Original article

Rescue of traumatized riders in world circuits: a comparison between Skidboard *vs* scoop Exl65 and aluminium scoop stretchers

Enrico Farabegoli[1], Alessandro Bellati[2], Marco Forestan[2], Massimo Berardi[3], G. De Feo[3], Eraldo Berardi[4]

[1]Medical Doctor MWC; [2]Eng. Dainese spa; [3]Nurse MWC; [4]Medical Director Misano World Circuit MWC

Abstract. *Introduction:* The medical rescue of traumatized riders recommends the spine board immobilization to avoid spine injury after trauma. There is no universal procedure to rescue the fallen rider on the track using a single type of spinal immobilization device. We compared three stretchers to identify the better and safer to immobilize a fallen rider on the track. *Matherial and Methods:* Simulate the rescue of a fallen rider in the Misano World Circuit. Perform rescue through lifting and transporting the patient using Exl65, scoop aluminium, and loading on the Skidboard and drag it for several reps. Transport the stretchers on a real path 25 meters long, including asphalt, curb, artificial turf, natural grass and gravel. Collect and compare data about stresses on the body of the rider, by means of sensors inserted into the suit and helmet, and on anatomical sites, representative of the vertebral column: chin, nape, C spine, sternum, iliac spine. The Dainese Company supplied suit and helmet with sensors. Dainese engineers processed data too. Performe risk analysis about a team physically frail. *Results:* Final data repetitions were: n. 34 Skidboard and n. 14 Exl65 and aluminum. On the Exl65, only the body of the patient was tied with the straps, it was not possible to tie the helmet because it is necessary to remove the helmet to tie the head. The aluminum scoop stretcher is not certified spine board on which it was not possible to tie the patient. The patient was tied to Skidboard from head to feet. Skidboard allows skidding on the ground to carry the traumatized patient properly strapped and with helmet on. The comparison with aluminum stretcher was quickly interrupted by the striking superiority of others. The average of the coefficients of Skidboard movements and Exl65 is between 0.25 and 0.84. The head anchoring on Skidboard restricts the rotation around three cartesian axes effectively. Exl65 is more excavated and allows a better housing of the hump, it limits the spine rotation. Skidboard is different because has a flat plate which creates a line of contact between support surface and hump, thus allowing the hump to rotate around the axis X. However the strain by Skidboard is less than Exl65. The chin and neck, data on X axis (rolling) was between 2% and 5% in favor of Skidboard. The chin and nape data on Y axis (pitching) was between 4% and 7% in favor of Skidboard. The various kinds of ground walked by rescuers with Exl 65, we noted a pronounced pitching stress of the patient's body especially on changing ground. The subtraction of signals between lumbar and neck on X axis, the spectra amplitude is higher in Exl65 than Skidboard. The same values on lumbar and chin. The rotation stress between lumbar, thoracic and cervical vertebrae is greater on Exl65 than Skidboard. The procedure time completed with Skidboard was on average 43". The Exl65 complete procedure with patient tied to stretcher, head excluded, lasted on average almost 60". Overall, Skidboard time was 17" less than Exl65. All operators reported they put more effort in raising the stretchers Exl65 scoop and aluminum than the Skidboard that they just dragged. *Discussion:*The aluminum scoop stretcher is inadequate to rescue the traumatized rider because is not a spine board and because creates more stress than other stretchers. In fact there is not a standard fixing system for the body and the head of the patient. Skidboard ensures the aligned immobilization of the cervical spine during the entire rescue process, including dragging, unlike Exl65 that does not immobilizes the cervical spine with helmet on and the head is in extension because the hump. This is not surprising when you consider that Exl65 does not fix the head with the helmet worn and has no headrest to align the spine. Exl 65 has

open bottom and the concave shape which welcomes the suit hump and makes the spine more stable against the roll in the transport, so it is less unstable even for the neck. The rest of the spine, even if tied on Exl65, moves more on Exl65 than on Skidboard especially rolling more than pitching. Skidboard does not only discharge less energy on patient than Exl65, but also greatly reduces the severity of the fall of the patient and stretcher because only a portion is dragged few centimeters high. The same happens if an operator falls down. Compared to all stretchers which must be raised to be transported, Skidboard is more ergonomic. Indeed, it produces a second-class lever which is always profitable, because it has the load between the fulcrum and the effort force. For example, to load 100 kg of weight, two operators load respectively 37.5 kg each. The female crew, too, suffered far less effort using Skidboard than using the other two stretchers. Skidboard has the ergonomic requirements required by the italian law. Exl65 scoop stretcher was born to be open to load the patient, unfortunately this main purpose is almost never used in world track. In world circuits, almost always, the rescuers do not tie the patient on scoop stretcher, probably because they need to act quickly and because fastening belts need about a minute of time by skilled operators: one minute is probably excessive in world circuits. Rescue speed is a factor that increases safety on track, therefore it is important in stretcher's evaluation. The time to closely tie the rider to Skidboard and to evacuate the track, head and neck fixed, is about 43 seconds to reach a safe zone at 25 meters distance. Skidboard is about 17 seconds faster than Exl65 which must be raised about a meter, with the additional danger of falling. *Conclusion:* Skidboard and Exl65 stretchers do not deliver detrimental energy, apparently, but it was not possible to prove it scientifically. Skidboard turned out to be the most innovative and secure spine board, because generates less energy than other stretchers and reduces, almost cancels, the harmful consequences of the patient's fall on the ground; it is the only spineboard that allows to tie the rider to the stretcher from head to toe with helmet on. Skidboard allows more speed than other stretchers, therefore, Skidboard procedure is safer because faster. Skidboard is better than others to rescue fallen and traumatized riders on the tracks quickly and safely.

Key words: spine board; stretcher; trauma; riders.

Assumptions

1. The fallen riders' rescue during amateur and professional activity in world circuits has very different procedures and instruments. There is no universal procedure to rescue the fallen rider on the track using a single type of spinal immobilization device (1).
2. Skidboard is a certified spine board, which allows skidding on the ground to carry the traumatized patient properly strapped and with helmet on (figure 1 A-B).
3. Exl65 is a scoop stretcher, certified spine board (2), which must be raised to transport the patient. It is necessary to remove the helmet to tie the patient to the stretcher (Figure 2).
4. The aluminum scoop stretcher is not certified spine board (3). It lacks a standard system of the patient's immobilization. Various types of belts are available as accessories, but none of them immobilizes the head with the helmet on. However, this is the more frequently used stretcher in world circuits (Figure 3).

Figure 1 A, B. A) Skidboard lifted side; B) Skidboard dragged side

5. The medical rescue of traumatized riders meets universal criteria scientifically recognized (4), recommends the spine board immobilization of traumatized patient, precautionally to avoid spine injury after trauma accidentally due to rescuers and ambulance transportation. The cervical spine immobiliza-

tion, which is a priority for rescuers, is particularly important.

6. The priority out-of-hospital trauma management is the safety of the scene, of the patient, and of the rescuers (5). In a circuit it is very difficult to ensure security, because the bikes come up in a very short time right on the site of the accident; this exposes other bikers and rescuers on the track to danger and injuries.
7. The rules of some circuits, like Misano World Circuit (MWC) (6), is to expose a red flag immediately, following the order of the race control, when traumatized riders or obviously dangerous situations occurs. However, even with a red flag up, there are multifactorial conditions that increase the risk of further crashes and the injury of rescuers (debris on track, speed, level of attention of the other riders, etc.). There are a lot of conditions that require to wave a yellow flag, which orders to slowdown and alerts the riders' attention on the track during the fallen rider rescue, but it does not eliminate possible dangers to rescuers.
8. Generally the rescuers do not follows world guidelines (7) and evacuate the traumatized rider on the track quickly and dangerously (8). In particular, they do not always use spine boards to guarantee the protection of the spine; often they do not bind the patient to the stretcher to avoid falling from the stretcher itself or the patient's dangerous movements. In this way, the rescuers expose the rider to potential injuries caused by themselves (9), probably because of inadequate training (10) (Figure 4).

Figure 2. Exl65: bound body, head free

Figure 3. body free on aluminum scoop stretcher

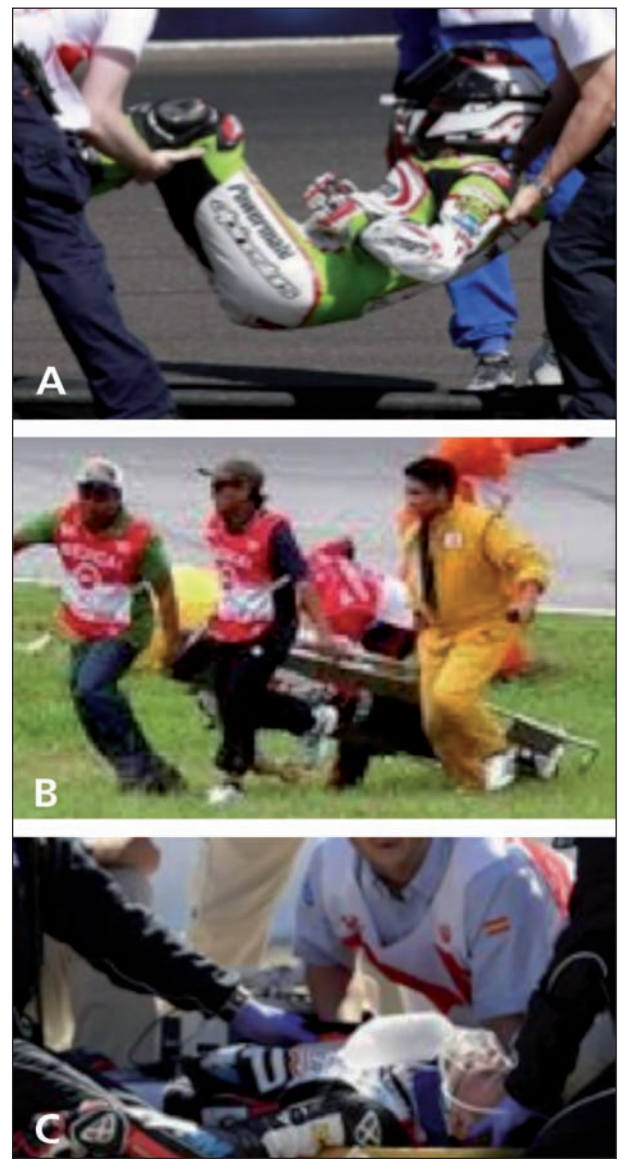

Figure 4. A) Rescue of a fallen rider, moto GP 2013; B) traumatized rider fallen from the stretcher during a rescue, motoGP 2011; C) traumatized rider transported on the Exl65 not tied to the stretcher and with neck free, moto 3-2013.

