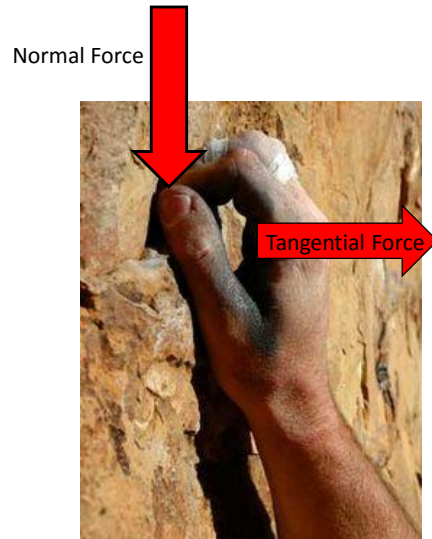


Introduction-Coefficient of friction

- $COF = \frac{\text{Tangential force}}{\text{Normal force}}$
- Static COF – The COF measured at the point of slippage
- Kinetic COF – The COF measured between two moving surfaces



Introduction-Chalk and friction

Author	Journal (year)	Results
Li FX, Margetts S, Fowler I.	J Sports Sci. (2001)	Chalk decreased the static COF
Fuss, F. K., G. Niegl, and A. M. Tan.	The engineering of sport (2004)	Chalk increased the static COF on a clean surface, but decreased on a messy surface
Amca AM, Vigouroux L, Aritan S, Berton E.	Sports Biomech. (2012)	Chalk increased the static COF
Carre MJ, Tomlinson SE, Collins JW, Lewis R.	P I Mech Eng J-J Eng. (2012)	Chalk decreased the kinetic COF

Methods – Participants

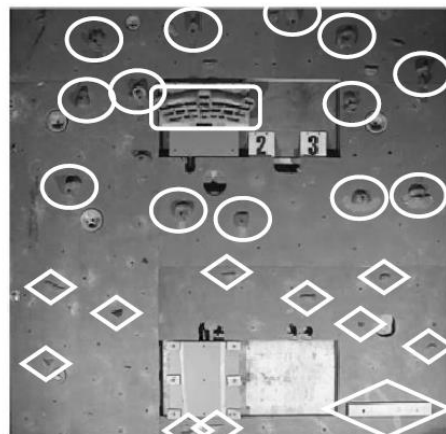
- 19 Recreational Rock Climbers (13 males, 6 females)

Table 1. Mean \pm standard deviation (SD), and significance level (p) of Height, Weight, Arm Span and Training time

	Chalk first	Chalk second	p
Height (cm)	174.6 \pm 7.1	172.7 \pm 6.4	0.32
Weight (kg)	68.7 \pm 5.7	65.9 \pm 6.9	0.53
Arm span (cm)	176.2 \pm 8.1	174.4 \pm 7.8	0.38
Training time (hours)	6.8 \pm 3.40	5.8 \pm 3.50	0.98

Methods

1. Randomized into chalk first or chalk second.
2. Washed hands
3. Completed a boulder route (5.8 YDS, V+, 8 IRCRA)
4. Hang until failure
5. 15 minute rest
6. Repeat, opposite condition



Methods- Variables measured

Climbing

- Variables
 - Forearm muscular activity
 - Climbing Time

Hanging

- Variables
 - Forearm muscular activity
 - Hang-time
 - COF
 - Ratio of vertical forces between the hands and feet (FR).

Results

Table 2. Mean \pm standard deviation (SD), the coefficient of variation (RSD), the observed power, the effect size (Cohen's d), and significance level (p), of each variable assessed.

	Chalk	No Chalk	RSD	Effect Size	P-value
Climbing time (s)	36.9 \pm 7.7	38.6 \pm 8.0	4.91	0.22	0.215
iEMG _{mean} (mV)	0.33 \pm 0.45	0.33 \pm 0.48	0.72	0.0	0.968
Hang time (s)	62.95 \pm 36.75	49.30 \pm 25.18	1.78	0.43	0.046
COF _H	0.37 \pm 0.12	0.38 \pm 0.15	3.16	0.08	0.748
FR	0.45 \pm 0.23	0.47 \pm 0.26	2.38	0.09	0.57

Discussion

- Participants could hang significantly longer with chalk ($p=0.04$)
- This may be due to:
 - Psychological benefit of chalk
 - Drying effect of sweat



Discussion-Drying effect

- During static hangs the surface of the rock occludes the skin⁶
- Causing a build up of moisture at the interface
- Chalk may attenuate this build-up



(Pasumarty, 1997)⁵

Limitations

- Ease of completing the route.
 - The experience of the participants greatly exceeded the difficulty of the route.
- Ability of the climbers
 - More experienced climbers, climber at a higher COF.⁷



(Fuss, 2009)⁶

Conclusions

- Chalk significantly increased hang time until failure.
- This may allow the climber:
 - Longer rests.
 - More time to plan the next series of movements.



Questions



References

1. Watts PB, Jensen RL, Agena SM, Majchrzak JA, Schellinger RA, Wubbels CS. Changes in EMG and finger force with repeated hangs from the hands in rock climbers. *Int J Exerc Sci.* 2008;1(2):62-70.
2. Amca AM, Vigouroux L, Aritan S, Berton E. The effect of chalk on the finger–hold friction coefficient in rock climbing. *Sports Biomech.* 2012;11(4):473-479.
3. Fuss FK, Niegl G. The importance of friction between hand and hold in rock climbing. *Sports Technol.* 2012;5(3-4):90-99.
4. LI F-X, MARGETTS S, FOWLER I. Use of `chalk` in rock climbing: sine qua non or myth? *J Sports Sci.* 2001;19(6):427.
5. Carré MJ, Tomlinson SE, Collins JW, Lewis R. An assessment of the performance of grip enhancing agents used in sports applications. *Proc Inst Mech Eng Part J J Eng Tribol.* 2012;226(7):616-625.
6. Pasumarty SM, Johnson SA, Watson SA, Adams MJ. Friction of the Human Finger Pad: Influence of Moisture, Occlusion and Velocity. *Tribol Lett.* 2011;44(2):117-137.
7. Fuss FK, Niegl G. Instrumented climbing holds and performance analysis in sport climbing. *Sports Technol.* 2009;1(6):301-313.

Extra Slides-Moisture

Author	Journal (year)	Results
Li FX, Margetts S, Fowler I.	J Sports Sci. (2001)	Water had no significant effect on COF
Fuss, F. K., G. Niegl, and A. M. Tan.	The engineering of sport (2004)	There is no difference between a dry and wet hand
Amca AM, Vigouroux L, Aritan S, Berton E.	Sports Biomech. (2012)	Humidity did not affect the COF
Carre MJ, Tomlinson SE, Collins JW, Lewis R.	P I Mech Eng J-J Eng. (2012)	Chalk did not change the dielectric constant of skin, however additional moisture increased the COF when chalk was applied.