Abstract: A Review of Friction Hitch Testing

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Friction hitches are used in a variety of rigging applications, most notably as belays, progress capture in haul systems, for personal ascending, and as rappel safeties. The importance of these functions has led to an array of friction hitch testing. This massive literature has yet to be reviewed to determine if broader trends can be discovered in the existing data. Presented here is a literature review of existing friction hitch research including testing on a variety of friction hitches tied with cord, webbing, and rope.

Data were found in 139 sources on the behavior of 28 different friction hitches; most research covered the behavior of single prusiks (N=756+ tests), tandem prusiks (N=347), VT prusiks (N= 138+), and Purcell prusiks (N=124). All other friction hitches show less importance to the broader rigging community, with less testing data available.

The vast majority of studies report sample sizes of 1 (N=526) out of a total of N=687 sample size records. There is a sharp drop off of studies reporting more than 5 samples, which may be indicative of convenience sampling. Studies reporting more than N>5 show progressively smaller standard deviations. The shape of the curve suggests that past ~N=20, standard deviations decrease much slower, so further research should aim for between 15 and 20 samples to constrain variability, but not use too many samples.

In a comparison between friction hitches, slip, hitch breakage, and rope damage occur at overlapping force values. Similarly, within one friction hitch, there are overlapping hitch behaviors at the same forces. These responses show that the hitch/rope system is exceptionally complicated with different system responses occurring at the same forces. It is notable that the slip force and the force at rope damage increase by ~5 kN when a second prusik is added, suggesting there is a strength increase with the addition of a second prusik. Note, however, that strength does not double.

In a comparison of wet and dry hitches (N=15), only 11 wet hitches showed a decrease in peak force relative to a dry hitch. While suggestive of decreased strength and grip ability with hydration, the sample size is small enough that conclusive results are elusive. Similarly, no consistent pattern emerges when comparing pull rate to peak force. However, faster pull rates do lead to smaller sample standard deviations, so future research should consider pulling samples at rates above about 8 in/min.

New versus used rope and cord showed a mild trend of newer materials yielding a higher potential peak force, though the overlap in data is striking for both new and used software. Similarly, there is substantial overlap between the peak forces observed with different rope fiber types. No clear pattern emerged, though this is probably because of small sample size artifacts. Rope diameter seemed to have minimal effect on hitch peak forces, though cord diameter had a clear effect on peak forces, with larger diameter yielding higher peak loads. These results indicate that the material the hitch is made out of is more important in determining hitch properties than the rope on which the hitch is tied. Finally, increasing the number of wraps in prusiks led to higher potential peak forces.

Ultimately these data show that the friction hitch and rope system is much more complicated than other systems investigated with meta-analyses. Therefore much more testing will be needed to generate more conclusive results! Future research should aim for larger sample sizes, N up to ~20, using a pull rate over ~8 in/min, and focus on the hitches themselves rather than the ropes on which they are tied.

A Review of Friction Hitch Research

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Introduction

Friction hitches are used in many rope rescue and rigging situations, from personal ascending and tether systems, to belays for rappelling and rope rescue. Therefore, understanding the strengths and behaviors of friction hitches in a variety of applications is important for understanding their appropriate use in rescue and sporting applications. Because friction hitches are used for so many applications, friction hitch behavior is a heated topic, one that can cause stern conversations between professional, sport, and volunteer riggers alike. However, when pressed to provide data, rarely can riggers trace their strong opinions to publically available testing data. As a result, there is quite a bit of rigging lore associated with friction hitches and their usage that may or may not be consistent with reality.

To gain a grasp of the state of friction hitch science, a literature review was performed to locate and synthesize a majority of data related to friction hitch strengths and behaviors. This paper is a data mining exercise designed to determine what we know and do not know about a variety of friction hitches. This article does not publish any new data, but instead produces analyses of existing data published by others. The synopsis of the meta-analyses provides some interesting results and shows what questions need to be addressed with further research.

Methods

A literature review was accomplished by searching through the readily available published literature (books, magazines, ITRS proceedings, etc.), followed by extensive Google and Youtube searches. A study was included only if (1) the hitch(es) tested could be identified, (2) there was a way to identify the methods used to gather the data, and (3) some form of data was presented (individual results, synopsis statistics, both, or either). Articles reporting results for hitches tied with, or on, non-climbing or rescue equipment were excluded; for example, articles on hitches tied from paracord, used to hang hammocks, or secure tent guy lines were excluded. Data and metadata for each citation was entered into a spreadsheet for direct comparison. The spreadsheet includes: the sample size, pull rate, if it was a drop test, number of wraps, number of hitches (1 or 2), descriptive statistics, failure location, make and model of rope and cord, new or used status of software, diameter of software used, composition, and the citation. Most studies had missing or omitted information, so when information was unknown it was recorded as unknown, and if the column was unnecessary a (-) was included to make it clear to the reader why information is missing in the combined spreadsheet.

Every attempt was made to be thorough, however, undoubtedly studies were missed. Therefore, this data set should be considered as a partial representation of the available data. If you are aware of other studies, or you have data sets you are interested in adding to this combined analysis, please contact SAR^3, and we will publish your data and add it to the combined suite of information.

The hitches tested and the number of samples tested for each were collated to determine what hitches have been tested the most and how many times. Data were mined to determine the variability in hitch testing results, failure mode (slip, breakage, or rope damage), effects of the number of hitches used, hydration (wet vs. dry), pull speed on slip and breakage measurements, age (new vs used), composition, rope and cord diameters, and number of wraps. Generally the results of studies with the relevant information for a given analysis were combined into a spreadsheet and plotted on the same graph for ease of comparison.

It is acknowledged that the studies presented here use different methods, different materials, etc., and that their results cannot be compared directly without incurring error. By plotting the results from many studies side by side it is hoped that larger scale patterns will emerge that deemphasize the variability in results due to methods alone. Consequently, readers should take the results with a grain of salt and understand that the results are general at best, and should be supported with further targeted hypothesis driven empiricism or experimentation. With that said, past meta-analyses have yielded surprisingly consistent results, yielding useful and actionable information (Evans and Truebe 2015, 2016).

Results

A total of 139 sources are included in this analysis, with a total of >1561 tests in the combined analysis. The hitches tested most are those used most frequently in sport and rescue rigging (Figure 1), with a single prusik, tandem prusiks, the VT prusik, Purcell prusik, and Valdotain being the five most common hitches tested. Table 1 lists the 11 hitches with at least 10 test results available across all sources, and Figure 1 shows the relative number of tests for each hitch in Table 1.

