

Cervicovestibular rehabilitation in sport-related concussion: a randomised controlled trial

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ABSTRACT

Background/aim Concussion is a common injury in sport. Most individuals recover in 7–10 days but some have persistent symptoms. The objective of this study was to determine if a combination of vestibular rehabilitation and cervical spine physiotherapy decreased the time until medical clearance in individuals with prolonged postconcussion symptoms.

Methods This study was a randomised controlled trial. Consecutive patients with persistent symptoms of dizziness, neck pain and/or headaches following a sport-related concussion (12–30 years, 18 male and 13 female) were randomised to the control or intervention group. Both groups received weekly sessions with a physiotherapist for 8 weeks or until the time of medical clearance. Both groups received postural education, range of motion exercises and cognitive and physical rest until asymptomatic followed by a protocol of graded exertion. The intervention group also received cervical spine and vestibular rehabilitation. The primary outcome of interest was medical clearance to return to sport, which was evaluated by a study sport medicine physician who was blinded to the treatment group.

Results In the treatment group, 73% (11/15) of the participants were medically cleared within 8 weeks of initiation of treatment, compared with 7% (1/14) in the control group. Using an intention to treat analysis, individuals in the treatment group were 3.91 (95% CI 1.34 to 11.34) times more likely to be medically cleared by 8 weeks.

Conclusions A combination of cervical and vestibular physiotherapy decreased time to medical clearance to return to sport in youth and young adults with persistent symptoms of dizziness, neck pain and/or headaches following a sport-related concussion.

Trial registration number NCT01860755.

BACKGROUND

After concussion, two of the most commonly reported symptoms are headache^{1–4} and dizziness,⁵ followed closely by nausea and neck pain.^{6–7} The majority of symptoms resolve in 7–10 days, but in approximately 30% of athletes they persist.^{6–8} Postconcussion headache has been reported as a predictor of longer time loss.⁸ The cervical spine is cited as a source of pain in individuals with whiplash.⁹ Conceivably, when forces are transmitted to the head at the time of a concussion, the cervical spine may also be injured. Cervical spine trauma may cause prolonged postconcussion headache.¹⁰ The upper cervical spine can cause cervicogenic headaches.^{11–12} Dizziness and balance dysfunction are also commonly reported symptoms following sport-related concussion and may be due to

dysfunction of the vestibular, proprioceptive or central systems.^{3–5 13–15}

Proper orientation in space requires accurate and consistent input from the proprioceptive, visual and vestibular systems.¹⁶ If one or more of these systems provide inaccurate information about spatial location, alteration in balance and dizziness may result due to mismatching of sensory information. Additionally, dysfunction of these systems may persist and may alter risk of future concussion.^{17–18}

There is little formal investigation on treatment for persistent symptoms of concussion within the literature.¹⁹ Post-traumatic dizziness is believed to occur secondary to benign paroxysmal positional vertigo, central vestibular, peripheral vestibular, visual or proprioceptive dysfunction.^{20–21} Many of these conditions have been shown to respond well to vestibular rehabilitation, which is the current standard of care.^{22–24} Multimodal treatment of the cervical spine is effective in individuals with neck pain and with mechanical neck disorders with or without headaches.^{25–26} Additionally, treatment of the cervical spine has demonstrated improvements in individuals with suspected cervicogenic dizziness.^{27–28} In the case of persistent dizziness, neck pain and/or headaches with suspected cervical or vestibular causes, treatment of the affected systems may facilitate functional and symptomatic improvements and shorten recovery.²⁹ Currently, there is a paucity of evidence evaluating physiotherapy (both vestibular and for the cervical spine) as a treatment for postconcussion symptoms of dizziness, neck pain and headache.¹⁹ Therefore, we examined whether a combination of vestibular rehabilitation and physiotherapy treatment for the cervical spine decreases the time until medical clearance to return to play in individuals with prolonged postconcussion symptoms of dizziness, neck pain and/or headaches.

