



Original article

Concussion part II: Rehabilitation – The need for a multifaceted approach

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ARTICLE INFO

Keywords:

Concussion
Treatment
Physiotherapy
Rehabilitation

ABSTRACT

Introduction: While most individuals recover in the initial days to weeks following a concussion, in up to 30% of cases symptoms and functional limitations may persist beyond the initial four weeks. There is emerging evidence that multifaceted physiotherapy techniques for individuals who have ongoing symptoms following concussion may be of benefit.

Purpose: The purpose of this masterclass article is to summarize the evidence for rehabilitation, describe treatment techniques and multifaceted interventions following concussion.

Implications: Concussion is a heterogenous injury and multiple types of rehabilitation may be required to address ongoing alterations in function. A greater understanding of evidence based rehabilitative techniques will enable the clinician to direct treatment and facilitate recovery for individuals who have ongoing symptoms following concussion.

1. Introduction

Concussion is among the most commonly occurring sport and recreation related injuries in today's society (Emery and Meeuwisse, 2006; Marar et al., 2012). At the time of concussion, a multifaceted assessment including symptom reports, assessment of neurological function, balance, cervical spine, orientation, memory and concentration is recommended (McCrory et al., 2016; Patricios et al., 2017). An initial period of both cognitive and physical rest for 24–48 h is recommended following injury (Schneider et al., 2017b). Following this time, a gradual return to activity ensues (Schneider et al., 2017b). The majority of individuals recover in the initial time period following a concussion (McCrory et al., 2013). However, in 20–30% of cases symptoms persist beyond the initial weeks following injury (Schneider et al., 2017c). For these people, rehabilitation may facilitate recovery (Marshall et al., 2012; Schneider et al., 2017b). The purpose of this Masterclass is to outline evidence informed rehabilitation, including physiotherapy specific techniques, that may be of benefit individuals following concussion. Assessment strategies are outlined in Part I and an online case study is presented to summarize these concepts in practice.

2. Typical treatment and recovery path

Typical treatment following a concussion is a period of both cognitive and physical rest for 24–48 h (Schneider et al., 2017b). Once the

acute symptoms subside, a gradual return to activities of daily living and a strategy of graded increase in both cognitive and physical exertion is initiated prior to returning to school/occupation and physical activity/sport (McCrory et al., 2013). Prolonged rest and avoidance of social and typical activities of daily living is not recommended (Schneider et al., 2017b). The return to sport strategy includes six steps that begin following the initial 24–48 h of rest (Fig. 1) (Echemendia et al., 2017). Medical clearance should occur prior to participating in full contact practice (step 5), and is advisable prior to multiplayer training drills. Each step should take a minimum of 24 h. Thus, the return to sport strategy takes a minimum of one week to complete. If symptoms recur while progressing through the protocol, the individual moves back to the previous step for an additional 24 h (Echemendia et al., 2017). If symptoms persist, the individual should cease activity and follow-up with their health care professional for further evaluation.

Return to school and occupational activities are important considerations following concussion. The cognitive demands, in conjunction with processing of multiple sources of sensory input required to complete school and work activities, may prove challenging. Thus, a return to school strategy was developed (Davis et al., 2017a; Davis et al., 2017b; McCrory et al., 2013) and includes four steps. (Fig. 2) (Davis et al., 2017b). Return to school should occur prior to returning to sport, however gradual reintroduction of physical activity can occur concurrently with gradual increases in cognitive activity (Davis et al., 2017b; Echemendia et al., 2017; McCrory et al., 2013). While the return to school strategy focuses on return to learning, these principles can

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<https://doi.org/10.1016/j.msksp.2019.01.006>

Received 29 January 2018; Received in revised form 9 December 2018; Accepted 15 January 2019

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Graduated Return to Sport Strategy

Exercise step	Functional exercise at each step	Goal of each step
1. Symptom-limited activity	Daily activities that do not provoke symptoms.	Gradual reintroduction of work/school activities.
2. Light aerobic exercise	Walking or stationary cycling at slow to medium pace. No resistance training.	Increase heart rate.
3. Sport-specific exercise	Running or skating drills. No head impact activities.	Add movement.
4. Non-contact training drills	Harder training drills, e.g., passing drills. May start progressive resistance training.	Exercise, coordination, and increased thinking.
5. Full contact practice	Following medical clearance, participate in normal training activities.	Restore confidence and assess functional skills by coaching staff.
6. Return to play/sport	Normal game play.	

In this example, it would be typical to have 24 hours (or longer) for each step of the progression. If any symptoms worsen while exercising, the athlete should go back to the previous step. Resistance training should be added only in the later stages (Stage 3 or 4 at the earliest).

Written clearance should be provided by a healthcare professional before return to play/sport as directed by local laws and regulations.

Fig. 1. Graduated Return to Sport Strategy (Permission to reprint granted) (Echemendia et al., 2017) (black and white acceptable).

also be applied to occupational environments as well.

