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| **CRITICALLY APPRAISED TOPIC** |

**FOCUSED CLINICAL QUESTION**

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| For active duty military personnel suffering from post concussion syndrome, will cervicovestibular rehabilitation in combination with progressive aerobic exertion training improve return to duty times when compared to progressive aerobic exertion training alone. |

**AUTHOR**

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**CLINICAL SCENARIO**

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| The patient is a 26 year-old active duty soldier in the army. He suffered a blunt trauma concussion while on tour in Afghanistan and continued to have symptoms of concussion 3 months after the injury. The patient had completed the concussion rehab program provided by the TBI center at Fort Bragg but was still experiencing exertional headaches along with other symptoms which limited his ability to complete training activities with his unit. The patient’s goal was to return to full duty and be able to train with his unit symptom free.  Concussions are common among military personnel due to blast exposure and blunt trauma. About 30% of individuals who suffer concussions develop post-concussion syndrome which can be accompanied by exertional headaches.6 The most common intervention used to treat these individuals is progressive aerobic exertion training, however this intervention is not effective for all patients with post-concussion syndrome. Research has begun to look at the effects of a multi-modal approach to concussion rehab including cervicovestibular interventions. The goal of this critical appraisal is to better understand if the inclusion of cervicovestibular rehabilitation will improve outcomes and help these individuals return to duty in a shorter period of time. |

**SUMMARY OF SEARCH**

[Best evidence appraised and key findings]

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| * 8 studies were found that met inclusion/exclusion criteria. Of the selected studies one was level II evidence, one was level III evidence and the remaining 6 were level IV evidence. Three studies were chosen for critical review and appraisal; those studies included one randomized control trial, one cross sectional study, and one prospective cohort study. The prospective cohort study was chosen because it was most closely related to the topic of interest. * Only one study was found that directly compared the combination of cervicovestibular rehabilitation and progressive aerobic exertion training with aerobic exertion training alone. This study was conducted by Schneider KJ et al. (2014) and found a significant difference in the number of athletes who were cleared to returned to full participation in sport within 8 weeks.6 Many of the studies investigated the effectiveness of graded exercise testing and progressive aerobic exertion training. No studies that met inclusion/exclusion criteria looked solely at the effects of cervicovestibular rehabilitation for post-concussion syndrome. * Further research is needed to investigate the effectiveness of including cervicovestibular interventions as part of a multi-modal approach to treating post-concussion syndrome. |

**CLINICAL BOTTOM LINE**

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| Evidence suggests that the inclusion of cervicovestibular rehab in addition to progressive aerobic exertion training can significantly increase the likelihood of medical clearance for return to activity in an 8 week period.6 Furthermore, evidence shows that progressive aerobic exertion training alone is more effective than rest in resolving symptoms of post-concussion syndrome.3 Both treatment methods appear to be safe and should be considered when treating patients with post-concussion syndrome, however further research is needed to compare the effectiveness of each approach. Future research is also needed to assess the effectiveness of these interventions on the population in question. |

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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) |
| Military  Active Duty  Service Members  Soldiers  TBI  Traumatic Brain Injury  Concussion  Head Trauma  Primary Exertional Headache  Exertion | Cervical  Neck  Strength\*  Cervicovestibular | Aerobic  Progressive  Graded  Exertion | Return to duty  Recovery |

**Final search strategy:**

#1 (Military OR Active Duty OR Service Members OR Soldiers) AND

#2 (TBI OR Traumatic Brain Injury OR Concussion OR Head Trauma)

#3 (Postconcussion syndrome OR post concussion syndrome OR primary exertional headache)

#4 (Aerobic Training OR Strength Training)

#5 (Aerobic Training OR Cervicovestibular rehabilitation)

Search Results

#1 AND #2 AND #3 AND #4 had 0 results in all 3 databases

#3 AND #4 only had 20 related results in Pubmed, 5 related results in CINHAL and 13 relevant results in SPORTDiscus.

#3 AND #5 had 90 results, with 2 that met inclusion criteria.