METHODS

Individuals between the ages of 12 and 30 years presenting to the University of Calgary Sport Medicine Centre with a diagnosis of sport-related concussion (based on the Third International Consensus Conference on Concussion in Sport)³⁰ and persistent symptoms (greater than 10 days) of dizziness, neck pain and/or headaches reported on the Sport Concussion Assessment Tool 2 (SCAT2) were screened by a study physician between November 2010 and October 2011. If clinical examination suggested vestibular and/or cervical spine involvement, participants were referred on to the study physiotherapist for an assessment that included measurement of secondary outcomes.

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Consent for participation (including parental consent if under 18 years of age) as per the Office of Medical Bioethics at the University of Calgary (Ethics ID 22710) was required to participate. Exclusion criteria included fracture, other neurological conditions, musculoskeletal injuries (other than the cervical spine) that restrict activity and medications that affect neural adaptation.

Given the 15 patients per group, $\alpha=0.05$ and $SD=15.56$, 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 (based on geometric mean time to return to sport).

Intervention

Patients who consented to participate in the study were randomly allocated to the control or intervention group. A computer-generated randomisation sequence in permuted blocks with sizes of four, six and eight was performed by a biostatistician not directly involved in the study to ensure balanced groups and allocation concealment. The primary outcome of interest was time to medical clearance to return to sport (days), which was determined by a study sport medicine physician who was blinded to the study treatment grouping of the patients. One study physiotherapist assessor evaluated the secondary outcome measures and was masked to treatment grouping at the time of assessment and reassessment. Eight weeks was chosen as the study endpoint as this is a common duration of typical physiotherapy treatment and was felt to reflect adequate time to address clinical findings that would be amenable to physiotherapy treatment.

Participants in the intervention and control groups were seen once weekly by the study treatment physiotherapist for 8 weeks or until the time of medical clearance to return to sport. Both groups performed non-provocative range of motion exercises, stretching and postural education as indicated and followed the current standard of care protocol for sport-related concussion, which is rest until symptom free followed by graded exertion. Participants were asked to keep a daily diary of activities to ensure adherence to the home programme. One physiotherapist performed the treatment for both groups and a different physiotherapist performed the secondary outcome measure assessments. The treating physiotherapist had 13 years of clinical experience and expertise in the area of musculoskeletal physiotherapy and vestibular rehabilitation.

In addition to the above, the intervention group received an individually designed combination of (1) cervical spine physiotherapy and (2) vestibular rehabilitation. These treatments were guided by the reassessment findings of the treating physiotherapist at each clinical visit and were determined following the clinical pathways outlined in the online supplemental table. Cervical spine physiotherapy intervention included manual therapy of the cervical and thoracic spines (joint mobilisation techniques), therapeutic exercise consisting of cervical neuromotor retraining exercises (craniovertebral flexor and extensor retraining) and sensorimotor retraining exercises.³¹ Vestibular rehabilitation included an individualised programme of habituation, gaze stabilisation, adaptation exercises, standing balance exercises, dynamic balance exercises and canalith repositioning manoeuvres.^{32 33} Typically, the symptoms of headache must be controlled prior to initiation of vestibular adaptation and habituation exercises. As such, individuals were typically treated with neuromotor retraining, manual therapy and sensorimotor retraining exercises prior to initiating vestibular rehabilitative exercises.

Main outcome measures

The primary outcome measure was the number of days from treatment initiation until medical clearance to return to sport and was determined by the study sport medicine physician who was blinded to the treatment group. This measure was chosen over actual return to sport as some athletes may choose not to return to sport (ie, retire or move to a different sport) or have their participation influenced by coaching decisions. According to the Zurich International Consensus Statement on Sport Concussion (consistent with the previous Prague Consensus), return to play should occur following a stepwise progression in which the athlete rests until symptom free and then progresses through a series of graded exertion steps.³⁴ Thus, medical clearance to return to sport reflected an improvement in symptoms of dizziness, headache and/or neck pain and clinical improvement.

