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Padec pri varovanju s plezalno vrvjo: ali tip varnostnega pasu vpliva na vzorec in resnost poškodbe?

Climbing Rope Falls: Does the Type of Harness Influence Pattern and Severity of Injury?

IZVLEČEK

Na podlagi eksperimentalnih podatkov je razširjeno prepričanje, da lahko vsak večji padec pri varovanju s plezalno vrvjo povzroči smrtno nevarne poškodbe, če plezalec uporablja le sedalni varnostni pas, predvsem zaradi nevarnosti poškodb prsne in ledvene hrbtenice in trebušnih organov pri hiperekstenzijski poškodbi, pa tudi zaradi tveganja, da bo plezalec obvisel v položaju z glavo navzdol. Cilj te retrospektivne študije je bil ugotoviti, ali vzorec poškodb, ki so ga pokazali eksperimentalni podatki, resnično najdemo pri dejanskih primerih nesreč in ali vrsta varnostnega pasu prispeva h obolevnosti in umrljivosti pri teh ponesrečencih. Analizirali smo skupaj 57 plezalcev, ki so v preteklosti padli v plezalno vrv. Od tega jih je 41 uporabljalo le sedalni varnostni pas, 16 pa kombinacijo sedalnega in prsnega varnostnega pasu. Pri nobenem od plezalcev, ki so uporabljali le sedalni pas, niso našli ne motenj na prsni in ne na ledveni hrbtenici ne poškodb trebušnih organov zaradi hiperekstenzijske poškodbe, kljub dolgemu padcu do največ 65 metrov. Vzorec in resnost poškodb plezalcev, ki so uporabljali le sedalni pas, se nista razlikovala od tistih, ki so uporabljali kombinacijo sedalnega in prsnega varnostnega pasu. Položaj z glavo naprej je bil med takimi padci pogost (33% vseh primerov), vendar ni bilo nobenega ujemanja z vrsto pasu, ki ga je plezalec uporabljal. Visenje z glavo navzdol po padcu je bilo manj pogosto in je nastopalo le, če plezalec ni uporabljal prsnega varnostnega pasu. Opažali smo, da je največ primerov smrtno nevarnih poškodb in multisistemske poškodbe na lažjih plezalnih smereh, vzorec poškodb pa je kazal na udarec ob skalo med padcem kot osnovni mehanizem teh poškodb. Nismo torej našli nobenih znakov ali dokazov, da bi vrsta plezalnega pasu značilno vplivala na vzorec poškodb ali resnost poškodb pri padcih med plezanjem. Naši podatki kažejo, da so hude in smrtno nevarne poškodbe pri nesrečah med plezanjem predvsem posledica udarca ob skalo med padcem in so pogostejše na lažjih smereh.

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ABSTRACT

Based on experimental data, it is widely believed that any extended climbing rope fall may cause life-threatening injuries when using a sit harness alone. This is mainly due to the danger of thoraco-lumbar spinal and visceral abdominal injuries secondary to hyperextension trauma, as well as the risk of a »head down« position during suspension. The aim of this ret-

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rospective study was to clarify whether the pattern of injury suggested by experimental data is indeed found in real life falls and whether the type of harness used contributes to morbidity and mortality in climbing accident victims. A total of 57 climbers with a history of a fall into the climbing rope were analysed, 41 using a sit harness alone and 16 using a combination of sit and chest harness. Neither a disruption of the thoraco-lumbar spinal nor abdominal visceral injuries secondary to hyperextension trauma were found in any of our victims using a sit harness alone, despite long falls up to 65 meters. The pattern and severity of injury were not different in climbers using a sit harness alone when compared to those using a combination of sit and chest harness. »Head first« position was common during the fall (33% of all cases), but without any correlation to the type of harness used. »Head down« position after the fall during suspension was less common and found only when no chest harness was used. There was a peak of life threatening injuries and multi-system-trauma cases in routes of low difficulty, the pattern of injury indicating rock contact during the fall as the underling mechanism responsible for these injuries. Taken together, we did not find any evidence that the type of harness used significantly influences the pattern or severity of injury in rock climbing accidents. Our data indicate that severe and life threatening injuries in rock climbing accidents are predominantly due to rock contact during the fall and are more common in routes of low difficulty.

