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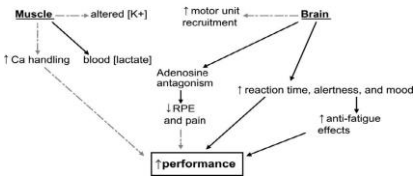
The effect of caffeine on strength and power

Truls Raastad

Proposed mechanisms for caffeine's ergogenic effects during short-term, high-intensity exercise



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REVIEW Open Access

Effects of caffeine intake on muscle strength and power: a systematic review and meta-analysis

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Jozo Grgic[1], Eric T. Trexler[2,3], Bruno Lazinica[4] and Zeljko Pedisic[1*]

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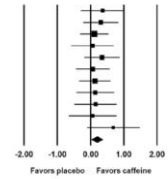
Effect on muscle strength

Study name	Hedges's g	Lower limit	Upper limit	p-Value
Arazi et al. 2016a	0.36	-0.29	1.02	0.279
Arazi et al. 2016b	0.31	-0.22	0.83	0.249
Astorino et al. 2008	0.11	-0.31	0.53	0.602
Brooks et al. 2015	0.06	-0.58	0.71	0.846
Diaz-Lara et al. 2016	0.35	-0.18	0.87	0.196
Goldstein et al. 2010	0.07	-0.44	0.57	0.799
Grgic et al. 2017	0.13	-0.35	0.61	0.587
Martin 2015	0.14	-0.43	0.71	0.629
Sabblah et al. 2015a	0.15	-0.47	0.78	0.634
Sabblah et al. 2015b	0.06	-0.65	0.77	0.869
Williams et al. 2008	0.69	-0.11	1.49	0.093
	0.20	0.03	0.36	0.023



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Effect on muscle power (jump height)

Study name	Hedges's g	Lower limit	Upper limit	p-Value
Ali et al. 2016	0.07	-0.55	0.69	0.827
Andrade-Souza et al. 2014	0.05	-0.58	0.68	0.881
Arazi et al. 2016	0.43	-0.25	1.11	0.216
Bloms et al. 2015	0.24	-0.16	0.64	0.242
Clarke et al. 2016	0.15	-0.55	0.85	0.680
Diaz-Lara et al. 2016	0.36	-0.18	0.90	0.196
Foskett et al. 2009	0.27	-0.30	0.85	0.353
Gant et al. 2010	0.20	-0.31	0.71	0.450
Gauvin 2016	-0.13	-0.54	0.28	0.535
Grgic et al. 2017	0.24	-0.24	0.73	0.323
	0.17	0.00	0.34	0.047

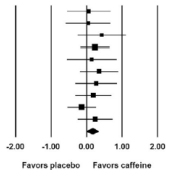

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Table 2 Results from the subgroup meta-analyses

Subgroup analysis	SMD [95% CI]	*p*-value	Mean caffeine dose (mg.kg^{-1})[range]
Strength outcomes			
Upper body strength	0.21 [0.02, 0.39]	0.026	4.7 [0.9–6]
Lower body strength	0.15 [−0.05, 0.34]	0.147	4.8 [0.9–6]
Capsule form of caffeine	0.27 [0.04, 0.50]	0.023	4.7 [2–6]
Liquid form of caffeine	0.11 [−0.17, 0.39]	0.462	6 [6]
Males	0.21 [0.02, 0.41]	0.034	4.7 [0.9–6]
Females	0.15 [−0.13, 0.43]	0.294	5 [2–6]
Trained participants	0.18 [−0.02, 0.37]	0.076	4.8 [0.9–6]
Untrained participants	0.27 [−0.09, 0.63]	0.144	4.8 [2–5]
Power outcomes			
Capsule form of caffeine	0.14 [−0.06, 0.34]	0.174	4.6 [2–7]
Liquid form of caffeine	0.24 [−0.06, 0.54]	0.124	5.2 [3.7–6]
Males	0.16 [−0.02, 0.34]	0.081	5.3 [3–7]
Females	0.23 [−0.23, 0.69]	0.323	4.8 [2–6]
Athletes	0.23 [0.03, 0.42]	0.025	4.4 [2–6]
Non athletes	0.03 [−0.33, 0.40]	0.854	6.5 [6–7]
Countermovement jump	0.14 [−0.04, 0.32]	0.138	5.0 [3.7–7]
Sargent test	0.31 [−0.09, 0.70]	0.129	4.3 [2–6]

