Test Review

NZMGA short-roping tests 2006

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There are two reports:
Report 1, published on the members' section of the NZMGA website
Report 2, published in the NZMGA September newsletter, currently on the open section of the NZMGA web site.

The Coroner's report following Erica Beuzenberg's accident recommended:
…to investigate whether there is any refinement to the guidelines on the use of, or techniques involved, or guide training, that might usefully be made as a result of these deaths in this case in respect of short roping. In addition to draw its members attention to the risks arising in the circumstances of this case.

The NZMGA newsletter September 2006 states:
The research described here is an initial study to determine the effectiveness of contemporary short-roping practices… The ***primary aim*** *of this study is to allow NZMGA guides to make well informed decisions about the appropriate use of various short-roping techniques as client safety management tools.*

The study involved two experiments:

Experiment 1 *to compare the techniques of :*
- combination of arm and waist-lanyard load absorption technique
with
- arm load absorption technique alone.

Experiment 2 *to measure the force generated during a client fall.* Report 1, pages 3 & 4.

Comment re experiment 1.

The guide stood with stable footing and a force was applied through the rope by 2 people from below. The force was ***steadily*** *increased until initial failure was achieved and the guide was pulled from their footing.* Report 1, page 3.

This important piece of information is missing in the summary and has also been omitted in Report 2. This information needs to be stated front up!

It needs to be highlighted that this was a **gradual** application of force, not a sudden application as one would expect in a real client fall. Experiment 1 measured a static situation not a dynamic one. In a static situation the guide has ample time to lean back in order to counterbalance the force on the rope. The two persons pulling from below were in full view of the guide. There was no surprise factor.

Experiment 1 simulated a tug-o-war on a snow slope, not a short roping fall. Naturally, in a tug-o-war the height at which the force of the rope acts on a person and the weight of that person are critical. One expects the outcome to support the calculation [(1)]. This is why yachties attach themselves with a sit harness (attachment at centre of gravity) in order to most effectively counteract the force of the wind in the sails. With gradual loading we can expect much higher holding forces than with sudden loading. The results of this experiment are therefore heavily skewed upwards and should not be used as an indication of what a guide might expect to be able to hold in a real client fall! **The suggested holding capability expressed in % of a guide's weight (up to 122%) is dangerously misleading!**

Had the experiment included a base line study for comparison, i.e. pulling with an attachment on the **harness only** without any arm support, the outcome would have without doubt shown **highest** holding power by far for **gradual** loading. Following the authors' logic it would then be best to short-rope with the harness attachment only! Guides know that this would in fact expose them to great risks as any sudden pull near their centre of gravity gives them little chance to counteract by shifting their centre of gravity. Intuitively guides have always done the right thing, holding the rope to the client in their hand when short roping. The arm acts like a shock absorber and buys the guide valuable reaction time. Particularly while moving, a small tug on the rope can be enough to unbalance the guide if the force comes directly onto the harness. [(2)]

Experiment 1 is of little value for *guides to make well informed decisions about the appropriate use of various short-roping techniques as client safety management tools*. It seems to be much more of a test of the strength of each guide than a test of technique! It may be useful information if you want to drag a heavy object uphill - this would naturally be easier with a harness than simply using your arm! **We cannot ask our clients to fall slowly!**

Comment re experiment 2.

This experiment was conducted to establish the forces that a falling climber can generate when being short-roped. Experiment 2 measured a dynamic situation, an actual sudden fall.

The following factors were held constant: Crampons used by the guide at all times…Firm snow conditions…relatively good sliding surface… Report 1, page 3.

