Commission of Material & Techniques

Central School of Alpine of
National Commission of Alpine School & Alpine Skiing (CNSASA)

Italian Alpine Club

Harness Used for Climbing Ice and Walls

Comments on film produced in 1997

March ‘98

Translation credits from Italian to English
Fabio and Tony Lacentra

Position of the central school of alpinism

Intro: 1 Defining the 3 different harness systems

i) Single sit harness
ii) Sit harness and chest harness attached by rope.
iii) Sit harness and chest harness free flowing form rope.

Body harness only marginally discussed due to lack of industry use.

In the 1960’s there was a disagreement in the UIAA on how to tie into either sit or body harness. Due to the fact that these attachments put excessive force on the spine some agreement was reached that the load/force should be transferred to the hamstrings. This should elevate the pressure on the spine. There is still doubts as to the distribution of force and the positioning of the body with the sit harness compared to a combination system. Further more there is no doubt as to the tie in when climbing on ice/glaciers.
In regards to tying in for vertical climbing there are advantages and disadvantage, we will try to explain adv. & disadvantage as reviewed in the video by Govine Duca. Our theme maybe reexamined by the UIAA harness security review.

2. The test/experiment conducted by School National of Ski & alpinism ENSA in Chamonix, France.

Jean Franch Charlet, carried out 2 experiments:

1. On ice with partner falling into a crevasse
2. A partner falling on a wall.

In all experiments a mannequin was used which was dropped with a factor **1 ma (factor 1 fall?)** and filmed with a high speed camera & references in order to calculate acceleration.

Conclusion:

On a glacier: If tied with a sit harness the fall was easier to hold.
Those tied in high (on chest) are pulled forward.
Those tied in low are pulled more into a seated position.

On the wall: Charlet is convinced that sit harnesses are superior by explaining the draw-backs of the combination sit and chest (combi)

1. If feet fall first: if the tie in is not correct the combi results in forces on the thorax & can restrict breathing.
2. A head first fall: with a sit harness the victim remains in a head down position through the fall. However with the combi the victim is briskly brought upright, but but during this brisk up-righting there may be a whiplash effect. this maybe with enough force to cause spinal lesions and the second pull is a forceful thrust towards the wall. Charlet does not dedicate much attention to sit harness tie in with the body horizontal at moment of impact force because he believes it is an improbability for the body to be in that position. He believes that the legs will end-up upwards, thus limiting the rearward curvature of the spinal cord. The Italians speculate that the leg loops provide corrective support in a fall.

3. The Italian experiments

Simulation of holding a fall on a glacier.

Passo Rolle - Dec. ‘96:

The experiment was conducted on horizontal glacial terrain (snow covered) with an 80kg mass and the friction at the edge was considered similar to friction resulting from a piece of wood at the edge.

Fall tower at Padova - Mar ‘97

A fall tower was set up using an electrical tower, a rope with a pulley and an 80 kg mass load and having the belayer standing in a sand trap. The fall was reproduced using both types of harnesses both sit and chest combi.

Glacier of the tooth of the giant Monte-Blanc, Jul. ‘97

2 persons with 10m of rope between them on flat terrain. #1 falls into a crevasse.