SMD standardized mean difference, *CI* confidence interval

REVIEW Open Access

Effects of caffeine intake on muscle strength and power: a systematic review and meta-analysis

Jozo Grgic[1], Eric T. Trexler[2,3], Bruno Lazinica[4] and Zeljko Pedisic[1*]

Conclusion: The meta-analyses showed significant ergogenic effects of caffeine ingestion on maximal muscle strength of upper body and muscle power. Future studies should more rigorously control the effectiveness of blinding. Due to the paucity of evidence, additional findings are needed in the female population and using different forms of caffeine, such as gum and gel.

Aim

- to investigate the effects of a moderate dose of caffeine (4 mg·kg^{-1}) on
  - maximal strength
  - power
  - rate of force development (RFD)
  - voluntary muscular activation level
  - muscular endurance

  in resistance-trained females

- Hypothesis:

caffeine ingestion will improve 1RM and muscular endurance during squat and bench press, vertical jumping power and muscle activation during maximal voluntary contractions

Design

- Randomized placebo-controlled, double-blind, cross-over design
  - Anhydrous caffeine: 4 mg·kg^{-1} mixed in Fun light
  - Placebo: Fun light
  - 72 hours between trials
  - refrain from alcohol, caffeine and vigorous physical activity 48h prior to the trials
  - Two familiarization sessions before first test

- Well-trained women
  - 18-45 years old
  - resistance-trained for minimum 12 months, 2-3 sessions/week
  - 1 RM squat >110 % and 1 RM bench press > 80 % of body mass
  - familiar with the bench press and back squat exercises (performed at least one time/week)

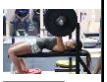
Participant characteristics

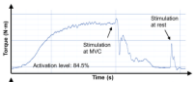
Parameter	Value	Range
Age (years)	30 ± 4	22 – 38
Stature (cm)	166 ± 5	156.5 – 173.6
Body mass (kg)	63.8 ± 5.5	56 – 75
Fat-free mass (kg)	52.3 ± 5.2	44.4 – 63.2
Fat mass (kg)	11.3 ± 4.0	4.9 – 21.2
Fat mass (%)	17.7 ± 5.8	8.1 – 32.3
Hormone contraceptive use (n - %)	n=9	56.3 %
Caffeine (mg·day^{-1})	341 ± 184	54 – 691

Training experience and strength

Strength characteristics		
RE experience (years)	7.0 ± 4.7	2 – 16
RE frequency (sessions·week^{-1})	3.7 ± 0.9	2 – 5
Squat 1RM (kg)	96.9 ± 12.6	75 – 115
Squat 1RM (kg·bw^{-1})	1.5 ± 0.2	1.2 – 1.8
Bench press 1RM (kg)	65.8 ± 10.4	50 – 82
Bench press 1RM (kg·bw^{-1})	1.0 ± 0.2	0.8 – 1.3

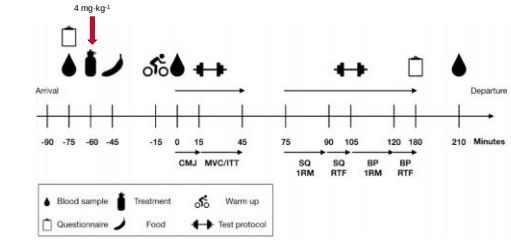
Tests



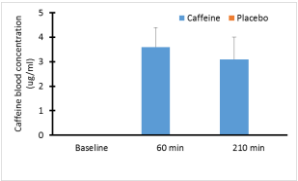


- Muscle strength
  - 1 RM test in squat and bench press
  - Isometric knee extension torque
- Muscle power and rate of force development:
  - Countermovement jump on force-plate
  - Rate of force development in isometric knee extension
- Activation level
  - interpolated twitch technique in isometric knee extension
- Muscular endurance:
  - Repetitions till failure test with 60% of maximal familiarisation 1RM
  - Rating of perceived exertion and pain
    - 10th repetitions and at failure