Objectives

Compare the patient's spine stress caused by the use of the stretchers examined, to identify the most suitable and safer device to immobilize the traumatized rider and to realize a quick and safe evacuation from the track.

Materials and Methods

N. 12 operators, engaged in different roles in teams of three, simulated the rescue of a fallen rider in a world track.

Perform loading of the traumatized rider on the Skidboard stretcher and drag it for n. 34 reps on a real path 25 meters long, including asphalt, curb of the track, artificial turf, natural grass and gravel (Figure 5).

Perform rescue through lifting and transporting the patient using Exl65 and scoop aluminium, n. 14 reps respectively, on a real path 25 meters long, including asphalt, curb of the track, artificial turf, natural grass and gravel.

Collect data about stresses on the body of the rider, by means of sensors inserted into the Dainese suit and AGV helmet (Figure 6), and on anatomical sites, representative of the vertebral column as shown in the Figure 7: chin, nape, C spine, sternum, iliac spine.

Time rescuing and transporting the stretcher and patient on a real path 25 meters long, including asphalt, curb of the track, artificial turf, natural grass and gravel. Detecting start at the touch of the helmet by the leader, does not take into account the time of reaching the fallen rider.

Compare data

Perform risk analysis about a team of women, physically frail, using both Skidboard, Exl65, and aluminum stretcher, along the same path (Figure 8).

Data processing was carried out by a Dainese engineers team. They had no conflict of interest about devices and authors.

The stretchers were available to the medical staff of Misano World Circuit because daily used on track rescue. A Skidboard was never used before in MWC, it was purchased by the authors of this work directly from producer (Northwall Innovation), who kindly provided technical assistance.

Figure 5. dragging the skidboard - test day July 19, 2012

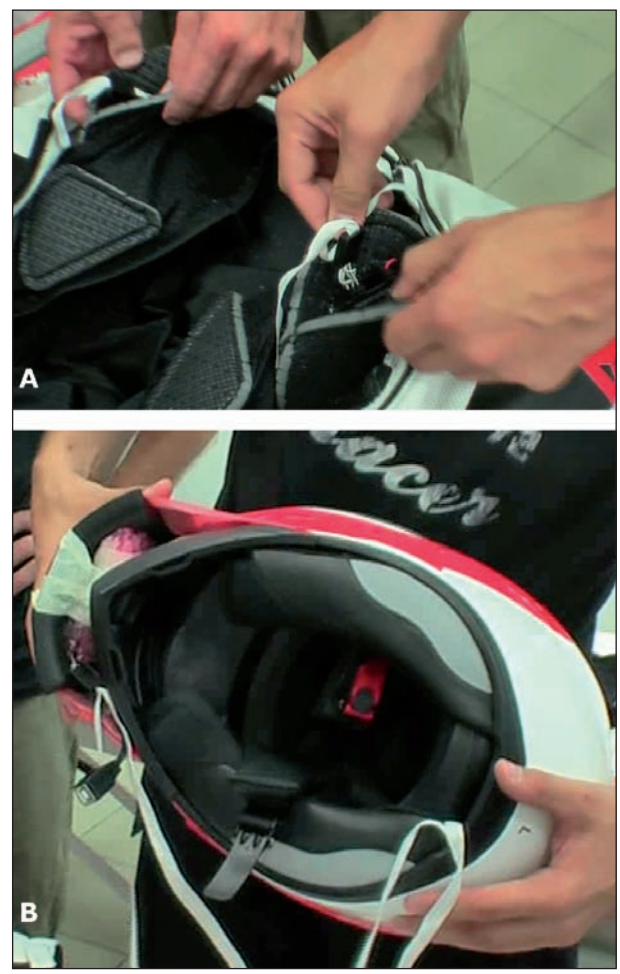

Figure 6. A) sensors into the suit; B) sensors into the helmet

Test days

July 19-2012 and February 2-2013, Misano World Circuit in Misano Adriatico (RN- Italy)

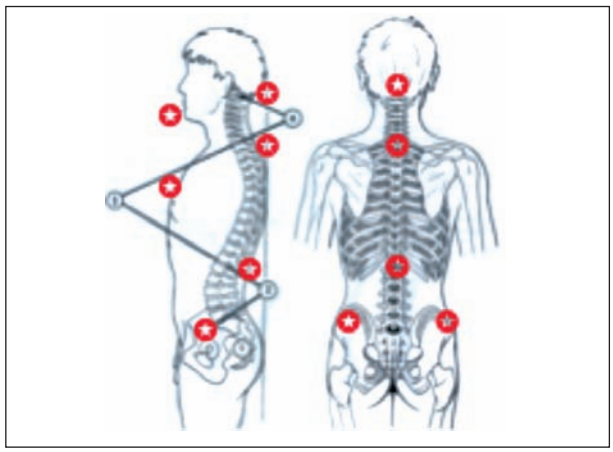

Figure 7. sensors inserted in anatomical highlighted sites

Figure 8 risk analysis: lifting Exl65 by a team of women

Figure 9. Dressing the rider suit and helmet, equipped with sensor

Dressing actor with suit and helmet sensors inside

The equipment is set to receive data by the sensors inside the suit and helmet (Figure 9). The sensors were: accelerometers, specially provided by Dainese company, GPS inside and synchronized with each other. The stresses were detected on the three Cartesian spatial dimensions calculated in degrees per second.

The sensors were placed in the following sites:

- Chin of helmet specifically provided by AGV
- Inside nape of helmet specifically provided by AGV
- Inside dorsal hump of the suit specifically provided by Dainese
- Cranial and caudal side of back protection, specifically provided by Dainese
- Iliac spine, pockets inside the suit specifically provided by Dainese

Training pre-test

About 10 sequences were performed to train each component in every role, to properly set Skidboard, Exl65, and aluminum stretcher.

Preparation of the field

The test path was turn 16 of the Misano World Circuit in Misano Adriatico (Rn) (Figure 10). Fixed and mobile cameras were placed, and the hardware was installed for data collection. The ground for the testing of the stretchers was asphalt, curb, synthetic and natural grass, and gravel. At the start, the rider was always lying on the same point of the track in prone position. The path was 25 meters long. Two skittles were placed at the start and at the end of the path. A part of the test was performed in the winter (February 2, 2013), and the rest

Figure 10 Turn n.16 Misano World Circuit

in the summer (July 19, 2012), weather conditions corresponding to the season.

Skidboard testing

N. 34 reps, changing the team setting.

Comparative testing

N. 14 repetitions with Exl65 and aluminum stretcher, changing the team setting.

Subjective data

Tests finished, operators answered questions about:
1. Practical stretchers' procedures
2. Manoeuvers' difficulties
3. How many reps to acquire a good stretchers' technic?

Rescue steps

During test practice were highlighted 5 steps:
1. Body's supination on stretcher by log roll manoeuvre
2. Body's anchoring to stretcher (complete or partial)
3. Partial or complete stretcher lifting
4. Stretcher transport 25 mt along
5. Stretcher landing on the ground

Teams walked on 5 ground types in phase 4 (transport of the stretcher): I Asphalt, II Curb, III Synthetic grass, IV Natural grass, VGravel.

Two operators walked on the path dragging Skidboard tail by holding up only the head part. Exl65 raised by three operators, two lateral and one at the tail. The same was done with aluminum stretcher.

Data acquisition

Each sensor inside the suit and helmet showed linear and gyro values on the three Cartesian axes during all manoeuvers.

We considered data from electronic devices placed on: • Chin; • Nape; • Hump; • Chest; • Lumbar region.

We compared the stresses to the spine during loading and transport steps with Skidboard and Exl65 only, because data showed the aluminum stretcher is evidently worse than the other two stretchers. Acceleration in percentage values less than 2mt/sec^2 and speed values less than 50°/sec were discarded because biomechanically not significant for the analysis. The percentage values of deviation less than 5% were considered not significant.

Results

About forty repetitions were carried out using Skidboard, twenty using Exl65, and twenty with the aluminium stretcher. Some manoeuvers were discarded for unavoidable problems and practical difficulties, for example: roles mistakes inside team, mistakes recording time, etc. Final data repetitions were: n. 34 Skidboard and n. 14 Exl65 and aluminum.