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| **Databases and Sites Searched** | **Number of results** | **Limits applied, revised number of results (if applicable)** |
| **Pubmed**  **CINHAL**  **SPORTDiscus** | **20**  **5**  **13** | **\*Altered to (post concussion syndrome OR post concussion syndrome OR primary exertional headache) AND (sport OR athlete). I conducted another search including “cervicovestibular” in place of “strengthing.” With these alterations in search strategy found 90 articles. The majority of these articles were less relevant- if relevant at all – to my topic of interest. – 2 of which met the criteria for inclusion in the table.** |

## INCLUSION and EXCLUSION CRITERIA

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| **Inclusion Criteria** |
| Randomized controlled trials, controlled trials, uncontrolled trials, systemic reviews, cohort studies, case series, case studies  Published in English  Studies that include physical therapy intervention directed to the cervical region, progressive aerobic training or both  Studies that include return to activity measures  Studies that include exertion related headache symptoms  ~~Studies that include Active Duty Military Personnel~~ |
| **Exclusion Criteria** |
| ~~Case studies or case series~~  Abstracts, narrative review articles  Studies that include patients with severe TBI |

**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** |
| **Kozlowski K, Graham J, Leddy J. 2013** | **21/29 (D&B)** | **III** | **Cross-Sectional Study** |
| **Leddy J, Cox J, Baker J. 2013** | **20/29 (D&B)** | **IV** | **Prospective Cohort Study** |
| **Leddy J, Kozlowski K, Donnely 2010** | **21/29 (D&B)** | **IV** | **Prospective Case Series** |
| **Schneider K, Meeuwisse W, Nattel-Agguire. 2014** | **8/11 (PEDro)** | **II** | **RCT** |
| **Fields M, Collins M, Lovell M** | **16/29 (D&B)** | **IV** | **Prospective Cohort Study** |
| **Baker J, Freitas M, Leddy J. 2012** | **17/29 (D&B)** | **IV** | **Prospective Cohort Study** |
| **Clausen M, Pendergast D, Willier B. 2016** | **19/29 (D&B)** | **IV** | **Prospective Cohort Study** |
| **Hugentobler J, Vegh M, Janiszewski B. 2015** | **10/29 (D&B)** | **IV** | **Case Series** |
| **Lee H, Sullivan S, Schneiders A. 2015** | **19/29 (D&B)** | **IV** | **Randomized Crossover Single Cohort Study** |
| **Baldassarree M, Smith B, Harp J. 2015** | **13/29 (D&B)** | **IV** | **Qualitative Observational Study** |

*(All 10 articles should appear in the reference list at the end)*

**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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| * **Schneider K, Meeuwisse W, Nattel-Agguire. 2014. This study has the highest level of evidence and is directly related to my topic of interest. It was a well conducted randomized control trial that examined the effectiveness of cervicovestibular rehabilitation in post-concussion rehab.** * **Kozlowski K, Graham J, Leddy J. 2013. This study had the second highest level of evidence and is also related to my topic of interest. This cross-sectional study looked at aerobic exercise intolerance in patients with post-concussion syndrome.** * **Baker J, Freitas M, Leddy J. 2012. Of the final 8 studies I found that related to my topic, none were higher than level IV evidence. The level IV studies all had relatively similar scores on the Downs and Black Checklist so I chose the article that was most closely related to my topic. This study looked at return to full function following progressive aerobic exercise treatment of post-concussion syndrome. Of the level IV studies it met the most of my original inclusion criteria.** |

**SUMMARY OF BEST EVIDENCE**

**(1) Description and appraisal of Cervicovestibular rehabilitation in sport-related concussion: a randomized controlled trial by Schneider KJ, Meeuwisse WH, Nettel-Aguirre A, 2014**

