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Optimizing Muscular Strength-to-Weight Ratios in Rock Climbing

BY AMAN ANDERSON

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ABSTRACT

BACKGROUND
There have not been many studies on the role of muscular strength and finger strength and their relationship to climbing ability.

OBJECTIVE
To evaluate the role major muscle groups and finger strength strength-to-weight ratios in sport climbers and boulderers to climbing ability in a gym setting.

METHODS
Strength measurements were taken using a force measuring device. Climbers were then given standardized exercises for different muscle groups and then later weighed to calculate their strength-to-weight ratio. Climbers were then questioned on their highest redpoint in bouldering, and sport climbing using a standardized questionnaire.

RESULTS
The majority of high level climbing athletes showed a significant difference in overall muscular strength, and hand strength. High-level climbers reflected high ratios for each hand excelling above 100% of their body weight on a 19mm wooden crimp, with the highest being 120%. Women and men were both tested.

CONCLUSION
Though other factors play a role in successful climbing ascents, not limited to height, experience, flexibility, or endurance of a climber, a climbers ability to recruit and sustain higher muscular forces in relative to their body weight, sustained higher climbing grades.

INTRODUCTION

The competitive climbing sport has grown significantly over the past 20 years. Previously, most of the focus of various studies have been dedicated toward injuries. Fortunately, more attention is starting to be dedicated to advance the science of the sport to produce strong top-level climbers. In the last 20 years, there have been international studies that have had a significant impact on the sport, dedicated to a climbers athletic performance, hand/forearm strength, VO2 max, and lactic acid threshold (Sheel, 2004).

There are multiple factors associated with climbing that make it difficult for climbers and coaches to progress effectively. The adaptation of the body's muscles and bones to external resistance is more rapid than the adaptation of the tendons (Burmitt & Cuddeford, 2015). In the case of climbing, it seems muscular strength can only translate into positive motion if the tendons can transfer and support the force. Another factor is that climbing is both dynamic and isometric in nature. In addition, there are many different types of training methods that may utilized by climbers and coaches such as traditional resistance training, hangboard, campus board, and system board. Many factors need to be taken into account in order to keep a climber injury free while increasing performance. The gaps of science within the sport have led to a lot of disparate methods being claimed as effective. Thus, it is imperative to continue to publish more research verifying the applicability of different training methods to increase climbing performance. The present study is designed to examine the impact of the strength-to-weight ratio of particular upper body muscle groups that could account for the differences in successful ascents of a range of climbers from the easiest 10a to the hardest 5.14c.

The present study has three goals. (i) to further examine the role climbing has on the body, whether strength training is necessary. (ii) To standardize strength-to-weight (STW) ratios for the ranges of climbing lead and bouldering grades. (iii) To further prevent risk injury by quantifying a required minimum in strength-to-weight ratios to ascend a route.

METHODS

Participants

15 male and 9 female athletes, ages 16 to 30, were drawn from a community sample and recruited via online advertisements for climbers interested in participating in the study from 2016 till late 2017. Some of the participants were local to Colorado, from the Beast Fingers Climbing Team, Denver University Climbing team. All participants had been climbing for at least a year. The participants were informed that they would be apart of the study, that would be later used to help correlate strength to the climbing grading system. If they were still interested in participating, the test continued. The climbers were informed that they would be performing a set of standardized workouts that would be logged and calculated to their weight. Climbers who were injured or unable to perform the required test were excluded from the study for safety. Climbers who only completed half of the test were also excluded from the final charts below, but some results may be included within the written form of this study to provide contextual application.

Materials and Apparatus

During the test, climbers filled out a chart that had a diagram of the human body, and on each muscle group had a box to record the force applied in lbs, and their strength to weight. On this form were fields to record, gender, highest sport climb grade, highest bouldering grade, and body weight. Grades provided were for outside and inside. If a climber ascended the same grade outside and inside, the result was merged into one field.

