Isometric handgrip exercise speeds working memory responses in younger and older adults

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Background

- Working memory (WM) performance is modulated by stress and emotion, but is unclear how changes in physiological arousal affect WM performance.
- The locus coeruleus (LC), a small brainstem nucleus, is the brain's arousal hub region. Higher tonic levels of LC activity are associated with poorer task performance [1].
- Pupil diameter reflects LC activity [2].
- Isometric handgrip exercise modulates arousal, with tonic pupil diameter elevated during handgrip and reduced following handgrip [3].

Hypotheses

Isometric handgrip improves subsequent WM performance in younger and older adults.

Effects on WM performance are coupled with post-handgrip reductions in tonic pupil diameter.

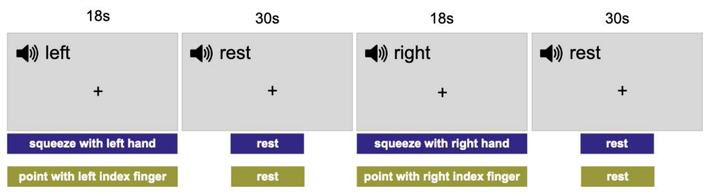
Methods

57 younger (ages 18-29) and 56 older (ages 65-85) adults completed alternating runs of an isometric handgrip protocol and an auditory n-back (WM) task. Those in a control group completed a control protocol instead of handgrip.

handgrip run 1 / control run 1	n-back run 1	handgrip run 2 / control run 2	n-back run 2	handgrip run 3 / control run 3	n-back run 3

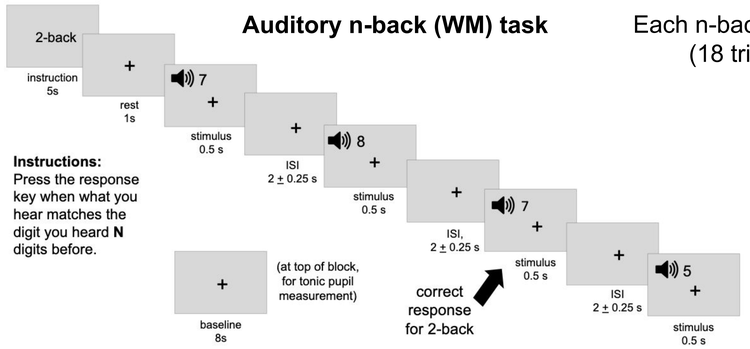
Handgrip/control protocol

handgrip and control group participants completed three 3.4-minute runs of a handgrip (or control) protocol. Both groups heard the same sounds but performed different tasks:



Eyetracking and **ECG** recordings were performed to assess arousal (pupil diameter, heart rate, and sympathetic tone [4]) during each phase, relative to a 4-minute initial baseline period. Handgrip strength was assessed using forearm **EMG**.

Auditory n-back (WM) task



Instructions: Press the response key when what you hear matches the digit you heard **N** digits before.

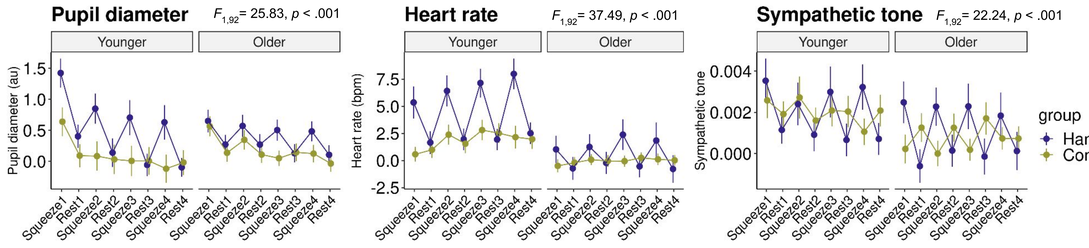
Each n-back run consisted of multiple blocks (18 trials/block), each testing a different WM load (0-, 1-, 2-, or 3-back).

Statistical analysis

ANOVAs (permuted and parametric) and Spearman correlations were used to assess effects of handgrip on arousal and WM performance.