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| **Aim/Objective of the Study/Systematic Review:** |
| The study was conducted to assess the effectiveness of combined vestibular rehabilitation and cervical spine physical therapy treatment in decreasing return to sport clearance times in patients with prolonged postconcussion symptoms. |
| **Study Design**  [e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]  Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| Randomized controlled trial --- 8 week treatment study with primary and secondary outcome assessor blinding. Participants could not be blinded because they were participating in the rehabilitation, however, hypothesized treatment effects were not discussed with participants. Administering physiotherapist was unable to be blinded. |
| **Setting**  [e.g., locations such as hospital, community; rural; metropolitan; country] |
| University of Calgary Sport Medicine Center; Calgary, Alberta, Canada. It is assumed the treatment took place in an outpatient rehabilitation clinic setting. |
| **Participants**  [N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]  Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| 31 individuals with a diagnosis of sport-related concussion and persistent symptoms (>10 days) of dizziness, neck pain and/or headaches. Participants were randomly allocated into treatment groups (Treatment group n=15, Control group n=16). The average age of both groups was 15 years (range (?)12-30 y/o). Three were 18 males and 13 females total (Treatment group 11M, 4F; Control group 7M, 9F). Participants were recruited over a 12 month period through convenience sampling (attending the clinic for rehab). Participant time since injury was very broad, however, the average times since injury was similar between groups. The range for all participants was 8 days to 276 days since injury, the median time since injury for the treatment group was 53 days and for the control group was 47 days. All participants had positive findings for cervical involvement and 84% (26/31) had positive vestibular findings at baseline. There were discrepancies between groups in gender distribution and percentage of participants with pervious concussion (55.3% in treatment group and 75% in control group).  There were two participants in the control group who withdrew; these participants had similar baseline characteristics to the participants in the study. All others participants completed all portions of the study. |
| **Intervention Investigated**  [Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| The same physiotherapist who had 13 years of experience in musculoskeletal and vestibular rehabilitation provided all treatment. All participants were seen in clinic once per week for 8 weeks or until the time of medical clearance. Participants completed range of motion exercise, stretching and postural education as indicated. They all also followed the sport-related concussion protocol of rest until symptom free followed by graded exertion. Participants were also asked to complete daily home exercise program. The duration of each exercise session was not specified. |
| *Experimental* |
| The experimental group completed the same intervention with the same therapist at the same location as the control group. The experimental group also completed an individually designed combination of cervical spine therapy and/or vestibular rehabilitation at each clinical visit. Reassessment findings at each clinical visit were used to determine these treatments. The duration of each exercise session was not specified.  Cervical spine therapy included cervical and thoracic joint mobilization, cervical neuromotor retraining and sensorimotor retraining exercise. Vestibular rehab consisted of habituation, gaze stabilization, adaptation exercises, standing balance exercise, dynamic balance exercise and canalith repositioning manoeuvers. |
| **Outcome Measures** (Primary and Secondary)  [Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| Primary outcome was the time (number of days) until medical clearance to return to sport from the initiation of intervention. A sports medicine physician who was blinded to the study treatment grouping determined this outcome. The authors analysed the difference in the proportion of participants in each group who were medically cleared to return to sport in the 8 weeks.  Secondary outcomes were measured at baseline and at time of medical clearance (or 8 weeks after initiation of intervention if the participant was not medically cleared) by a physiotherapist who was blinded to the study groups. These measures included 11-point Numeric Pain Rating Scale, Activities-specific Balance Confidence Scale (16 item questionnaire on a scale of 0-100%), Dizziness Handicap Index (/100), Sport Concussion Assessment Tool 2(SCAT2)(/100), Dynamic Visual Acuity (lines lost after head motion is initiated), Head Thrust Test, Modified Motion Sensitivity Test (/40), Functional Gait Assessment (/30), Cervical Flexor Endurance (seconds), and Joint Position Error Test (/3 trials of proprioceptive accuracy). |
| **Main Findings**  [Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable] |