The force scale used measured in lbs/kilos up to 600lbs. Accuracy class:OIML III. Tare range:100%F.S. Zero range:4%F.S. The Min.cap.2kg; Resolution:0.1kg and Division: 3000. The device was anchored to accommodate the standardized workout procedure. Measurements were taken as a 5 rep max. Climbers were asked to warm-up with at least 20 minutes of climbing before testing.

The force meter had multiple hand attachments to measure accurately. For most exercises a rounded handle was attached. For the testing of finger strength, the Grippul apparatus was used, with a 19mm climbing hold that was in-cut 15 degrees. Climbers were allowed to use chalk before testing.

Procedure

Prior to testing, participants were briefed on what they would need, and participated in a screening for injuries. Local testing was performed at a local climbing gym, and one test was remote. Participants in this study were asked to climb for at least 20 minutes to warm-up before testing. Testing approximately lasted between 30-40 minutes. All procedures with the Denver University Climbing team were approved by coaching staff and board of athletics. The muscle groups tested were: Latissimus dorsi (one arm) on a pulldown machine (one arm lat pulldown), Subscapularis muscle (L,R), Deltoid muscle (L,R), Triceps muscle (L,R), Biceps muscle (L,R), Hand (L,R), Forearm (L, R), Extensor (L,R).

RESULTS

The bouldering measurements revealed top-level climbers had significant margins in the one arm lat pulldown, hand half crimp, and subscapularis (Fig 1). There was less of a margin in forearm, bicep, tricep, and deltoid. For sport climbing, the one arm lat pulldown did not provide a clear difference in strength, with one outlier (Fig 2). Hand strength had a similar curve as bouldering showing significant differences between the 10a climber and a 14c climber,

FIGURE 1

Overall Bouldering Strength-to-weight Ratios By Grade

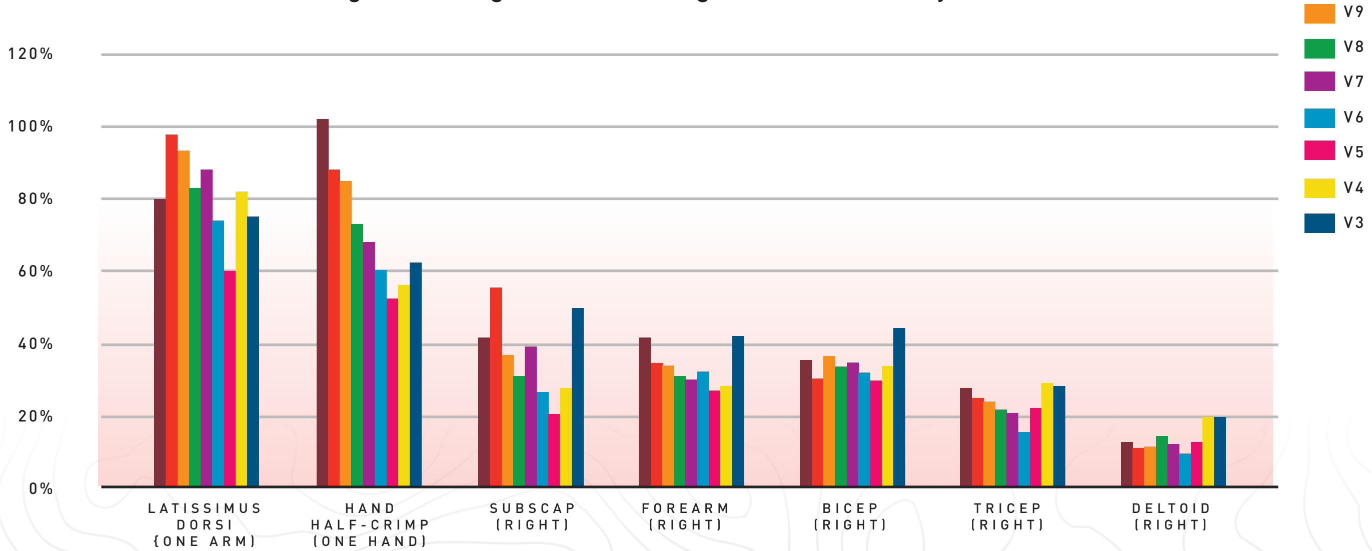

Chart showing bouldering strength to bodyweight correlations for climbing grades ranging v3 to v13.