Phase 1, the rider was moved from prone to supine position and transferred from asphalt to stretcher using the log roll manoeuver (10). When

Skidboard was near to patient, at the beginning, the log roll maneuvre was always effective and it was not necessary to realign the patient on the stretcher. Otherwise, the patient's loading on Exl65 and aluminum stretcher often required further corrective manoeuvre of realignment of the patient's body on the longitudinal axis of the stretchers. The reason seems to be that the scoop Exl65 and aluminum stretcher are both concave, the first more than second, and the side thickness is greater than the Skidboard which is much less concave and has a total thickness of 0,5 cm. Because of the hump of the suit, the cervical spine has extension position in Exl65 and aluminum stretcher, unlike Skidboard which is provided with head rests, about 4 cm thick, and keeps the cervical spine aligned in neutral position (Figure 11).

Phase 2, the patient was tied to Skidboard from head to feet, while the leader kept the head aligned and stable. On the Exl65, only the body of the patient's was tied with the straps, it was not possible to tie the helmet, because of the lack of a certified head immobilizer system. On the aluminum stretcher it was not possible to tie the patient because of the lack of certified straps. On February 2, 2013 on second test day, we used new certified belts (Northwall) for Skidboard, Exl65 adaptable, making possible to tie the patient to both stretchers, effectively and quickly (Figure 12). It is possible to open the Exl65 scoop stretcher to load the patient using the new Northwall's belts but we don't evaluated it in this work. Unlike it was never possible to tie the head with the helmet on, because it lacks a standard system of the head's immobilization with helmet on.

Phases 3 and 4, a lot of data collected. The comparison with aluminum stretcher was quickly interrupted by the striking superiority of Skidboard and Exl65.

The most significant findings regarding the comparison between Skidboard and Exl65 are shown in the graph below. The sensors detected the rotational stress (rolling), as shown in the graph on the X axis. The longitudinal stresses (pitching) are shown in the graph on the Y axis (measurement units: degrees per second). It was not possible to detect a level over which the energy can be considered dangerous on the spine. With a reasonable approximation, kinesiologically, the sensors in the neck and chin were both considered like cervical vertebrae. The lumbar sensors correspond to lumbar vertebrae. The average of the coefficients of Skidboard movements and Exl 65 is between 0.25 and 0.84 (significant if> 0.02): Skidboard creates less energy than Exl 65 generally. Considering chin and nape as corresponding to the entire cervical spine, biomechanically, data show that the head anchoring on Skidboard restricts the rotation around three cartesian axes effectively, in comparison with what happens with Exl65 (Figure 13).

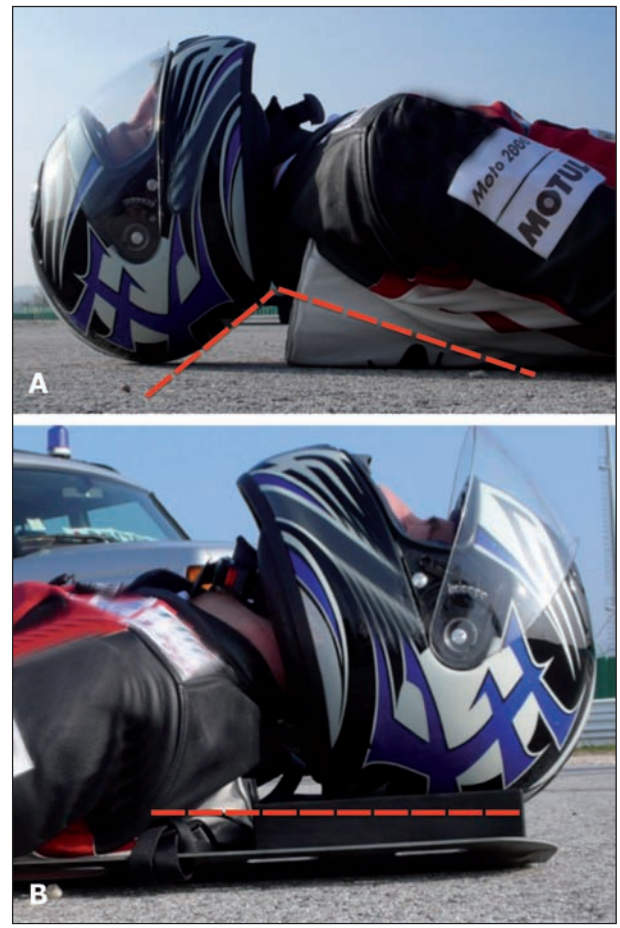

Figure 11. A) Exl65 and aluminum, cervical spine is in extended position (the lack of the stretcher in the photo was needed for photographic technique); B) Skidboard, cervical spine in a neutral position

The table 1 shows as an example a peak analysis of data recorded by nape.

Examining dorsal spine by sensors on the hump and sternum, we noted that Exl65 is more excavated and allows a better housing of the hump, it limits the

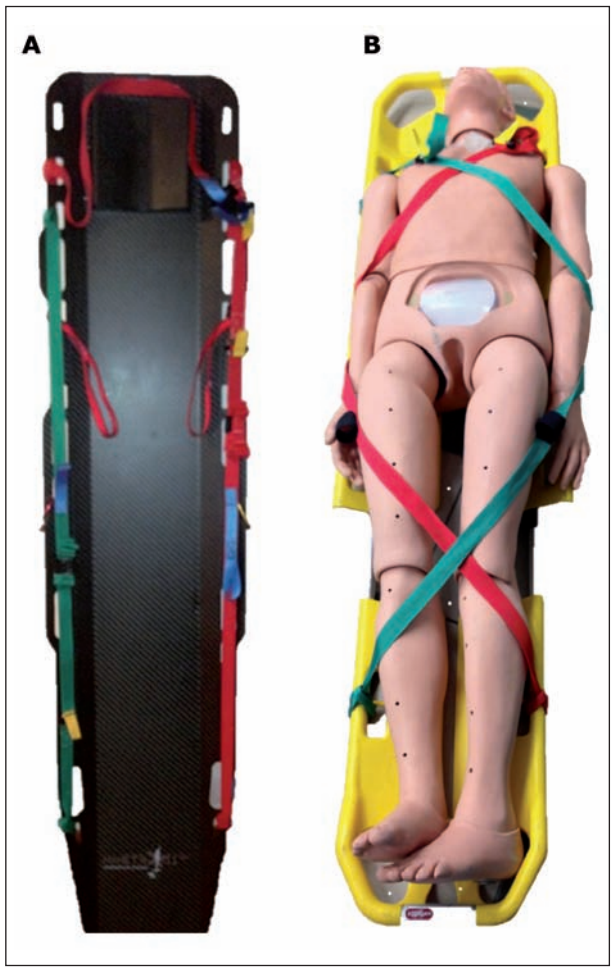

Figure 12. A) Skidboard, Northwall with belts generation two; B) Exl65 – with new Northwall belts

spine rotation. Skidboard is different because has a flat plate which creates a line of contact between support surface and hump, thus allowing the hump to rotate around the axis X. However, as seen below, the strain by Skidboard is less than Exl65. The chin data are on X axis and represent the rotation stress (rolling). We recorded different percentage values starting from 37 g°/sec values. In particular, there was a difference between 2% and 4% in favor of Skidboard, as displayed in table 2 and Figure 14.

As it happened for chin data, comparing Skidboard and Exl65, the difference of the neck rolling (percentage) started from values above 46 g°/sec. In particular, there was a difference between 2% and 5% better for Skidboard. Above 75 degree/sec Skidboard values are almost zero if compared to Exl65, as shown in table 3 and Figure 15.

On the chin, the Y axis represents the longitudinal stresses (pitching), we recorded a different percentage from values above 28 g°/sec. In particular, the difference was between 4% and 7% in favor of Skidboard, though uneven, as shown in table 4 and Figure 16.

On the nape, the Y axis represents the longitudinal stresses (pitching), we recorded the percentage of data difference starting from 28 degrees/sec values. In particular, we recorded differences between 2% and 5% in favor of Skidboard, as shown in table 5 and Figure 17.

Data did not considered the difference during the stretchers' transport.

Analytically, analysing the various kinds of ground walked by rescuers (step 4) with Exl 65, we noted a pronounced pitching stress of the patient's body (Y axis reported) especially on changing ground: from curb to asphalt, from synthetic to natural grass and gravel. The rescuers, walking, keep Exl65 aligned and raised and continuously move to compensate the stretcher because of the advancing effort, especially on the gravel.

Substraction of signals

To evaluate the spine distortion on X (rotational) and Y (longitudinal) lines, we compared the lumbar spine sensor data vs the neck and chin of each stretcher, then compared them subtracting the signals. Figure 18 A and B represent the subtraction of signals between lumbar and neck on X axis of Exl65 and Skidboard, respectively. Note that the spectra amplitude is higher in Exl65 than Skidboard, on average, that means that the relative rotation between lumbar portion and neck is greater in Exl than Skidboard. Considering the lumbar tract, including the neck, as the entire spine, the roundabout stress between lumbar vertebrae, thoracic and cervical vertebrae is greater in Exl 65 than Skidboard. The figure 19A and 19B show the signals subtraction on the Y axis (pitching) in Exl65 and Skidboard. The reported values are similar to those of previous diagrams, although less obviously.