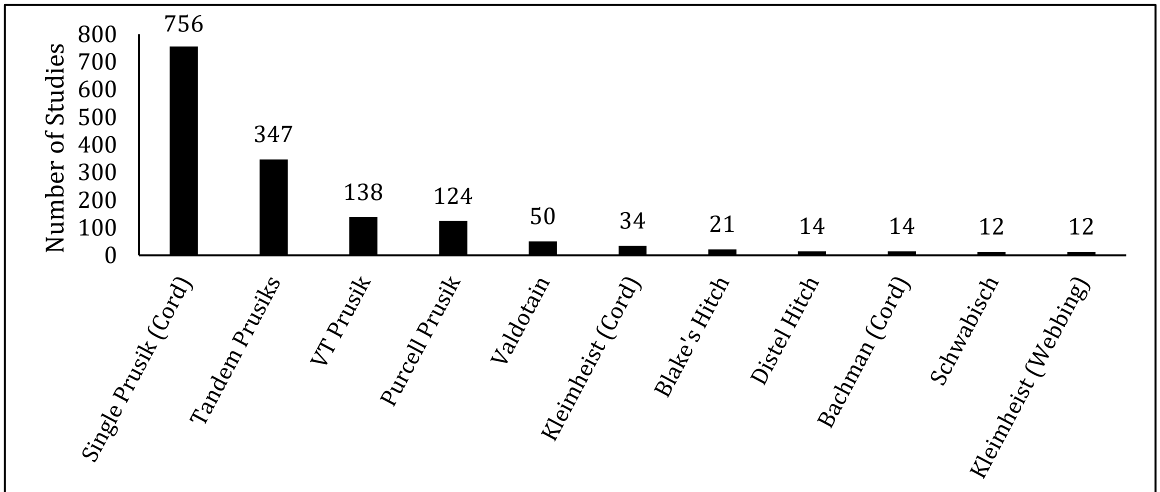

Figure 1: Number of test results for the eleven most commonly tested hitches, all with 10 or more data points reported.[1]

Studies report sample sizes between 1 and 43 (Figure 2, Table 2) with the vast majority of measurements reporting sample sizes of 1 (N=526), with 5 or less being the most common number of samples when multiple samples were tested.

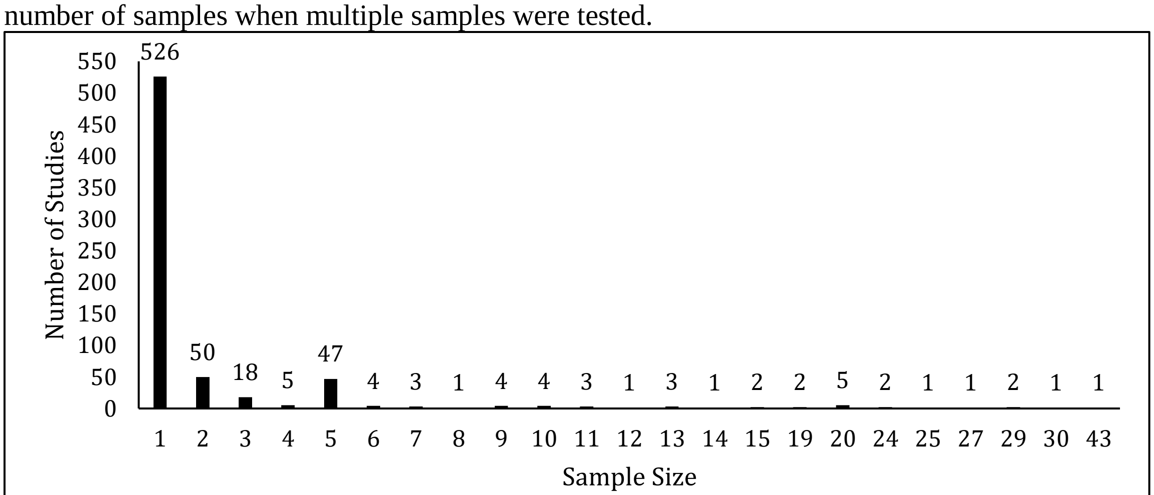

Figure 2: The number of hitch studies reporting a given sample size (N=687).[1]

In a comparison between studies with sample sizes of N=6 or more, the resulting standard deviations for prusik failure (Figure 3, N=14) showed the expected pattern of lower standard deviations with larger sample sizes. Above about N=20 there is no observable advantage of adding more samples. Not enough data is available to draw similar conclusions about friction hitch slip, however the available data are plotted in Figure 4 (N=8) for reference. Tandem prusiks, single prusiks, and Purcell prusik data are presented in Figure 4. Data for other friction hitches did not meet the inclusion criteria (N>5), so are not presented due to small sample size issues.

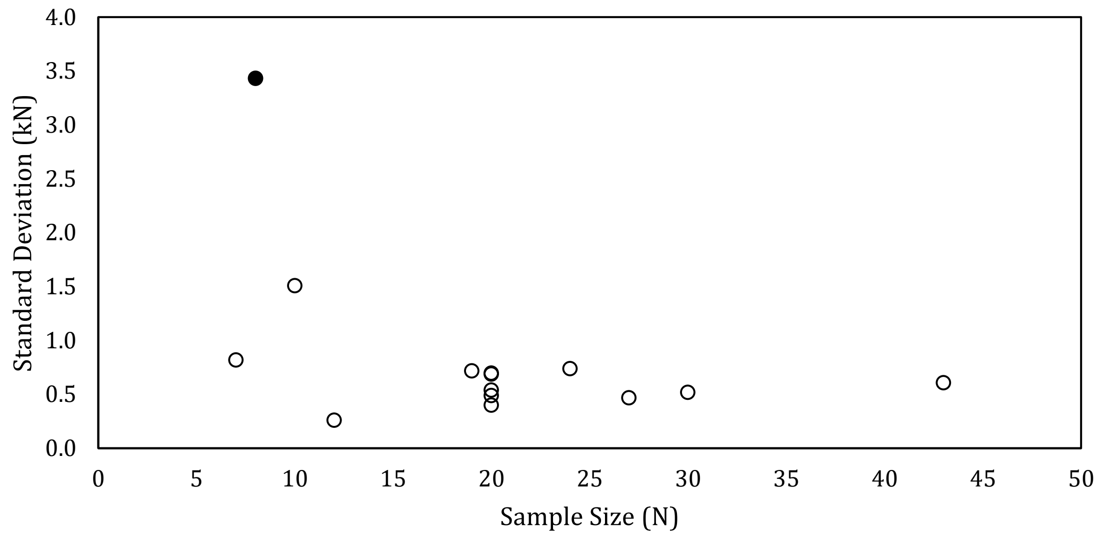

Figure 3: Sample size versus standard deviation for prusik failure (N=14) with open circles being individual prusiks, and solid circles being tandem prusiks. The larger the sample size, the lower the standard deviation, with most being below about 1 kN.[2]