| The main finding in the study was that 11/15 (73.3%) of the participants in the treatment group were medically cleared to resume sporting activity within the 8 week treatment period where as only one of the 14 (7.1%) participants in the control group who completed the 8 week intervention were medically cleared to return to sport. The mean difference in proportion of participants returning to sport within 8 weeks between groups was 66.2%, 95% CI 40 to 92.3.  The study found that of the participants who completed the study, the treatment group was 10.27 times more likely to be medically cleared within 8 weeks (95% CI 1.51 to 69.56)(p<0.001). All individuals with history of concussion in the treatment group were medically cleared to play within 8 weeks and the sole participant in the control group who was cleared in 8 weeks had a reported history of 6 or more concussions. Using an intention to treat analysis and considering the 2 dropouts from the control group that figure would drop to 3.91 times more likely to be cleared (95% CI, 1.34 to 11.34) |
| **Original Authors’ Conclusions**  [Paraphrase as required. If providing a direct quote, add page number] |
| A significantly higher proportion of individuals who are treated with cervical spine therapy and vestibular rehab in addition to conventional rehabilitation were medically cleared to return to sport in 8 weeks then those who were treated with conventional rehab methods alone. It is common for cervical spine and vestibular systems to be involved following head trauma and addressing these factors may expedite the recovery process. The author mentioned that clinical findings of dizziness, neck pain and headaches were generally correlated alterations in balance, cervical spine function and proper orientation in space. If altered proprioception in the upper c-spine is not addressed in clinic then compensation will occur more slowly and less completely leading to poorer clinical outcomes. |
| **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.] |
| This article scored 8/11 on the PEDro scale.  A strength of the study was random group allocation, however there was some disparity between groups (gender, h/o concussion) at baseline. There were only 2 drop outs so all data was collected from 29 of the 31 participants. The individuals determining the primary and secondary outcomes were blinded. However the authors mentioned that “differential misclassification bias resulting in an overestimation of the effect of treatment may have occurred” (pg 4)(expectation bias), this is due to the inability to blind patients who are actively participating in treatment, but expected treatment results were never discussed with the participants. Along these same lines, the same physiotherapist administered all treatment and was also unblended. The physician who determined medical clearance was blinded and based medical clearance on objective evaluation of symptoms and function. A limitation of the study is the sample size; there was disparity in age, gender, dates since initial injury and history of other concussion that could have had a confounding effect on treatment outcomes. Many of the secondary measures were questionnaires that are vulnerable to patient response bias. Additionally, formal vestibular diagnoses could not be made for participants because a full vestibular evaluation was not completed. Also, the primary outcome measure (medical clearance to return to sport) was not described in depth, it was reported that participants were evaluated by a single blinded sports medicine physician however that may result in measurement error decreasing the validity of the study.  Another interesting downfall of the study is in the methods section the authors report “the minimal clinically relevant and statistically significant difference between groups in time to medical clearance that would be discernible with 80% power was that of 16 days” (pg 2) however the results of the study did not report “days to recovery” but rather number of participants to be medically cleared by the 8 week mark. |
| **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.] |
| I feel the results of the study are substantial. The absolute effect size for the difference in intervention group and control group participants being medically cleared at the conclusion of the 8-week treatment session was 66.2%. That is 11/15 participants were cleared in the intervention group compared to 1/14 cleared in the control group. The sample size was small, however with such a large effect size it takes fewer participants to show significance. Due to the small sample the authors were unable to show improvement in many of the secondary measures and the study was not powered to identify differences in these measures. The study did show that a significantly higher proportion of participants were medically cleared within 8 weeks of initiating treatment if cervical spine therapy and vestibular rehab were included in the treatment protocol. To corroborate the findings this study should be repeated with a larger sample size to tease out the possible areas of bias mentioned above. However, at this particular point in time the effect seems to be clinically important. |