The same subtraction of the signals operation was performed between the values lumbar and chin. They are shown in the Figure 20 A, Exl65, and B,

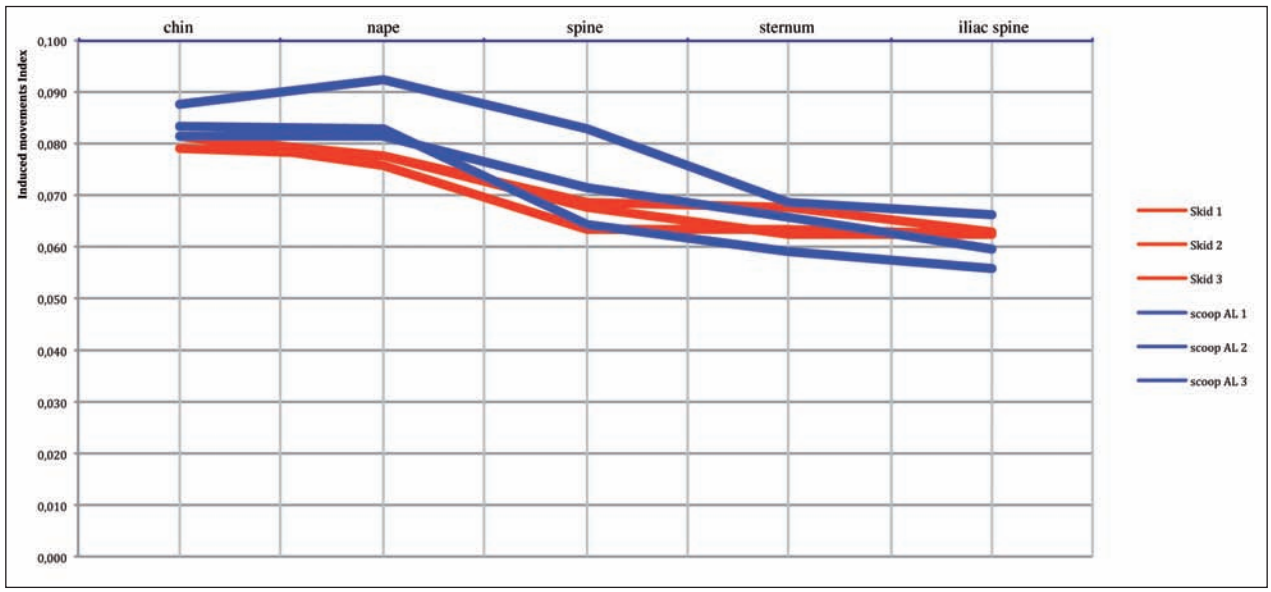

Figure 13. Index based on biomechanical movements

Table 1. Peak analysis of sensors on the back of the head

Nape	Acc X [m/s²]			Acc Y [m/s²]			Acc Z [m/s²]		
	Max Peak	Min Peak	Avg Peak	Max Peak	Min Peak	Avg Peak	Max Peak	Min Peak	Avg Peak
Phase 1	60,00%	-8,00%	32,00%	/	N.S.	14,00%	/	22,00%	34,00%
Phase 2	50,00%	-8,00%	18,00%	34,00%	20,00%	50,00%	14,00%	N.S.	N.S.
Phase 3	70,00%	N.S.	12,00%	46,00%	70,00%	24,00%	10,00%	5,00%	20,00%
Phase 4	10,00%	12,00%	10,00%	36,00%	36,00%	/	21,00%	/	22,00%
Phase 5	/	N.S.	N.S.	/	N.S.	16,00%	33,00%	40,00%	34,00%
	Gyro X [°/sec]			Gyro Y [°/sec]			Gyro Z [°/sec]		
	Max Peak	Min Peak	Avg Peak	Max Peak	Min Peak	Avg Peak	Max Peak	Min Peak	Avg Peak
Phase 1	16,00%	80,00%	-48,00%	/	66,00%	46,00%	/	/	16,00%
Phase 2	13,00%	N.S.	24,00%	/	/	18,00%	/	32,00%	60,00%
Phase 3	64,00%	40,00%	10,00%	40,00%	/	42,00%	/	/	15,00%
Phase 4	61,00%	59,00%	-8,00%	36,00%	12,00%	22,00%	62,00%	54,00%	30,00%
Phase 5	N.S.	/	6,00%	12,00%	60,00%	22,00%	48,00%	24,00%	60,00%

/: under minimum threshold; N.S.: below 5% difference

Skidboard, along the X axis. The Figure 21 A, Exl65, and B Skidboard, show the values along the axis Y. Similarly to nape in comparison with chin, we noted that the spectra amplitude is higher in Exl65 than in Skidboard, on average, which means that the relative rotation between lumbar portion and chin is greater on Exl 65 than Skidboard. When chin was used as anatomical reference for the cervical vertebrae entire, confirmed by nape data, the rotation stress between lumbar, thoracic and cervical vertebrae is greater on Exl65 than Skidboard. The longitudinal stress on the same vertebrae is less than the roundabout stress.

Table 2. Rolling percentage on the chin

TGX Value between/ Field (%)	Current selection / TGX: 10 -100	Current selection / TGX: 10 -100
10,00-19,00	45,39%	16,42%
19,00-28,00	26,19%	8,71%
28,00-37,00	15,46%	37,07%
37,00-46,00	7,98%	19,90%
46,00-55,00	2,49%	7,46%
55,00-64,00	1,75%	4,48%
64,00-73,00	0,75%	4,23%
73,00-82,00	0,00%	1,24%
82,00-91,00	0,00%	0,50%
91,00-00,00	0,00%	0,00%

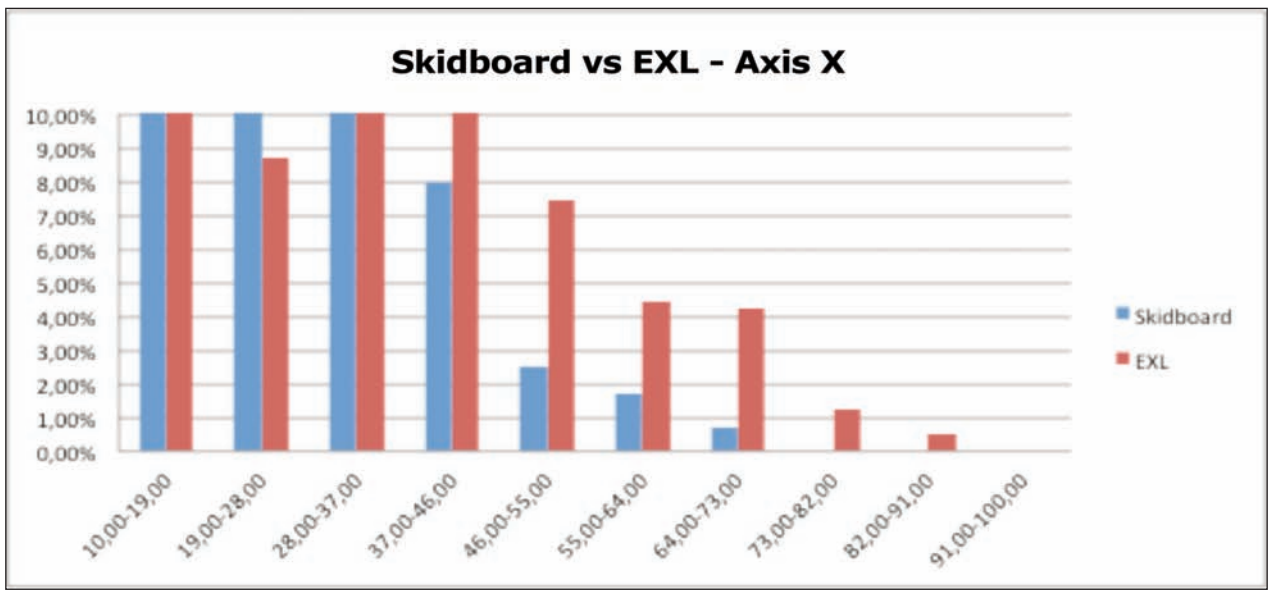

Figure 14. Rrolling differences between Skidboard and Exl65 chin level

Although limited by probable biases that advise caution in data interpretation, we noted a substantial overlap between neck and chin. Therefore, data seem to demonstrate that Exl65 generates higher rotative stress distorting the entire spine, than Skidboard, even if the patient was properly tied to Exl65 with straps. The longitudinal stresses do not seem very different between the two stretchers. Despite Skidboard seems more noisy because is dragged on the ground, to transport the Exl65, lifted from the ground, is affected by the compensatory movements of the rescuers. Skidboard keeps the patient more stable and firmly tied during dragging on the ground.

Time

The time recording each sequence started when the leader touched the rider's helmet and finished when the last operator arrived at the skittle pin 25 me-

Table 3. Roll percentage on the nape

TGX Value between/ Field (%)	Current selection / TGX: 10 -100	Current selection / TGX: 10 -100
10,00-19,00	33,25%	19,92%
19,00-28,00	22,57%	18,01%
28,00-37,00	17,34%	24,52%
37,00-46,00	15,68%	11,115
46,00-55,00	8,08%	10,73%
55,00-64,00	1,90%	6,13%
64,00-73,00	1,19%	4,60%
73,00-82,00	0,00%	2,68%
82,00-91,00	0,00%	1,92%
91,00-00,00	0,00%	0,38%