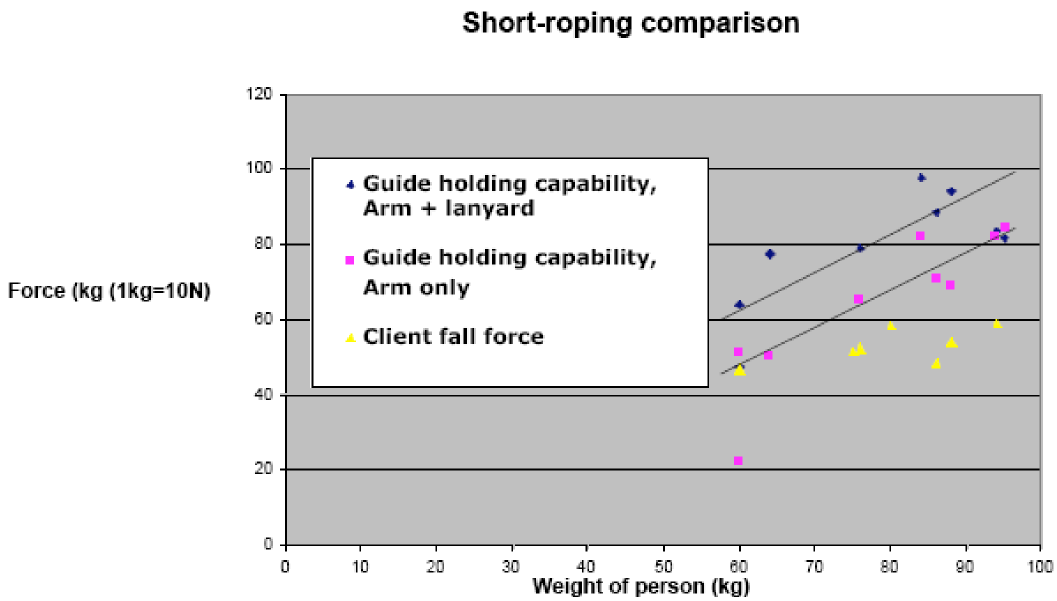
It is not clear from the report whether the falling climbers needed crampons or not. I assume they did not wear crampons, i.e. surface conditions provided sufficient friction to walk without. Photos in Report 2 indicate that. It needs to be stipulated that it is near impossible in firm snow conditions (not ice!) to keep the surface in such a way that friction remains constant after trampling the surface, and over considerable length of time, i.e. several days with changing day time temperatures.

The guide and client crossed the slope. Report 1, page 4.

I assume that only one guide (which one?) did all the holding while a variety of test persons did the falling. Both *guide and client crossed the slope.* The guide was using the lanyard tie back to the harness.

According to Newton's third axiom [(3)] one cannot measure a force generated in separation from a force held. They are both the same. The yellow points on the chart "short roping comparison" (both reports) represent both the holding power of one guide as well as the falling forces of different persons at the same time. This is the only way I can explain the strange outcome that there does not appear to be a linear increase of falling forces with the falling climbers' body mass. In order to make the statement, *The average fall force was … 67% of body weight of the person falling*, one would expect there to be a linear increase for the yellow points.

NZMGA chart1, plotting results of experiment 1 together with results of experiment 2:



Experiment 2 measured the holding forces of the same guide! The range of measured falling forces might be quite different for a different guide holding the falls, depending on how he/she manages to react to the fall of the client.

Hence the conclusions from experiment 2 are questionable.

The only conclusion that one can draw from this experiment is that on the given firm snow surface the particular guide was holding a variety of test persons' falls with a certain probability.

Comment re force gauge used.

According to the information provided by Marcus King the force gauge used in both experiments has a refresh rate of 0.001 second. One needs to be extremely careful using any force gauge in a dynamic situation. What was measured in all experiments was the peak force of any 0.001 s during the sampling. What happened outside this one thousandth of a second remains unknown. In statistical terms only the highest reading of a distribution was taken without any regard to the width of the distribution. A narrow peak of 0.001 s shows the same reading on the force gauge as a wide bulge of 0.5 s with the same maximum.

Recording only peak forces can lead to erroneous results: In order to get a complete picture one needs to look at the transfer of momentum (impulse), i.e. the product of force x time = mass x speed. Recording forces in a dynamic situation, i.e. when fast loading is applied, requires continuous data logging over a set time period, and integrating the respective forces over time. Only the comparison of measured impulses of both a "standard fall" and a test person's "standard hold" will enable us to determine whether that test person is likely to hold a person's fall in a given setting.