Simulation of a fall on a wall

Tower of Padova, Mar ‘97

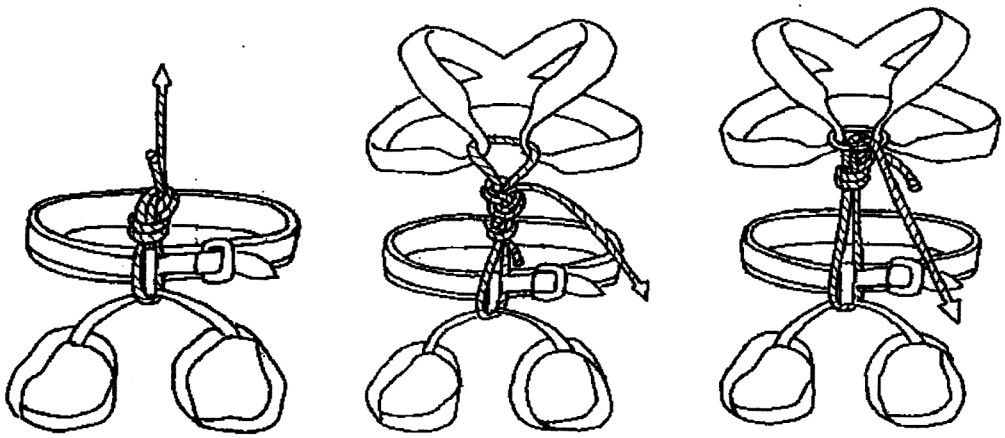


Fig. 1 - a) Sit Harness
b) Combination Harness with fixed tie-in
c) Combination Harness with floating Chest tie in

With a fall factor of @ 1, a 4m fall, and a vertical net was used to simulate a wall inside the fall area, in order to demonstrate the movement of a body towards the wall after the 4m fall.

Climbing Stadium di Arco, Mar '97

With a fall factor of about 1 to 2 and a fall of 7m. The experiment was conducted to allow for a pendulum to occur.

- In all instances the load was projected in a pendulum towards a simulated wall.
- The fall was never perfectly straight in line with the anchor.

4. <u>The experiment with a Mannequin conducted in Tolosa.</u>

- Using an antrophomorphic mannequin & high speed film.
- Both types of harness systems were examined
- A fall factor of 1 was generated.
- With a static hold the arrest impact is higher than a dynamic one. This was done to give the best evidence from the mannequin, however there is a potential for a static hold on the rope due to the contact with rock or carabiners.

5. <u>Our consideration on the two types of harnesses.</u>

Assumptions:

- It would be best to associate our findings with the video produced in 1997.

- No discussion on body harness will be used because if they are good they will conduct themselves similar to a combi. body harness have attachment points too high and bring force onto the thorax & spinal cord.
- The combi - details of the tying in are not covered, we suggest the use of a figure “8” as a stopper knot at the chest harness.

5.1 The advantages of the sit harness
- More practical for adjusting of clothing, more adapted to freedom of movement.
- Some noted the weight of the rope on shoulders with the combi system. If the rope is not fixed in chest harness there is a greater load on shoulders than just the weight of the rope.

Advantage of combination harnesses.
- Not necessary to tighten harness to tight even if a fall head first.
- More attachment points for climbing gear.

note: the risk of slippage with a not properly tightened sit harness cannot be overstated.

5.2 Test on glaciated terrain.
- Holding partner who falls into a crevasse:

The only advantage of the combination harness; is the suspension of the fallen climber in a combi tied off low is more difficult to hold and more painful, but since the priority is to hold (especially with a backpack on) the combi tied off low is the best.
Advantages of the sit harness; test on snow and sand agreed with Charlet. With a high tie point the head (of the arresting person) is propelled forward. While with the sit harness the arresting person tends to assume a rearward lean and flanked position with feet ahead.

