Deutscher Alpenverein
Sicherheitsforschung

The climbing gym study of 2012

The DAV Safety Research Group conducted a comprehensive study amongst 11 German climbing gyms to shed light on the question 'How well do Germans belay?'. Conclusion: The most frequent errors could have been easily avoided.

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Gym climbers are playing a bigger and bigger part inside the climbing community. A search in the German Alpine Club's climbing gym base turns up more than 350 gyms. DAV Sicherheitsforschung (the German Alpine Club's safety research group) conducted a major study on gym climbers last year. Its focus was a closer look at the type of climber that frequents gyms, but also their skill level with respect to belaying.

A similar study had pursued almost the same goal eight years ago, but there have been a few developments on the nation's artificial walls since then: The Munter hitch, but even more the Figure-8, have mostly been retired as gym belay devices. Instead, more than 60% of belaying happens with a Tube today (Fig. 2). A bit more than a fifth belays with a semi-automatic device. The rest carry several devices or, pardon us, an exotic one like a Munter carabiner. The numbers of men climbing show a trend similar to the Munter hitch, but they still can't be called a discontinued model. It looks much more like gender equality coming to the climbing gyms. One things seems not to have changed much over the last few years: gym climbing is very attractive. Those who climb there tend to do it several times per week.

Besides sociodemographic data we were really interested in belay practices in gyms. To gain the clearest picture possible, we visited ten climbing gyms in Germany and one in Switzerland. We observed a total of more than 360 people climbing and belaying. We counted all known and safety relevant climbing and belaying errors. Each test person was observed in one climbing and one belaying process or action. To avoid affecting the outcome, the observation was preferably done without the test persons' knowledge. In comparison to the last study, where any misuse of a belay device was considered one error, we now valued identifying each individual error. That makes it possible to differentiate not only according to the frequency, but also to the severity of the observed errors.

But even only the frequency of observed errors allows the calculation of a first important parameter: the error rate. It is derived from the sum of all climbing and belaying errors

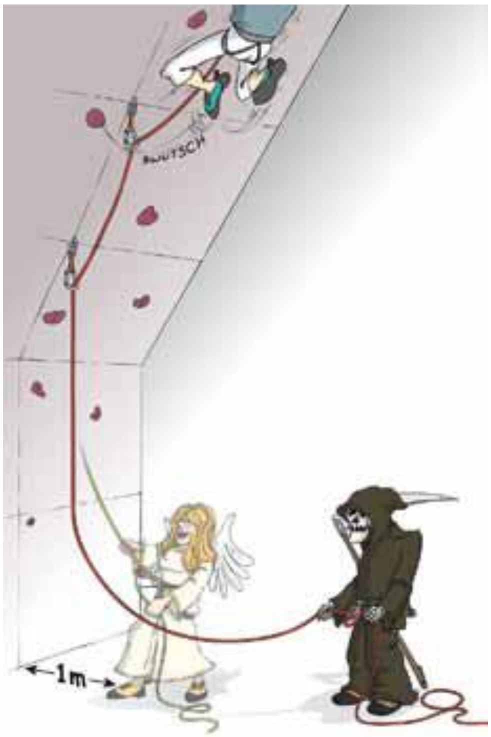


Figure 1. Too much slack und too far away:
Independently of the belay device, the combination of these two errors, creates a high risk of a ground fall for the lead climber, in particular at the first five bolts.

divided by the number of test persons. It indicates how many errors, on average, were observed per person and process. An error rate of 1.0 means that on average each test person committed one error. A comparison of the error rates of individual climbing actions, i.e. leading and following, and belaying a leader and a follower, shows that belaying a leader is clearly the most error prone process (1.43 errors per action). The values were even a bit higher than in the last study in 2004, but this is probably due to the significantly more differentiated capture of the belay devices used. The error rate in top rope belaying also rose lightly, while error rates in belaying leaders and followers dropped. In general we assume that error rates stayed constant or that they even dropped slightly.