INTRODUCTION

Modern climbing ropes absorb a significant portion of the energy of a fall by distension. Furthermore, dynamic belaying techniques are routinely used by most climbers, absorbing additional energy by friction. Nevertheless, forces up to 600 Newton may be observed after a major fall and sophisticated harnesses are undoubtedly necessary to avoid major injuries when these forces are transferred to the human body.

Three types of harnesses have been more widely used during the last decades: chest harnesses, sit harnesses and a combination of chest and sit harnesses. It is well known that using a chest harness alone will result in cardio-respiratory failure and death within a few hours in case of free suspension *(1)*. Therefore, the sole use of a chest harnesses is no longer recommended and nowadays rarely used. Based on an experimental study, Magdefrau suggested that using a sit harness alone should also be avoided whenever a major fall into the climbing rope is a possible risk *(2)*. Using a sit harness alone, any major fall may result in severe abdominal visceral and spinal injuries due to a hyperextension trauma of the thoraco-lumbar region, as well as a »head down« position during suspension. Taken together, the use of a combination of chest and sit harness may be the safest way to deal with the forces associated with a major fall into the climbing rope. Despite all concerns, however, the sole use of a sit harness is very popular in both sports as well as alpine climbing.

Table 1. *Difficulty of the climbing routes and height of the falls. [1]According to the UIAA grading; III/IV = routes of low and moderate difficulty, V/VI = routes of high difficulty, VII/VIII = routes of very high and extraordinary high difficulty. [2]Minimum height of the fall 5 meters, [3]Maximum height 65 meters.*

difficulty[1]	III/IV	V/VI	VII/VIII
victims	n=10	n=26	n=21

height of fall	1–9 meters[2]	10–19 meters	20–29 meters	30–39 meters	>40 meters[3]
victims	n=11	n=24	n=11	n=6	n=5

To clarify the influence of the type of harness used on pattern and severity of injury in real life climbing accidents we started a retrospective, clinical study a few years ago. So far 57 victims with a history of a fall into the climbing rope using either a sit harness alone or a combination of a sit and chest harness have been included and we therefore want to report the results of an initial analysis.

METHODS

Patients were identified through a search of the emergency room charts of three Austrian hospitals (Innsbruck, Zell am See and St Johann) located near busy climbing areas, as well as a search of the helicopter operation protocols of three Tyrolean emergency medical helicopters (Christophorus 1, Christophorus 4 and Christophorus 5).

Concerning the circumstances of the accident the following data were obtained: age and sex of the victim, type of harness used (sit harness alone or a combination of a sit and chest harness), reason for the fall, height of the fall, body position during the fall, body position during suspension and difficulty of the climbing route. These data were obtained either by a personal interview of the injured climber himself or a companion climber accompanying him on his tour.

Using the medical records of the admitting hospitals for each patient the eventual discharge diagnoses were obtained. Thoracic and lumbar spinal injuries were classified according to Magerl, based on x-ray and CT scan findings *(3)*. Briefly, this classification allows one to diagnose the underlying mechanism for thoraco-lumbar spinal injuries and thus to separate spinal injuries caused by hyperextension (Magerl class B3) from those secondary to compression trauma (Magerl class A) associated with rock contact during the fall *(3)*.