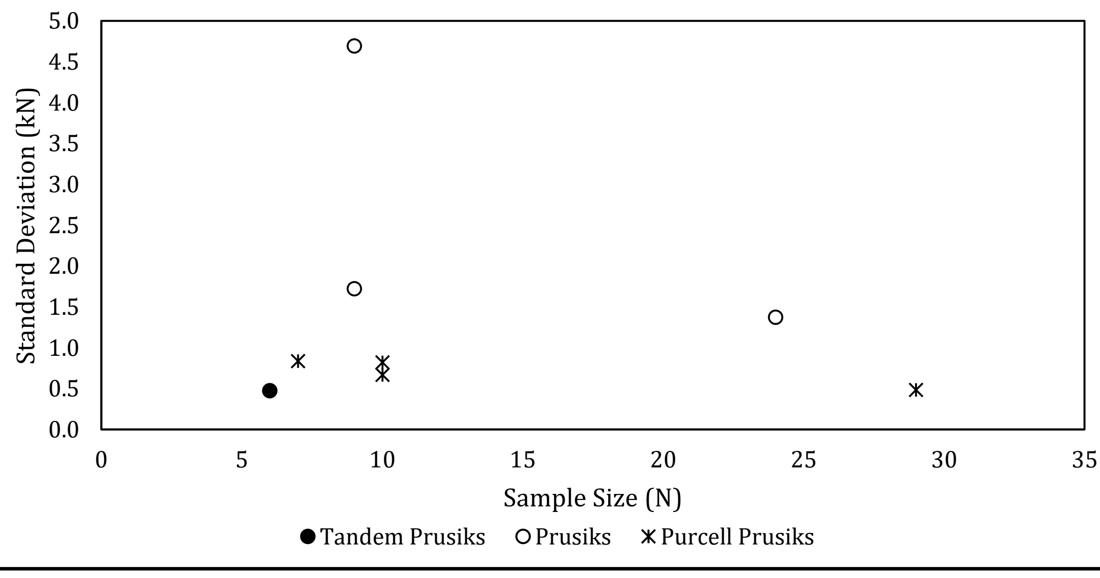

Figure 4: Sample size versus standard deviation for prusik slip (N=8) for tandem prusiks, single prusiks, and Purcell prusiks. The small sample size prevents robust data interpretation.[3]

Friction hitch slip, failure, and rope damage data is plotted in Figure 5 (N=383). Hitch failure is depicted in blue, hitch slip in green, and rope damage in red. The most obvious features are the general overlap between the three behaviors of a single hitch, and the overlap between the behaviors of different hitches. In other words, in broad terms, friction hitches slip, fail, and damage rope at roughly the same forces regardless of the hitch compared. Similarly, the presence of one versus two prusiks, does not yield a large change in behavior. Having two versus one prusik increases the force at slip, breakage, and rope damage by only a few kilonewtons (~5 kN).

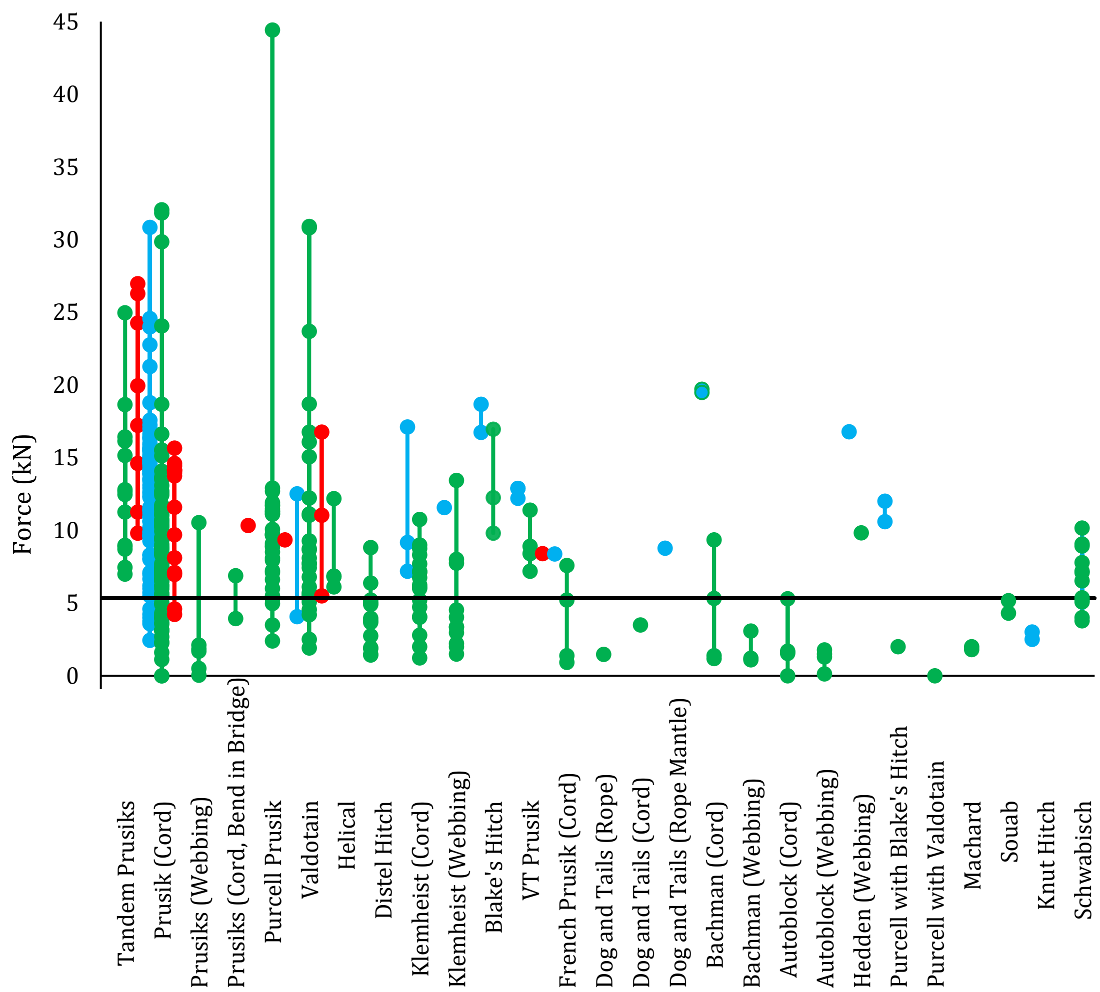

Figure 5: Comparative friction hitch slip (green), failure (blue), and damage to rope (red). All three behaviours are observed at the same forces between and within each friction hitch. A horizontal line at 5.34 kN (~1200 lbs) is plotted to depict the force at which some friction hitches supposedly slip. Hitches slip at higher and lower forces than the horizontal line.[4]

<u>*Wet vs. Dry.*</u> In a comparison between wet and dry friction hitches (Figure 6, N=15), eleven hitches slipped or broke at lower forces when wet versus dry. This is weak evidence that there may be a strength or grip reduction in wet hitches versus dry hitches. Unfortunately, the small sample size precludes concrete interpretation because the results suffer from the vagaries of small sample size artifacts.