Example:

A force F = 500 N acts on a mass of 5 Kg for 0.001 s. What is the speed gain of that mass after 0.001 s ?

force x time = mass x speed

F(N) x t(s) = M(Kg) x v(ms^{-1})

1N = 1 Kg m s^{-2}

500 Kg m s^{-2} x 0.001 s = 5 Kg x v

v = 0.1 ms^{-1} . The speed gain of the 5 Kg mass is just 10cm per second.

If your arm has a mass of 5 Kg the 500 N force measured would just accelerate your arm to 10 cm per second, nothing more. You hardly bat an eyelid!

What about a 250 N force over 0.2 s acting on your entire body mass of 80 Kg?

250 Kg m s^{-2} x 0.2 s = 80 Kg x v

v = 0.625 ms^{-1} . Your entire body is moving at 0.625 m a second. You are very likely being pulled downhill!

Hence the use of any force gauge measuring peak loads only is not giving us enough information to draw any conclusions about "holding power" of a guide in a short roping, i.e. dynamic situation.

To compare the results of experiment 1 (static load) with the results of experiment 2 (dynamic load) by using the force gauge readings alone (NZMGA chart 1) is simply leading us down the garden path. Hence the conclusions regarding holding power of guides need to be dismissed.

Comment re discussion points.

The author gives a number of examples whether it is possible for a guide with a certain body mass to hold a fall of a client with a certain body mass. For the reasons given above these examples hold little value. Apart from that the author omitted to use his own calculated standard deviations to draw his conclusions. The results need to be given as a probability of holding a fall. Those probabilities make for uncomfortable reading! "Not possible" is a zero probability! Example 1 has certainly not a zero probability, it is a little less than that of the other examples!

The example of a guide having to hold two clients falling on a 30^0 slope needs to be expressed as a probability and needs to be highlighted! That example has been omitted from report 2.

Comment re units

There is a continuous mix up of units in the paper. Kg measures mass, N measures force. The relationship between the two is 1 N = 1 Kg m s^{-2}

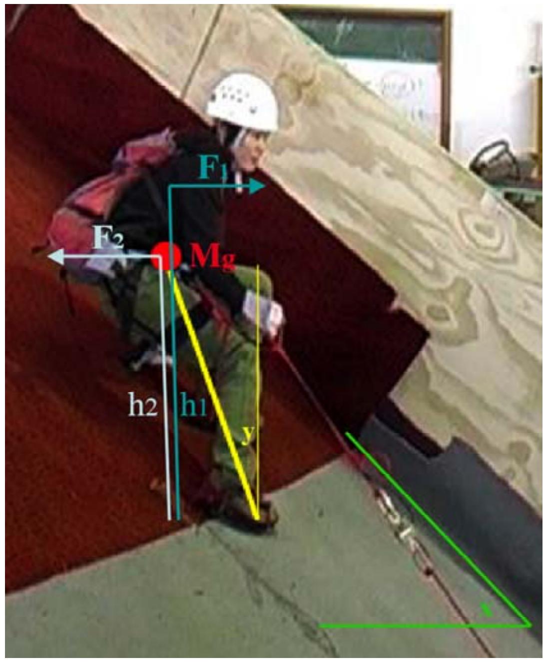
The chart "Short-roping comparison" states: 1 Kg = 10 N. This is simply wrong and does not belong into a scientific paper.

Weight is a force, not a mass. It is the gravitational force acting on a given mass.

The gravitational force acting on a mass of 1 Kg at sea level is 9.81N.

Notes

(1) Once the guide has reached equilibrium with the fallen climber we have a static situation as follows:



A guide with mass M_g is reclining with his/her centre of gravity by the angle y from the vertical. This results in a horizontal force F_2.

