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ORIGINAL RESEARCH

Cervical Spine Alignment in Helmeted Skiers and Snowboarders With Suspected Head and Neck Injuries: Comparison of Lateral C-spine Radiographs Before and After Helmet Removal and Implications for Ski Patrol Transport

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Objective.—Current protocols for spine immobilization of the injured skier/snowboarder have not been scientifically validated. Observing changes in spine alignment during common rescue scenarios will help strengthen recommendations for rescue guidelines.

Methods.—Twenty-eight healthy volunteers (18 men, 10 women) age 47±17 (range 20–73) (mean ±SD with range) underwent a mock rescue in which candidate patrollers completing an Outdoor Emergency Care course performed spine immobilization and back boarding in 3 scenarios: 1) Ski helmet on, no c-collar; 2) helmet on, with c-collar; and 3) helmet removed, with c-collar. After each scenario, a lateral radiograph was taken of the cervical spine to observe for changes in alignment.

Results.—Compared with the control group (helmet on, no collar), we observed 9 degrees of increased overall (occiput–C7) cervical extension in the helmet on, with collar group ($P < .001$), and 17 degrees in the helmet off, with collar group ($P < .001$). There was increased extension at the occiput–C2 intersegment in the helmet on, with collar group (9 degrees, $P < .001$) and at both the occiput–C2 (9 degrees, $P < .001$) and C2–C7 (8 degrees, $P < .001$) intersegments in the helmet off, with collar group.

Conclusion.—Ski helmet removal and c-collar application each leads to increased extension of the cervical spine. In the absence of other clinical factors, our recommendation is that helmets should be left in place and c-collars not routinely applied during ski patrol rescue.

Keywords: ski, snowboard, helmet, spine immobilization, c-collar, ski patrol

Introduction

Alpine winter sports are popular recreational activities with an estimated 19.8 million participants annually in the United States alone.[1] According to the National Ski Area Association, there are 470 ski areas in the United States, with 57.1 million visits that generate $7.3 billion annually in direct spending.[2]

Injuries are common among skiers and snowboarders with 1 study showing approximately 230 injuries per 100,000 mountain visits. Head and neck injuries comprise more than 10% of these injuries and are more common in younger athletes and snowboarders.[3] Spinal cord injuries are rare but potentially devastating. According to the National Spinal Cord Statistical Center there are approximately 17,000 new spinal cord injuries in the United States annually, of which about 9% result from sports and recreation. Winter sports and snow skiing have one of the highest frequencies of spinal cord injury.[4] Severe injuries and fatalities among alpine winter athletes typically involve closed head or spinal injury. In 2011–12 there were 54 fatalities and 51 severe injuries (coma, paralysis) reported in 51 million skier visits by the National Ski Area Association.[2]

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The National Ski Patrol was started in 1930 by Charles "Minnie" Dole and is a national organization with more than 28,000 volunteers that provide first aid, triage, and emergency medical care and transportation to injured skiers and snowboarders. National Ski Patrol patrollers are trained as Outdoor Emergency Care (OEC) technicians having completed a course consisting of 80–100 hours of classroom and practical skills training and testing as well as spending 1 year as a candidate patroller to become a certified patroller. Patrollers must also attend an annual "refresher" course covering approximately one third of the OEC curriculum to maintain certification. As patrollers, OEC technicians provide initial resuscitation, stabilization, triage, and transport, not invasive or advanced medical treatments, and care is usually dictated by both national and local procedures and protocols.[5,6]

As outlined in the *OEC Manual*, 5th edition, patrollers must have an understanding of head and spinal injury mechanisms, anatomy, physiology, and pathology as well as rescue skills including assessment of the neurologic injuries, manual spinal stabilization, sizing and applying a c-collar, placing patients on a long spine board, and helmet removal.[7] Rescues may require toboggan, snowmobile, or even airlift in order to cross rugged and remote terrain. Thus, it is felt that athletes with suspected head/neck injuries have appropriate stabilization before transport.

Helmet use among alpine skiers and snowboarders has been shown to reduce the risk of closed head injury by up to 60% without an increased incidence of spinal trauma.[8–13,23] The use of helmets among recreational skiers and snowboarders has increased steadily in the past decade from 25% in 2002–03 to 67% in 2011–12, and helmet use is now mandatory in the Canadian Province of Nova Scotia.[14]

Studies in other helmeted sports such as football and hockey have helped create guidelines for the emergency transportation of athletes with suspected head/neck injuries regarding the appropriate timing and location of helmet removal.[15–18] To date there have been no studies that address this issue for alpine winter sports, and ski patrollers currently must rely solely on clinical judgement to decide when to remove a helmet rather than scientific evidence, leading to potential confusion and variation in practice.

The purpose of the current study was to observe changes in cervical spine alignment after the addition of a cervical collar to a helmeted skier, and after helmet removal and c-collar application in the mock-injured athlete stabilized on a spinal backboard by obtaining lateral c-spine radiographs in 3 common scenarios: 1) helmet on, without a cervical collar; 2) helmet on, with a cervical collar; and 3) helmet removed, with a cervical collar. We hypothesize that observing changes in spinal alignment in these scenarios will help establish evidence-based guidelines for the safe transport of alpine winter athletes with suspected head/neck injuries.

Methods

Approval to conduct research on human subjects was obtained from the Institutional Review Board at St Luke's Hospital and the Whiteside Research Institute, Duluth, MN. All volunteers were provided detailed information about the study and the risks of ionizing radiation and provided informed consent to participate.[19]

Twenty-eight healthy adult volunteers (18 men, 10 women) age of 47 ± 17 (20–73) were enrolled. Participants were current and candidate ski patrollers who agreed to participate in a scenario-based exercise in which helmeted alpine athletes with suspected cranial/cervical injuries were assessed and stabilized by ski patrol candidates completing an Outdoor Emergency Care course under the supervision of experienced course instructors. Volunteers were asked to bring their own personal ski wear (helmet and jacket) and were excluded from participation if they were age <18, known to be pregnant, or if they had any history of prior cervical spine injury or surgery.

Helmeted volunteers with mock head/neck injuries were stabilized on a long spine back board and had a lateral radiograph of the c-spine taken after each of 3 rescue scenarios. In scenario 1 (helmet on, no collar), the helmet was left in place and the patient immobilized directly on the spinal board without a c-collar using stable blocks to secure the head and helmet. For each individual, this scenario served as a control as it would be assumed to be the least time consuming and require the least spinal manipulation to perform. In scenario 2 (helmet on, with collar) the helmet was left in place and a cervical collar was applied to provide additional stabilization to the spine. In scenario 3 (helmet off, with collar) the helmet was removed and a cervical collar was applied using a standard 2 or 3 person rescue technique (Figure 1) taught in the OEC manual, and the length of time needed to perform the helmet removal and stabilization was recorded.

Radiographic analysis of the x-ray images was performed blindly by 2 independent observers and was identical to the technique used by Swenson et al in their study on American football players.[15] Observers used digital imaging software to mark the posterior occiput line, posterior dens line, and C7 inferior end plate line on