FIGURE 2

Overall Lead Strength-to-weight Ratios By Grade

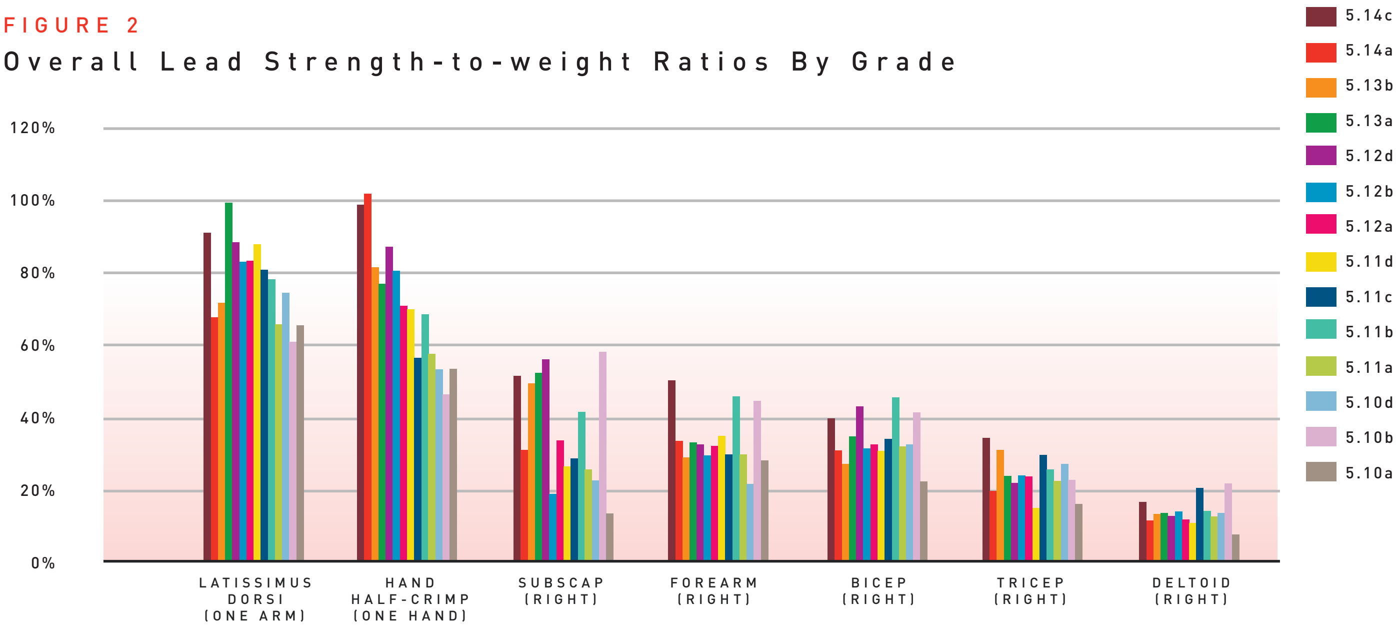

Chart showing bouldering strength to bodyweight correlations for climbing grades ranging v3 to v13.

subscap strength showed significant margins, forearm strength martinis were relatively the same, with the 14c climber showing significant gains. Tricep strength was strength did not have significant differences, nor did the deltoid.