So what concrete errors are hiding behind the error rates? We limit this article to the errors while leading, because errors are more frequent here, and there is significantly more leading. Besides, the errors are the same in both actions.

In lead climbing an error was observed in every second action. The most frequent error by far was missing a partner check. Only 12% of test persons executed a full partner check, consisting of a check of the belay device, the tie-in knot, and the security of the end of the rope. We assumed that harness closures were checked in the beginning of the time at the gym. Now one can argue that the necessary length of rope is known in a gym and securing the loose end is not necessarily required. But there have been several climbing gym accidents in the last few years where the length of the rope was insufficient. So we calculated how many test persons performed a correct partner check without securing the loose end of the rope. They were still close to 40%. More errors are rare in lead climbing. No more than 4% of test persons committed additional errors like left-out clips with ground fall potential or overstretched clipping. In total it's fair to say that the belay safety of leading is well understood by climbers, but that the importance of the partner check is underestimated. Only a carefully performed partner check allows recognition of the worst errors, like an incomplete tie-in knot, before the climber is on the wall.

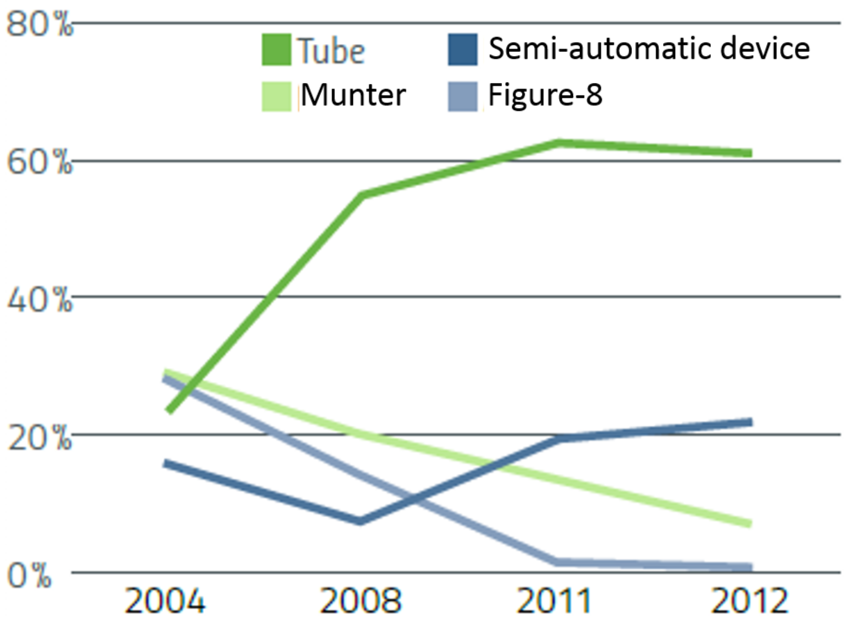


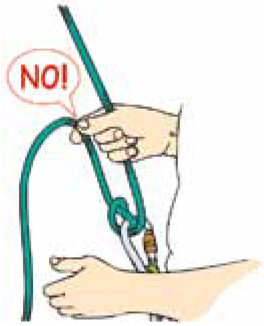
Figure 2: This diagram shows the rise of the Tube and the decline of Munter hitch and Figure-8 as gym belay devices. The data are from the DAV studies of 2004 and 2009 as well as from a study by Ernst and Kuntnawitz from 2011.

In leader belaying, errors are overall more frequent, but omitting a partner check is the most common error here, too. That makes sense because it takes two to perform a partner check. So omitting a partner check could be classified as an error of the party. Besides skipping partner checks, we found three errors that gave us pause because they are so easy to avoid: about 15% of test persons selected a position more than 1.5 meters from the wall in spite of ground fall potential. Even that wasn't enough for another 8% and they positioned themselves more than 4 meters from the wall. The bottom line was that almost a quarter of the belayers stood in a potentially dangerous spot. Of those, a third belayed with too much slack – a dangerous combination (Fig. 2). Remarkable was also the tenth of test persons belaying a partner who weighed at least 1.3 times as much as they did. Those usually female belayers did not use additional measures like sandbags.