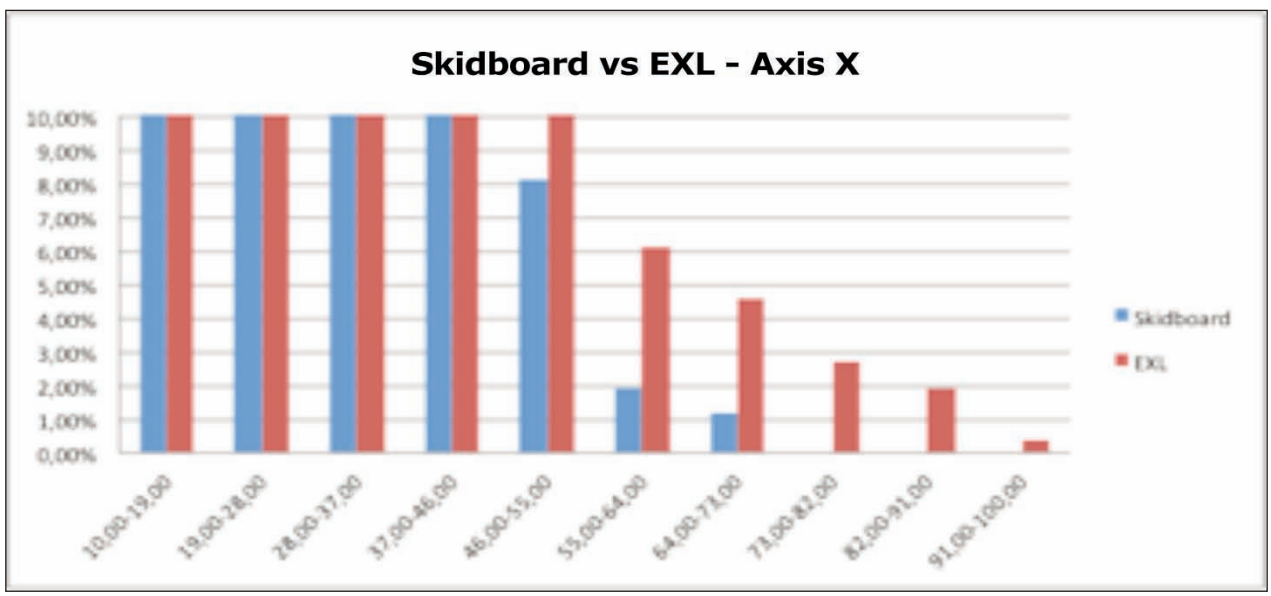

Figure 15. Rolling differences between Skidboard and Exl65 on the neck

ters away. The Skidboard dragging time in 25 mt was on average 31", maximum 38" and minimum 21" (Table 6). The procedure time completed with Skidboard, from helmet touch until the arrival along the path of 25 meters, head and body linked to stretcher, was on average 43", maximum 53" and a minimum of 30" (Table 7). The Exl65 complete procedure with patient tied to stretcher, head excluded, lifted and transported by three operators, lasted on average almost 60", maximum 80", minimum 44" (Table 8). Overall, Skidboard time was 17" less than Exl65. We excluded the landing time of the stretchers, which proved to be faster and safer with Skidboard.

Loading on the stretcher

We always used the log roll manoeuvre to load the patient on the stretcher. In scientific literature, log roll manoeuvre is done by at least two operators, up to

Table 4. Pitching percentage values on the chin

TGX Value between/ Field (%)	Current selection / TGX: 10 -100	Current selection / TGX: 10 -100
10,00-19,00	70,37%	65,59%
19,00-28,00	25,29%	18,48%
28,00-37,00	3,70%	11,55%
37,00-46,00	0,37%	0,23%
46,00-55,00	0,37%	3,93%
55,00-64,00	0,00%	0,23%
64,00-73,00	0,00%	0,00%
73,00-82,00	0,00%	0,00%
82,00-91,00	0,00%	0,00%
91,00-00,00	0,00%	0,00%

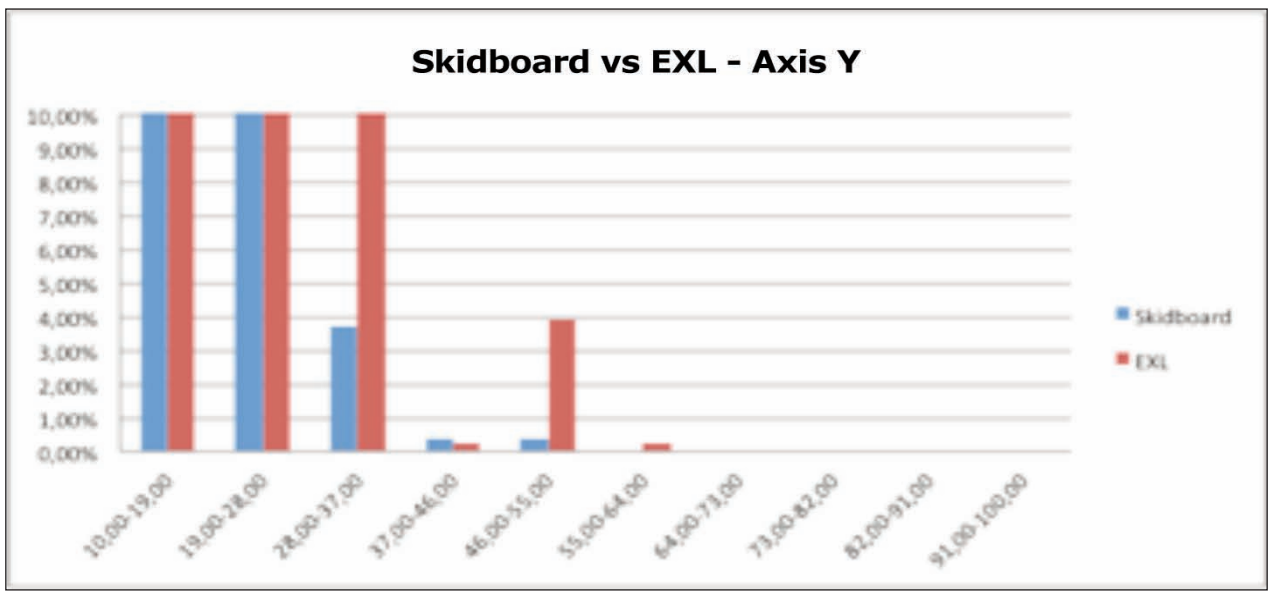

Figure 16. pitching differences between Skidboard and Exl65 on the chin

a maximum of five (11); we excluded the "lift-and-slide technique" that requires five operators (12), and the "6 + lift manoeuvre" which requires six operators (13). Team members were always three because at the Misano World Circuit the main activity allows crews of three health professionals each. We always used the log roll manoeuvre in compliance with scientific standards in literature (14). In particular, we used the "log roll push" because less strong than "log roll pull" (15). It was often necessary to reposition the patient to align the body longitudinal axis on Exl65 and aluminum scoop (16), unlike Skidboard which did not require corrective maneuvres. It is necessary to emphasize that the scoop stretchers are structured to be used opened to load the patient and closed below the body to lift it. Performing the loading with the scoop closed make the operation hazardous. Unfortunately, often world circuits rescuers do not use scoop stretchers properly, they load the patient on stretcher closed, probably due to rapidity. This evidence makes Skid-

Table 5. Pitching percentage values on the nape

TGX Value between/ Field (%)	Current selection / TGX: 10 -100	Current selection / TGX: 10 -100
10,00-19,00	76,19%	53,21%
19,00-28,00	23,08%	44,11%
28,00-37,00	0,00%	2,32%
37,00-46,00	0,37%	0,18%
46,00-55,00	0,37%	0,00%
55,00-64,00	0,00%	0,18%
64,00-73,00	0,00%	0,00%
73,00-82,00	0,00%	0,00%
82,00-91,00	0,00%	0,00%
91,00-00,00	0,00%	0,00%

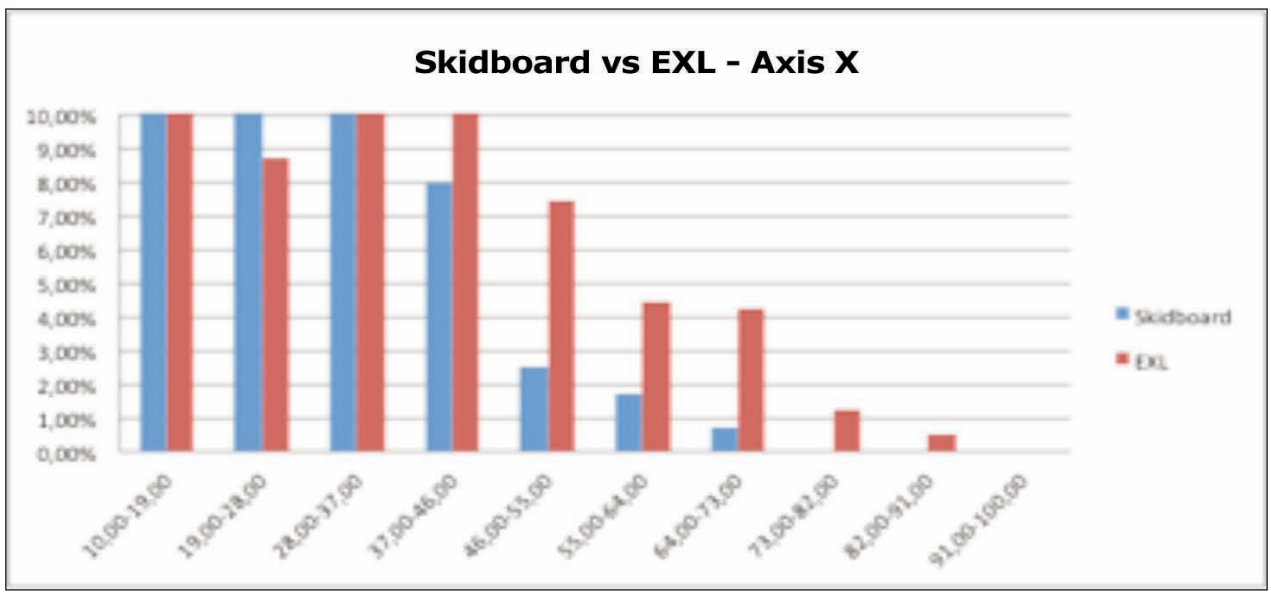

Figure 17. Pitching differences between Skidboard and Exl65 on the nape

board more functional and safer to do the log roll manoeuvre.