The level of difficulty between climbs shows a progression of strength throughout the body. Table 1 shows two climbers with weight differences. Climber 12 and 13 redpoint 5.14. Climber 12 - 5.14c, and climber 13 - 5.14a. Both climbers half crimped 100% and above on the 19mm crimp. Climber 12 weighs 128 lbs, and climber 13 weighs 147 lbs. When you compare climber 20, who is a female to climber 8, you see very similar strength percentages. In some areas, climber 20 has higher percentages in the biceps, deltoids, and lats. In hands (half-crimp), Climber 8 exceeds climber 20 by 22%.

Progressing from less difficult climb to higher difficulty, was where you began to see strength numbers line up with or surpass body weight. The key strength separator was finger strength. With hard climbing requiring a climber to sustain 90%-100% or more of body weight on each hand as shown in figure 3 and 4. Collecting strength data on other muscle groups made it very clear that, although important, a lower percentage of strength in the hand would be a key limiting factor for a climber desiring to climb harder grades. Typically, on harder grades, with hand edges and foot placements get smaller, a climber is required to sustain high force transfers to ascend the route.

TABLE 1

Strength-to-weight Ratios By Grade

	Climber 12	Climber 13	Climber 8	Climber 20
Gender	M	M	F	F
Weight	128 lbs	147 lbs	138 lbs	109 lbs
Bouldering	V13	V13	V6	V8
Sport	5.14c	5.14a	5.11a	5.13a
Lat (One Arm)	118 lbs - 92.1%	100 lbs - 68%	93 lbs - 67%	97 lbs - 88.9%
Subscap (L)	72 lbs - 56.2%	46 lbs - 31.2%	21 lbs - 15.2%	34 lbs - 31.1%
Subscap (R)	67 lbs - 52.34%	46 lbs - 31.2%	23 lbs - 16.6%	35 lbs - 32%
Deltoid (L)	22 lbs - 17%	17 lbs - 11.5%	15 lbs - 10%	16.5 lbs - 15%
Deltoid (R)	21 lbs - 16.4%	17 lbs - 11.5%	16 lbs - 11%	18 lbs - 16.5%
Tricep (L)	43 lbs - 33.5%	30 lbs - 20.41%	17 lbs - 12.3%	22 lbs - 20.1%
Tricep (R)	44 lbs - 34.4%	30 lbs - 20.41%	17 lbs - 12.3%	23 lbs - 21%
Bicep (L)	50 lbs - 39%	47 lbs - 31.9%	34 lbs - 24%	36 lbs - 33%
Bicep (R)	51 lbs - 39.8%	47 lbs - 31.9%	35 lbs - 25%	37 lbs - 33.9%
Hand (L)	128 lbs - 100%	150 lbs - 102%	65 lbs - 47%	88 lbs - 80.7%
Hand (R)	128 lbs - 100%	150 lbs - 102%	77 lbs - 55%	88 lbs - 80.7%
Forearm (L)	65 lbs - 50.7%	50 lbs - 34%	45 lbs - 32.6%	36 lbs - 33%
Forearm (R)	60 lbs - 46.8%	50 lbs - 34%	42 lbs - 30%	34 lbs - 31%
Extensor (L)	41 lbs - 32%	31 lbs - 21%	28 lbs - 20%	34 lbs - 31%
Extensor (R)	41 lbs - 32%	31 lbs - 21%	30 lbs - 21.7%	31 lbs - 27.5%

Full table in Appendix 1. Showing male-female climbers side-by-side. The variance between muscle groups.

DISCUSSION

The difficulty of a route is usually assessed by the community, starting with a a climber achieving the first ascent, and follow-up repeat ascents by other climbers to either affirm, decrease, or increase the graded difficulty. Climbers expressed their indoor grade climbed closely correlated to their outdoor grade climbed. It is still unclear whether it is tendon mechanical force adaption, or finger tip callus thickness, or both that allows a climber to sustain the demanded finger force on a range of small to large climbing edges. Other muscle groups that seemed to play a key role in top-level climbers; subscapularis, latissimus dorsi, and tricep. What we were surprised by was the small margin of difference with the forearm, extensors, which are key players in grip strength. Furthermore, through the lens of this study, it may show that a new metric is need to bring clarity to a climbers hand strength. Through our test, we were able to replicate the pinch, slopper, jug, and pocket.