**(2) Description and appraisal of Return to full functioning after graded exercise assessment and progressive exercise treatment of post-concussion syndrome by (Baker JG, Freitas MS, Leddy JJ, Kozlowski KF, Willer BS)**

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| **Aim/Objective of the Study/Systematic Review:** |
| This study was conducted to provide descriptive information on functional outcomes and assess the effectiveness of graded exercise assessment and progressive exercise intervention on return to full daily function for individuals suffering form post-concussion syndrome. |
| **Study Design**  [e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]  Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| Prospective cohort study. Group allocation was based on symptom exacerbation during maximum exercise activity testing and participant willingness to complete graded exercise rehabilitation. No parties were blinded. Duration to follow-up was not specified. |
| **Setting**  [e.g., locations such as hospital, community; rural; metropolitan; country] |
| University at Buffalo Sports Medicine Concussion Clinic, Buffalo, NY |
| **Participants**  [N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]  Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| 91 participants were initially included in the study. Participants experienced more than 3 persistent post-concussion symptoms at rest for more than 3 weeks. 63 cases were available for follow-up assessment over the phone.  Based on symptom exacerbation during graded exercise testing the group was split into a physiologic post-concussion syndrome group (P-PCS) or a non-physiologic post-concussion syndrome group (PCS). The P-PCS group had a mean age of 28.9 (SD 14.0) with an age range of 13-54 years old. The group consisted of 33 males and 32 females (n=65). The groups mean time since injury was 7.6 months with a range of 1-54 months.  The PCS group had a mean age of 27.0 (SD 12.9) with a range of 15-48 years old. The group consisted of 14 males and 12 females (n=26). The group’s mean time from injury was 11.7 months with a range of 1-71 months. |
| **Intervention Investigated**  [Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| Specific methods are somewhat unclear. All participants completed a graded exercise treadmill test. Regardless of the results each participant was offered a progressive exercise rehabilitation program. The control group (PCS) was able to exercise to maximum heart rate on the graded exercise test without symptom exacerbation and was given a structured exercise program based on maximum heart rate (1 participant declined). Authors then attempted to reach participants by telephone for follow-up (23 of 26 were reached in the control group).  Specific treatment protocols were not mentioned including total hours and total weeks. Specific examiners and treatment administers were not mentioned. |
| *Experimental* |
| The P-PCS group experienced symptom exacerbation prior to reaching maximal heart rate on the graded exercise test. Participants were then offered a structured exercise program based on the heart rate at which they experienced symptoms during testing (5 declined). Authors then attempted to reach participants by telephone for follow-up (40 of 65 participants were reached in the experimental group).  Specific treatment protocols were not mentioned including total hours and total weeks. Specific examiners and treatment administers were not mentioned. |
| **Outcome Measures** (Primary and Secondary)  [Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| Primary outcome measure – Return to full daily functioning based on participant report to questionnaire.  Secondary outcomes – Patient reported headache, dizziness/balance, depression/sadness, irritability, fatigue, insomnia, and concentration/memory issues. Based on patient report to questionnaire (recorded as present or absent)  Specifics on these measures were not explained in the article. |
| **Main Findings**  [Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable] |
| There was no statistical significance between the percentage of patients who participated in the exercise program and returned to full daily functioning in the P-PCS group (77%) and the PCS group (64%) (P=0.37).  The authors completed a Fisher’s exact test to compare the P-PCS group that competed the exercise program with those who did not and found statistical significance in the number of participants who returned to full daily functioning (*P <* 0*.*02). 27 of the 35 participants in the exercise group returned to full daily functioning where as only 1 of 5 participants in the non-exercise group did. A statistically significant difference was also seen when comparing the total number of exercisers (P-PCS and PCS) who returned to full daily function with that of the non-exercisers (Fisher’s exact test - *P <* 0*.*02).  Regression analysis of secondary outcomes found age to be the strongest significant association with return to full daily functioning (Wald statistic: 8.15, P=0.004 (significance at P=0.05)). Irritability was also found to have a strong correlation but lacked significance (Wald: 3.44, P=0.06) |
| **Original Authors’ Conclusions**  [Paraphrase as required. If providing a direct quote, add page number] |
| The authors concluded that the effects of the exercise rehabilitation program on return to daily functioning couldn’t be properly assessed with the results of this study because the number of non-exercisers was so small. The authors noted that age and irritability at initial assessment are possible predictors of full daily return to functioning. The authors believe this study confirmed previous studies that concluded graded exercise testing can be used to determine physiologic PCS. The results of this study suggest areas of focus for future studies. The authors also note that the majority of participants with P-PCS who exercised recovered to full daily functioning where as only one of the non-exercisers did. This suggests the need for further study on this topic. |
| **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.] |
| This article scored 17/29 on Downs and Black  Strengths of this study are that the hypothesis and patient characteristics are clearly stated. The statistical analysis takes into account length of time to follow-up and length of time from injury onset to the beginning of intervention. As a pilot study the authors did a nice job of including the characteristics of the patients lost to follow-up as well. Finally, the authors used appropriate statistical testing for the data collected.  Limitations of the study include a vague description of the exercise intervention, outcome measures and individuals conducting the experiment. There was no reported blinding or random allocation of groups. The non-exercise group was simply made of individuals who chose to forgo treatment. The P-PCS and PCS groups were unequal in size, which is a limitation for statistical analysis. Likewise the proportion of each group who was contacted for telephone follow-up was disproportionate (40 of 65 or 62% versus 23 of 26 or 88%). The range of time since injury was large in both groups as well which can be another confounding factor. The values found when comparing exercise and non-exercise groups lacks validity as well because the non-exercise group was so small (n=6), this makes it difficult for authors to detect the effects of the treatment program. The small sample size makes it difficult to make any conclusions based on the results of this study. The authors also admitted there were missing values in the results for patients in both groups, which hurts the validity of the statistical analysis.  Additionally, the PCS group was further classified into diagnosis groups (cervicogenic etiology, migraine, depression, PTSD, and residual symptoms), this highlights the fact that the control group lacked homogeneity adding another variable. Authors may be unable to determine how the different diagnoses would respond to the treatment provided. Also, the main outcomes were patient report, which can cause bias. The authors did not report power, they only mentioned that the small size of the non-exercise group “could” reflect in low statistical power but a significance level of P=<0.05 was used for statistical comparisons and regression analyses. |
| **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 of the study are difficult to interpret due to the disparity in the size of the groups. It is common for pilot studies to have small sample sizes however the study may have been improved if after the initial exercise testing was completed the PCS and P-PCS groups were randomly allocated into exercise and non-exercise intervention groups. The absolute effect size for the difference in return to full daily function for exercisers (27/35; 77%) and non-exercisers (1/5; 20%) in the P-PCS group was 57%. For total exercisers (42/57; 73%) compared to total non-exercisers (1/6; 17%) the absolute effect size is 56%. Due to the small number of non-exercisers it is difficult to make any inferences with those findings. Regardless, 73% of individuals who participated in progressive exercise training for PCS returned to full daily function. This indicates a need for further research in this area to determine the utility of progressive exercise for the treatment of PCS. The study also highlighted a few possible predictors of recovery. Clinically, this study confirmed progressive submaximal exercise training based on heart rate values that are determined by graded exertion treadmill testing seems to be a safe and feasible treatment to promote full return to functioning in patients suffering from post-concussion syndrome; however more research is needed to validate these findings. |