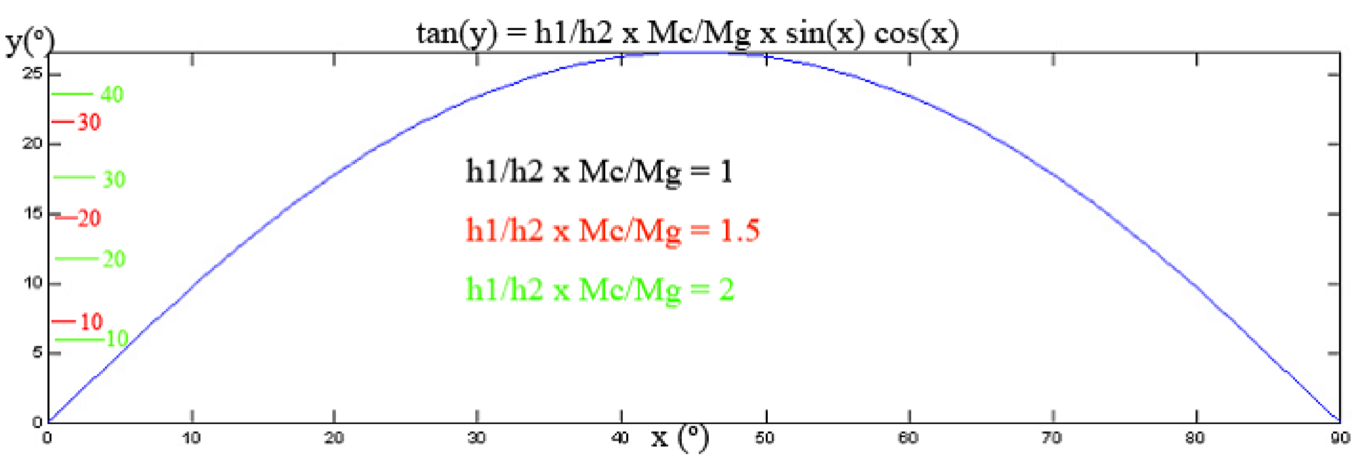
A client with mass M_c on a frictionless slope of gradient x is being held by the guide's rope. This results in a force F_1.

When balanced $F_2 \times h_2 = F_1 \times h_1$

$M_g \times g \times \tan(y) \times h_2 = M_c \times g \times \sin(x) \cos(x) \times h_1$, $g = 9.81 ms^{-2}$

$\tan(y) = h_1/h_2 \times M_c/M_g \times \sin(x) \cos(x)$

For different values of h1 / h2 and Mc / Mg the graph looks as follows:



If the reclining angle y is a measure for the difficulty of staying in balance then it is obvious that

- The smaller the ratio h_1 / h_2 the better
- The smaller the ratio M_c / M_g the better

This is the finding of experiment 1 of the NZMGA short-roping test series.

For slope angles > 45^0 the horizontal force F_1 becomes smaller again. However, the vertical component of the force acting on the guide increases with $M_c \sin^2(x)$.

The vertical component is not a matter of counterbalance it is a matter of the guide's strength and sufficient traction on the slope.

This describes a static situation, not a dynamic one. It applies to a gradual loading only where the guide has ample opportunity to lean back. It should not be confused with the guide's holding power when a sudden loading is applied.

In a dynamic situation, i.e. sudden loading, upper body movement is essential to absorb the falling climber's momentum (impulse) before reaching an equilibrium through reclining the centre of gravity. For this very reason guides need to hold the rope with their angled arm and not have it attached directly to their harness. If the load comes onto the harness too soon, i.e. before an equilibrium has been reached there is a high likelihood that the guide will be pulled over.

For full coverage of this topic please refer to the report on my short rope tests with Lincoln University: http://www.alpinerecreation.com/ShortRopeTests.pdf

(2) Please refer to test results of http://www.alpinerecreation.com/ShortRopeTests.pdf

and

DAV Sicherheitskreis tests 1982, Pit Schubert, as referred to in
whttp://www.alpinerecreation.com/shortroping.pdf

(3) Newton's Third Law: To every action (force applied) there is an equal and opposite reaction (equal force applied in the opposite direction). Another way of stating Newton's third law, an interaction between two objects, is that, if object A exerts a force on object B, object B will exert the same magnitude force on A, but in the opposite direction.

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Lake Tekapo, December 2006