If the research is expanded, this type of research could assist in injury prevention. Having quantified grade averages lets a climber and coach better prepare their bodies for routes that they wish to ascend. Routes range in difficulty by finger strength, pinch strength, sloper strength, in case of the biomechanics of a climb or flexibility of a climber to sustain rest, and find ways to be efficient in a climb. Further work must be done to collect more strength data from climbers within each sport and bouldering climbing grade to make the data more complete. What this study does is opens the discussion to how we also prepare a boulderer and sport climber to excel with optimal strength to reduce injury.

We hope our exploration into the performance of an climber on easy to difficult routes changes the way see the sport in performance, injury prevention, and success in the competition space. The fingers ability to sustain force, matching the body weight or passing the body weight is important to hard climbing ascents, with climbs above 5.14a and v12 sustaining forces 100% of body weight and higher on each hand. The higest finger strength to weight ratio we have seen was from v14-v15 climbers, where able to sustained forces 115-130% of body weight on each hand separately. We can only assume this is the case for climbs 5.15a and beyond. Having data on each climbing grade allows a climber or coach to set attainable goals, and walk a climber through performance markers to track success. To expand the research, a further look into the differences in muscular development of short climbers versus tall climbers would be advantageous. Short climbers are demanded upon to jump and pull, rather then reach and stand.

REFERENCES

Sheel, A.W. (2004). Physiology of sport rock climbing. British Journal of Sports Medicine.

Brumitt, J., & Cuddeford, T. (2015). Current concepts of muscle and tendon adaptation to strength and conditioning. International Journal of Sports Physical Therapy.