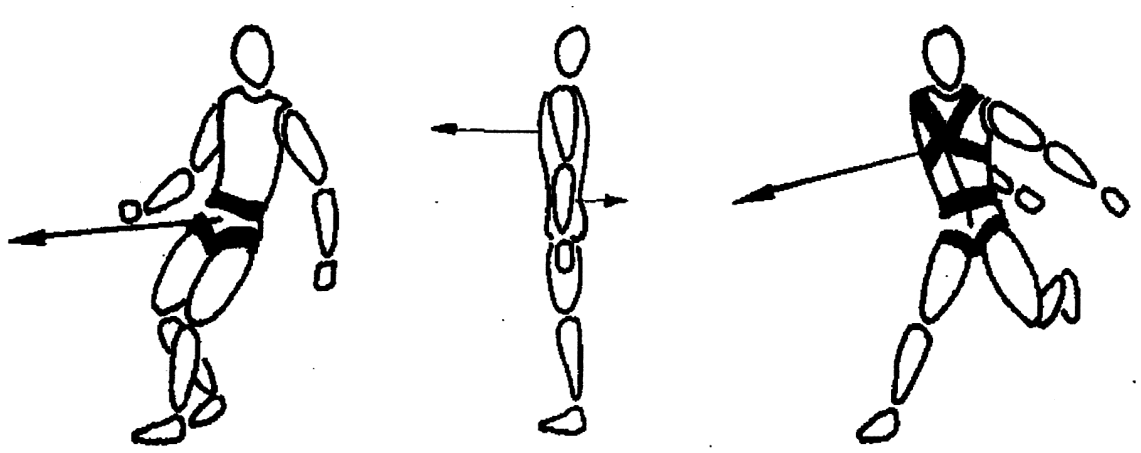


Fig.2 - a) Sit harness - force of inertia in line: the body is pulled only Forward
b) Combination harness- there is a coupling of the force of the rope + inertia
c) Combination Harness- rotation forward and downward

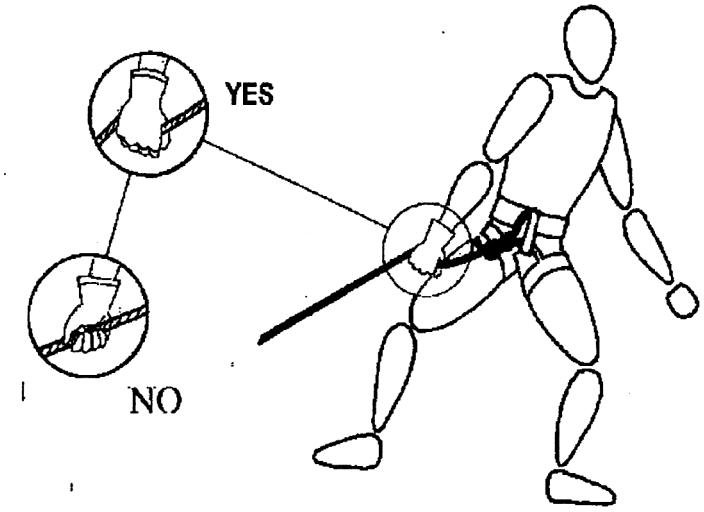


Fig. 3 - Use of body position and hand friction in arresting the rope, hand friction applied in a palm down manner.

At first glance the projection of the head forward with the high tie in due to the large distance of the tie in from ones feet (which is true).
This is not the principal point;
The distance of the tie in and its relevance to the ground does not create great differences between a high or low tie in pint.
The important fact is the dynamic force that is created at that particular point in time.

- As the rope accelerates the body resists with the force of inertia proportional to the mas of the body & acceleration itself which is centered at about the height of the umbilicus (belly button).

With the sit harness the force is applied at about the height of the umbilicus and it is in line with the force or inertia.
The high tie in point; there is a coupling of forces between inertia and the force of the rope at the high tie in point, which causes the arrester to be pulled head & shoulders forward. Resulting in the arrester being toppled forward or if the pulling force is weak or the fallen person not so heavy will cause the arrester to take staggered steps forward in order to accommodate the load. (see fig #2)
Speaking dynamically the sit harness is closer to the bodies central mass as opposed to the high tie in point. With the sit harness the load is quickly transferred to the leg muscles thus allowing for a more stable arrest.
With the high tie in the load must be absorbed more by the back muscles and resulting in a requirement to take staggered steps forward to regain balance.

Use of a prussic, or a held cord acting as a dissipater between the rope and the harness.

It seem advantageous to maintain a grip on the rope in order to reduce the pull on the harness. Holding the roe allows for an early warning system and allows the arrester to prepare themselves for the pull. Holding the rope with the hand is more effective in allowing for slippage than to use a prussic (figure #3). With the prussic the body is solicited to being pulled forward. The hand held rope method the load has the possibility to come higher than center of gravity (umbilicus) rather than directly onto the harness (the hand creates a shock absorber effect).