The majority of individuals who suffer a sport-related concussion recover in the initial 7–10 days following injury (McCroory et al., 2013). However, in the younger age group, 30% of children presenting to an emergency department and 20% of elite youth ice hockey players remain symptomatic one month following injury and 14% of school-aged children remain symptomatic 3 months following injury (Barlow et al., 2010; Schneider et al., 2017a; Zemek et al., 2016). Typical recovery time has been reported to be 14 days in adults and up to 4 weeks in children and youth (Makdissi et al., 2017; McCroory et al., 2013). Most individuals have an uncomplicated recovery and progress well through the return to sport and return to school/work strategies. Nevertheless, some individuals have persisting symptoms and functional alterations that may require treatment (Makdissi et al., 2017) (see Fig. 3).

To date there is limited high quality study evaluating the efficacy of treatment strategies for individuals with persistent symptoms following concussion (Schneider et al., 2017b; Zonfrillo, 2016). Concussion has a heterogeneous clinical presentation, likely representing multiple subtypes of disease (Schneider, 2016). Additionally, different treatments may be more appropriate at different time points (e.g. the needs of a patient at 10 days will likely be different to needs at 3 months following injury) (Makdissi et al., 2017; Schneider et al., 2018). This multifaceted presentation of concussion creates a challenge when trying to evaluate the efficacy of treatment techniques. One type of treatment is unlikely to be suitable for all. Rather, a number of different treatments may be

appropriate for each subtype of ongoing alterations in function (Schneider, 2016). Fig. 4 outlines various treatments that may be appropriate in the rehabilitation of persons with persisting symptoms post-concussion.

Headache is the most common symptom following concussion (Kerr et al., 2016; Marshall et al., 2015). A variety of different subtypes of headache may present and treatment should match the headache type (Heyer and Idris, 2014; Heyer et al., 2016; Schneider et al., 2014b). Similarly, a variety of different types of vestibular/balance disorders occur following concussion and these respond well to individualized treatment (Ernst et al., 2005; Schneider et al., 2014b). Thus as discussed in Part 1, a thorough interdisciplinary and multifaceted assessment is an important first step in identifying appropriate management strategies for individuals who do not recover in the initial weeks following concussion (Makdissi et al., 2017).

Evaluation of specific consequences of concussion by the relevant health care professional informs the most appropriate care delivery. In some cases, a full health care team approach may be warranted and may optimize outcome (Makdissi et al., 2017). A challenge in the area of concussion is the lack of one validated measure of recovery. Common outcomes to define recovery are changes in symptoms or medical clearance to return to sport. These have inherent limitations due to the nature of self-report or clinician report of outcome. Measurement of clinical recovery using validated tests and measures in each subdomain assists in identifying recovery of specific areas of function. In addition,

Graduated Return to School Strategy

Concussion may affect the ability to learn at school. The athlete may need to miss a few days of school after a concussion. When going back to school, some athletes may need to go back gradually and may need to have some changes made to their schedule so that concussion symptoms do not get worse. If a particular activity makes symptoms worse, then the athlete should stop that activity and rest until symptoms get better. To make sure that the athlete can get back to school without problems, it is important that the healthcare provider, parents, caregivers and teachers talk to each other so that everyone knows what the plan is for the athlete to go back to school.

Note: If mental activity does not cause any symptoms, the athlete may be able to skip step 2 and return to school part-time before doing school activities at home first.

Mental Activity	Activity at each step	Goal of each step
1. Daily activities that do not give the athlete symptoms	Typical activities that the athlete does during the day as long as they do not increase symptoms (e.g. reading, texting, screen time). Start with 5-15 minutes at a time and gradually build up.	Gradual return to typical activities.
2. School activities	Homework, reading or other cognitive activities outside of the classroom.	Increase tolerance to cognitive work.
3. Return to school part-time	Gradual introduction of school-work. May need to start with a partial school day or with increased breaks during the day.	Increase academic activities.
4. Return to school full-time	Gradually progress school activities until a full day can be tolerated.	Return to full academic activities and catch up on missed work.

Fig. 2. Graduated Return to School Strategy (Reprint permission granted) (Echemendia et al., 2017) (black and white acceptable).

the use of quality of life measures provides better understanding of the overall impact of rehabilitation (Brown et al., 2016). Evidence for treatments for multiple subtypes of injury individually and in combination is limited, however there are some treatments with demonstrated efficacy in concussion and these will be summarized and described below (Gagnon et al., 2016b; Leddy et al., 2010; McCarty et al., 2016; Schneider et al., 2017b; Schneider et al., 2014b).

3. Management of post-traumatic headache

Management of post-traumatic headache (PTH) is often directed by the headache type. Unfortunately, studies evaluating the effects of treatment in PTH following concussion are limited (Schneider et al., 2013b). It is generally accepted that a multifaceted approach to headache management (including behaviour therapies, physical therapy, education on sleep hygiene and management of stress) is appropriate to ensure contributing factors to headaches are addressed (Blume, 2015; Pinchefskey et al., 2015a, b, Zaslser, 2015). In the case of migraine or tension-type headaches, pharmacological management is often a

treatment of choice, however opioids should be used judiciously (Blume, 2015; Zaslser, 2015). Medication overuse can occur and it should be ensured that this is not the source of headaches (Heyer and Idris, 2014). For some, preventive pharmacological treatments may be of benefit (Pinchefskey et al., 2015b; Zaslser, 2015). Cervicogenic headaches can be treated effectively with physical therapies (Jull et al., 2002; Schneider et al., 2014b). PTH have also been assisted with greater occipital nerve blocks in both children and adults (Hecht, 2004; Seeger et al., 2014). Thus, differential diagnosis of headache in PTH and working with physicians with expertise in PTH in an interdisciplinary team is vital to direct appropriate clinical care.