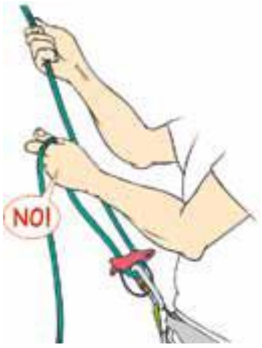
Besides those common errors there were device specific errors in belaying leaders. The design of our study allows us to describe the average error rate and the most frequent errors for each belay device (Fig. 3).

Munter Hitch. When leading, the Munter hitch is the most error prone method with a rate of1.14 errors per person and action. The tweezer grip alone, observed in half the users, is the most frequent error in all belay devices. Another 30% of Munter hitch users had their brake hand too close to the knot, a potentially painful mistake.

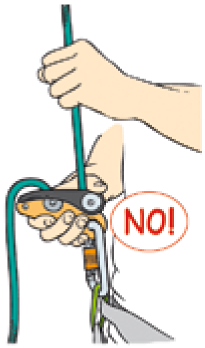
Tube. The error rate with a tube belaying a leader was 1.09 errors per person and action. The most frequent error was a brake hand too close to the Tube. This entails a danger of pinching the brake hand and letting go of the rope in a pain reflex. More serious however is the high number of climbers who did not keep their brake hand down consistently: More than a seventh of users are disregarding the Tube's functional principle this way. Another 10% held the brake rope incorrectly, for example just between thumb and forefinger.



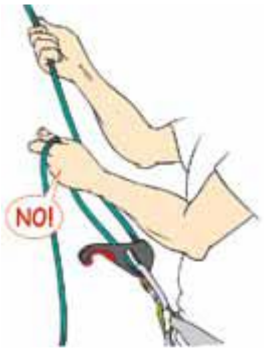
Munter: The ‘pincer grip’ is one of the most frequent belaying errors. A leader fall will almost certainly lead to a ground of fall due to letting go of the brake hand.



Tube: The brake hand, when positioned above the belay device can be fatal. In this case the braking mechanism of the Tube is suspended.



Grigri: Letting go of the brake hand and suspending the blocking mechanism will most likely result in a ground fall.



Smart and Click-Up: Holding the brake hand parallel to the climber rope will sabotage the blocking mechanism of semiautomatic devices.

Figure 3.

Grigri. 0.75 errors per belay action were counted with the Grigri. We observed that every fourth Grigri user let go of the brake rope to pay out rope, thus disabling the blocking mechanism. Should the climber fall at that moment, this could be catastrophic. A similar number of climbers let go of the brake rope, but without disabling the blocking mechanism.

Smart. The error rate of Smart users was 0.58 per climber and action. We noted that the most frequent error here was letting go of the brake rope, observed in 13% of test persons. Another 10% did not hold the brake rope correctly. Fewer still showed the 'brake hand up' error.

Click Up. The Click Up showed a low rate of 0.5 errors per person and action in this study. In 17% of climbers we observed an unnecessary length of time of the brake hand above the device when paying out rope and the brake hand was too close to the device in 8%.

To this point of the evaluation errors have only been captured quantitatively, but this is where it gets interesting: errors will become comparable by categorizing them. To that end, all single errors were slotted into a five step scale, from the most serious possible error in A, which will automatically lead to a fall in a normal climbing action, down to an E error without an inescapable consequence. An incomplete tie-in knot is an example of an A error that leads to a fall at the latest when settling into the rope to be lowered. A skipped partner check on the other side is an E error. It is possible to never do a partner check and to never fall in spite of that.

