (Primary and Secondary) |
| * Primary outcome measure: Number of days from initial treatment until the subject was medically cleared to return to play. Medical clearance was granted by a physician who was blinded to the treatment groups and determined by clinical improvement in post-concussive symptoms (dizziness, headache and/or cervical pain).
* Baseline measurements: sex, age, mechanism of injury, type of sport and position played, how many years playing the sport and other sport participation, prior concussion or history of dizziness, and cervical pain and instability.
* Secondary outcome measures:
	+ 11-point Numeric Pain Rating Scale score
	+ Activities-specific Balance Confidence Scale (%)
	+ Dizziness Handicap Index (/100)
	+ SCAT2 (/100)
	+ Dynamic Visual Acuity (lines lost)
	+ Head Thrust Test
	+ modified Motion Sensitivity Test (/40)
	+ Functional Gait Assessment (/30)
	+ Cervical Flexor Endurance (seconds)
	+ Joint Position Error test (/3 trials)
* Secondary measures were performed at baseline and either when the subject was medically cleared to return to play or at 8 weeks after the treatment initiation. Measurements were performed by a physiotherapist blinded to the treatment groups.
 |
| **Main Findings** |
| * Within 8 weeks of initial evaluation, 73% of the treatment group was medically cleared to return to sport versus only 7% of the control group.
* Individuals in the treatment group were 3.91 times more likely to be cleared to return to play within 8 weeks using an intention to treat analysis (95% CI 1.34 to 11.34). Assuming the control group individuals who dropped out would be able to return to sport within 8 weeks.
* Of the participants who completed the study the subjects in the treatment group were 10.27 times (95% CI 1.51 to 69.56) more likely than the control group to be cleared for return to sport within 8 weeks.
* All the subjects medically cleared to return to sport reported zero symptoms of dizziness (or headache) and stated they felt 100% able to return.
* Those that were cleared to return to sport had statistically significant improvements on both the SCAT2 (p=0.009) and the Dizziness Handicap Inventory (p=0.019).
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| **Original Authors’ Conclusions** |
| In individuals with sport related concussion, a combination of vestibular rehabilitation and cervical spine treatments might be beneficial in decreasing post-concussive symptoms such as neck pain, headaches and/or persistent dizziness. Similarly, individuals that are treated with both vestibular rehabilitation and cervical spine treatments after sport related concussion might also be more likely to be cleared to return to sport within 8 weeks post-injury.  |
| **Critical Appraisal** |
| **Validity**[Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.] |
| * PEDro Scale Score: 8/10 [Eligibility criteria: Yes; Random allocation: Yes; Concealed allocation: Yes; Baseline comparability: Yes; Blind subjects: No; Blind therapists: No; Blind assessors: Yes; Adequate follow-up: Yes; Intention-to-treat analysis: Yes; Between-group comparisons: Yes; Point estimates and variability: Yes.
* Strengths: Subjects were randomized, allocation was concealed, and study assessors were blinded. Subjects were compared at baseline, between groups and had adequate follow up.
* Limitations: Small sample size; no blinding of any of subjects or treating therapists and a potential expectation bias as a result; lack of formal neuropsychological and vestibular function testing; inability to clear for concurrent cognitive impairments ongoing prior to studied injury; previous concussion or treatments could have confounded data in the this study; specific diagnosis (sport-related concussion) and age range (12 years to 30 years) which could make it difficult to apply the resultant data to other patient populations.
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| **Interpretation of Results** |
| Results indicate that in individuals with symptoms of dizziness after TBI/concussion it could be beneficial to evaluate and treat patients with physical therapy for both the vestibular system and cervical spine. This study found that those subjects who were treated with both musculoskeletal (for the cervical spine) and vestibular rehabilitation techniques were able to achieve medical clearance and return to play in less time than those who were treated with basic therapeutic exercise (range of motion, stretching, and postural education) alone. Specifically, individuals in the treatment group were almost four times more likely to be cleared to return to play within 8 weeks than the control group.One area that could have been studied further was the true mechanism of injury for the subject’s cervical spine. Whether the cervical spine impairments were a result of the trauma from the concussion or a result of movement patterns due to the vestibular system involvement. There are several additional limitations in this study, namely lack of blinding of the subjects or therapists and the limitation patient population studied, this study still does a satisfactory job attempting to present balanced evidence. This study demonstrates the highest level of evidence reviewed relevant to the clinical question presented. The implications of this study for clinical practice are positive and despite the small sample size should be considered when treating similar patient populations. |

**EVIDENCE SYNTHESIS AND IMPLICATIONS**

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| The results of all three studies examined in this critical appraisal indicate that vestibular rehabilitation could be beneficial to individuals with symptoms of dizziness after TBI. All three studies found that symptoms of dizziness decreased after various forms of vestibular rehabilitation. Vestibular rehabilitation techniques utilized in the studies include: Epley maneuver, gaze stabilisation, adaptation exercises, standing balance exercises, dynamic balance exercises, habituation, canalith repositioning manoeuvres, 360 degree barbeque rotation maneuver (with or without prolonged positioning), head shaking, and/or the fourth step of the Semont maneuver. The patients with post-concussive symptoms (such as dizziness) could take longer to recover but after the initial signs and symptoms dissipate the reoccurrence rate between patients with idiopathic and post-traumatic dizziness is likely similar. From the evidence found in the studies reviewed, the patient in the clinical scenario would likely benefit from vestibular rehabilitation. The treating therapist should be sure to evaluate to determine if BPPV is the cause and try to narrow down which form of BPPV (PSC versus HSC and canalolithiasis versus cupulolithiasis), the patient is experiencing to provide them with the most beneficial vestibular rehabilitation treatment. Additionally, the physical therapist should also evaluate the cervical spine and consider utilizing manual therapy and therapeutic exercise techniques if the therapist thinks the patient has cervical spine impairments. This could help decrease the time needed to return to play in sport situations but also potentially help return those in non-sport situations back to their typical activity level more quickly. Finally, despite targeted treatment to address symptoms of dizziness the patient might require more treatment sessions than similar patients with symptoms of dizziness related to non-traumatic sources. The treating therapist should take this into consideration during treatment and also educate the patient about this information so all have a realistic idea of the plan of care length anticipated. The overall quality of evidence for this patient population and diagnosis is limited. In the searches completed, the majority of the evidence was observational and/or retrospective in nature. Despite searching multiple databases there was only one randomized controlled trial that related to the clinical question. The two other studies reviewed in depth for this critical appraisal, as well as the rest of the studies listed (save the RCT) had low levels of evidence. The majority of the studies utilized a case series or case control study design, and many of them were retrospective in nature. This limits the ability to apply the results from the studies in a standardized manner. Despite similarities in patient population and diagnoses, many of the subjects received treatment that was completely individualized based on what the treating therapist thought would be beneficial. In the future more studies of high methodological quality and large sample size should be done. Studies should be of prospective design and focus on utilizing both treatment and control groups. One specific area of research that could also be beneficial would be to focus the treatments utilized in vestibular rehabilitation. By focusing the specific treatments utilized, the dosage applied, and accounting for personal variables (such as history of concussion, time since injury, and mechanism of injury) the resultant data could be more beneficial to clinical practice.  |

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