4. Evidence for physiotherapy treatment following concussion

Evidence is emerging of positive outcomes with physiotherapy management of the cervical spine and vestibular/balance systems following concussion (Alsalaheen et al., 2010; Schneider et al., 2014b, 2018). Reports of dizziness, identified deficits in vestibulo-ocular and ocular motor function and cervical spine findings have been reported to

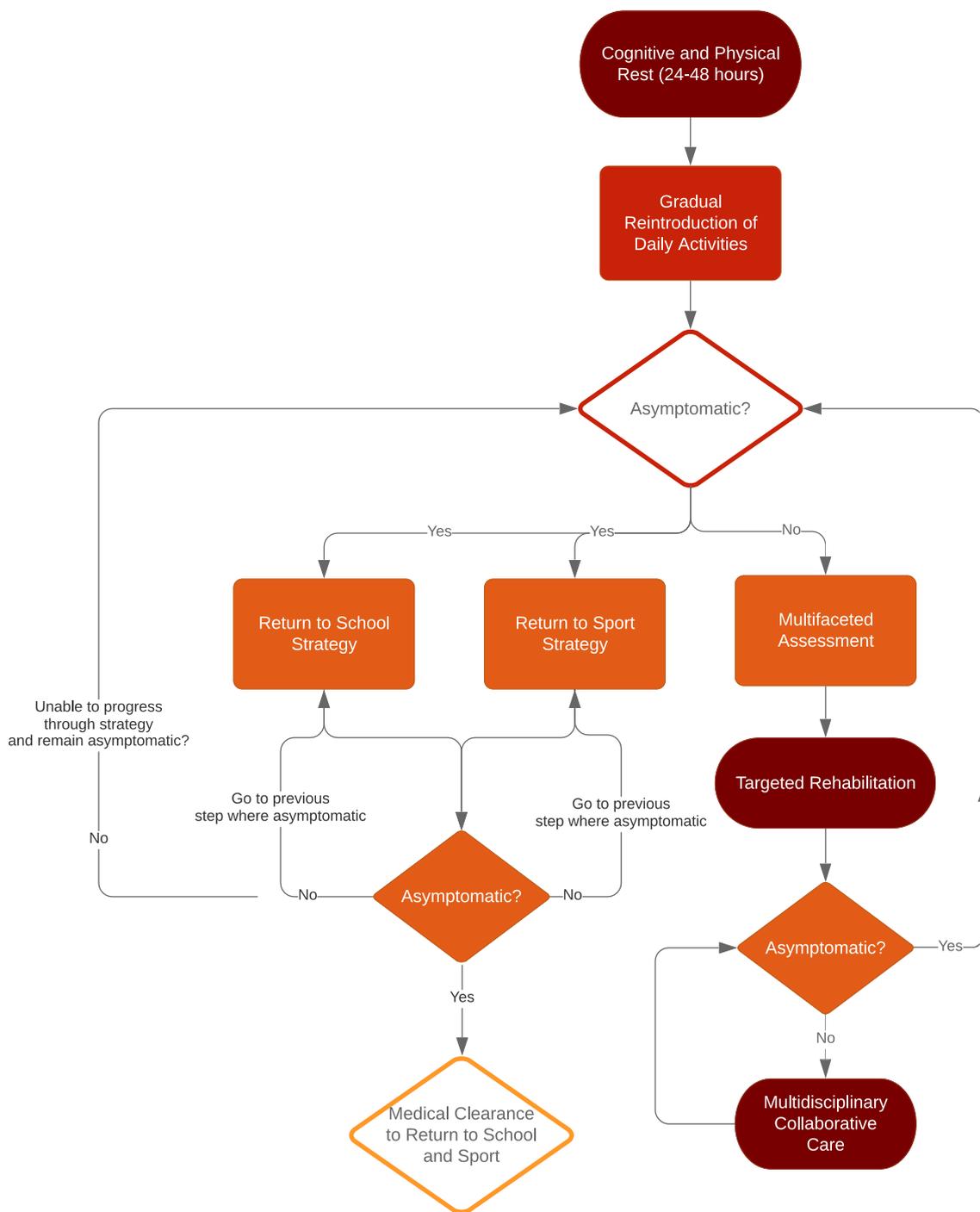


Fig. 3. Initial management of Concussion (black and white acceptable).

be predictors of longer-term recovery following concussion (Corwin et al., 2014; Ellis et al., 2017, 2018; Lau et al., 2009). Thus, rehabilitation to address the above stated areas may facilitate recovery and prevent the development of post-concussion syndrome. Symptoms may also occur secondary to a variety of different sources (Leddy et al., 2015; Makdissi et al., 2017; Schneider et al., 2017d). Thus, a targeted assessment to inform differential diagnosis is recommended and can inform management and rehabilitation. Part I of this Masterclass article describes a number of assessment techniques that can be used to inform treatment.