Risk Analysis

Tests involved three operators teams, men and women, they all reported they put more effort in raising the stretchers Exl65 scoop and aluminum than the Skidboard that they just dragged. The two women in the team often interrupted the lifting of Exl65 and aluminum scoop due to fatigue and tiredness. The lifting performed by three operators is much more stable and secure. Unfortunately, often the number of the rescue team in the world tracks consists only of two operators who raise the stretcher by grasping the head and feet: this position is very dangerous because the operator at the front walks backwards and is likely to stumble and fall because he or she cannot see the ground (Figure 22).

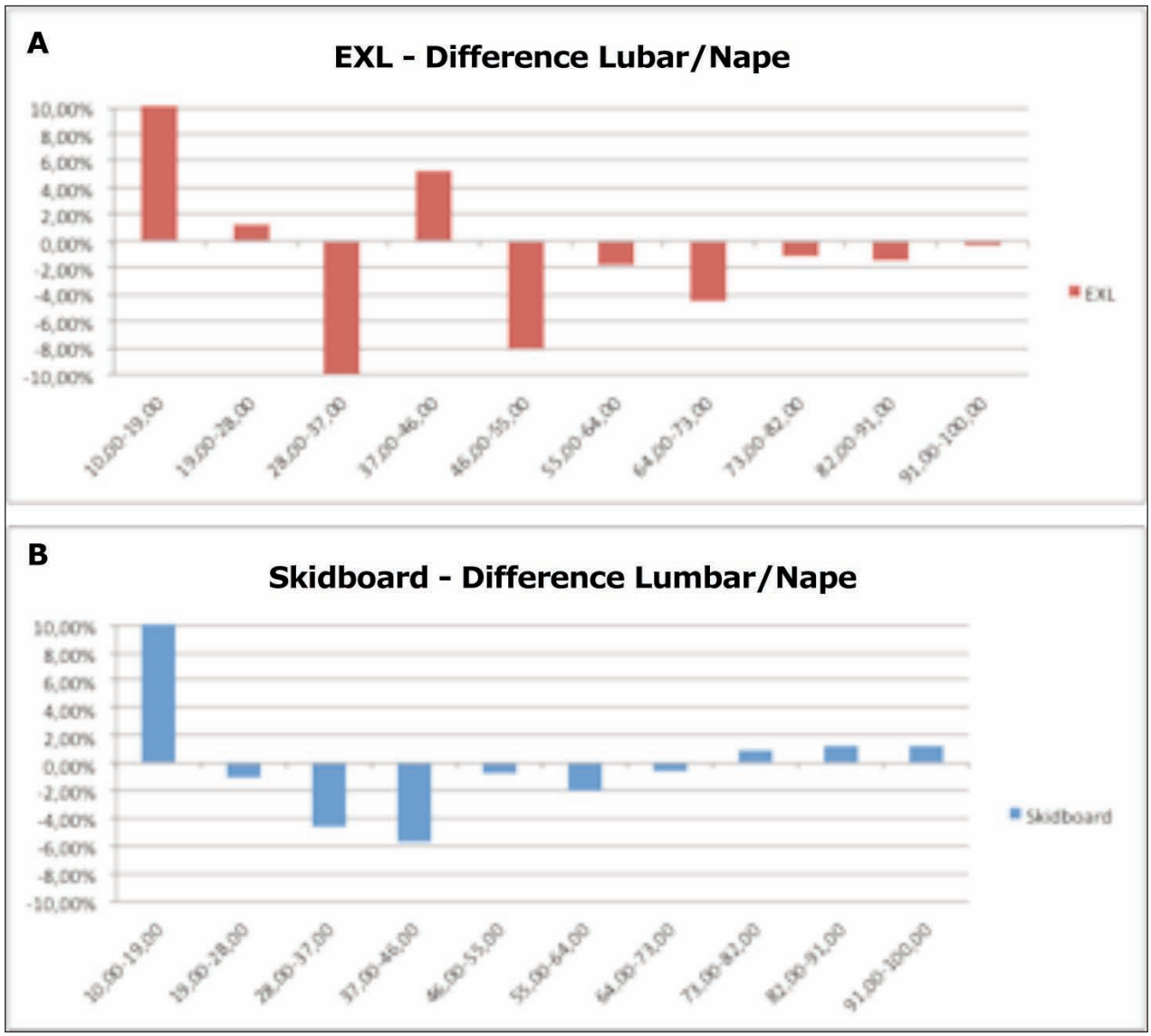

Figure 18. A) X-axis, Exl65, differences lumbar vs nape; B) X-axis, Skidboard, difference lumbar vs nape

If the operator takes the stretcher to walk forward is not likely to fall but s/he cannot see her/his partner and therefore does not notice if s/he has difficulties and/or falls. For a team of just two operators, the goal is to take the stretcher laterally, they can see each other, synchronise actions and manage difficulties. We think that the Exl65 best team configuration is three operators: the leader keeps the rider's head firmly in place during transport with Exl65 and the other two operators on the sides raise the stretcher. Skidboard requires only two operators for the transport. The leader fixes the head to speed up the execution and leaves two operators to drag the stretcher. In Figure 23, we report the physical principles underlying Skidboard.

Discussion

We detected few biases, but the aluminum scoop stretcher is inadequate to rescue the traumatized rider than Skidboard and Scoop Exl65, because it is not a spine board and because creates more stress than other

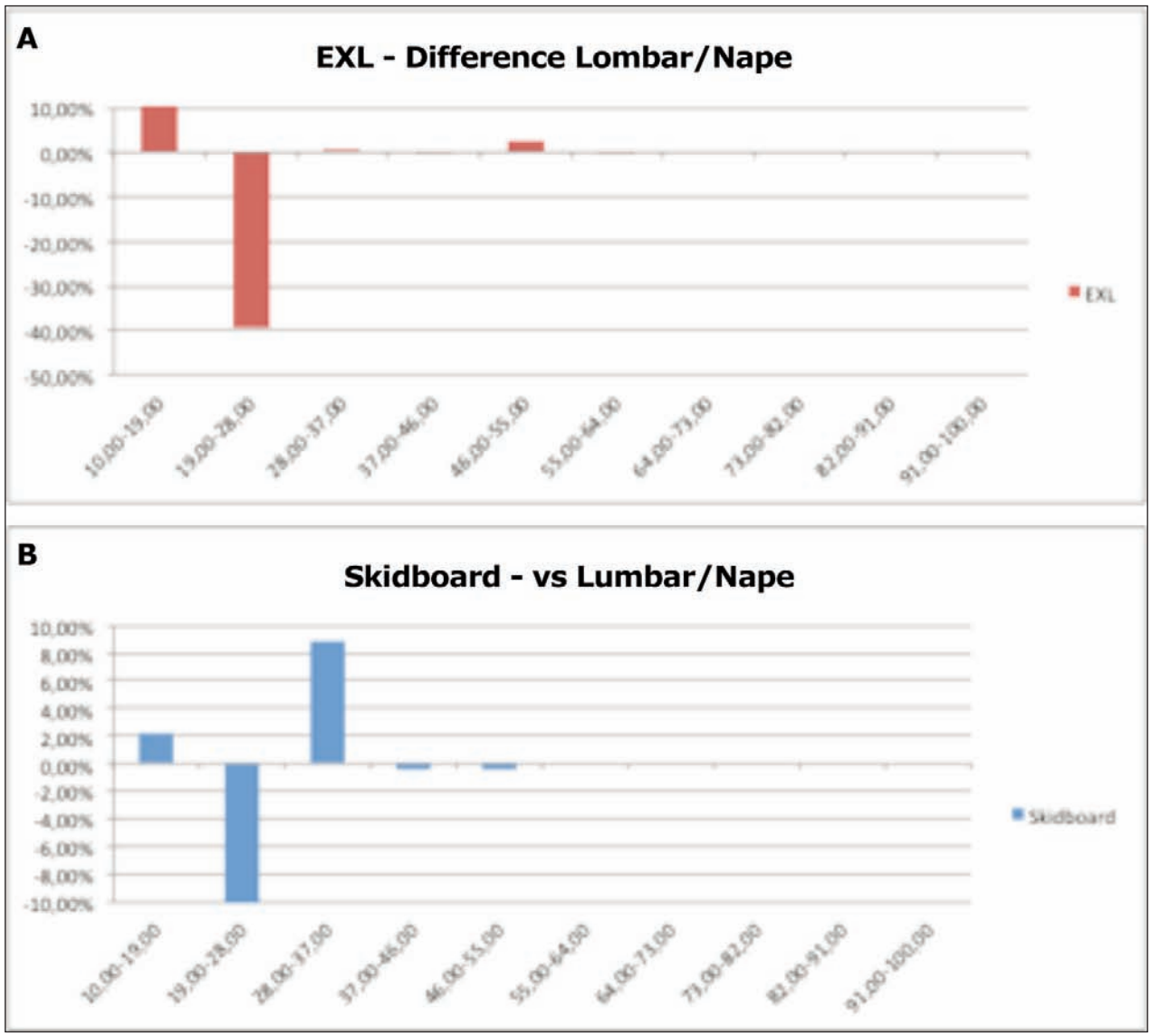

Figure 19. A) Y axis, Exl65, difference lumbar vs nape; B) Y axis, Skidboard, difference lumbar vs nape

stretchers. In fact there is not a fixing system for the body and the head of the patient. Skidboard ensures the aligned immobilization of the cervical spine during the entire rescue process, including dragging, unlike Exl65 that does not immobilizes the cervical spine and the head is in extension (Figure 11). This is not surprising when you consider that Exl65 does not fix the head with the helmet worn and has no headrest to align the spine. It is interesting to consider that Exl 65 has open bottom and the concave shape which welcomes the suit hump and makes the spine more stable against the roll in the transport, so it is less unstable even for the neck. The rest of the spine, even if tied on Exl65, moves more on Exl65 than on Skidboard especially rolling more than pitching. This finding is not surprising because the stresses dragging Skidboard are physically more noisy and we were expecting the body to absorb the vibrations and turn it into injury, but it is not so. Probably because the fastening system of Skidboard makes the body an integral block with stretcher, and the energy developed by skidding is dissipated in other forms, without injury to the spine. Exl65 seems to vibrate