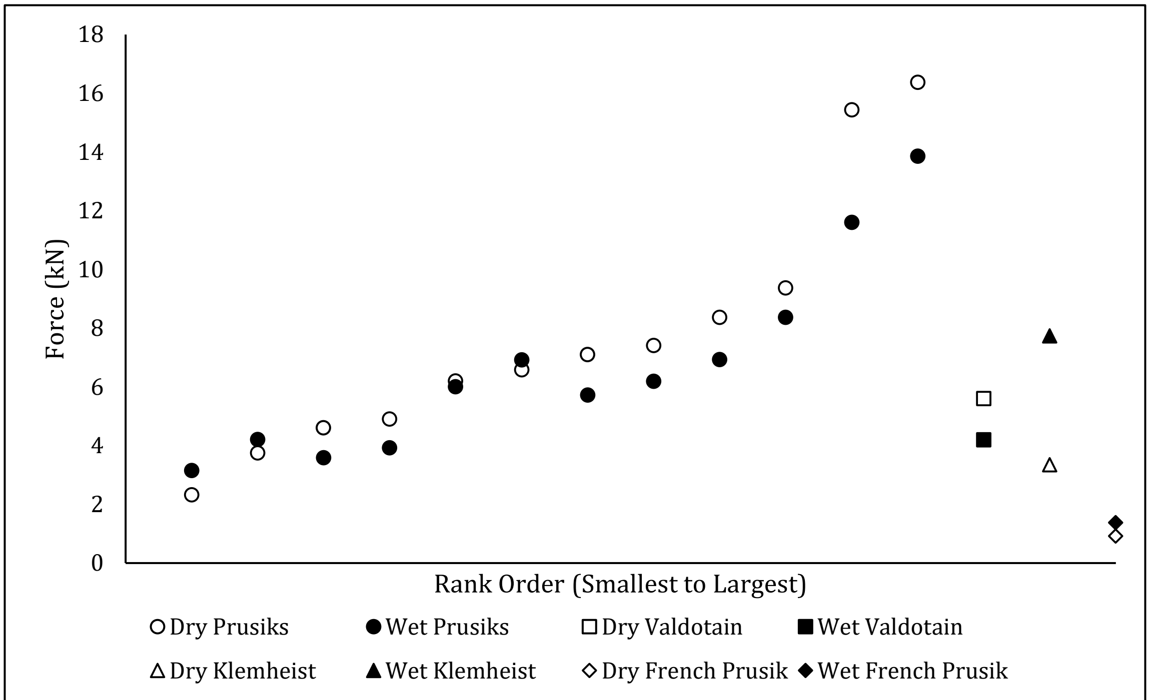

Figure 6: Force at friction hitch slip or failure when dry (open symbols) and wet (filled symbols) (N=15). Results are plotted in rank order (smallest to largest). It is unclear if wet friction hitches slip or fail at lower forces than dry friction hitches, though the data weakly supports the interpretation that the addition of water decreases force at failure and slip.[5]

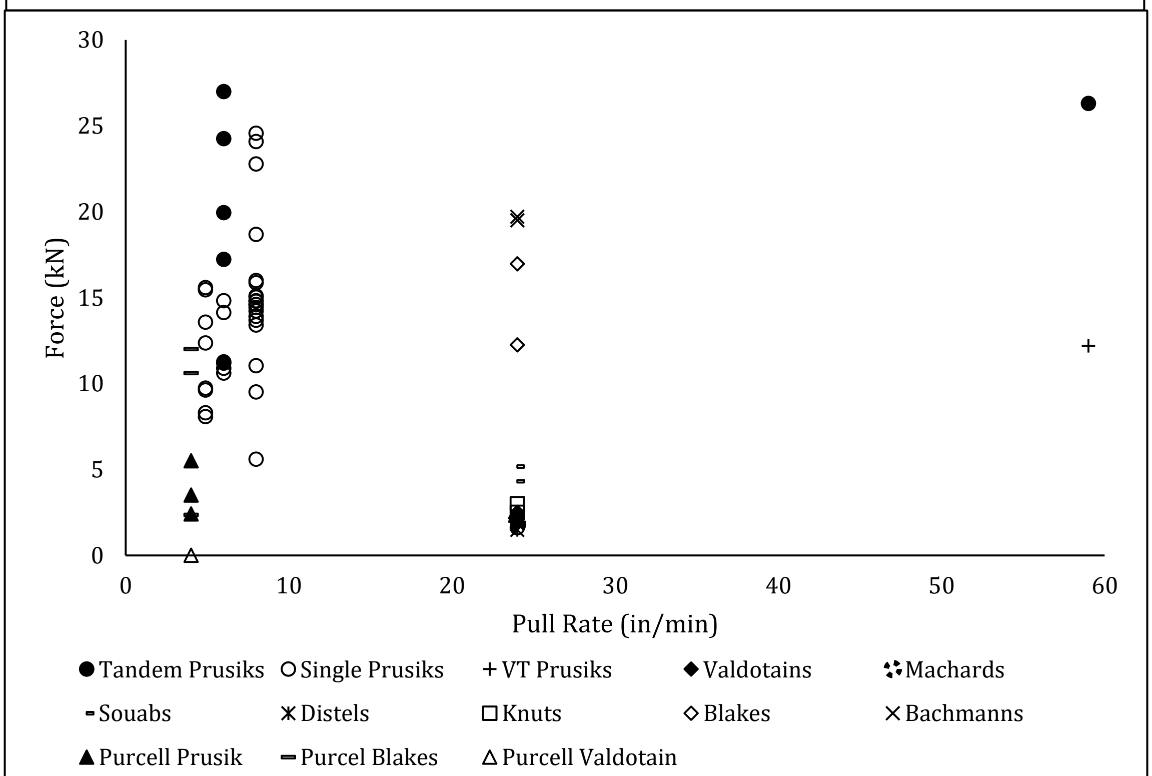

Figure 7: Friction hitch breakage, slip, or rope damage versus pull rate (N=63). There is not enough data to draw firm conclusions due to small sample sizes at each pull rate.[6]

Testing Pull Rate. No clear trend is evident when friction hitch slip, failure, and rope damage data are plotted versus pull rate (Figure 7, N=63). Even when prusik data are viewed in isolation (N=35, not shown) no clear pattern exists. The small number of samples at each pull rate preclude certainty in interpretation because any observed trends may be artifacts of small sample sizes. In a plot of pull rate versus standard deviation of prusik failure strength (Figure 8, N=14) it is evident that with faster pull rates, smaller standard deviations result.

