Novel Use of a Synthetic Training Device in the Rehabilitation of Chronic Neck Pain of Rotary Rear Crew

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BACKGROUND: Chronic flight-related neck pain is a common, well-recognized problem in military aircrew. The reasons for flight-related neck pain are multifactorial; however, there are currently no evidence-based guidelines for its prevention or clinical management. This case study describes the novel use of a synthetic training device in the rehabilitation of a Chinook crewman with chronic neck pain.

CASE REPORT: The patient is a 34-yr-old rear crewman with 10 yr flying experience in the Chinook helicopter. He has a history of intermittent neck and shoulder pain since 2009 following a rugby injury. Over the years he has self-managed recurrent episodes of neck pain. However, in November 2017 his pain was so severe that he could no longer continue flying. This pain made him unfit for flying duties for 18 mo and he received intensive rehabilitation and injection therapy. RAF Odiham's new flying simulator was used in his return to flying program, so enabling him to become fully fit and return to all flying duties.

DISCUSSION: Management and treatment of chronic flight-related neck pain is challenging. This case study highlights the importance of a multifactorial management approach and how a synthetic training device can be used in the rehabilitation of rotary rear crew.

KEYWORDS: flight related neck pain, flying simulator, multifactorial management, rehabilitation.

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Chronic neck pain is a well-recognized problem in military aircrew, leading to reduced in-flight performance due to reduced range of movement in the cervical spine and distracting pain causing reduced situational awareness and, therefore, affecting flight safety. High G and heavy equipment have been well researched as causes of neck pain in fast jet pilots. Extensive research has been conducted on neck pain in fast jet pilots and, more recently, research has addressed the concern of flying-related neck pain in the rotary environment. The prevalence of neck pain in the global military population has been reported as between 56.6–84.5%.[8] The lifetime prevalence is reported as 81% for pilots and 84% for crewmembers—a level which is significantly higher compared to the general population.[6] There are multiple causes for flight-related neck pain, with many aggravating factors, including biomechanical, anthropometric, physiological, and psychosocial influences. It has been shown that prolonged loading of the cervical spine due to the use of a helmet and helmet mounted devices, such as Night Vision Information Systems, leads to muscle fatigue and overuse of the cervical structures.[3,5] Depending on position and posture in the aircraft, flying hours, and the type of flight missions, theses unfavorable neck loads can be increased.[4] There is a clear causative relationship between neck load and neck pain.[13] Prior injuries to the neck have been shown to be a reliable predictor of the development of flight-related neck pain at a later stage.[5] Whole body vibration has also been linked to an increased risk of musculoskeletal pain, which is of particular significance to rotary crews within the airframe environment. Psychosocial factors are also implicated in the development of and in the delayed recovery of flight-related neck pain.[11]

Due to the multifactorial nature of flight-related neck pain, prevention and treatment approaches are unclear.[1] There are no evidence-based guidelines for the prevention or clinical management of flight-related neck pain.[6] Research has looked into

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helmet fitting and optimizing helmet load as a preventative measurement.[12] A number of studies have looked into the role of exercise therapy as prevention and treatment.[6,9] There is only very weak evidence for hands-on treatment.[2] Thus with all these factors at play, the treatment of flight-related neck pain remains a challenge and requires clinicians to develop new and innovative ways to improve long term outcomes.

Severe episodes of neck pain can result in loss of flying status, commonly called "grounding" by aircrew. Significant time off flying can lead to a permanent loss of operational flight status, which leads to an increase in costs for the Royal Air Force, not only due to loss of manpower, but also in compensation to the individual. Long term absence from flying also deconditions individuals to their job role so that rehabilitation needs to be specific to the job role as well as to everyday functioning. The Chinook is a twin-engined, tandem-rotor, heavy lift helicopter. It possesses several means of loading various cargoes, including multiple doors, a wide loading ramp located at the rear, and a total of three external cargo hooks to carry underslung loads. The crew is comprised of two pilots in the cockpit and two crewmen in the back. In its various configurations and evolution, it has provided essential support to UK troops on operations all over the world for four decades. It can carry up to 54 troops or 10 tons of cargo. It is primarily used for troop and load carrying and performs a crucial secondary casualty evacuation role. By its nature and configuration, the occupational roles and musculoskeletal demands placed on the pilots and rear crew are profoundly different.

The main tasks of a crewman working in the back of the helicopter are troop management, material handling, surveillance, and clearance tasks. These tasks require different body and head postures such as sitting forward, kneeling, standing, and sitting with the trunk flexed and rotated. Head positions include looking through a window and lying down with the head outside the hatch for hooking and hoisting tasks. These physical maneuvers are undertaken in a moving platform that is constantly changing yaw, roll, and pitch. Different operational needs may also require the crew to wear protective body armor, which increases the whole body loading and can alter body posture due to its bulk, all of which puts more strain on joints and muscles. This case study highlights the novel use of the synthetic training device in rehabilitating a Chinook crewman with neck pain back to full military duties after 18 mo of being unfit for flying.