**(3) Description and appraisal of (Exercise Intolerance in Individuals with Postconcussion Syndrome) by (Kozlowski K, Graham J, Leddy J, Devinney-Boymel L, Willer B. 2013)**

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| **Aim/Objective of the Study/Systematic Review:** |
| The objective of the study was to assess exercise intolerance in individuals with post concussion syndrome based on symptom exacerbation during graded exercise testing. |
| **Study Design**  [e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]  Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| Cross-sectional study. Group allocation was based on pre-existing condition. No parties in the study were blinded. |
| **Setting**  [e.g., locations such as hospital, community; rural; metropolitan; country] |
| Laboratory setting |
| **Participants**  [N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]  Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| 56 participants were enrolled in the study. 34 participants had post concussion syndrome (PCS) and 22 were considered healthy individuals. Participants were recruited by convenience. Participants in the PCS group had an average age of 27.5 (± 12.9; range 15-53) and an average of 226.2 days since injury (±219.3; range 34-949). All patients reported they were sedentary (less than 30 minutes of purposeful physical activity per week for 3 months prior to the study). A board certified internist confirmed all PCS diagnoses. 4 patients were excluded for being unable to walk on a treadmill. Any patients with orthopaedic injuries limiting their ability to perform aerobic exercise or who were taking symptom altering medications were excluded as well. There were no baseline differences in demographics or mean resting physiologic measures between groups (P > 0.05). |
| **Intervention Investigated**  [Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| Historical laboratory data was gathered on 22 participants (11 male, 11 female) with a mean age of 23.3 (±6.2; 18-45) range years old who matched the control group in age, sex and sports participation. All participants completed a health history form, had resting profiles taken manually, and completed graded exercise testing. Balke protocol as follows: Treadmill speed was set at 3.3 MPH. Treadmill incline was set at 0.0% for the first minute, increased to 2.0% after minute 1 and increased 1.0% grade every minute there after. Heart rate and rate of perceived exertion was assessed each minute from minute 3 on. Blood pressure was taken every two minutes during the test. Testing was terminated when individuals could no longer maintain adequate speed or reached the end of the test (21 minutes).  \*Amount of time spent in clinic on testing day not noted. |
| *Experimental* |
| 34 participants (17 male, 17 female) with PCS were screened at a local university sports medicine clinic. Participants had a mean age of 27.5 (±12.9, range 15-53). All participants attended a 90-minute test duration including resting profiles (HR and BP taken manually), symptom assessment and graded exercise testing. Graded exercise testing was administered by the primary author of the study following the Balke protocol as follows: Treadmill speed was set at 3.3 MPH. Treadmill incline was set at 0.0% for the first minute, increased to 2.0% after minute 1 and increased 1.0% grade every minute there after. Heart rate and rate of perceived exertion was assessed each minute from minute 3 on. Blood pressure was taken every 2 minutes throughout the test. Testing was terminated when individuals notify the administrator of any PCS symptoms onset or exacerbation, if they could no longer maintain adequate speed or if they reached the end of the test (21 minutes). |
| **Outcome Measures** (Primary and Secondary)  [Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| The main outcome measures were heart rate, blood pressure, Borg rating of perceived exertion, time (in minutes) at termination of testing and self reported symptoms (blurred vision, dizziness, drowsiness, excess sleep, easily distracted, fatigue, feel “in a fog”, feel “slowed down”, headache, inappropriate emotions, irritability, loss of consciousness, loss of orientation, memory problems, nausea, nervousness, personality change, poor balance/coordination, ringing in ears, sadness, seeing stars, photophobia, noise sensitivity, sleep disturbances and vomiting),  \*HR, BP and RPE were recorded at rest, during testing according to the previously mentioned Balke protocol, and at test cessation.  Secondary measures included pre-test Head Injury Scale (dizziness/balance issues, difficulty concentrating, drowsiness, fatigue, feeling slowed down, feeling like “in a fog”, headache, nausea, trouble sleeping - each rated on a 7 point scale with 0 indicating never and 6 indicating always), |