We applied these error categories back onto the quantitative error evaluation and found a clear result: The semi automatic belay devices showed an increased margin of safety in their application. Most of all, the grave A, B, and C errors appeared significantly less often (Fig. 4). Another evaluation step corroborated this result: we combined the B and C errors of all semi automatics and compared them to those associated with using a Tube (Fig. 5). It became clear that Tube users commit a serious error in every second belay action while such errors showed up only every seventh time with semi automatics. This difference is statistically significant. To compare individual devices as to their error rate does not make sense particularly when the differences are small. The difference in the Smart's rate of 0.58 and the Click Up's error rate of 0.5, for example, could at about 20 test persons per device be random.

Now what does that mean in practical terms? Do all gym climbers have to belay with a semi automatic device now? No, but they should think about the application of their device. For a beginner, holding a fall has absolute priority. A semi automatic shows its strength here. Once they have internalized the brake hand principle, gained first experiences in holding falls, want to belay significantly lighter climbers, or want to let their partner enjoy softly caught falls, then dynamic belay devices can be used. Particularly when the terrain does not allow an active follow-through, which can happen when climbing outside. Not everybody who uses a semi automatic device knows that they too must have a hand on the brake rope at all times. Each semi automatic has situations in which the device will not block without a brake hand. With any device, it's important to understand the brake's mechanics, to observe the brake hand principle, and to be able to perform the necessary actions for correct use mostly automatically. This can best be achieved by fall training. It can deliver experience in holding falls. A climbing course is a good choice to learn the correct belay method. For our study has shown that course participants are better at using belay devices.

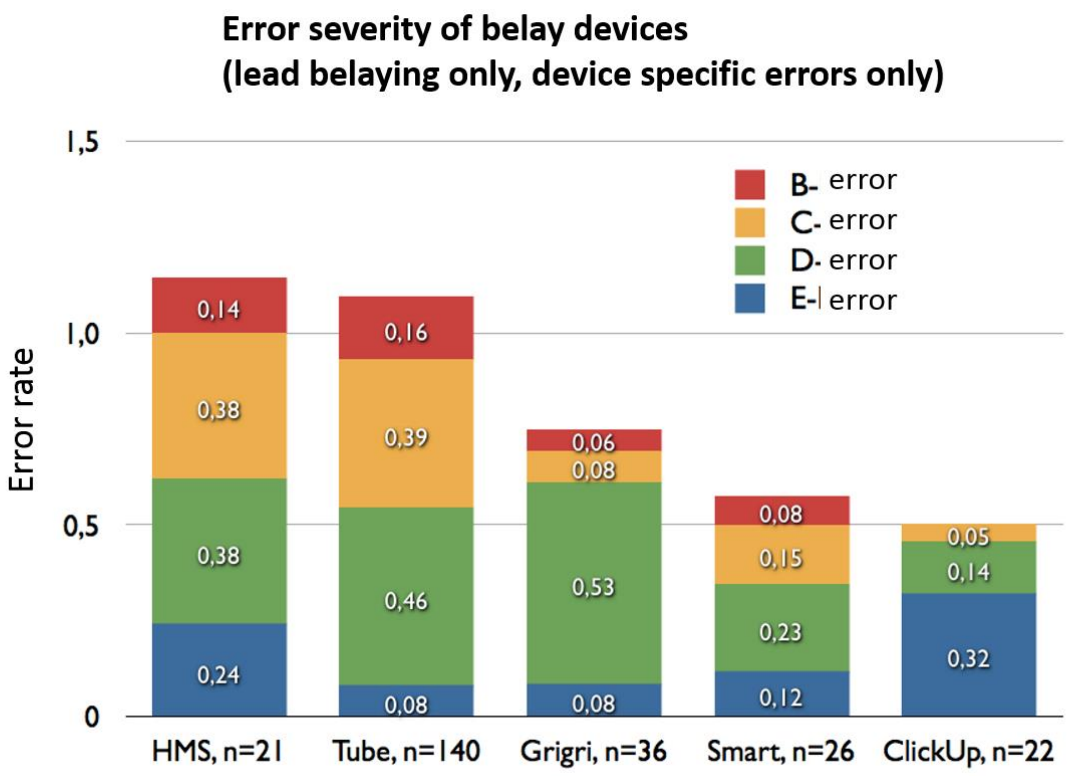


Figure 4. Error rates of individual belay devices in lead belaying. Error severity was integrated here. E errors are errors of the lowest severity. B errors were the most severe errors observed. The error severity model is explained in Table 1.