APPENDIX 1

TABLE 1

	Gender	Bouldering	Sport Grade	Weight	Lat (one arm)	Subscap (L)	Subscap (R)	Deltoid (L)	Deltoid (R)	Tricep (L)	Tricep (R)	Bicep (L)	Bicep (R)	Hand (L)	Hand (R)	Forearm (L)	Forearm (R)	Extensor (L)	Extensor (R)
Climber 1	M	10	13b	135	72.22%	49.63%	49.63%	13.33%	13.33%	31.11%	31.11%	27.78%	27.78%	81.48%	92.59%	29.63%	29.63%	33.33%	25.93%
Climber 2	M	10	13a	141	127.66%	21.99%	24.82%	10.64%	10.64%	17.73%	21.28%	24.82%	21.28%	92.2%	92.2%	21.28%	24.82%	12.06%	8.51%
Climber 3	F	6	11a	127	77.17%	22.83%	23.94%	13.78%	3.94%	29.13%	13.39%	25.67%	25.67%	62.99%	62.99%	19.69%	19.69%	16.46%	16.14%
Climber 4	F	5	10a	120	66.67%	14.17%	13.33%	9.17%	7.5%	21.67%	16.67%	21.17%	21.67%	54.17%	62.5%	29.17%	28.33%	19.17%	24.17%
Climber 5	M	7	11d	133	88.72%	24.06%	26.32%	12.03%	11.28%	27.82%	15.04%	30.08%	30.83%	71.43%	71.43%	36.09%	36.09%	16.54%	21.05%
Climber 6	M	8	12a	161	89.44%	26.71%	19.88%	13.66%	14.91%	27.33%	27.14%	33.54%	40.99%	71.43%	71.43%	38.51%	40.37%	19.88%	19.88%
Climber 7	M	5	10d	160	75%	18.44%	22.5%	13.75%	14.31%	28.75%	26.88%	28.75%	33.75%	53.75%	56.88%	21.88%	23.13%	19.38%	19.38%
Climber 8	F	6	11a	138	67.39%	15.22%	16.67%	10.87%	11.59%	12.32%	12.32%	24.64%	25.36%	47.1%	55.8%	32.61%	30.43%	20.29%	21.74%
Climber 9	M	7	12a	127	80.31%	26.77%	27.56%	16.54%	11.81%	29.13%	23.62%	31.5%	32.28%	70.87%	74.8%	29.92%	32.28%	31.5%	25.2%
Climber 10	F	8	12b	107	70.09%	22.06%	19.53%	14.95%	15.89%	20.65%	21.5%	31.78%	33.64%	80.37%	80.37%	24.3%	22.43%	24.3%	27.01%
Climber 11	M	5	11a	146	81.51%	19.93%	19.18%	14.38%	11.16%	30.14%	29.45%	34.93%	35.62%	46.58%	47.95%	34.25%	28.22%	24.66%	23.29%
Climber 12	M	13	14c	128	92.19%	56.25%	52.34%	17.19%	16.41%	33.59%	34.38%	39.06%	39.84%	100%	100%	50.78%	46.88%	32.03%	32.03%
Climber 13	M	13	14a	147	68.03%	31.29%	31.29%	11.56%	11.56%	20.41%	20.41%	31.97%	31.97%	102.04%	102.04%	34.01%	34.01%	21.09%	21.09%
Climber 14	F	5	11a	110	17%	28.18%	28.18%	10.91%	19.09%	20%	20%	28.18%	28.18%	54.55%	54.55%	27.27%	27.27%	20.91%	20.91%
Climber 15	F	9	12b	133	97.74%	19.55%	19.55%	12.56%	12.63%	26.32%	27.82%	38.35%	30.08%	82.71%	90.23%	36.09%	33.08%	19.55%	19.55%
Climber 16	M	8	12a	156	83.33%	45.51%	55.13%	10.71%	10.77%	22.44%	23.72%	32.69%	25.64%	72.44%	80.13%	30.77%	28.21%	16.67%	16.67%
Climber 17	M	9	12d	136	89.71%	56.62%	56.62%	12.5%	13.24%	23.53%	22.06%	44.12%	44.12%	88.24%	80.88%	33.09%	36.03%	33.09%	24.26%
Climber 18	F	6	11b	131	79.39%	41.22%	41.98%	14.5%	14.5%	25.95%	25.95%	45.8%	45.8%	68.7%	68.63%	45.8%	47.33%	38.17%	38.17%
Climber 19	M	4	11c	168	82.14%	22.62%	28.57%	20.83%	20.83%	30.95%	29.76%	30.95%	34.52%	57.14%	57.74%	29.76%	33.33%	20.24%	23.81%
Climber 20	F	8	13a	109	88.99%	31.19%	32.11%	15.14%	16.51%	20.18%	21.1%	33.03%	33.94%	80.73%	80.73%	33.03%	31.19%	31.19%	27.52%
Climber 21	M	7	13a	143	93.71%	63.64%	64.34%	15.24%	15.38%	29.93%	29.3%	42.73%	41.82%	61.05%	63.85%	25.87%	25.87%	19.3%	22.38%
Climber 22	M	3	11a	177	88.7%	29.38%	41.81%	15.25%	17.51%	42.37%	34.46%	49.15%	47.46%	77.97%	77.4%	39.55%	36.72%	48.59%	50.28%
Climber 22	M	10	13a	140	92.86%	91.43%	92.86%	12.36%	12.36%	25.71%	25.71%	40%	42.86%	90.71%	90.71%	55%	55.71%	29.29%	30.71%
Climber 23	F	3	10b	107	61.68%	58.88%	58.88%	20.56%	22.43%	23.36%	23.36%	42.06%	42.06%	46.73%	51.4%	44.86%	38.32%	24.3%	23.36%