Baseline measures included: age, sex, type of sport, position, mechanism of concussion (contact with another player, contact with the playing surface, etc), history of concussion, history of dizziness, headache, neck pain and unsteadiness, number of years playing sport and other sports played. Secondary outcome measures were: 11-point Numeric Pain Rating Scale score,^{35–37} Activities-specific Balance Confidence Scale,³⁸ Dizziness Handicap Index,^{39–43} SCAT2,³⁰ Dynamic Visual Acuity,^{44–46} Head Thrust Test,^{47 48} modified Motion Sensitivity Test,⁴⁹ Functional Gait Assessment,⁵⁰ Cervical Flexor Endurance (CFE)^{51 52} and Joint Position Error (JPE) test.⁵³ Baseline questions and objective examination tests were recorded on standardised forms. The secondary outcome measures were evaluated at baseline and at the time of medical clearance to return to sport or 8 weeks following initial intake (if a participant was not medically cleared by 8 weeks) by one study physiotherapist who was blinded to treatment grouping.

The initial planned hypothesis was that all players would have an observable time point of medical clearance (ie, be medically cleared prior to the 8-week time point). Thus, linear regression to evaluate the difference in number of days to medical clearance to return to sport by the treatment group was the initial planned analysis. However, not all individuals were medically cleared by the 8-week time point and we had censored data which do not lend itself to the usual linear regression. We then evaluated the differences in proportions who were medically cleared by the 8-week time point and, to take into consideration the censored data, we performed a Kaplan-Meier survival analysis. An intention to treat analysis was performed. Descriptive and non-parametric statistics were used to evaluate differences between baseline and follow-up values for all secondary measures by the study group. Statistical tests were performed using an a priori α -level of 0.05. All statistical analysis were conducted in STATA (V.10).⁵⁴

RESULTS

Fifty-eight individuals were referred for participation in the study. Twelve did not meet the inclusion criteria, 1 declined to participate (transportation unavailable) and 14 did not respond. The remaining 31 individuals participated in the study and were randomly allocated to the treatment group. Two control participants withdrew from the study: one decided not to continue with the protocol and one was unable to attend the clinic during business hours. The individuals who withdrew had similar baseline characteristics to the participants in the study.

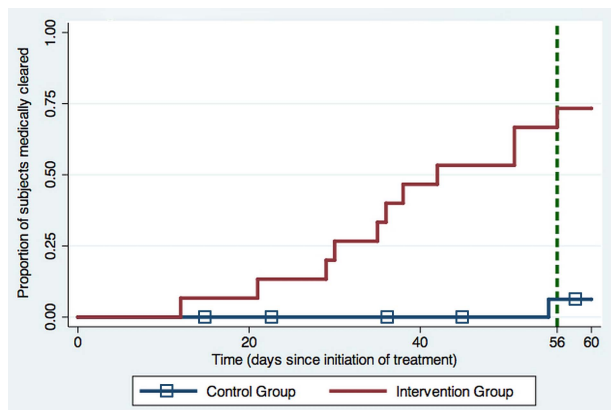
Baseline characteristics for each group are presented in [table 1](#). The majority of participants in this study had clinical assessment

Table 1 Baseline characteristics

	Treatment group Median (range) or percentage (%)	Control group Median (range) or percentage (%)
Age	15 years (12–27)	15 years (13–30)
Sex	11 male, 4 female	7 male, 9 female
Previous concussion	55.3% (8/15)	75% (12/16)
Neck pain	93.33% (14/15)	87.5% (14/16)
Headache	93.33% (14/15)	93.75% (15/16)
Dizziness	86.33% (13/15)	82.75% (13/16)
Vestibular findings	80% (12/15)	87.5% (14/16)
Cervical findings	100% (15/15)	100% (16/16)
Time since injury	53 days (8–276)	47 days (31–142)
ABC Scale score	80% (40–95)	85% (45–100)
DHI score (/100)	46 (6–84)	42 (0–66)
Physical (/24)	10 (0–18)	10 (0–24)
Functional (/36)	14 (4–36)	18 (0–28)
Emotional (/40)	12 (2–30)	14 (0–22)
Percentage now (/100)	80% (40–95)	70% (50–97)
BES score (/30)	19 (4–30)	19 (4–28)
SAC score (/30)	27 (16–29)	26 (23–30)
SCAT2 score (/100)	71 (52–96)	70 (47–92)
Neck pain (/10)	3 (0–7)	3 (0–9)
Headache (/10)	4 (0–8)	4 (0–9)
Dizziness (/10)	3 (0–8)	5 (0–8)
DVA (lines lost)	3 (0–7)	3 (1–5)
FGA (/30)	27 (17–30)	27 (24–30)
CFE (seconds)	14 (6–27)	15 (8–28)