5.3 Falls on the vertical wall

We examined three situation; (in which the rope comes tight)

1. falling with head up (vertical)
2. falling head first (vertical)
3. falling horizontally.

Note: because the fall happened against the vertical wall, the pull of the rope seemed to result in a swing toward the wall.

5.3.1Fall with head up (sit harness)

The two typical results can be seen (figure #4), usually the body maintains an upward orientation especially as the body is held ridged (fig. 4.A), in which the body is held more compact and allows better access to the rope. The film shows that if this does not happen and the arms are higher then the body to be thrown backwards (Fig. 4-B.)

Fig.4 - FALLING WITH FEET DOWN, WHILE IN A SIT HARNESS

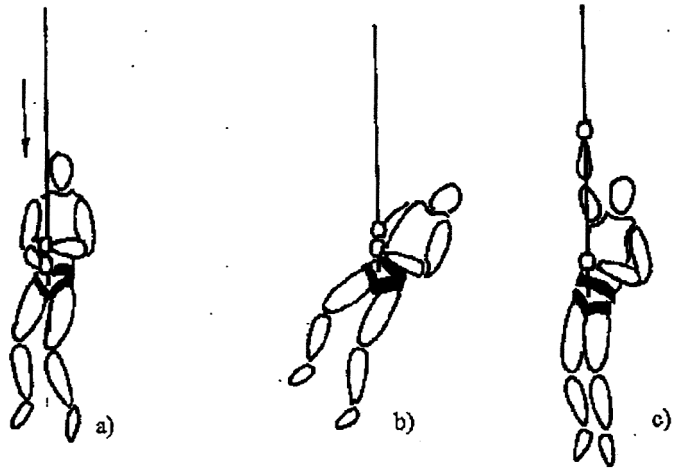


Fig. 4a Falling in a head-up position
Normally, falling people will grab the rope (b). When suspended at the end of a fall equilibrium can be maintained with one hand on the rope (c).

Fig. 4 - FALLING FEET FIRST, WITH SIT HARNESS

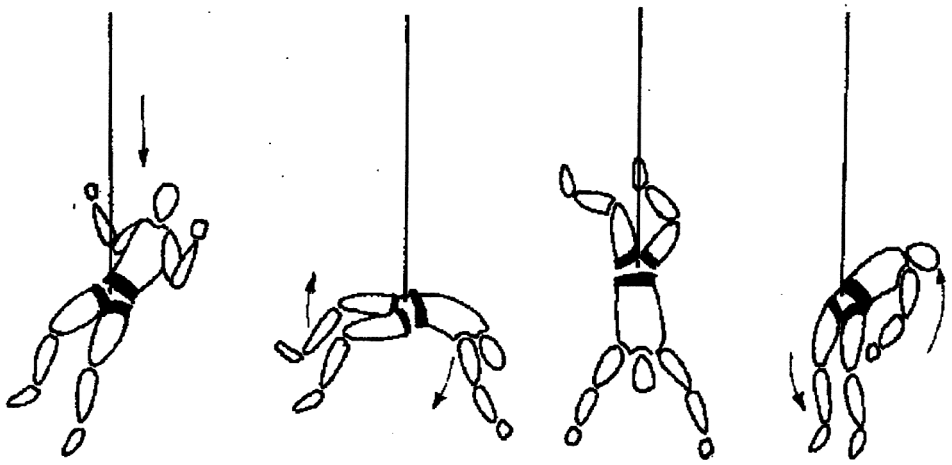


Fig. 4B - When the fall is arrested, if the hands are up, there is a rotation of the body which is often corrected after momentum is lost

In this case the position of head up will occur near the end of the arresting of the fall. The jarring the body receives at the end of the arrest is more violent in the combi set up which is less dispersed than in other systems; this is verified by stuntmen who use this system.