Case studies have demonstrated that individuals who have sustained head trauma achieved good symptomatic and functional improvements with cervical and vestibular rehabilitation (Schneider et al., 2009). A

randomized controlled trial (RCT) compared a multifaceted and individualized physiotherapy intervention (cervical manual therapy and therapeutic exercise and vestibular physiotherapy – cervicovestibular rehab) to a control intervention (rest and non-provocative range of motion exercises) for children, adolescents and adults with persistent symptoms of dizziness, neck pain, and/or headaches following sport-related concussion (Schneider et al., 2014b). Both groups completed the standard protocol of rest followed by a protocol of graded exertion (McCroly et al., 2013). The primary outcome was medical clearance to return to sport, evaluated by a blinded sports medicine physician. Participants who received an individualized multimodal cervical and vestibular physiotherapy were 3.91 (95% CI 1.34 to 11.34) times more likely to be medically cleared to return to sport by eight weeks than

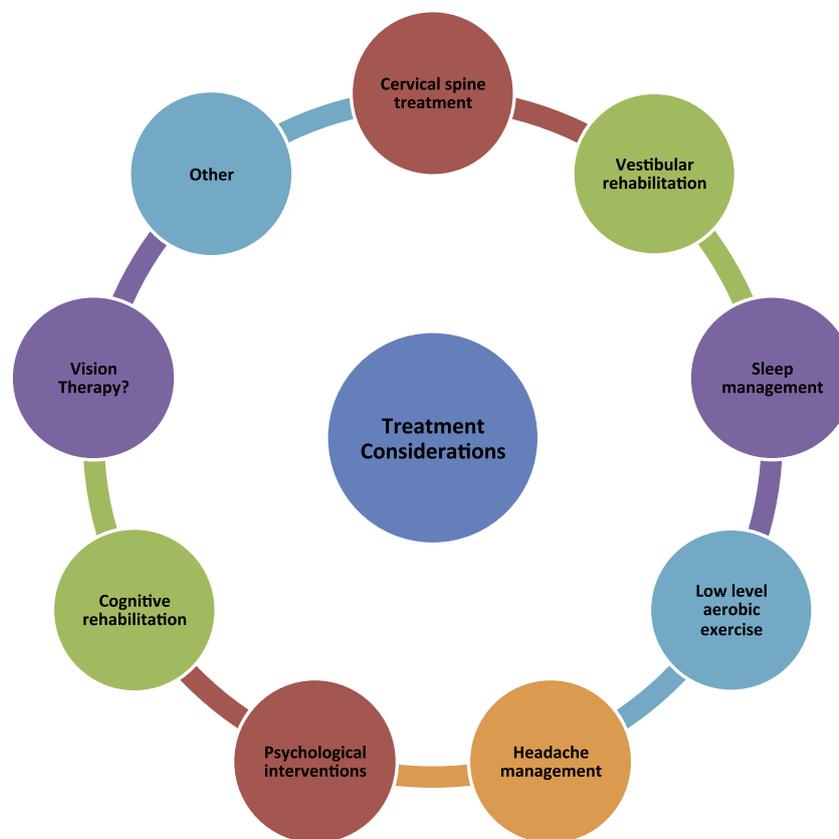


Fig. 4. Treatment considerations following concussion (black and white acceptable).

those treated with the control intervention (Schneider et al., 2014b). While this study is promising, further evaluation is needed to better understand the effects of age, dosage and time since injury on treatment outcome (Schneider et al., 2018). Nevertheless, initial evidence suggests that a multifaceted approach including cervical, sensorimotor and vestibular rehabilitation, is beneficial for individuals who have persisting dizziness, neck pain and headaches following concussion. The principles of treatment from this RCT, cervicovestibular rehabilitation, are presented.

5. Cervical spine rehabilitation

A number of different alterations in cervical spine function have been reported in individuals with neck pain. Clinical assessment including a number of different tests to identify potential areas that may require rehabilitation is important. Clinical tests such as the cranio-cervical flexion test, cervical flexor and extensor endurance, joint position error, cervical movement sense, smooth pursuit neck torsion test, a manual spinal exam, cervical flexion rotation test and cervical spine strength can all assist in identifying the underlying source of symptoms. Differential diagnosis and detail regarding the assessment is discussed in Part I of this Masterclass article. Identification of areas of dysfunction through a multifaceted clinical examination will identify targeted areas for rehabilitation.

Evidence for treatment of cervical dysfunction following concussion is limited despite neck pain and headaches being some of the most common symptoms following a concussion (MacGregor et al., 2017). There is a large body of evidence evaluating treatments for neck pain. Evidence suggests that a combination of manual therapy (either mobilisation or manipulation) and exercise is more effective than passive modalities, interventions that focus on function are more effective than those that do not, additional sensorimotor exercises (including eye fixation and proprioceptive training) can be of benefit, and that specific

training appears to be more effective than general training (Andersen et al., 2008; Gross et al., 2004; Hurwitz et al., 2008; Jull et al., 2002; Kay et al., 2005; Treleaven, 2008). These interventions have been found to improve pain, function and quality of life in both the short and longer term. Thus, consideration of multifaceted treatment strategies, including manual therapy, specific exercise (including sensorimotor exercises) with a focus on function for individuals with cervical spine pain is appropriate.