FIGURE 1B
Bouldering Half Crimp Strength-to-weight Ratios By Grade

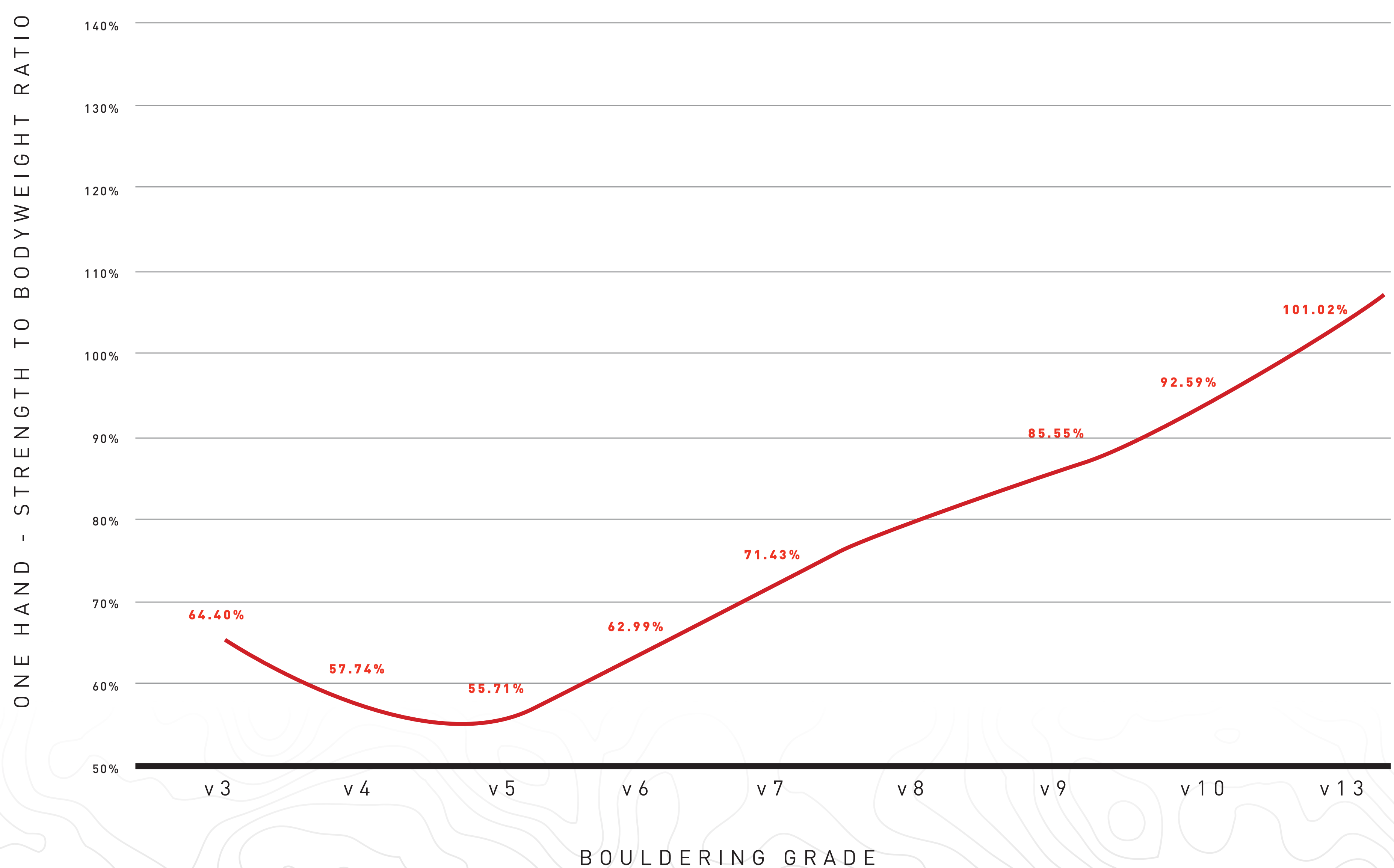

Chart showing bouldering (single) hand to weight correlations for climbing grade ranging v5 to v13.