Combi Harness

This case is not demonstrated in the figures, the bodies reaction is easily predicted. This is considered the best harness system for this case because it absorbs the shock over the entire body and keeps the body in the most upright position through the arrest even when the person is unconscious, this is not true for the sit harness.

There were few cases noted of a slingshot effect but the number of instances were not note worthy.

The projection of the body forward toward the wall is not much faster than that which occurs with the sit harness.

5.3.2 Head down

Note-this case is more frequent in fall in the mountains.

Sit Harness

In this case please refer to fig. 5.

If the body is in a vertical position (fig. 5A), the body is maintained in a position of head down though the fall and arrest and then the body is projected back and head first into the wall. If the body is only inclined rearward (fig. 5B) it will usually be righted at the end of the arrest.

Combi Harness

In this case please refer to fig. 6.

The position of head up is quickly acquired with a rapid rotation, which can cause a whiplash to the next; this was demonstrated during trials and verified by the stuntmen.

How severe this would be is unknown because all subjects wore neck collars to reduce chance of injury. Visually an acceleration was not observed at the head level comparable to the French mannequin tests which were arrested in a static manner. It seems correct in saying that the whiplash can be proven however its relevance was statistically not proven. The French trials on the mannequin result in a very relevant acceleration, however the results are still lower than what is considered to be dangerous. A projection towards the wall is usually with head up facing the wall, this projection is more violent with the combi harness than with a sit harness; this is due to the acceleration which is gained during rotation and re righting of the person toward the wall.

5.3.3 Body Horizontal

Unfortunately there were not many satisfactory numbers of test in this position due to the potential risk of injury to the volunteers. In two cases, with a sit harness and the body in a horizontal position at the point of impact there is clearly an arching of the back even if it is reduced by the thrusting of the legs upward due to the leg loops of the harness (fig. 7); the stuntmen complained of pain which lasted a day after the test. The same horizontal test was not conducted wit the combi, but it is safe to assume that the same type of force would be concentrated on the neck.

Fig. 5 -FALLING HEAD DOWN WHILE WEARING A SIT HARNESS

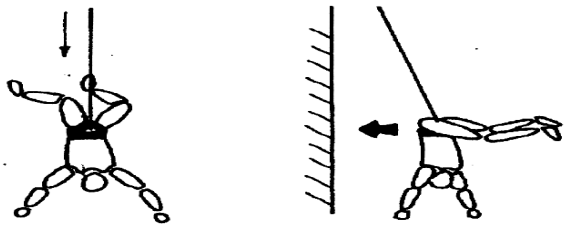


Fig.5A - Body Vertical at moment of impact. Usually the body is maitained head down and is pulled toward the wall, striking the spine.

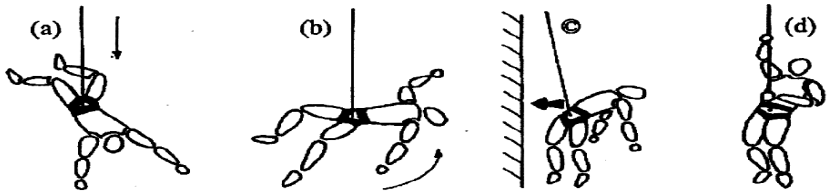


Fig.5B - Body inclined backwards at moment of impact. Usually the body flips (b,c) and will right itself to vertical in phase (b). The hamstrings push upward and force is applied to the lower back, thus causing arching of the back