ABC Scale, Activities-specific Balance Confidence Scale; BES, Balance Examination score; CFE, Cervical Flexor Endurance; DHI, Dizziness Handicap Inventory; DVA, Dynamic Visual Acuity; FGA, Functional Gait Assessment; SAC, Standardised Assessment of Concussion; SCAT2, Sport Concussion Assessment Tool 2.

findings suggesting vestibular involvement ($n=12/15$ in the treatment group and $n=14/16$ in the control group) and all participants had clinical findings suggesting cervical spine involvement. The median number of follow-up sessions (range) attended in the treatment group was 6 (3–8) and in the control group was 6 (2–8). The majority of individuals in both groups reported performing their home programme daily (treatment group $n=10/15$ and control group $n=9/14$). Eleven of 15 (73.3%) individuals in the

**Figure 1** Proportion of patients medically cleared over time.

treatment group were medically cleared to return to sport within 8 weeks of treatment. One of 14 (7.1%) individuals in the control group was medically cleared to return to sport within 8 weeks of treatment. A greater proportion of individuals in the treatment group were medically cleared to return to sport within 8 weeks of initiating treatment than in the control group (66.2%, 95% CI 40 to 92.3; $p<0.001$). Of the participants who completed the study, individuals in the treatment group were 10.27 times (95% CI 1.51 to 69.56) more likely to be medically cleared to return to sport within 8 weeks than the participants in the control group ($\chi^2=13.08$, $p<0.001$). Medical clearance status over time following intervention initiation is depicted in an exploratory Kaplan-Meier curve ($\chi^2=50.12$, $p<0.001$; [figure 1](#)).

If the individuals who dropped out from the control group were assumed to have achieved medical clearance to return to play (3/16 (18%) medically cleared) and were included in the analysis, 55% (95% CI 25 to 84) more of the individuals in the treatment group would be cleared to return to sport in 8 weeks than in the control group ($p=0.002$). Expressed as a ratio, 3.91 (95% CI 1.34 to 11.34) times more individuals in the treatment group were medically cleared to return to sport compared with the control group ($\chi^2=9.31$, $p=0.002$). All individuals who had a history of concussion in the treatment group were medically cleared to return to play within 8 weeks. The participant in the control group who was medically cleared within 8 weeks was female and reported a history of six or greater previous concussions.

Time since injury was measured and was similar between groups at the start of the study (median of 53 days in the treatment group and 47 days since injury in the control group). All of the individuals who were medically cleared reported feeling 100% and reported zero symptoms of headache and dizziness ([table 2](#)). The majority (64%) of individuals who were medically cleared reported no neck pain. In the intervention group, individuals who were medically cleared to return to sport had a greater improvement in the SCAT2 total score (Wilcoxon rank-sum, $p=0.009$) and the Dizziness Handicap Inventory Score (Wilcoxon rank-sum, $p=0.019$) when compared with the individuals who were not medically cleared to return to sport ([table 3](#)).

Table 2 Proportion of patients achieving maximal improvement

	Control group*		Treatment group	
	Cleared n=1	Not cleared n=12	Cleared n=11	Not cleared n=4
NPRS neck pain=0	1	0.25	0.64	0
NPRS neck pain>0	0	0.75	0.36	1
NPRS headache=0	1	0.25	1	0
NPRS headache>0	0	0.75	0	1
NPRS dizziness=0	1	0.25	1	0
NPRS dizziness>0	0	0.75	0	1
Feeling 100%	1	0.27	1	0
Feeling<100%	0	0.73	0	1
DHI=0	1	0.17	0.73†	0
DHI>0	0	0.83	0.27	1
ABC Scale=100	1	0.25	0.64	0
ABC Scale<100	0	0.75	0.36	1

*One participant in the control group did not complete the follow-up measures.