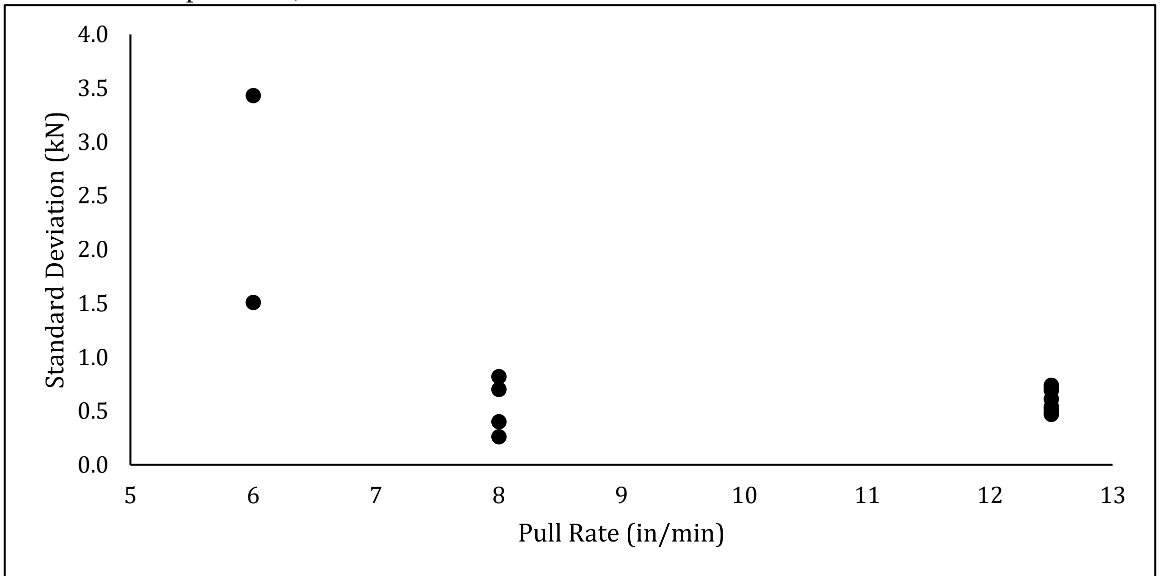

Figure 8: Friction hitch pull rate versus standard deviation which shows a reduction in standard deviation with increased pull rate (N=14).[7]

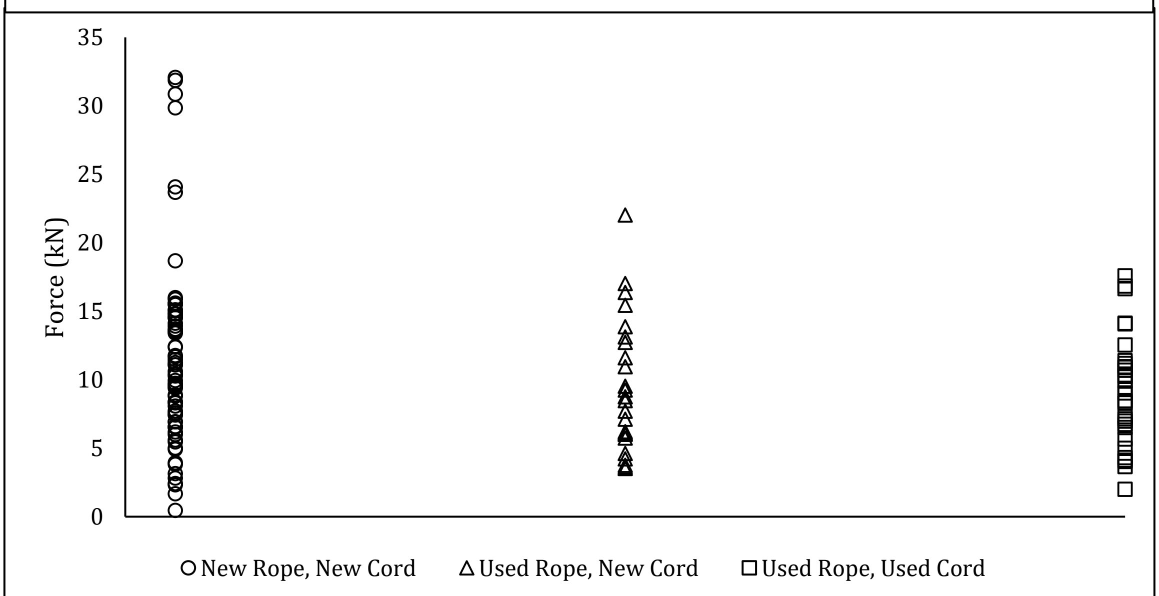

Figure 9: Single prusik breakage, slip, or rope damage strengths for new rope and cord (N=71), used rope and new cord (N=25), and used rope and cord (N=31). There is a general trend to lower peak strength with greater usage for both rope and cord.[8]

New vs Used. To determine the effects of rope and cord use on the force at which friction hitches break, slip, and cause rope damage, data for each hitch was plotted in four categories: 1. New rope and cord, 2. Used rope and new cord, 3. New rope and used cord, and 4. Used rope and cord.

Binned data was used rather than plotting rope and cord age directly because so few studies reported the age of both the rope and cord used. Unfortunately there was not enough data to make meaningful graphs for all hitches except for single prusiks. These data are depicted in Figure 9, which shows a slight trend indicating that with more used materials in use, the peak force at prusik failure, slip, or rope damage decreases. It is significant that there is substantial overlap between the three fields of data, showing that prusiks have overlapping behavior when tied using both new and used materials.