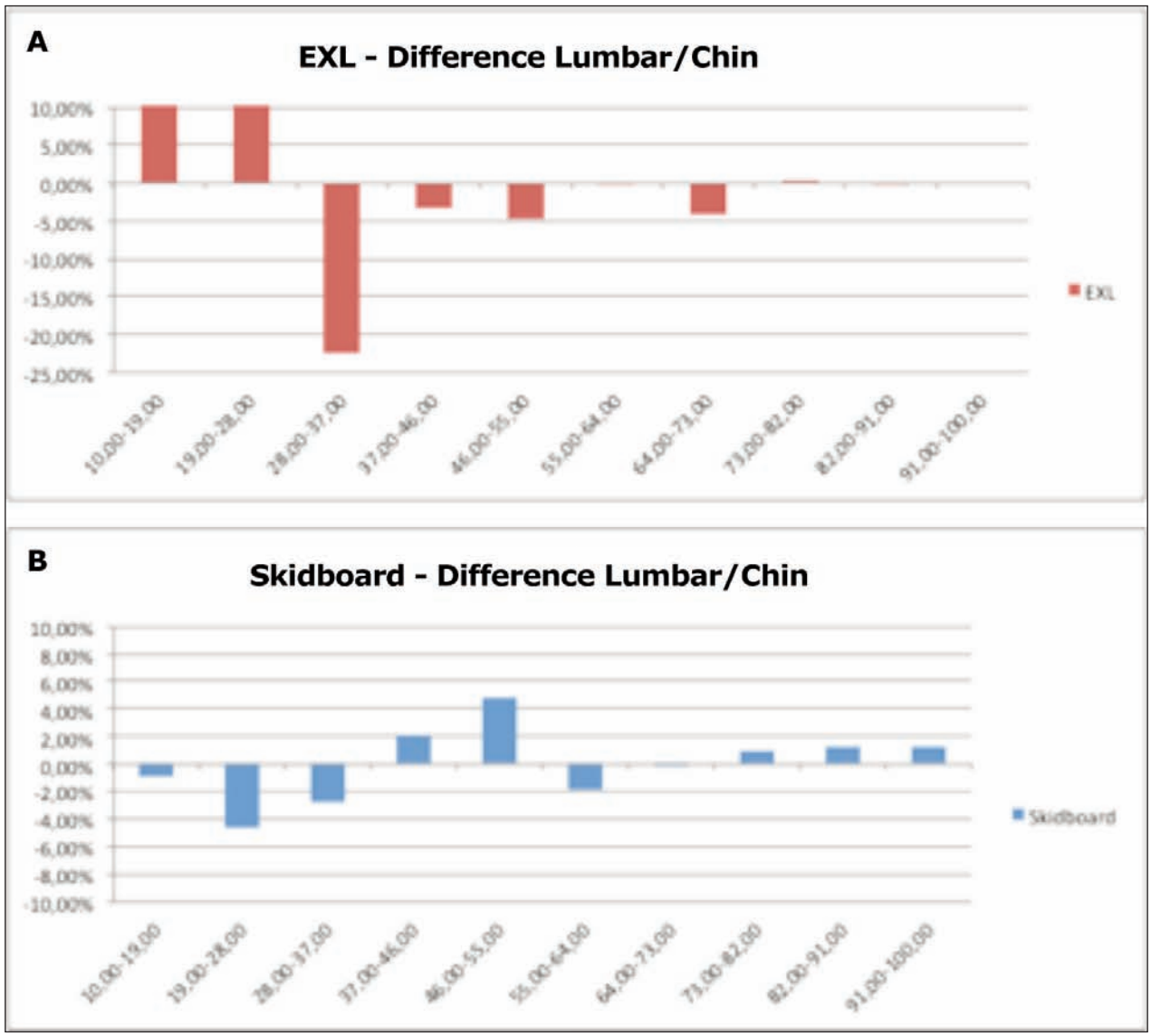

Figure 20. A) X-axis (roll), Exl65, difference lumbar vs chin; B) X-axis (roll), Skidboard, difference lumbar vs chin

slightly during the transport, however the operators perform instinctive ergonomic and compensatory acts that generate energy on the patient, although tied to the stretcher. Skidboard does not only discharge less energy on patient than Exl65, but also greatly reduces the severity of the fall of the patient and stretcher because only a portion is dragged few centimeters high. The same happens if an operator falls down. Compared to all stretchers which must be raised to be transported, Skidboard is more ergonomic. Indeed, it produces a second-class lever which is always profitable, because it has the load between the fulcrum and the effort force. For example, to load 100 kg of weight, two operators load respectively 37.5 kg each. The female crew, too, suffered far less effort using Skidboard than using the other two stretchers. Skidboard has the ergonomic requirements required by the italian law (17) because operators extend their arms and bend their legs to lift and drag the stretcher. The procedure can be performed by two operators only, but it twill increase execution time. Exl65 scoop stretcher was born to be open to load the patient, unfortunately this main purpose is almost nev-

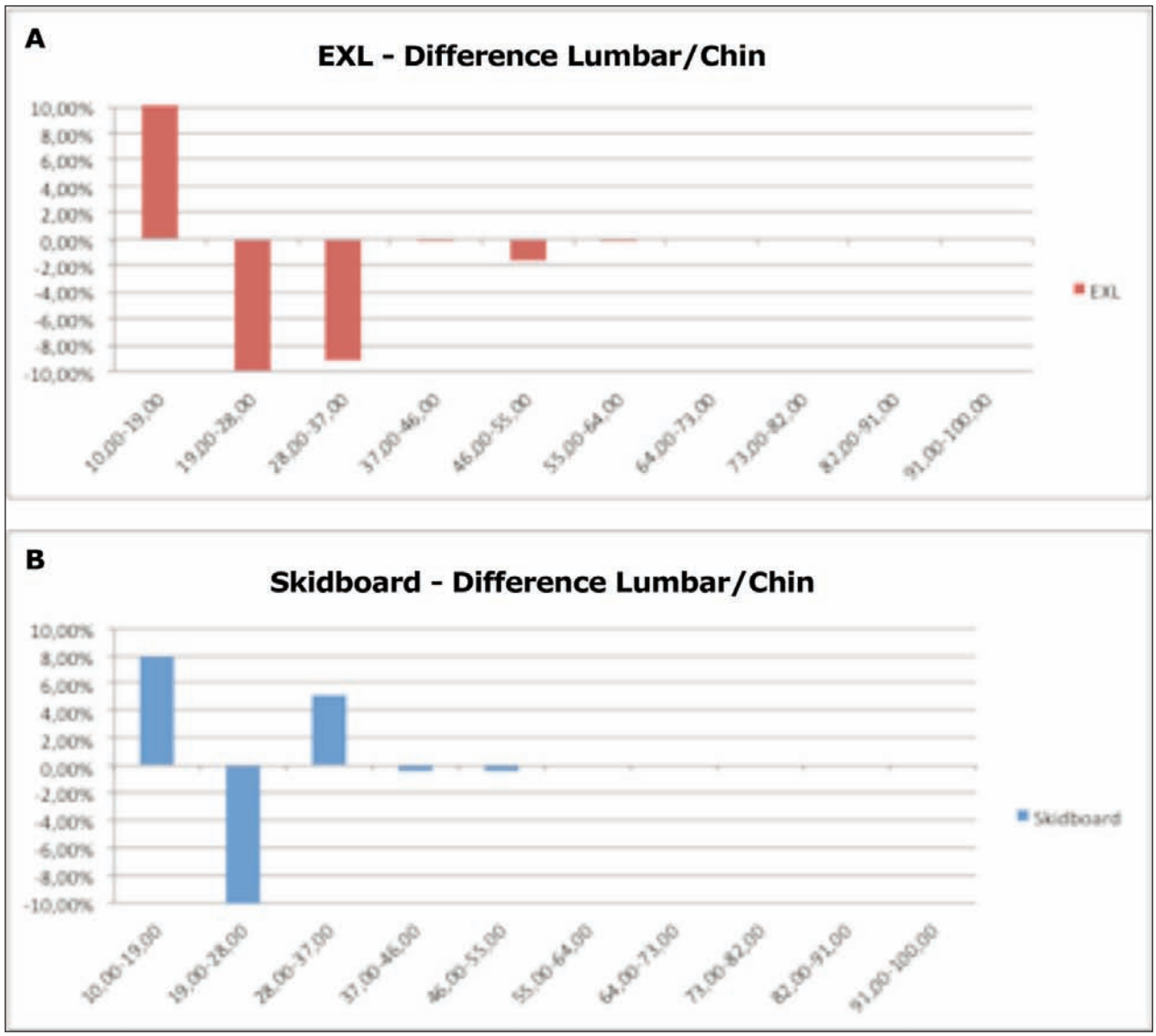

Figure 21. A) Y-axis (pitch), Exl65, difference lumbar vs chin; B) Y-axis (pitch), Skidboard, difference lumbar vs chin