†DHI score 2/100 for the other three participants (27%).

ABC Scale, Activities-specific Balance Confidence Scale; DHI, Dizziness Handicap Inventory; NPRS, Numeric Pain Rating Scale.

Table 3 Change in secondary outcome measures following treatment

	Control group* Median change score (range)		Treatment group Median change score (range)	
	Cleared n=1	Not cleared n=12	Cleared n=11	Not cleared n=4
Neck pain (/10)	-4	-1.5 (-8, 3)	-3 (-5, 0)	-1 (-5, 0)
Headache (/10)	-7	-2.5 (-7, 1)	-3 (-8, 0)	-2.5 (-4, 0)
Dizziness (/10)	-5	-1.5 (-6, 0)	-2 (-7, 0)	-1 (-4, 1)
ABC Scale score (%)	30	12.75 (0, 55)	8 (0, 52)	19.5 (-6, 43.5)
DHI score (/100)†	-48	-21 (-58, 2)	-24 (-50, -6)	-13 (-16, -8)
Percentage now (/100)	35	20 (-17, 50)	20 (5, 60)	20 (-20, 23)
Total symptom (/22)	-15	-8.5 (-22, 3)	-12 (-22, 0)	-5.5 (-11, -2)
BES (/30)	10	5 (-6, 18)	2 (-9, 14)	-3.5 (-9, 5)
SAC (/30)	1	0 (4, 5)	1.5 (-2, 7)	0 (-2, 7)
SCAT 2 (/100)‡	26	12 (-5, 42)	18 (10, 30)	8.5 (-9, 11)
DVA (lines lost)	-2	-1 (-4, 2)	-1 (-5, 3)	-0.5 (-4, 1)
FGA (/30)	3	1 (2, 6)	1 (-1, 5)	3 (1, 5)
CFE (seconds)	19	5.5 (-8, 19)	7 (0, 32)	2.5 (-6, 6)
MSQ (/40)	-20	-7.25 (-22, 0)	-10 (-20, -5)	-1.75 (-13, 4.5)
JPE test (/3 trials)				
Right	-2	0 (-1, 3)	-1 (-3, 2)	0 (-3, 2)
Left	-2	0 (-3, 1)	-1 (-3, 3)	-1 (-1, 0)

*One participant in the control group who was not cleared did not attend the follow-up session and is not included in this analysis.

†Individuals who were medically cleared had a greater improvement in score than those who were not ($p=0.019$).

‡Individuals who were medically cleared had a greater improvement in score than those who were not ($p=0.0088$).

ABC Scale, Activities-specific Balance Confidence Scale; BES, Balance Examination score; CFE, Cervical Flexor Endurance; DHI, Dizziness Handicap Index; DVA, Dynamic Visual Acuity; FGA, Functional Gait Assessment; JPE, Joint Position Error; MSQ, Motion Sensitivity Quotient; SAC, Standardised Assessment of Concussion; SCAT2, Sport Concussion Assessment Tool 2.

DISCUSSION

The current consensus guideline for treatment following a sport-related concussion is rest followed by graded exertion.¹ In this study, we demonstrated that a significantly higher proportion of individuals who were treated with cervical spine physiotherapy and vestibular rehabilitation were medically cleared to return to sport within 8 weeks of initiating treatment.