While there is debate in terms of the clinical utility of manual therapy assessment and treatment techniques (Rabey et al., 2017), there is evidence that manual examination used in combination with pain provocation tests quite accurately identifies the symptomatic segment when compared to local blinded placebo controlled anaesthetic blocks (currently considered the gold standard for diagnosis for facet joint pain) (Schneider et al., 2013a, 2014a). There is also a body of research demonstrating positive analgesic effects of manual therapy in the short-term (Coronado et al., 2012; Voogt et al., 2015; Zusman, 2004). Comparison of different types of manual therapy techniques for individuals with chronic neck pain, cervicogenic headache and cervicogenic dizziness show that they result in similar benefits in the long-term for pain, disability and movement (Gross et al., 2015; Perez et al., 2014; Reid et al., 2014b). Reid et al. (Reid et al., 2014a) found that sustained natural apophyseal glides (SNAGs) and passive mobilisation (Maitland) improved symptoms and neck range of motion in individuals with cervicogenic dizziness but notably no changes were observed in joint repositioning or balance with either technique.

Specific neck muscle retraining has been found to be more effective than general exercise for individuals with neck pain, whiplash associated disorders, cervicogenic headache and cervicogenic dizziness (Landen Lundvigsson et al., 2016; Treleaven et al., 2016). Training neuromuscular control of the craniocervical region in addition to manual therapy has demonstrated positive improvements for patients with headaches and neck pain (Jull et al., 2002). In a randomized



Fig. 5. Craniocervical flexion training (black and white acceptable).



Fig. 6. Prone head lift in craniocervical neutral (black and white acceptable).

controlled trial combining cervical and vestibular rehabilitation following sport-related concussion, training craniocervical neuromuscular control was a key component utilized in nearly every individualized treatment plan (Schneider et al., 2014b). Thus, addressing any alterations in neuromuscular control of the craniocervical region may facilitate recovery in individuals with persisting neck pain and headaches following concussion (Jull et al., 2002; O'Leary et al., 2009; Schneider et al., 2014b; Treleaven et al., 2016). Initially, exercises to activate the deep cervical flexor, extensor and axioscapular muscles are performed as well as low-load endurance exercises (O'Leary et al., 2009) (Figs. 5 and 6). Progressively increasing load with a focus on motor learning then ensues (O'Leary et al., 2009), progressing to a strengthening program as soon as the patient is able (Jull et al., 2008). These exercises are performed, as indicated, in tandem with a battery of sensorimotor exercises to address head, neck, eye and balance dysfunction (discussed in subsequent sections) (Kristjansson and Treleaven, 2009; Schneider, 2016; Schneider et al., 2014b).

It has been hypothesized that exercise treatment effects may be enhanced with the addition of a behavioural approach, including information on pain-management and problem solving, relaxation, management of symptom relapses and explanation of pain mechanisms. However current studies in whiplash associated disorders have not identified any differences in treatment outcomes with the addition of a behavioural approach to a specific exercise program (Ludvigsson et al., 2015; Treleaven et al., 2016). Studies evaluating cervical interventions specifically in sport-related concussion are sparse. However, our RCT included these neuromuscular retraining exercises as a key initial step in multifaceted treatment of persons with ongoing symptoms following concussion and demonstrated a significant positive treatment effect (Schneider et al., 2014b).

Alterations in the ability to relocate one's head in space occurs in individuals with idiopathic and traumatic neck pain as evaluated using a joint position error test (Kristjansson and Treleaven, 2009; Revel et al., 1991). Head relocation in space and head on neck movement control change with training in individuals with neck pain, and is believed to occur secondary to improved processing of cervical proprioceptive input (Jull et al., 2006; Revel et al., 1994). Of interest,

craniocervical flexion training has similarly positive effects on changes in cervical joint position error compared with proprioceptive training, thus suggesting that cervical relocation sense may be facilitated through different exercise regimens (Jull et al., 2006). Additional exercises aimed at improving sensorimotor function in individuals with neck pain include eye movement control and balance exercises. In general, sensorimotor training programs include exercises to facilitate visual, vestibular and proprioceptive processing (Kristjansson and Treleaven, 2009).

In summary, most of the literature on treatment of the cervical spine is focused on individuals with nonspecific neck pain, cervicogenic headache and whiplash disorders. A case series of 21 patients who suffered a concussion and had cervical spine findings on evaluation reported improvements in function and pain following cervical spine physiotherapy treatment (Kennedy et al., 2017). There is emerging evidence that many of the above stated techniques may be appropriate and effective following sport-related concussion, especially when combined with vestibular rehabilitation (i.e. cervicovestibular rehabilitation) (Schneider et al., 2014b).