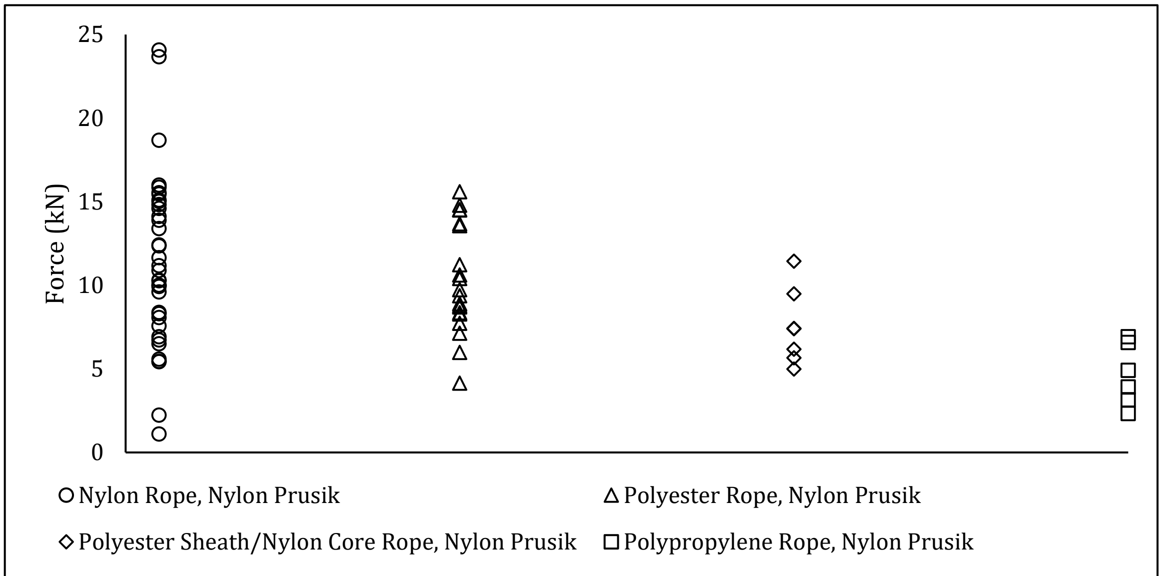

Figure 10: Single prusik breakage, slip, or rope damage strengths for nylon rope and cord (circles, N=37), polyester rope and nylon cord (triangles, N=20), polyester sheath/nylon core ropes and nylon prusiks (diamonds, N=7), and polypropylene rope and nylon prusiks (squares, N=5).[9]

Composition. Data was mined for composition comparisons with at least 5 measurements for each composition category, which ultimately eliminated all comparisons except for single prusiks in four material combinations (Figure 10): 1. Nylon rope and cord, 2. Polyester rope and nylon cord, 3. Polyester sheath/nylon core rope and nylon cord, and 4. Polypropylene rope and nylon cord. Based on the standard deviation data presented in Figure 3, samples sizes of 5 are insufficient to capture the variability in a population of friction hitches. However, the first two composition combinations had sufficient sample sizes to show that the strength at prusik failure, slip, or rope damage is essentially the same between nylon and polyester ropes. The greater variability seen in nylon rope and cord friction hitches is likely due to the larger sample size. Mixed polyester/nylon ropes and polypropylene ropes are shown for comparison, though insufficient data are available to draw robust conclusions.

Rope and Cord Diameter. Rope diameter, cord diameter, and force at friction hitch failure, slip, or rope damage were plotted on a trivariate scatter plot (not shown), which showed no consistent trends for most hitches. The only friction hitch with enough data for the analysis to show any trends is the single prusik. No consistent trends were observable as a function of rope diameter (Figure 11, N=147), probably because not enough data is available for rope diameters other than 11 mm. However, there is an increase in the peak force with larger diameter cord (Figure 12, N=147). In other words, with larger diameter cord the peak force recorded for a prusik before failure, slip, or rope damage, increased.

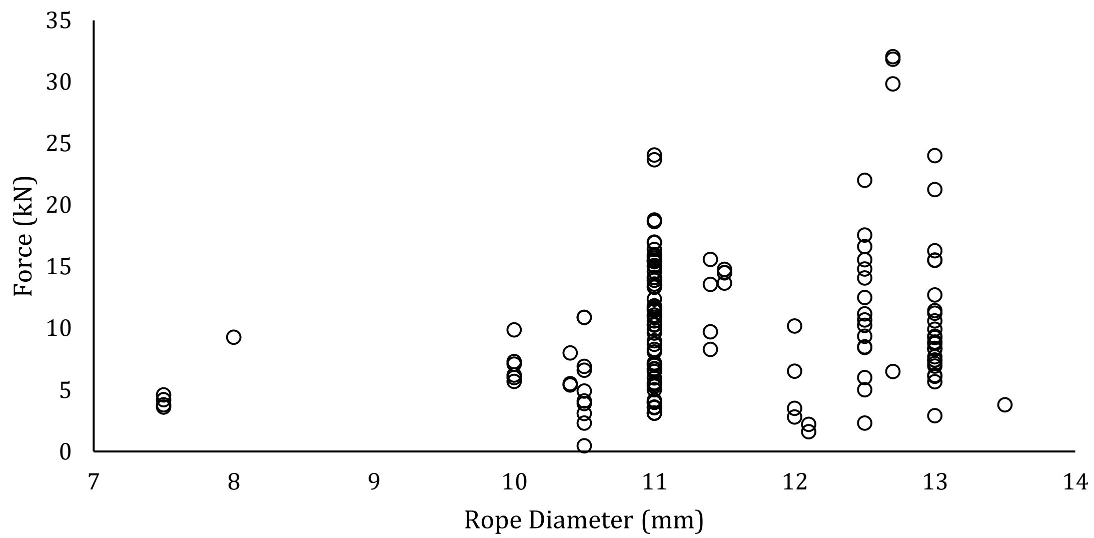

Figure 11: Single prusik breakage, slip, or rope damage strengths on ropes of a variety of rope diameters (N=147). No clear trend is observable, probably due to low sample sizes for ropes of diameters other than 11 mm.[10]

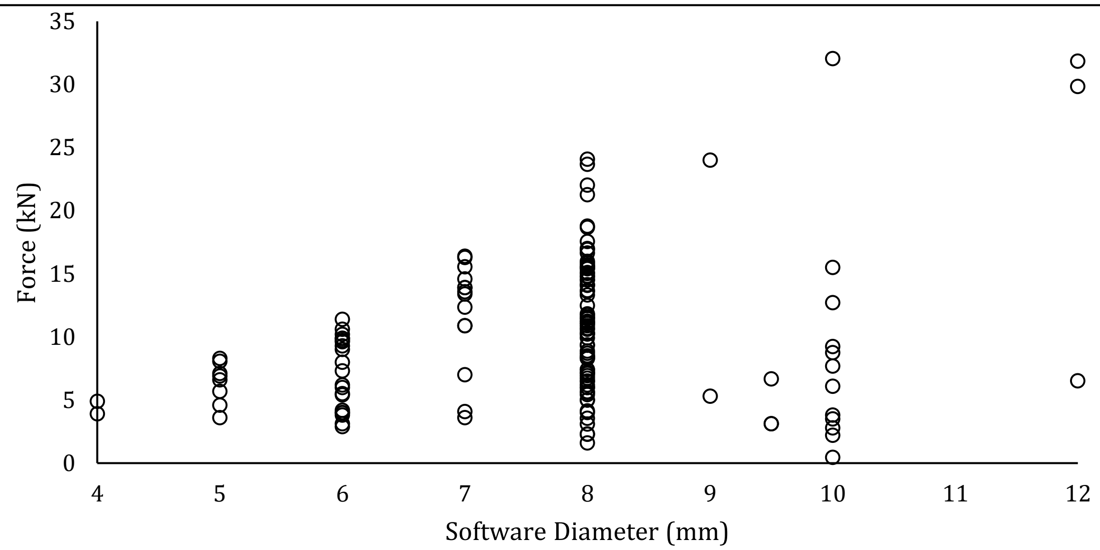

Figure 12: Single prusik breakage, slip, or rope damage strengths constructed from a variety of cord diameters (N=147). There is a clear increase in peak force with increased cord diameter. Note that the lower bound for different cord diameters is nearly the same.[10]

Number of Wraps. The number of wraps in tested friction hitches was plotted versus their peak force at breakage, slip, or rope damage. There were not enough data points for most hitches, but there were enough data points to plot the results for single prusiks (Figure 13, N=184). Generally, higher peak forces can result from hitches with more wraps, however, there is considerable overlap in behavior between hitches with different numbers of wraps.