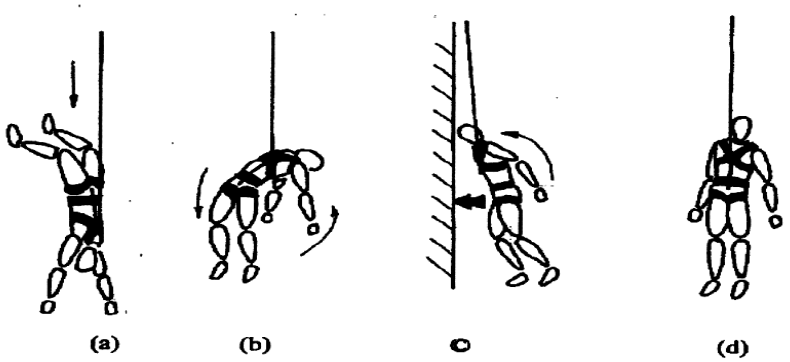
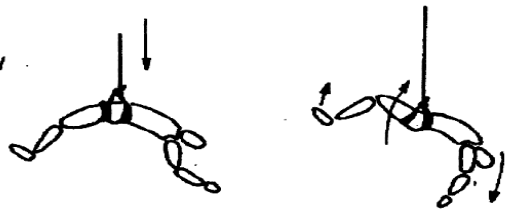


Fig. 6 - Combination Harness, falling with head down. It is noted there is a force of acceleration and rotation (b) and a projection of the body towards the wall (c).

Fig. 7 - Sit Harness:
If the body is horizontal at the moment of impact there is a severe arching of the back.



5.3.4 Falling while wearing a backpack

This test was not conducted, due to the lack of enthusiasm of the volunteers and that no one disputed the advantages of the combi harness in this circumstance.

5.3.5 Suspension of unconscious climber

The obvious advantages of the combination (combi) harness do not require any further comments.

6. Conclusion

As we promised, there are no definite conclusions to be found, this was only an exercise in exploration and observation with sufficient objectivity. The element most important is to justify the validation of the probability of the most dangerous events, in which falls are incurred using the two types of harnesses. These test are unable to add much to research already done in regards to horizontal body position (at moment of impact) with or without backpack, the only data available refers to the data from cadavers of DAV (private notes of Pit Schubert). There are 20 cases of spinal fractures, which about half are a clear result of a jolt caused by the harness/arrest and not due to striking rock. It must be said for now we can only accept the common sense and for each alpinist to weigh the pros and cons of each system. Therefore it is possible using a mannequin that details can be gained of the horizontal fall with and without a backpack. For now we are only able to provide the reader with the following condensed table of the considerations expressed above.

Situation: Travelling on a glacier holding a partner who has fallen into a crevasse.

Wearing a Sit Harness:
Good Results, even better if there is a use of a dissipater i.e. holding of the rope in the hand (not using a prussic). If a prussic is to be used do not hold it with a hand. The sit harness is also advantageous in the activities following the arrest.

Wearing a Combination Harness:
Not recommended (arrester is projected forward). If wearing the combi, on should tie in directly to the sit portion of the harness.

Situation: Falling in a head up position.

Wearing a Sit Harness
Both are good harnesses. Modest risk of the faller flipping.

Wearing a Combination Harness
Both are good harnesses. Modest forward pull on fallen climber. A recommended harness system when climbing with a backpack.

Situation: Falling in a head down position.

Wearing a Sit Harness
It is possible for the climber to remain head down and hit the wall with their back/spine.

Wearing a Combination Harness
There is a violent re righting into a head up position with a whiplash effect on the neck.
There is a stronger projection towards the wall, but often with feet forward and facing the wall.

Situation: Falling both head first and/or feat first with a backpack

Wearing a Sit Harness
Greater risk of being is a horizontal position at moment of impact/arrest. Remaining in a difficult position while being suspended after the arrest.

Wearing the Combination Harness
The Combi was better.

Situation: Falling in a horizontal position.

Wearing a Sit Harness
Risks to the spinal cord.

Wearing a Combination Harness
Better system, even if there is a whiplash to the neck.

Situation: The person arresting/holding the fall.

Wearing a Sit Harness
A small risk of being flipped forward, especially if pulled from the side.

Wearing a Combination Harness
Best System.