6. Vestibular rehabilitation

Vestibular rehabilitation consists of a variety of individualized exercises aimed at facilitating central vestibular reorganization. When Benign Paroxysmal Positional Vertigo is identified following concussion, particle repositioning maneuvers are used (Hilton and Pinder, 2002; 2004; Shepard et al., 1993). Systematic reviews have demonstrated efficacy of vestibular rehabilitation in patient populations with vestibular involvement (Hillier and Hollohan, 2007; Hilton and Pinder, 2002, 2004). In some cases eye movement control exercises (without concomitant head movement) are included in treatment protocols.

6.1. Benign paroxysmal positional vertigo (BPPV)

Assessment of BPPV is done using either the Dix-Hallpike test or the Roll test (Bhattacharyya et al., 2017a). A positive test occurs in the presence of a characteristic pattern of nystagmus observed in combination of reproduction of vertigo (Bhattacharyya et al., 2017a). Canalith repositioning maneuvers are used to treat BPPV and involve a series of head motions to clear the affected canal of debris, thus alleviating the biomechanical problem in the peripheral vestibular system (Hilton and Pinder, 2014; Imai et al., 2017). The type of maneuver that is selected is based on the findings in either the Dix-Hallpike test or the Roll test (Bhattacharyya et al., 2017b). If symptoms of vertigo plus a characteristic pattern of nystagmus are present in one of the test positions, the appropriate canalith repositioning maneuver is then performed (Bhattacharyya et al., 2017b; Uchterlony et al., 2016). There is a large body of research demonstrating that canalith repositioning maneuvers are safe and effective in treating BPPV in as few as one treatment, with the majority of individuals having resolution of symptoms within the 1–3 treatments (Bhattacharyya et al., 2017b; Prokopakis et al., 2013). If the treatment does not alleviate symptoms in first few treatments, other diagnoses should be considered. In post-traumatic BPPV, individuals may require more treatments, be more likely to have recurrences of BPPV and have multiple canal involvement (Prokopakis et al., 2013). At this time, postural restrictions are not recommended following a canalith repositioning maneuvers (Bhattacharyya et al., 2017b).

6.2. Adaptation exercises

Adaptation exercises are used to train the vestibulo-ocular reflex and are among the most commonly prescribed exercises following concussion (Alsalaheen et al., 2013; Schneider et al., 2014b, 2018). The individual focuses on a target and moves the head side to side over a small distance (Fig. 7). The exercises are often termed gaze stabilization

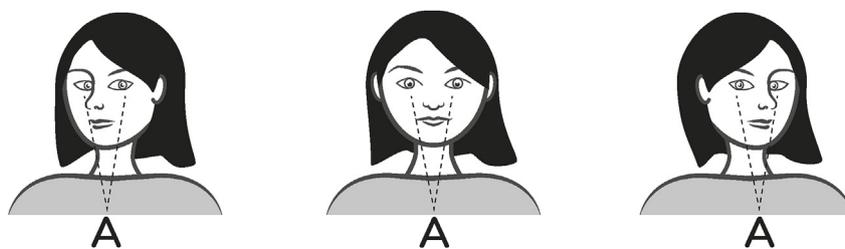


Fig. 7. Gaze stabilization exercises (x1 viewing) (black and white acceptable).

exercises (Herdman and Clendaniel, 2014). Examples of progressions include performing this exercise in standing, while walking or while moving the target a small distance in the opposite direction of the head motion. It is important that this exercise is context specific and should eventually be trained in the direction and environment in which the individual is required to function.

6.3. Habituation

Habituation exercises are exercises that repetitively expose the individual to movements that provoke a mild amount of dizziness (Herdman and Clendaniel, 2014). The symptoms that are felt during these exercises should not be presyncopal but more of a general disorientation in space/lightheadedness. As per the adaptations exercises, a mild and brief increase in symptoms following performance of these exercises is acceptable, however prolonged or intense symptoms should not occur.

In some cases individuals may report symptoms of dizziness and unsteadiness in visually challenging environments (i.e. crowds, walking through store aisles, watching movies) (Marousa, 2010). Examples of terms used to describe these sensations include visual vertigo or a visual vestibular mismatch. It is believed that individuals with these symptoms may be overly reliant on visual cues. In cases of visual vertigo, visual desensitization exercises are included within a program of vestibular exercises with the aim of decreasing sensitivity to visual stimuli and possibly facilitating sensory integration (Marousa, 2010).

6.4. Balance exercises

Postural stability exercises are part of a vestibular rehabilitation program (Hall et al., 2016; Han et al., 2011; Herdman and Clendaniel, 2014; Shepard and Telian, 1995). Depending on the functional level of the individual, exercises are given that challenge the balance systems in a safe way. A spotter is often recommended to minimize the risk of falls and to also increase the individual's confidence when performing the exercises. Standing balance exercises include, progressively, a double leg stance, tandem stance and single leg stance (Hall et al., 2016). Alteration of other sensory input can facilitate improvement in standing balance. For example, closing the eyes to remove visual input and stance on a compliant surface to alter the proprioceptive afferent input can increase the demands to the balance system. Safety must be considered at all times.