| **Main Findings**  [Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable] |
| All participants of the PCS group terminated the test prior to completion (21 minutes) due to exacerbation of PCS symptoms. Mean exercise test duration for the PCS group was 9.4 minutes than the control group (PCS: 8.5 ±4.4 minutes, Control: 17.9 ±3.6 minutes; P < 0.001). Mean percentages in heart rate were 12% lower (PCS: 142.8 ±24.1, Control: 175.2 ± 17.4; P < 0.001) and systolic blood pressure was 10% lower (PCS: 142.1 ± 18.3 mm Hg, Control: 155.5 ± 24.5 mm Hg; t53 1⁄4 2.3, P 1⁄4 .02) in the PCS group at the termination of testing (P < 0.05). Cohen d effect size criteria found a high effect size for test duration (2.3), max HR (1.5) and RPE (1.6) as well as moderate effect size for maximal systolic blood pressure (0.61) and diastolic blood pressure (0.58). The authors also noted that “multivariable Cox regression analysis showed the odds of a shorter exercise duration were nearly 8 times greater among PCS than control participants (hazard ratio 1⁄4 7.93; 95% confidence interval [CI] 1⁄4 3.39, 18.56)” (pg. 4). |
| **Original Authors’ Conclusions**  [Paraphrase as required. If providing a direct quote, add page number] |
| The authors concluded that the graded exercise test provided a means to objectively measure exercise intolerance and exercise induced physiologic response in patients with PCS. They added that this tool should be used to diagnose and track physiologic symptoms of PCS. The physiologic measurements taken at cessation of the testing may also be appropriate to establish individualized guidelines for patients to safely perform aerobic exercise without symptom exacerbation. |
| **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.] |
| The study scored 21/29 on the Downs and Black checklist.  The study clearly described the objective, outcome measures, participant characteristics, testing procedures, and main findings (with specific P values). The study also used appropriate statistical tests to analyse the data that was collected. They reported the clinically meaningful effect sizes prior to completing the statistical analysis (greater than 0.80 high effect, greater than 0.50 to 0.80 mild effect, less than 0.50 small effect).  The authors admit a limitation of the study is that “the population with PCS evaluated was a convenience sample of patients who reported consecutively to a local university sports medicine clinic” (pg. 7). Also, two of the main outcome measures used (RPE and patient reported symptoms) were patient report measures, and all participants in the PCS group terminated testing due to patient reported symptoms; both of which are areas possible patient report bias. The primary author of the study administered the graded exercise testing which creates the potential for expectation bias. The presence of PCS could not be directly assessed in the control group because historical data was used and the patients weren’t present for the current study. All 35 participants who were enrolled in the PCS group completed the testing, however one participant’s data was removed after completing the graded exercise testing because the recorded values were greater than 2 times the standard deviation. There was no random group allocation and no blinding of involved parties. Finally, the age range and time since injury range were both large in the PCS group which creates potential confounding factors. |
| **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 study showed good evidence that graded exercise treadmill testing can differentiate between patients with physiologic PCS and patients without. The study showed individuals experiencing PCS symptoms are unable to exercise at the intensity of healthy individuals without exacerbating their symptoms (median exercise duration was 40% lower in individuals with PCS). The study also shows individuals with PCS are unable to tolerate physiologic stress (HR, systolic BP) equal to healthy individuals without symptom exacerbation. The Cohen d effect size criteria for clinical differences was an appropriate statistical analysis to conduct and found a high effect size (>0.80) for test duration, maximal heart rate and RPE. Clinically, based on the data presented, graded exercise testing using the Balke protocol seems to be a safe and valid measure to differentiate PCS from other diagnoses while establishing baseline physiologic levels of exercise intolerance at an individual level. It also may be a valid means of establishing safe exercise guidelines to progress aerobic training to avoid exacerbations.  There are areas of bias in this study that decrease the validity so further research is needed to confirm the findings. |