Table 6. Drag time Skidboard

Drag time skidboard	25 mt
Average time sec.	31:23
Maximum time sec.	38:06
Minimum time sec.	21:00

Table 7. Time of complete procedure with Skidboard

Average time skidboard sec.	43:18
Maximum time skidboard sec.	53:07
Minimum time skidboard sec.	30:07

Table 8. Time of complete procedure with Exl65

Average time scoop Exl65 sec.	59:52
Maximum time scoop Exl65 sec.	80:00
Minimum time scoop Exl65 sec.	44:05

er used. In world circuits, almost always, the rescuers do not tie the patient on scoop stretcher, probably because they need to act quickly and because fastening belts need about a minute of time by skilled operators: one minute is probably excessive in world circuits. Anyway,

Figure 22. transport of a stretcher in Moto GP: the operator on the left walks backwards ⇐ the arrow indicates the walking direction

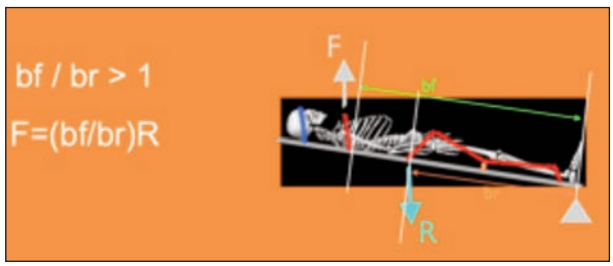

Figure 23. physical principles Skidboard – to lift a weight of 100 kg two operators need a 75 kg force which corresponds to 37.5 kg each.

Exl65 does not guarantee the helmet fastening because of the lack of suitable belts and the neck is always vulnerable all time during rescue and transport. The time to closely tie the rider to Skidboard and to evacuate the track, head and neck fixed, is about 43 seconds to reach a safe zone at 25 meters distance. Skidboard is about 17 seconds faster than Exl65 which must be raised about a meter, with the additional danger of falling. Because of obvious ethical reasons, it was not possible to check how much administer energy may be dangerous for the spine of the patient on the stretcher. Also, the actors who undergone tests were obviously healthy and using new personal protective equipment. The energy theoretically produced in rescuing should be zero, as much as possible, respecting the caution medical principle and because the physics laws remind that kinetic energy is potentially an injury. With due caution, we think that the main danger of injury, following crash, is the stretcher falling on the ground or the patient's falling from the stretcher, or the rescuer's stumbling and falling during transport. This is why it is important that adequate training of health workers be carried out, but this is not enought without a secure device, especially because the ambulance delivers a lot of energy on the patient, dramatically greater than the rescuers maneuvres, and it is important that the patient is strapped securely to withstand any stress.

Conclusions

The aluminum scoop stretcher is inadequate to rescue the traumatized rider. The log roll maneuver to load the patient on Exl65 it is more dangerous than the same manoeuver with Skidboard. Exl65 requires the opening of the scoop before loading the patient but it does not happen in many world circuits, unfortunately. Skidboard allows to bind tightly and quickly the patient to the stretcher, to bind the helmet also guarantees neck alignment and immobility during rescue and transport. Data show the strain on the cervical spine is significantly lower with Skidboard than Exl65. Maybe it is due to the complete lack of head fixation in Exl65, but the comparison nape vs lumbar spine and between chin and lumbar spine demonstrates that the entire spine is more firmly tied to Skidboard and therefore safer than Exl65. Data show that the patient does not undergo stress by Skidboard dragging over any grounds. Skidboard lifts the patient by few centimeters, so it is decidedly safer than Exl65. Data confirm that Skidboard administers lower energy to the patient's body than Exl65. Apparently, both stretchers do not deliver detrimental energy, in absolute terms, but it was not possible to prove it scientifically because of ethical reasons. Exl65 exposes the spine, especially cervical spine, to a significant rolling and pitching, caused by the rescuers' involuntary movements carrying the stretcher. From Skidboard the patient would fall from about 30 centimeters height, involving the upper side only because the other side is just on the ground. This heigth is less than Exl65 (1 mt about) and the resulting damage would be significantly lower, or null. Rescue speed is a factor that increases safety on track, therefore it is important in stretcher's evaluation. Skidboard allows more speed than other stretchers. Therefore, Skidboard procedure is safer because faster! Please note that Exl65 procedure was performed by three operators, unlike other

international circuits where there are just two operators. This is dangerous because it increases the falling risk of stretcher or of the patient from the stretcher. Unlike the other boards, Skidboard could be used by two operators only and be always secure: the leader places the helmet, then moves laterally to bind the patient, after s/he loads and drags with his/her fellow operator on the opposite side, without compromising the effectiveness of the procedure, only a bit slower than a three-operator crew.

This work is not subject to any conflict of interest.

Acknowledgements:

This work would not have been realized without the support of people and companies to whom the authors extend thanks and gratitude.

Below the list in alphabetic order:

Bailetti Simone, Betti Gianfranco, Bobeica Emilia. Campani Nicola (Northwall innovation), Cardinale Ivan, Celi Silvano (Dainese spa), Conte Cristian, Manuzzi Marco, Martini Gianluca (Northwall Innovation), Masi Lara, Melaccio Pietro, Pratelli Marco, Severi Sabrina, Tirani Giacomo, Urro Franca

References

1. Spinal immobilisation for trauma patients- Irene Kwan1,*, Frances Bunn2, Ian G Roberts3- Editorial Group: Cochrane Injuries Group-Published Online: 21 JAN 2009-Assessed as up-to-date: 30 JUN 2007-DOI: 10.1002/14651858. CD002803- Copyright © 2009 The Cochrane Collaboration. Published by John Wiley & Sons, Ltd.
2. Comparison of the Ferno Scoop Stretcher with the Long Backboard for Spinal Immobilization 2006, Vol. 10, No. 1, Pages 46-51 (doi:10.1080/10903120500366375). Julie M. Krell, MD1,4†, Matthew S. McCoy, MD1, Patrick J. Sparto, PhD, PT2, Gretchen L. Fisher, NEMT-P3, Walt A. Stoy, PhD3 and David P. Hostler, PhD1
3. Del Rossi G, Rechtine GR, Conrad BP, Horodyski M. "Are scoop stretchers suitable for use on spine-injured patients?" Am J Emerg Med. 2010 Sep;28(7):751-6. doi: 10.1016/j.ajem.2009.03.014. Epub 2010 Feb 25
4. ATLS Advanced Trauma Life Support, American College of Surgeons-Committee on Trauma- 8° edizione 2008.
5. PHTLS - National Association of Emergency Medical Technicians' Prehospital Trauma Life Support Committee, in collaborazione con il Committee on Trauma (COT) dell'American College of Surgeons (ACS) edizione italiana ASSITRAUMA cap. 3
6. Procedura operativa Poliambulatorio Misano World Circuit -12 marzo 2011.
7. PHTLS - National Association of Emergency Medical Technicians' Prehospital Trauma Life Support Committee, in collaborazione con il Committee on Trauma (COT) dell'American College of Surgeons (ACS) edizione italiana ASSITRAUMA cap. 3
8. Vedi contributi video sul soccorso in pista di D. Kato http://www.youtube.com/watch?v=BDPOkxtfjZc&feature=related, e M. Simoncelli http://sport.sky.it/sport/motori/2011/10/25/morte_simoncelli_caduta_barella_soccorsi.html
9. PHTLS - National Association of Emergency Medical Technicians' Prehospital Trauma Life Support Committee, in collaborazione con il Committee on Trauma (COT) dell'American College of Surgeons (ACS) edizione italiana ASSITRAUMA cap. 3
10. PHTLS - National Association of Emergency Medical Technicians' Prehospital Trauma Life Support Committee, in collaborazione con il Committee on Trauma (COT) dell'American College of Surgeons (ACS) edizione italiana ASSITRAUMA cap. 3
11. Del Rossi G, Horodyski M, Conrad BP, Dipaola CP, Dipaola MJ, Rechtine GR. Transferring patients with thoracolumbar spinal instability: are there alternatives to the log roll maneuver? Spine (Phila Pa 1976). 2008 Jun 15;33(14):1611-5. doi: 10.1097/BRS.0b013e3181788683.
12. Del Rossi G, Horodyski M, Conrad BP, et al. Evaluating the effectiveness of the six-plus-person lift transfer technique in comparison to other methods of spine-boarding. J Athl Train 2008
13. Del Rossi G, Horodyski M, Heffernan TP, et al. Spineboard transfer techniques and the unstable cervical spine. Spine 2004;29(7): E134-8.
14. Jeffrey D. Orledge, MD, Paul E. Pepe, MD. MPH Out-of-hospital Spinal Immobilization:Is It Really Necessary?
15. Swartz EE, Del Rossi G. Cervical spine alignment during on-field management of potential catastrophic spine injuries. Sports Health. 2009 May;1(3):247-52.
16. Del Rossi G, Horodyski M, Powers M. The effect of training on spineboard transfer technique performance. J Athl Train 2003;38(3):204-8.
17. D.L. 9 aprile 2008 n. 81 - coordinato con il Decreto Legislativo 3 agosto 2009, n. 106 -Attuazione dell'articolo 1 della legge 3 agosto 2007, n. 123, in materia di tutela della salute e della sicurezza nei luoghi di lavoro - Sezione IV FORMAZIONE, INFORMAZIONE E ADDESTRAMENTO Art. 36.

Accepted: 30/08/2013
Correspondence:
Dr. Enrico Berardi
Medical Doctor
Misano World Circuit
E-mail: docringhio@gmail.com