FIGURE 2B
Sport Climbing Half Crimp Strength-to-weight Ratios By Grade

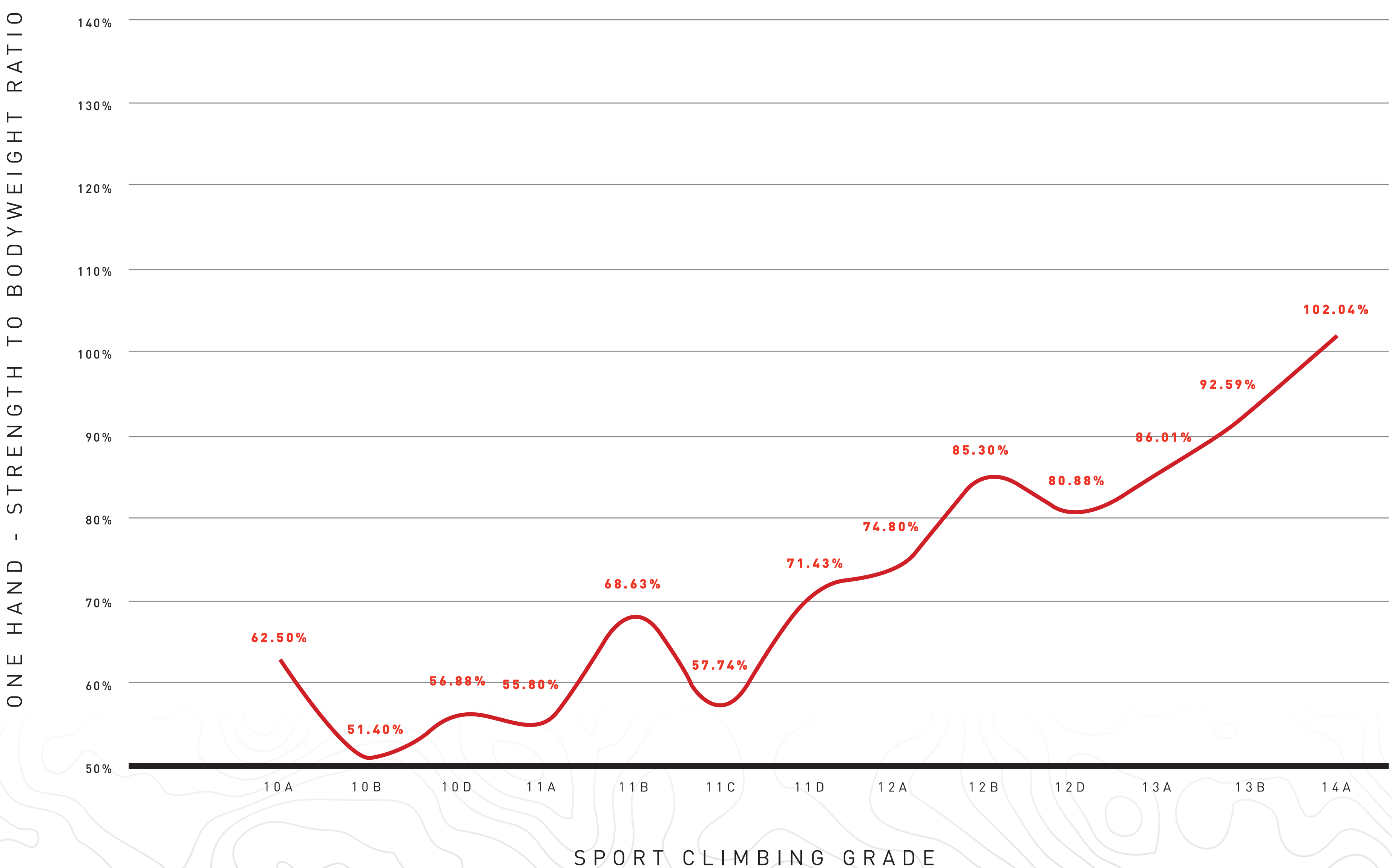

Chart showing bouldering (single) hand to weight correlations for climbing grade ranging 5.10a to 5.14c.