**EVIDENCE SYNTHESIS AND IMPLICATIONS**

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| **Implications for Practice:** In general the evidence reviewed was low-level; studies that met inclusion/exclusion criteria consisted on one randomized control trial, one cross sectional study and the remaining studies were level IV evidence. The articles reviewed show a lack of evidence to support the inclusion of cervicovestibular rehabilitation to expedite the return to duty time in active duty military personnel with post-concussion syndrome. Schneider et al. were the only group to directly study the topic and they showed substantial evidence in support of cervicovestibular rehab.6 Other studies hypothesized that post-concussion syndrome can have multiple origins1,3 thus strengthening the argument for the clinical applicability of a multi-modal approach that includes cervicovestibular and progressive aerobic exertion interventions. Kozlowski et al. argue that graded exercise testing can help diagnose physiologic post-concussion syndrome from other origins.3 These findings may help determine the appropriateness of cervicovestibular interventions and determine baseline physiologic measures for a progressive aerobic exertion program without exacerbating symptoms, however more research is needed on this topic.  None of the research that was reviewed specifically studied the active duty military population, much of the research was conducted on athletic populations with post-concussion syndrome. Therefor the results may not apply to the military population because there are differences in the mechanisms of blast-induced concussions and blunt trauma (sport) concussions.13 Military personnel who suffer sport type concussions are likely to respond similarly to the athletic populations that were studied. However, these findings are not applicable to individuals with blast-induced concussions as the injuries have different etiologies.  The current review found no evidence contraindicating progressive aerobic exertion training or cervicovestibular rehabilitation in individuals with post-concussion syndrome. The origins of post-concussion syndrome are poorly understood so it could be argued that best practice would be to include both interventions in a multi-modal treatment plan until future evidence is available. Under utilizing this treatment approach due to a lack of high evidence would be a disservice to active duty military personnel who are able to forgo the financial implications of medical intervention and do not suffer from the common drawbacks of additional care.  **Future Research:**  Post-concussion syndrome is a fairly new topic in the literature, the majority of studies reviewed were level IV evidence. The only randomized control trial considering cervicovestibular rehab as an intervention was published in 2014.6 The studies reviewed had relatively small sample sizes so future research is needed to assess the best practice for individuals with post-concussion syndrome with larger samples.  Only one article was found comparing the two treatment methods in question and there were also no articles that met the inclusion/exclusion criteria that directly assessed cervicovestibular intervention for post-concussion syndrome. This highlights the need for future research focused on both of the afore mentioned topics. Future research is also needed validate the use of progressive aerobic exertion training for patients with post-concussion syndrome and tests used to establish baseline physiologic levels for progressive aerobic training programs because the studies reviewed on these topics have poor validity.  Further research should be completed on the active duty military population to assess the applicability of the findings in this population. Military personnel are exposed to different environmental hazards that can cause different types of injuries so they are likely to respond differently than the civilian population. |

*Notes*

* *This section synthesizes your appraisal of your articles; you may mention other related research that you have read or that supports your interpretation and discussion of this evidence. Please be sure to address the quality of the evidence available to guide clinical practice related to your PICO question. Discuss the implications for clinical practice and research.*
* *Students may wish/need to discuss implications with clinicians or peers for suggestions*
* *This section should be ¾-1 page*
* *Be sure to address both implications for clinical practice and future research (separately)*

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[List all references cited in the CAT]

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