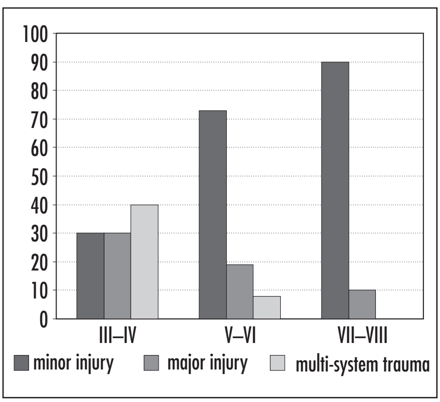

Figure 1. *Correlation between severity of injury and difficulty of the climbing route. UIAA III/IV=routes of low and moderate difficulty, UIAA V/VI=routes of high difficulty, UIAA VII/VIII=routes of very high and extraordinary high difficulty.*

Table 2. *Pattern of injury in those 28 climbers sustaining major injuries.*

injury	climbers
multi-system trauma	n=9
isolated cerebral trauma	n=2
isolated spine fracture	n=5
dislocation/fractures	
shoulder, upper extremity	n=1
pelvis, lower extremity	n=11

RESULTS

A total of 57 climbers with a history of a fall into the climbing rope could so far be included. 41 climbers (72%) used a sit harness alone whereas 16 climbers (28%) used a combination of a sit and a chest harness. The height of the falls and the difficulty of the routes (according to the UIAA grading) are shown in table 1, demonstrating that most of the falls were more than 10 meters and occurred in rather difficult routes.

Pattern and severity of injury varied over a wide range. With 29 climbers, injuries were minimal or minor whereas 28 climbers sustained major injuries, 9 of them severe multi-system trauma. Distribution of major injuries is shown in table 2, demonstrating that fractures and dislocations of the lower extremities were the most common injuries. A total of 6 spinal fractures (3 in climbers using a sit harness alone, 3 in climbers using a combination of sit and chest harness) were observed, three of them in the thoraco-lumbar region (2 in climbers using a sit harness alone, 1 in a climber using a combination of sit and chest harness). All three fractures in the thoraco-lumbar region were secondary to compression trauma (Magerl class A). No

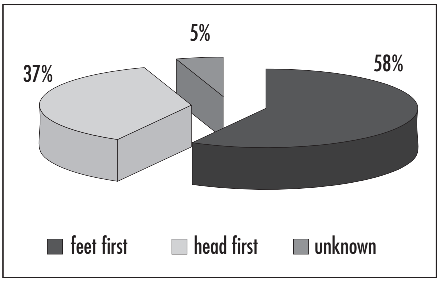

Figure 2 A. *Body position in climbers using a sit harness alone.*

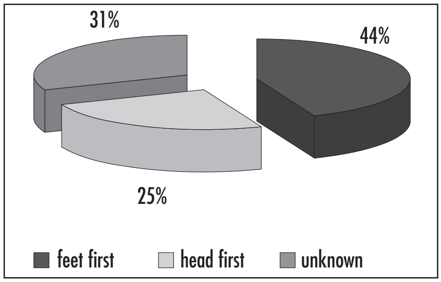

Figure 2B. *Body position in climbers using a combination of sit and chest harness.*

hyperextension associated spinal fracture (Magerl class B3) was observed in any of the climbers. No abdominal visceral injuries were observed.

Pattern and severity of injury were not different in climbers using a sit harness alone when compared to climbers using a combination of sit and chest harness. However, there was a peak of severe injuries and life-threatening multi-system trauma cases in climbers injured in routes of lower difficulty (figure 1), with the history and pattern of injury indicating that these injuries were most likely caused by rock contact during the fall.

A »head first« position during the fall (n = 19, 33%) was equally common using a sit harness alone when compared to climbers using a combination of sit and chest harness (figure 2 A and 2 B). It was more common than a »head down« position during suspension (n = 6, 15%), which was found only when no chest harness was used. In all climbers using a combination of sit and chest harness, an upright position was documented after the fall during suspension. Body position during suspension could also be documented in 6 unconscious patients, 2 using a sit harness alone and 4 using a combination of sit and chest harness. In both climbers without a chest harness, a »head down« position was documented, whereas all 4 climbers using a chest harness were in an upright position after the fall.