Table 1.

Error Type	Definition	Example
A error	Error will lead to a ground fall in a normal climbing process	Tying into the gear loop.
B error	Error will lead to a ground fall in conjunction with another event, for example a fall.	Letting go of the brake rope with a Tube or Munter hitch.
C error	Error will lead to a fall or at least in injury in conjunction with another event, such as a fall. Or a ground fall if several events occur.	Climbing in the trajectory of a fall.
D error	Could lead to an injury. A long error cascade is necessary, or examples of accidents are known, but extremely rare.	Tied in to lead with a karabiner.
E error	Error without necessary consequence.	Forgetting partner check.

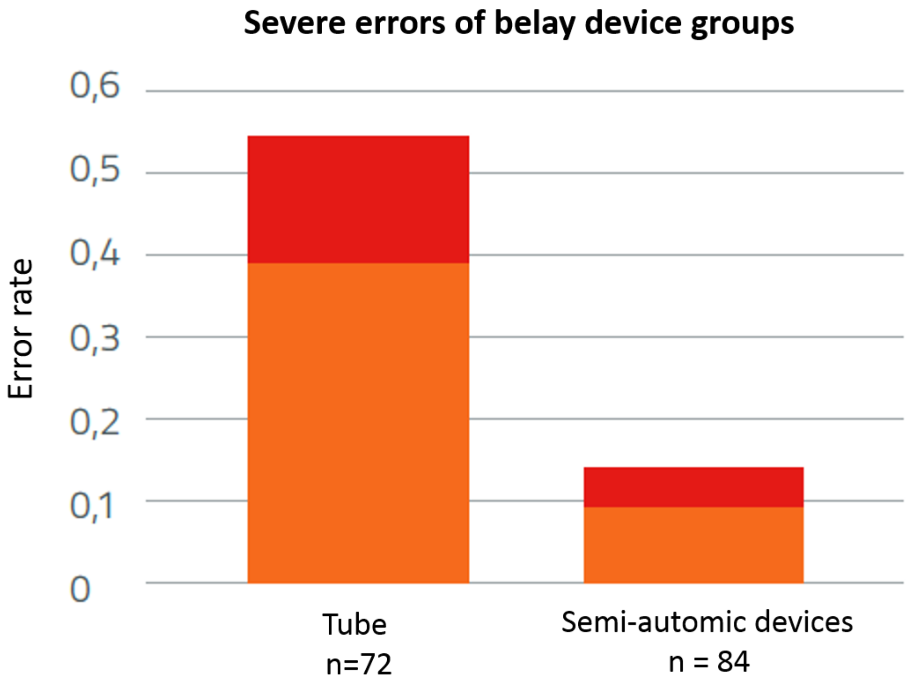


Figure 5. A summary of the most severe belaying errors (B and D errors; only lead climbing) for Tubes and semi-automatic devices clearly shows, that climbers who are belayed with a Tube are, according to this study, at a much high risk.

In addition to using the belay device correctly, climbers should also choose their position while belaying carefully. Whoever belays more than 1.5 meters from the wall risk that their climbing partner hits the deck in case of a fall. Even more when there is slack rope present. This is particularly awkward until the fifth bolt has been clipped.

Finally a word on partner checks. A partner check can simply exclude fatal errors like a half finished tie-in knot. We don't know how many fatal errors partner checks have already helped to avoid, but if it was only one serious paraplegia, that is already a success. Under the motto 'check and be checked' it can **contribute** to an open error culture in climbing sports. The culture in climbing gyms has been shown to be definitely safety relevant through significantly different error rates in the climbing gyms we observed.