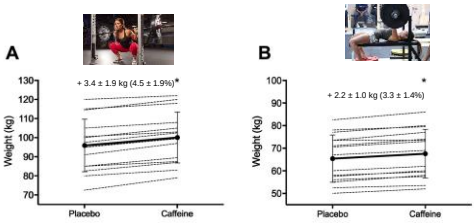
Test protocol:



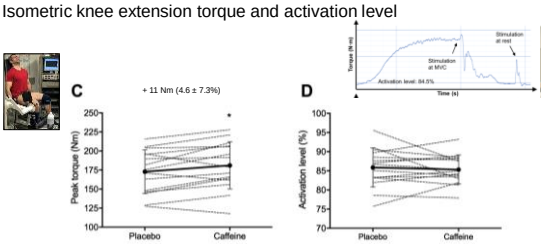
Results!



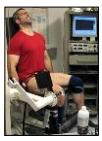
1 RM in squat and bench press

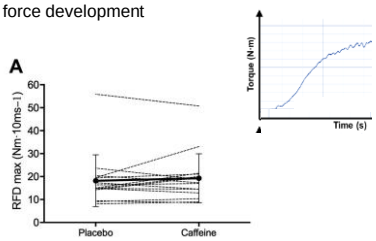


Isometric knee extension torque and activation level

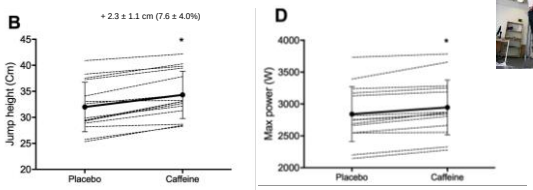


No effect on rate of force development

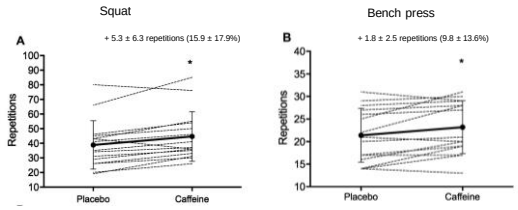




Effect on jump height and power



Repetitions till failure



*No differences between trials were found in RPE or perceived pain

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Summary

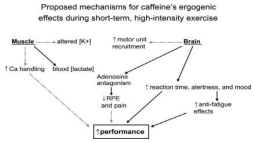
- A moderate dose of caffeine (4 mg·kg^{-1}) improved:
  - Muscle strength
    - 1 RM squat and bench press (3-4%)
    - MVC (4-5%)
  - Muscle power:
    - Jump height in CMJ (7%)
  - Muscular endurance
    - Repetitions till failure at 60% of 1 RM (10-15%)

But had no effect on:

- Rate of force development
- Activation level in MVC

Perspectives

- Should strength and power athletes use caffeine to improve performance?
- What are the mechanisms?



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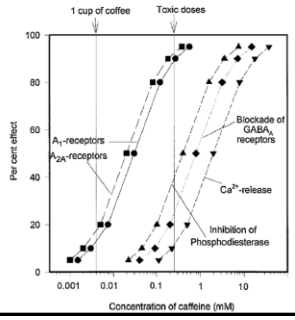
Menstrual cycle

- The participants were tested on either
  - any day within the 3-week, or longer, period of hormone contraceptive use
  - in the early follicular phase of the menstruation cycle, i.e. day 1-5, for those not using hormone contraceptives.
- The trials were thus, low oestrogen and progesterone level days