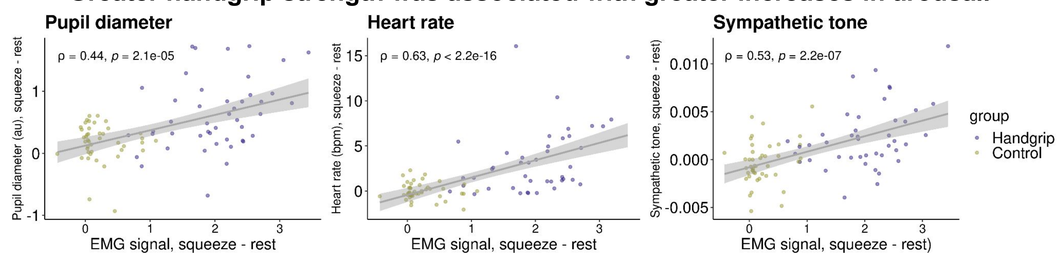
Results

Isometric handgrip increased physiological arousal in younger and older adults.

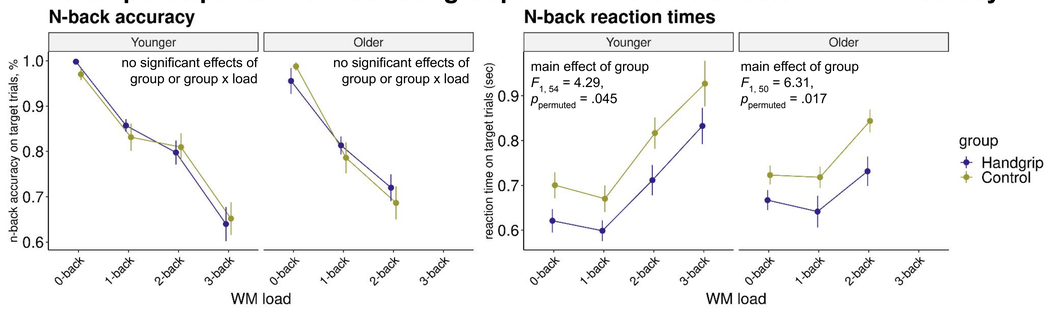


F statistics refer to group (handgrip/control) x phase (squeeze/rest) interaction effects.

Greater handgrip strength was associated with greater increases in arousal.

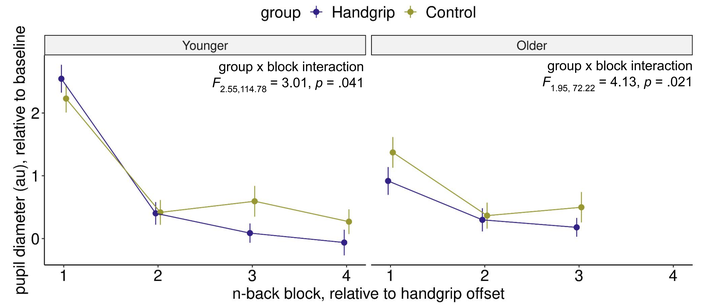


Participants in the handgrip group had faster WM reaction times than participants in the control group. There were no effects on WM accuracy.

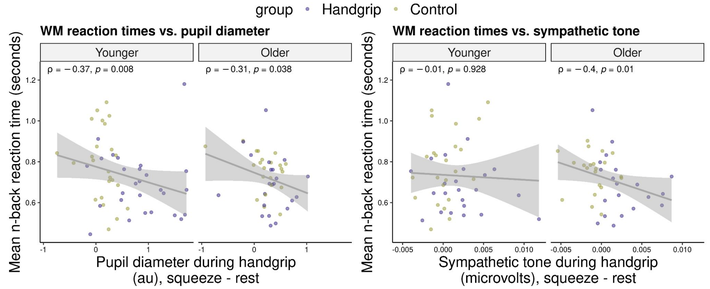


Tonic pupil diameter was reduced after handgrip.

Figure shows pupil diameter at the baseline phase preceding each n-back block, relative to the offset of handgrip.



Increases in pupil diameter during handgrip were linked to faster WM responses.



Conclusions

- Isometric handgrip led to expected changes in arousal and speeded subsequent WM responses.
- Handgrip effects on WM were related to arousal changes.
- The potential for acute isometric exercise to temporarily improve processing speed may be of particular relevance for older adults who show declines in processing speed and working memory.

References

[1] Aston-Jones & Cohen (2005), *Ann Rev Neurosci 28*(1), 403-50
[2] Joshi et al. (2016), *Neuron 89*(1), 221-34
[3] Mather et al. (2020), *NeuroImage 210,* 116560
[4] Kusayama et al. (2020), *Nat Protoc 15*(5), 1853-77

Acknowledgments

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