Harness Discussion
The position of the Central School of Alpinism
Notes from the Director

During courses of alpinism most instructors use only sit harnesses however the manuals and regulations of the CNSASA insist that all students use either the fullbody or combination type harnesses. This variation between types of harnesses used by the instructor verses the ones the students are forced to wear causes some uncertainty to the students as to what is the best system; for many years I had thought that the schools should reconsider their position in regards to their chosen harness system, weather to modify them or at the very least justify why the system was chosen. This would be done to alleviate the difficult contradictions which the student finds themselves in when taking a course and from what they may find in specialized readings in reference to this topic.

These considerations in addition to a recent manual in which an article from J.F. Charlet (comparing the harness systems), have convinced me to pursue this problem to find a satisfactory answer. The manual of (Allen Fyffe and Iain Peter- "The Manual of Alpinism", Idealibri, 1990), the reference to harnesses it reports: **Today's harness have reached a high grade of perfection and they are divided into two large categories: sit harness and high tie in point. In general today most people prefer the sit harness, however there are contradictions particularly when used on high mountains (mountaineering).** In review of the test there seems to be more instances with the sit harness than any other.

Other considerations are presented in Charlet's article "Quels baudriers choisir?Baudrier cuissard et baudrier complet", which conclude that: **"wearing a high tie in harness is very far from being as secure as we would think. In effect the high tie in point is far away from the center of gravity of the climber, creates a head down position during the arrest of the fall and creates a strong rotation force with great acceleration."**

To revisit the problem of the harnesses, on 7 Nov. 1996 I wrote a letter to all the instructors of the Central School of Alpinism (SCA) and added a copy of Charlet's article. I requested that they write me in regards to Charlets findings and the use of the sit harness in both mountaineering and free climbing courses. Further if there were no objections I would publish this article, followed by a declaration of the instructors of the SCA favoring the use of the sit harness in all the climbing schools.

This imposed use of sit harness was not completely agreed upon by some instructors, although not having any objection to the sit harness, they requested further testing before a final decision was to be rendered. The instructors reservations towards Charlets experiments were that the results were too unbalanced towards the sit harness, from what was known of the tests with the anthropomorphic mannequin in a laboratory setting. To follow up these constructive criticisms and at the request of many instructors I turned to the Commission of Materials and Technology (CMT), to create such tests which were more realistic and followed the same guidelines as those tests conducted in France. I agreed that it was important to furnish the schools with clear proof which showed the differences, in cases of falling from a wall and arresting a fallen partner on a glacier and which harness was best for each instance. It was noted that the CMT was already considering programming an activity of study in this very area, also because the Commission of Security of the UIAA had already been solicited by J.F. Charlet to take a position on this particular argument.

After one year, a tight and good collaboration with the CMT brought a conclusion to the work; in particular in the realization of a video cassette which was sent to all the regional schools accompanied by an article explaining all the test conducted.

The experiment was reexamined at the Central School during technical meeting (Sept. ‘97). After lengthy discussions the school made a decision and is reported as such: **After all the discussions The Central School has decided that during all mountaineering courses and free climbing it is recommended that the combination harness be used. The use of the sit harness is recommended only when climbing without a backpack. In regards to movement on a glacier, the attachment of the rope to the harness has to be in a fashion as to only effect a pull on the sit harness.**

Another discussion emerged at the SCA as to the advantages and disadvantages of the use of each harness system in regards to the person falling or the one arresting the fall. It was reemphasized that the second runs a reduced degree of risk and that they could always climb with a sit harness even when carrying a backpack; it was important to note that this is not always true especially when traversing.

The discussion was then raised in regards to the fact that in most cases the lead climber does not have a pack and therefore should be able to use the sit harness; it was noted that in private and/or professional courses, the components of the rope team are altered on command (leader/second). Therefore we suggest that the two components of the rope team wear a combi harness when a backpack is to be worn.

This decision may seem restrictive for the young, or too permissive for the traditionalists. The SCA believes that this compromise is the most sensible solution to a problem which truly does not exist, like always in life the optimum solution is in each viewpoint.

Claudio Sant’Unione.