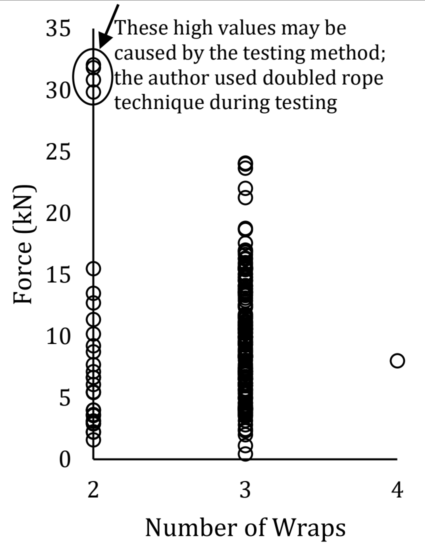

Figure 13: Single prusik breakage, slip, or rope damage strengths constructed with different numbers of wraps (N=184). Higher peak forces can be observed with more wraps, though there is considerable overlap.[2]

Discussion and Conclusions

There is a massive amount of friction hitch testing data available to riggers, though most of it concerns commonly utilized hitches (Figure 1). While much research is available, most of it is comprised of studies with small sample sizes (N<6, Figure 2), which is consistent with the interpretation that most studies are implementing convenience sampling (see also Evans and Truebe 2016). Convenience sampling is when researchers use a convenient number of samples based on ease and availability rather than on how many samples would be needed to address a particular research question. Given the consistency in results from studies with larger sample sizes (Figures 3 and 4), future research should aim for sample sizes of up to about 20 to constrain the variability in hitch behavior. If larger sample sizes are implemented, we could reasonably expect reported standard deviations of less than about 1 kN in most research. This range in variability is consistent with numerous other studies measuring the variability in behaviors of various types of software (Evans 2013, 2014, 2016a,b,c, Evans and Stavens 2011, Evans and Truebe 2015, Evans et al. 2012). This uniformity in low standard deviations is probably a function of consistent product manufacturing quality.

There is a remarkable overlap in the performance between hitches; they slip, fail, and damage rope at similar forces. This result is not unexpected given that all the hitches are constructed from the same materials, though some variability in hitch performance was expected. Similarly, the three different behaviors (slip, hitch material breakage, and rope damage) occurred at overlapping force values. These two observations demonstrate how complicated the friction hitch/rope system is. A commonly held opinion by riggers is that the combination of rope and cord materials is more important in determining hitch behavior rather than other variables, like rope or cord diameter alone. These results support this interpretation by demonstrating that hitches respond differently at the same forces.

One result that can be gleaned from these data is that adding a second prusik tends to increase the slip force or rope damage force by about 5 kN (Figure 5). An expected result, but notable in that doubling the number of prusiks does not double the slip or failure strength. Rather peak forces do increase, but not linearly, thus demonstrating how rigging systems are frequently nonlinear in their aggregate behavior.

Figure 5 also demonstrates that friction hitches slip or fail at forces much less than 5.34 kN (~1200 lbs). These results bolster the conclusions based on the work of Evans (2015) and Smith (2015), which also showed friction hitches (prusiks) slipping below values they purportedly should hold. These data should stimulate further discussion of the prusik clutch effect and how it is an oversimplification to teach riggers that prusiks will slip around 5.34 kN (~1200 lbs), thus alleviating stress in a system. While this effect may be consistent and observable with some rope and cord combinations, it is certainly not the rule across hitches, compositions, and hitch materials (cord and webbing).

Unfortunately, there is not enough data to determine if there is a strength reduction of friction hitches when wet. While a majority of wet friction hitches broke or slipped at lower force values than their dry counterparts (N=11), the sample size (N=15) is simply too small to form robust conclusions (Figure 6). Future research should include studies comparing wet and dry friction hitches with large sample sizes so this issue can be addressed with sufficiently robust data.

Similarly there is a paucity of data concerning pull rates during testing (Figure 7). Most pull testing data is collected with a pull rate under about 8 in/min, so higher pull rates are necessary to determine if there is an effect of higher pull rates. However, at higher pull rates it is clear that software demonstrates more consistent behavior, with smaller standard deviations at higher pull rates (Figure 8). Future research using pull tests should consider using higher pull rates (above 8 in/min) to gain more sample consistency.

Used software tends to slip, become damaged, or break at lower force values. However, combinations of new materials had overlapping behaviors with used materials, suggesting that other variables are more important to hitch function than software age (e.g., composition, diameter, etc.). Ultimately it appears that the newer the materials the higher the peak loads could be, and with age the possible peak loads decline (Figure 9).

With such a limited data set, it is not possible to determine the performance effects of different rope and cord compositions with any rigor (Figure 10). However, if the results are assumed to be representative, friction hitches on polypropylene ropes would yield lower peak loads than on other materials (e.g., nylon or polyester). More testing is needed comparing different rope and hitch fiber types side by side (e.g., Evans 2015, Smith 2015) so we can gain a better understanding of how fiber types interact to create different performance characteristics. This broad brush stroke analysis did not have the statistical power to tease out these differences so further research is necessary to address this question.

A relationship was expected between the combined rope and cord system, but none was observed. There was no consistent relationship based on rope diameter (Figure 11), but a noticeable trend was clear based on cord diameter (Figure 12). Larger diameter cordage led to higher potential slip and failure values. These two observations indicate that the friction hitch material has a greater influence on hitch performance than rope diameter. This conclusion is notable because it indicates it is more important to perform future research with a variety of hitch materials than it is to use a variety of rope diameters.

Greater numbers of wraps around a rope generally leads to higher possible slip or failure values (Figure 13). Intuitively this makes sense because the more wraps around the rope, the greater contact angle with the rope which generates considerably more friction (Attaway 1999). It is notable that, like many of the figures, the behaviors between the number of wraps overlap considerably, suggesting that how tight a hitch is tied has a bigger impact on its function than the number of wraps.

Finally, these composite results show how complicated friction hitches are. The sheer number of variables involved prevents more robust conclusions because each variable has its own effects on friction hitch performance. The literature reviews on webbing anchors (Evans and

Truebe 2015) and knots (Evans and Truebe 2016) yielded more definitive results because the number of variables in each comparison was smaller, even though both studies compiled less data. As such, it is of paramount importance that further testing be performed so these analyses can incorporate more data which will result in more robust conclusions.