The cervical spine and vestibular systems may be injured following head trauma and may be amenable to treatment.^{13 55} Manual therapy is believed to decrease pain and improve function through a variety of biomechanical and neurophysiological effects.⁵⁶ A combination of manual therapy and exercise has been shown to be more effective than passive treatment modalities in individuals with neck pain.²⁵ In the current study, all individuals had clinical findings suggesting cervical spine involvement. Vestibular rehabilitation has demonstrated a positive treatment effect in individuals with peripheral vestibular disorders.^{57 58} A retrospective case series of 67 children and 47 adults referred to a balance centre following a (non-specified) concussion found improvements in all self-report, gait and balance performance measures at the time of discharge for children and adults.³²

Individuals with persistent symptoms of dizziness, neck pain and/or headaches presented with clinical findings suggesting alterations in balance and cervical spine function. Proper orientation in space requires equal and consistent visual, vestibular and proprioceptive input and dysfunction in sensory input from any of these systems may result in dizziness and/or balance deficits.¹⁶ Vestibular rehabilitation focuses on adaptation, habituation and increased reliance on other balance systems (ie, visual, proprioceptive and the remaining vestibular cues) in the case of individuals with vestibular dysfunction.²³ If proprioceptive cues from the upper cervical spine are also altered, compensation

may occur more slowly or less completely. Treatment that addressed the cervical spine dysfunction (either mechanically or from a neuromotor and sensorimotor control aspect) and/or facilitated compensation for a vestibular deficit was most likely the factor that facilitated recovery in this group. However, this was not measured specifically in this study and is an area that requires further investigation.

Owing to the small sample and large variability of the secondary measures in the current study, an improvement in many secondary measures was not demonstrated; however, this was an exploratory objective and the study was not powered to identify differences in these measures.

Limitations

It was assumed that it was best to initiate treatment as soon as possible following injury. However, the optimal timing for initiation of treatment is not currently known. Some of the participants in the study may have had ongoing cognitive dysfunction that could have affected recovery. The SCAT2 was performed and has a component of a paper and pencil neurocognitive test but formal neuropsychological testing was not performed as part of this study. Formal vestibular function testing was not performed. As such, a specific vestibular diagnosis could not be made. An expectation bias may have occurred if the participants perceived that they were in the hypothesised optimal treatment group. In this case, a differential misclassification bias resulting in an overestimation of the effect of treatment may have occurred. This is difficult to control for in a clinical trial since the participants are actively partaking in the rehabilitation. As such, they cannot be completely blinded to the type of treatment that they have received. However, the hypothesised effect of the study was not discussed with the participants. Participants in both groups were still required to complete a protocol of

graded exertion after reaching an asymptomatic state. Study participants were asked not to participate in any other treatments during the course of the study. One individual who withdrew from the control group reported having a massage for her cervical spine. No other cointerventions were reported during the course of the study. There may also have been unmeasured modification or confounding of the effect of previous concussion on treatment outcome by age and/or sex which we were unable to detect in the current study due to the sample size. This study only included individuals who had suffered a sport-related concussion and were between the ages of 12 and 30 years of age. Thus, it is not known if similar results would hold in other age groups and different injury types.

CONCLUSIONS

A greater proportion of adolescents and young adults with persistent symptoms of dizziness, neck pain and/or headache, who were treated with a combination of vestibular rehabilitation and cervical physiotherapy treatment, were medically cleared to return to sport by 8 weeks following initiation of treatment than individuals with the same kind of symptoms who continued with rest instead. Future research to evaluate the effect of other variables, such as the time since injury, age, mechanism of injury and neurocognitive status on treatment effect, is warranted. A combined approach to treatment of the cervical spine and vestibular systems may facilitate recovery and decrease time lost from sport in individuals with persistent symptoms of dizziness, neck pain and/or headaches following a sport-related concussion.

What are the new findings?

- ▶ Individuals with persistent symptoms of dizziness, neck pain and/or headaches following a sport-related concussion were more likely to be medically cleared to return to sport within 8 weeks of initiation of treatment when they were treated with multimodal physiotherapy.
- ▶ A combination of vestibular rehabilitation and cervical spine physiotherapy may facilitate recovery in individuals with persistent dizziness, neck pain and/or headaches following a sport-related concussion.

How might it impact on clinical practice in the near future?

- ▶ Cervical spine physiotherapy and vestibular rehabilitation may be considered as treatment options for individuals with persistent symptoms of dizziness, neck pain and/or headaches following sport-related concussion.
- ▶ Future research to evaluate the optimal timing of treatment and the effects of covariates such as age, history of concussion and dosage is warranted.

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Competing interests None.

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