Dynamic balance exercises vary depending on the functional level of the individual as well as the activities to which the individual will be returning. It is important to consider not only the functional demands when stationary but also to consider the demands to the balance systems with motion. For example, an individual may be required to turn their head, look up, perform cognitive tasks while balancing or while moving their head. Thus, combining different basic exercises gradually to work toward a whole task completion is of benefit (Figs. 8 and 9). While outside the scope of this paper, it is also important to take into account factors such as motor learning and self efficacy in the course of treatment.

When neck pain, dizziness and headaches are ongoing,

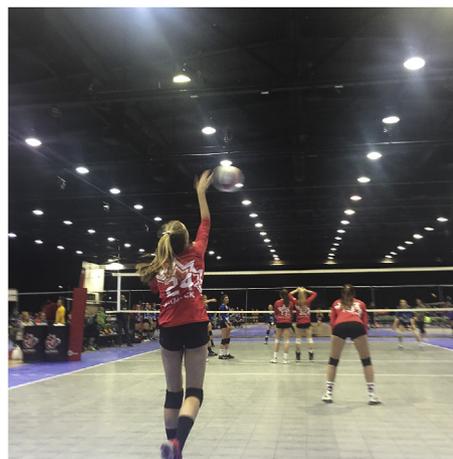


Fig. 8. Example of sport specific environment – volleyball (black and white acceptable).



Fig. 9. Single leg stance with ball toss (black and white acceptable).

physiotherapy including cervicovestibular rehabilitation is indicated and is often conducted in a team environment (Schneider et al., 2014b). In an individual with persistent headaches and/or neck pain, it is imperative that headaches are addressed prior to initiating vestibular rehabilitation exercises. Pain free and adequate head on neck control is desirable prior to implementing vestibular exercises that incorporate more rapid neck motions and that may exacerbate symptoms of headaches and neck pain. In many cases, physiotherapists with expertise in manual therapy may work collaboratively with a physiotherapist with expertise in vestibular rehabilitation, or vice versa, to ensure optimal rehabilitation within each practitioner's area of competency.

7. Low level aerobic exercise

Current treatment recommendations following concussion include a brief period of cognitive and physical rest (24–48 h) followed by a gradual return to graded exertion activities (Schneider et al., 2017b).

The level of both cognitive and physical activity are gradually increased, providing symptoms do not recur. In most cases, individuals are able to gradually increase their activity level, but some have difficulty with exertional activities.

There is some evidence indicating that low level aerobic exercise may be of benefit and facilitate recovery following a concussion in youth and adults with persistent symptoms who may or may not report exertional symptoms (Gagnon et al., 2009a, 2016a; Leddy et al., 2013; Leddy et al., 2010). In adolescents and adults, a protocol of training at 80% of their maximum subsymptom tolerated heart rate 5–6 times per week until symptoms no longer increase with exercise has been found to be safe and facilitated recovery (Leddy et al., 2010). In children, a protocol of exercise at 60% of max heart rate (calculated as 220-age) for up to 15 min in combination with coordination exercises, mental imagery and reassurance has demonstrated positive effects in case series (Dobney et al., 2017; Gagnon et al., 2009b; Gagnon et al., 2016b). Other studies evaluating exercise as an intervention following concussion have demonstrated primarily positive results (Cordingley et al., 2016; Kurowski et al., 2017; Maerlender et al., 2015; Majerske et al., 2008). Unfortunately, many studies did not include valid measures of activity, such as Actigraphy, so the actual amount of activity/exercise performed is not known. Individuals who perform higher levels of activity earlier on following injury may take longer to recover (Lischchynsky et al., 2017; Majerske et al., 2008). Further research to better understand the optimal frequency, intensity, timing and type of exercise following concussion is needed given the potential benefits of this type of treatment (Schneider et al., 2017b).

8. Additional treatment considerations

Postural education is an important component of treatment when it is an exacerbating factor in patients with neck pain (Farmer et al., 2015; O'Leary et al., 2009). Postural correction facilitates the cervical postural muscles, so becomes an element of neuromuscular training (Falla et al., 2007). If a “bracing” type posture is adopted, it may result in additional cervical spine loading or muscle soreness (Falla et al., 2004). Learning and training a good postural position for activities that involve sitting (such as school or occupational work periods; cycling), can be of benefit (Kim et al., 2015). In the presence of cervico-craniofacial pain, consideration must be given to the temporomandibular joint (TMJ) and associated musculature (Munoz-Garcia et al., 2016). A thorough differential diagnosis of the source of underlying dysfunction is an important component of care.

After concussion, some individuals have sensitivity to visual stimulus (Digre and Brennan, 2012). In the case of photophobia, wearing a hat or sunglasses may alleviate these symptoms and improve quality of life. The type of glasses tint suitable for the patient may vary depending on the source of the photophobia (Clark et al., 2017). Changing incandescent lighting to less provocative lighting may also be of benefit. There is some evidence that binocular occlusion (blocking parts of the image that would be seen by both eyes) may reduce visual motion sensitivity in some individuals post concussion (Ciuffreda et al., 2017; Cluffreda et al., 2013). The literature evaluating these types of treatments is limited so benefits must be interpreted with caution.