DISCUSSION

In an experimental landmark study Magdefrau measured the forces possible during a fall into the climbing rope *(2)*. Extrapolating the results on the human body, Magdefrau concluded that the forces observed were sufficient to cause severe hyperextension trauma of the thoraco-lumbar region when using a sit harness alone, resulting in life-threatening spinal or abdominal visceral injuries. When using a sit and chest harness in combination, however, these forces act on the human body in a longitudinal direction and are in general within the range known to be tolerated without significant injury *(2)*. To support his hypothesis, Magdefrau collected a number of climbing accidents in which victims using a sit harness alone had sustained spinal injuries, postulating that these injuries were caused by hyperextension trauma, although no detailed information about the injury was given. It is obvious that factors apart from the type of harness used can cause spinal injuries in climbing accidents and it remains to be proven in each case whether a spinal fracture is indeed secondary to a hyperextension trauma and therefore sit harness use. In addition, the fact that a particular mechanism of injury is possible in an experimental setting does not necessarily mean that it is more common or of major significance in real life accidents.

In our retrospective clinical study, no climber using a sit harness alone sustained a hyperextension trauma of the thoraco-lumbar spinal or an abdominal visceral injury, despite a significant number of large falls with a maximum of 65 meters. Thoraco-lumbar spinal injuries were observed in our study population, however, also in climbers using a combination of sit and chest harness. Based on the type of fractures observed, thoraco-lumbar spinal injuries were caused by compression trauma and were most likely the consequence of rock contact during the fall.

We conclude that the problem of hyperextension trauma, postulated on the basis of experimental data, is not an important mechanism for injury in real life climbing accidents.

Because of the retrospective study design and the limited number of cases included so far, we can not definitely exclude that spinal or abdominal visceral injuries secondary to a hyperextension trauma can rarely occur after a major fall when using a sit harness alone. However, our data clearly indicate that hyperextension trauma is a rare and uncommon reason for morbidity or mortality in climbing accidents. Furthermore, one should also keep in mind that if the problem of hyperextension trauma in climbing accidents really exists, the use of a combination of sit and chest harness will not eliminate, but rather transfer the problem to the cervical spine region.

It has been argued that the body turns in a »head first« position when the rope stops the fall in those climbers using a sit harness alone *(2)*. In addition, in case of unconsciousness the body will remain a »head down« position during suspension. Although no scientific valid data are available, it is obvious that a »head first« position during any phase of the fall is a significant risk factor for severe head and cervical spine injuries. In our data we could document a »head first« position equally often in climbers using a sit harness alone when compared to climbers using a combination of sit and chest harness. We assume that a very common reason for a »head first« position in climbing accidents is from contact with the rock during the fall. This can turn the climber from a »feet first« into a »head first« position and this mechanism is independent from the type of harness used.

In accordance with Magdefrau we could demonstrate that only a combination of sit and chest harness guarantees an upright position after the fall during suspension, in particular in an unconscious victim *(2)*. This is the only parameter in our data demonstrating a clear difference between climbers using a sit harness alone and those using a combination of sit and chest harness. It has been argued that an upright position during suspension improves survival in a patient with cerebral trauma, as it avoids the marked increase in intra-cerebral pressure associated with a »head down« position *(2)*. However, this is a very theoretical speculation as one might also argue that an upright position carries the risk of airway obstruction and asphyxia. Without immediate professional help the prognosis of an unconscious climber with cerebral trauma suspended in a rope will be extremely poor anyway, no matter which type of harness is used.

In our data we found a clear a peak of life-threatening injuries and multi-system trauma cases in routes of low difficulty. We believe that this is a clear hint that rock contact during the fall – more common in low difficulty routes – is by far the most important reason for severe or life-threatening injuries in climbing accidents.

CONCLUSIONS

In conclusion, we did not find any evidence that the type of harness used significantly influences the pattern or severity of injury in rock climbing accidents. Our data suggest that severe and life-threatening injuries in rock climbing accidents are predominantly due to rock contact during the fall and are more common in routes of low difficulty. Not the type of harness used, but the number of correctly placed bolts to reduce the possibility of rock contact during the fall can improve the safety of rock climbing and reduce the risk of major injuries.

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