CASE REPORT

The patient has specifically consented to the publication of his personal health information for the purposes of this paper. All crucial information that can lead to identifying the patient have been removed from the case report.

He is a 34-yr-old Chinook crewman with 10 yr flying experience, having flown over 2000 h in the Chinook helicopter. He has no other medical conditions or musculoskeletal disorders. His first episode of neck pain was in 2009. While playing rugby, he ran headfirst into an opponent, resulting in an axial loading injury and neck pain. Despite this neck pain, he played a second game a few days later. This episode of severe neck pain lasted for about a month. The pain was not associated with any neurological symptoms. Subsequently the patient reported his neck pain as 'manageable'. The next severe episode occurred in 2015 on an overseas detachment. The mechanism of this episode was unclear. He received some physiotherapy input, essentially consisting of strength training and acupuncture. He was able to continue with his flying duties despite his ongoing neck pain. During the subsequent 2 yr he was never completely pain free, but self-managed his symptoms while maintaining his flying duties. In November 2017, he presented again, this time complaining not only of neck pain, but also of left shoulder pain. This pain was referred up into the upper arm and scapula, with episodes of paresthesia in the first to third fingers and reported symptoms of a whole dead arm. Due to the severity of his symptoms, he was unable to continue with his flying duties. Objective assessment revealed a restricted range of motion, mainly in left side flexion and left rotation of the cervical spine. An MRI scan showed a left-sided C6/7 disc protrusion. Physiotherapy focused initially on achieving pain relief via mobilizations, soft tissue therapy, yoga-based mobility exercises, and pain education. It should be noted that at this point, the patient's symptoms were too acute for any form of strength work. In March 2018, he attended a 3-wk intensive rehabilitation course. However, this conservative treatment failed to show any significant improvement of his symptoms and, thus, he was referred to a spinal surgeon in July 2018 for a second opinion. The opinion was that spinal surgery was inappropriate, but rather left-sided nerve root block injections were the preferred option. These were performed in October 2018 and achieved an improvement in his pain, allowing a more intensive exercise therapy program, including whole body strength work and cardiovascular training. This progressive build-up was managed under the supervision of a physiotherapist and a Military Medical Officer specializing in Aviation Medicine. Several joint clinics were conducted involving not only the patient but also his military line management.

In March 2019 he was finally at a level where we could start sessions in the synthetic training device, using its unique capability of simulating the dynamic forces of a real time flight experience in a totally controlled environment. The patient wore all his usual equipment for flying, but a virtual reality (VR) device was attached to the helmet. This VR device has similar weight to standard night vision googles and can provide different flying scenarios. His equipment could then be increased to wearing a full set of body armor as he became more conditioned to flying. Initial sessions involved very basic tasks, moving around in the cabin with equipment on, and changing between all the rear crew positions including rear bubble window, center hook, and ramp areas. His second session focused on underslung loading, putting himself in different positions to test his biomechanical control. The next few sessions were scheduled as more composite sorties, which involved more than one skillset such that the body position and loading to the neck would change throughout the trips. They involved formation flying, which causes that rotation position in the rear bubble window, underslung load, and general handling. They also involved moving around the cabin and ramp to perform normal duties. All sessions in the flying simulator were conducted in a slow, methodical manner to allow both instructors to watch his actions, but also so that he could spend more time in the positions to really get a feeling of any changes with his fitness or pain levels. After successful completion of these sessions, the next step in his rehabilitation allowed commencement of short-term flights in a Chinook. The movements he had practiced with confidence, without developing pain, in the simulator were then allowed to take place in a real time environment without the risk of compromise to the mission task. These were entirely successful and he was able to return fully to all flying duties and, indeed, has recently completed a challenging exercise in the United States involving multiple flights and mission tasks without any neck problems at all.

DISCUSSION

As previously discussed, flight-related neck pain is a multifactorial problem, with this patient typifying this and the complexity clinicians are faced in managing it. The previous trauma to his neck during the rugby game increased his risk of developing flight-related neck pain. For several years his symptoms were manageable, meaning that he would always recover sufficiently to remain on active flying duties. In November 2017 the symptoms deteriorated such that he was unable to continue his flying duties.