Persons may have difficulties with dividing attention following concussion (Kleiner et al., 2018; Schneider, 2016). Thus, as individuals progress from basic to more complex exercises, treatment strategies aimed at retraining multiple systems concurrently are included in the treatment programs (Gurley et al., 2013; Kristjansson and Treleaven, 2009; Schneider et al., 2014b, 2018). In cervicovestibular rehabilitation, as an example, exercise progressions combining activities, such as balance, gaze stabilization, busy visual environments, cognitive tasks and cervical spine exercises are included (Schneider et al., 2014b). The progressions should be patient specific and based on the requirements for the typical activities and sport/occupation/school requirements of the patient.

At this time, there is limited evidence to support specific visual training programs. There is some preliminary evidence that adults and children with convergence and accommodative disorders may respond to a multifaceted visual therapy program (Galloway et al., 2017; Master et al., 2018; Scheiman et al., 2011a, 2011b). However, future research using rigorous designs and objective outcome measures is warranted to better understand the efficacy of vision therapy. In the case of suspected visual involvement, referral to an optometrist or ophthalmologist with expertise in this area may be warranted.

Knowledge of treatment efficacy of any pharmacological therapies for concussion is limited. Depending on headache type, there may be medications of benefit that are used for management, however research specific to headache management in concussion is still limited. Screening for mood, psychological, cognitive and sleep disorders should be considered when symptoms are ongoing. Early education including expectations on the course of recovery and coping strategies may decrease symptoms in youth who have had a mild traumatic brain injury (Ponsford et al., 2001). An evaluation by a neuropsychologist can assist in the differential diagnosis of cognitive dysfunction following injury. However, the evidence to support cognitive interventions is limited at this time (Robinson et al., 2014). Cognitive behavioural therapy has demonstrated positive outcomes in other populations and may be of benefit but the literature in individuals with concussion is limited at this time (Mittenberg et al., 1996; Silverberg et al., 2013). If sleep difficulties persist, sleep hygiene education may have positive effects on sleep outcomes (Bogdanov et al., 2017). Sleep hygiene recommendations typically include: waking at a similar time each day, regularly scheduled bed times, stress management, regular exercise, reduced caffeine intake, avoid late afternoon naps and alcohol, avoidance of bright light prior to bedtime and noisy sleep environments (Avidan and Zee, 2011; Bogdanov et al., 2017; Brown et al., 2002). There is some evidence to suggest that multidisciplinary collaborative care including cognitive behavioural therapy, care management and psychopharmacological consultations may be of benefit (Makdissi et al., 2017; McCarty et al., 2016).

9. Implications for practice

Initial management of concussion includes a period of both cognitive and physical rest, 24–48 h, to enable to acute symptoms to subside. Following this time, it is recommended that individuals gradually return to their activities of daily living. A gradual return to school and sport is then recommended. The majority of individuals will recover in the subsequent days to weeks, however in the case of ongoing symptoms an interdisciplinary and multifaceted assessment is recommended (see Part I). Individualized and targeted care may be of benefit.

Concussion is heterogeneous in nature and a variety of health care professionals may need to be engaged in the treatment of persistent symptoms following injury as a number of different systems may be involved (Schneider, 2016). Integrated interdisciplinary team approaches are the ideal management but the geographic landscape may mean that a single practitioner may be providing care for these individuals.

A timely and thorough history and clinical assessment is imperative. In some cases, red flags may be present which warrant referral for urgent medical evaluation. Thus, a neurological scan is a priority and includes a cranial nerve scan, evaluation of cerebellar function, long tract signs, reflexes, dermatomes and tests for key muscle weakness. Following this, a multifaceted assessment based on the individual patient presentation is appropriate. Assessment of the cervical spine (including a manual spinal exam, sensorimotor and neuromotor control), vestibular, standing balance, dynamic balance, dividing attention, exertion, vision/ocular motor function, a detailed headache assessment and screening for cognitive, sleep and mood disorders is important. Part I of this Masterclass article summarizes the assessment of concussion that can be used to direct management. Findings will direct treatment

to provide an individualized management program and identify areas where additional referral for treatment may be warranted. While research evaluating the effects of treatment following concussion is still in its infancy, there is evidence to support multifaceted physiotherapy strategies including vestibular and cervical rehabilitation for individuals with ongoing headaches, dizziness and/or neck pain. Low-level aerobic exercise may also be of benefit and there is emerging evidence for benefits of collaborative care (including cognitive behavioural therapy, care management and pharmacological consultation). Future research is needed to better understand the optimal care delivery pattern, including timing, combinations of therapies and duration of treatment.

Conflicts of interest

None Declared.

Ethical approval

Not applicable.

Conflicts of interest

There are no competing interests to declare.

Funding

Not applicable.

Acknowledgements

A special thank you to Dr. Carolyn Emery, Dr. Gwen Jull, Dr. Geoff Schneider, Ms. Sheelah Woodhouse and Dr. Keith Yeates for their insightful comments and critical review of this manuscript.

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