Given the meta-analyses presented above, the following research topics would help clarify the trends observed here:

A. Testing on lesser known or used friction hitches to fill out the knowledge base about these less understood hitches (Figure 5, right side)
B. Testing direct comparisons between friction hitches both wet and dry (Figure 6)
C. Testing friction hitches with variable pull rates; particularly pull rates greater than 8 in/min (Figures 7 and 8)
D. Testing on friction hitches constructed of different materials besides nylon (Figure 10)
E. Testing friction hitch performance with different initial tensions
F. Testing the “prusik clutch” effect directly comparing prusik behavior on an unloaded line versus a loaded line (e.g., does a prusik slip on a tensioned line at a lower value than an unloaded line that the prusik can kink)

Lastly, further “backyard” and “quick look” testing is essential to identify what variables are important to investigate with more targeted and controlled research. So please keep breaking gear and know that it is scientifically necessary and valuable!

Acknowledgements

This article was stimulated by a discussion with Bruce Parker at ITRS a few years ago. He commented that we do not need more prusik testing, but a synopsis of the data already available. I took this to heart and started collecting the testing data for knots and friction hitches for a few big review articles. The logical underpinning of this article was his idea, and he should get the credit for it.

Footnotes

[1] Data taken from nearly all citations listed were used in the compilation of this figure.
[2] Data taken from: Evans 2014, 2015, Walker et al. 2014
[3] Data taken from: Delport 2016, Evans 2015, Gibbs 2006, 2007
[4] Data taken from: Aaron Bird 2008, ACMG 2015, Antonini and Piazza 2013, Baveresco Unknown Date, Born 2000, Delport 2016, Dirtbaglawyer 2016, Eric Campbell 2009a,b, Evans 2014, 2015, Frank 1998, French School of Canyoneering 1998, FSTC 2008, Gibbs 2005, 2014, Goulet 2001, Guglielmo Di Camillo 2011a, Hayes and Zimmering Unknown Date, Heald 2009, Holden et al. 2009, Jens Plinke 2016, Kevin Bingham 2012b, Koprek 2015, Kovach 1999, Marc Beverly 2007, Mortimer 2015, Moyer 1999, 2000, Moyer et al. 2000, North Wash Outfitters 2015a,b,c,d, NZcaver 2007c, 2010, 2012, OTE Rescue 2014, Prattley 2014, Prattley et al. 2001, Richard Delaney 2012a,b,d, Rigging for Rescue 2015c, Sheehan 2004a,b, Smith 2015, Sonnylawrence 2004, Sterling Unknown Date, Stiller 2005, Taylor Unknown Date, Thrun 1971, Trihey 2006, Unknown Author 1997, 2010, Unknown Author Unknown Date a,c, Vandeford 1968, Vickers 2006, Walker et al. 2014
[5] Data taken from: French School of Canyoneering 1998, Heald 2009, Smith 2015, Unknown Author Unknown Date a
[6] Data taken from: Evans 2014, 2015, Koprek 2015, Sonnylawrence 2004, Unknown Author Unknown Date c, Walker et al. 2014
[7] Data taken from: Evans 2014, 2015, Walker et al. 2014
[8] Data taken from: ACMG 2015, Baveresco Unknown Date, Delport 2016, Evans 2014, 2015, Frank 1998, Heald 2009, Kane 2011, Kovach 1999, Lyon Equipment Limited 2001, Mortimer 2015, Moyer 1999, 2000, NZcaver 2007c, 2010, 2012, OTE Rescue 2014, Prattley 2014, Richard

Delaney 2012a,b, Sheehan 2004a, Smith 2015, Trihey 2006, Unknown Author 2010, Unknown Author Unknown Date a,c, Walker et al. 2014

[9] Data taken from: Aaron Bird 2008, Baveresco Unknown Date, Dill 1991b, Evans 2014, 2015, Gibbs 2014, Heald 2009, Kane 2011, Lyon Equipment Limited 2001, NZcaver 2007c, 2010, 2012, Richard Delaney 2012d, Smith 2015, Walker et al. 2014

[10] Data taken from: Baveresco Unknown Date, DeHart 2016, Delport 2016, Evans 2014, 2015, Frank 1998, Gibbs 2014, Goulet 2001, Heald 2009, Kane 2011, Kovach 1999, Lyon Equipment Limited 2001, Marc Beverly 2007, Moyer 1999, 2000, NZcaver 2007c, 2010, 2012, OTE Rescue 2014, Prattley 2014, Prattley et al. 2001, Richard Delaney 2012a,b,d, Sheehan 2004a,b, Smith 2015, Thrun 1971, Trihey 2006, Unknown Author 2009, 2010, Unknown Author Unknown Date a,c, Vickers 2006, Walker et al. 2014

[11] Data taken from: Aaron Bird 2008, ACMG 2015, Baveresco Unknown Date, Bressan Unknown Date, DeHart 2016, Delport 2016, Dill 1991b, Evans 2014, 2015, Frank 1998, FSTC 2008, Gibbs 2014, Goulet 2001, Heald 2009, Kane 2011, Kovach 1999, Lyon Equipment Limited 2001, Marc Beverly 2007, Matt Hinkle 2011a, Mortimer 2015, Moyer 1999, 2000, Moyer et al. 2000, North Wash Outfitters 2015a,b,c, NZcaver 2007c, 2010, 2012, OTE Rescue 2014, Prattley 2014, Prattley et al. 2001, Richard Delaney 2012a,b,d, Sheehan 2004a, Smith 2015, Thrun 1971, Trihey 2006, Unknown Author 2009, 2010, Unknown Author Unknown Date a,c, Vandeford 1968, Walker et al. 2014

Table 1: Number of reported data points for the eleven most commonly tested hitches.

Friction Hitch	Total Number of Reported Data Points
Single Prusik (Cord)	756+
Tandem Prusiks	347
VT Prusik	138+
Purcell Prusik	124
Valdotain	50
Klemheist (Cord)	34
Blake’s Hitch	21
Distel Hitch	14+
Bachman (Cord)	14
Schwabisch	12+
Klemheist (Webbing)	12

Table 2: The number of tests reporting a given sample size. Most are 5 and lower.

Sample Size	Number of Tests Reporting the Sample Size
1	526
2	50
3	18
4	5
5	47
6	4
7	3
8	1
9	4
10	4
11	3
12	1
13	3
14	1
15	2
19	2
20	5
24	2
25	1
27	1
29	2
30	1
43	1

Literature Cited

Aaron Bird, 2008, Prusik Knot Drop Tests (https://www.youtube.com/watch?v=0Snpthv91Oo)

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