Being 'grounded', the pejorative term used by aircrew, is often associated with negative thoughts and beliefs. It has a severe psychological impact for patients and prognosis of returning to their flying duties gets worse the longer the patient is removed from active flying duties. Patients feel guilty about not performing their actual job role, lose hope of making a full recovery, and worry about their career. Such negativity can have an influence on their pain levels. It is currently theorized that altered central processing of pain is present in many pain conditions, with the immune system and pain sensitization playing a vital driving force. Research also indicates that unhelpful thoughts of patients and clinicians toward pain, including the belief that the pain will not get better or will worsen over time, are driving factors.[10] Exercise therapy is well documented as a therapy to prevent and treat flight-related neck pain. However, there is no consensus on the type of exercise therapy and a randomized clinical trial could not show a significance between group differences.[6] It has been argued that this lack of improvement was due to a self-administered intervention and the possible aircrew noncompliance. In our case the patient had received many rehabilitation sessions conducted by different therapists. Patients find difficulty in remaining motivated in doing exercises prescribed by therapists if the results are either completely absent or only showing minimal improvements. We found that using the flying simulator in the late stage of his rehabilitation process significantly improved the patient's motivation and built his confidence in returning to the air environment. The gear used in the simulator is similar in weight to the equipment used during live flying. The team used the VR device to build up muscular strength and endurance by increasing sortie length and simulating more fatiguing positions and specific tasks in the aircraft. This would be almost impossible to recreate in a gym or by using standard rehabilitation equipment. Essentially, the augmented reality technology created an environment where the patient could build up his strength and resilience, practice his skills, and hence gain confidence after a long absence from his flying duties. The input from experienced instructors was extremely useful to the clinicians as it gave us confidence that any learned habits such as bad posture or adaptive movements to compensate for pain could be quickly identified. It also does not carry any safety risk due to being in a protected environment. We are very fortunate to be able to use this extraordinary facility for our patients. The Chinook Mk 6 synthetic training facility was opened at RAF Odiham in 2018 following a £53 million contract with Lockheed Martin UK, Rotary and Mission system. This state-of-the-art technology consists of two flight deck device simulators, a rear crew device, and a suite of computer-based training equipment. This augmented reality technology helps Chinook crews to rehearse virtual missions as a whole crew and practice the handling of the aircraft in a range of emergency scenarios, such as rotor blade damage or complete electrical emergencies. It presents a highly realistic and immersive environment and delivers around 4000 simulator hours each year.

In the past it was challenging to return our aircrew to their flying duties after a long-term break from flying. Rehabilitation in the gym could never recreate the harsh environment which crewmen face in the rear of the helicopter. Our strength exercises had low fidelity and were rightly doubted by the aircrew, resulting in a low motivation to perform them. In order to assess when a crewman might be fit to return to flying, we have previously asked patients to complete the RAF Fitness Test (multistage fitness test, press-ups, and sit-ups) and then to fly with a crewman instructor in a supernumerary role on a live flight. This can be difficult to arrange as the sortie type may not be easily changed and finding time for the Medical Officer, instructor, and patient to all be on the flight can be challenging. Both Medical Officers and physiotherapists have observed that this is a costly and not ideal way of assessing fitness for such a physically demanding role. Furthermore, the unpredictability of the air environment does not lend itself to reproducibility of tasks and forces. The synthetic trainer gives the patient, the rehabilitation team, and the chain of command the confidence that the individual is fit for all aspects of their role, including deployment.

If the patient has not been flying for some time, they can become deconditioned for their role and lose their role-specific fitness and strength. With the introduction of the VR device for crew, there is now an opportunity to gradually start to load the patient in a controlled environment while being observed for signs of pain or discomfort. With the help of the instructors we can increase the time of sorties, the physical nature of the flight profile, and the loading of the individual by wearing body armor, etc.

The use of VR in rehabilitation is not new. It has been used in sensorimotor training, in motor rehabilitation of patients with disabilities, as a distraction method for pain reduction, and as exposure therapy in patients with posttraumatic stress syndrome.[7] Several studies have shown that the use of VR devices can provide training in complex environments which are not easy to replicate otherwise. It has also been shown that compared to conventional rehabilitation, motivation and engagement of patients is much higher when virtual reality training is conducted. A randomized controlled trial showed greater improvements in neck pain and disability in the group training with virtual reality compared to the group receiving conventional proprioceptive training.[7] The use of VR in our case study was, however, not used as pain distraction or motor rehabilitation as previously described in other studies. We use the flying simulator to create the complex environment a Chinook crewman works in and to slowly build up the patient's resilience to his highly physically demanding duties in the back of the helicopter. The use of the simulator allowed us to target rehabilitation to improve operational function. This augmented other more conventional therapy methods that we used alongside the VR device. The simulator allows us not only to improve a patient's strength and endurance for flying, but also to test his ability to return to flying safely and comfortably without the need for several live flying sorties which we had to do in the past.

In conclusion, flight-related neck pain is a multifactorial problem and therefore requires a multifactorial management approach. Our case study highlighted clearly that despite 18 mo off flying duties, our patient returned to full fitness. We addressed all contributing factors and had a successful outcome. From our experience with this patient, we can recommend the use of the simulator as part of the toolbox in preparing long term musculoskeletal injured patients in returning to an air environment. Further research into this area should therefore investigate all these different factors instead of isolating one factor.

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