Cortical activity underpinning natural walking is robust to effects of physical load carriage

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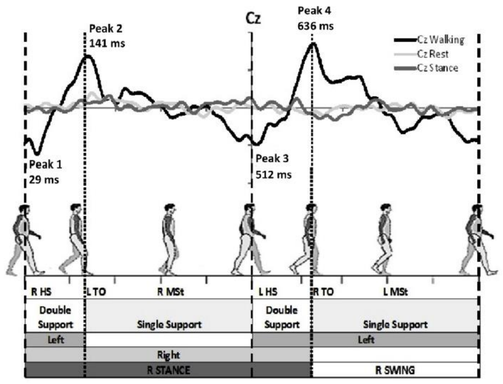
Background

Physical load carriage has clear psychological and physiological effects but very little is known about how physical load carriage affects brain activity. Physical load carriage requires additional effort that affects physiological, cognitive and behavioural outcomes. Typically, performance in these outcomes decreases over time. It is unknown if this additional effort necessitated by load carriage affects the availability of cognitive resources at the cortical level. The aim of this study is to establish if carrying a physical load reduces the cortical response during walking in comparison to walking without a load. A relatively novel ERP component, the gait related cortical potential (GRCP) is used for the comparison. The GRCP was identified in [1] during treadmill walking. We aimed to (1) identify the GRCP during 'natural' walking and (2) examine if physical load carriage attenuates the GRCP when walking. .



The GRCP as identified during treadmill walking [1]

Method

Sample

- *N* = 17 (9 F, 8 M)
- Height *M* = 171 (1.05) cm
- Weight *M* = 65.18 (2.77) kg
- Load *Mdn* = 22 (16-24) kg
- Activity *N* = 8 high, 9 moderate

Procedure

- Three minute walk outdoors with continuous EEG recorded using mobile SMARTING amplifier
- 2 conditions 1 x LOAD (one third body weight carried in backpack to a max of 24 kg), 1 x NO LOAD
- Researcher carried laptop wirelessly receiving EEG signals and manually inserted event markers into EEG stream on visualising heel contact with ground
- Distance travelled recorded with GPS device
- Ratings of physical exertion (RPE) and subjective experiences (fatigue, distress and positive feelings recorded by questionnaire following each condition

EEG data Processing

- 1 Hz high-pass filtered, 1000 ms epochs created around left heel strike marker (-100 ms – 900 ms), mean epoch baselined, ocular artefact attenuation by ICA.
- Artefact processing followed methods of [1] (mean epoch rejection 10.23 % for LOAD, 9.89 % for NO LOAD)
- 30 Hz low pass filtered, re-referenced to average of Tp9 and Tp10.
- Global field power to ERPs at electrode Cz determined latency windows for ERP analysis: three distinct time windows showed equal power fluctuations; 120 – 382 ms, 384 – 652 ms, and 654 – 904 ms post epoch onset
- Gait cycle characterised for each of these windows by searching electrode Cz for peak amplitudes from which latency and a 20 ms mean was calculated around the peak to provide two estimates (latency and amplitude) for peaks 1, 2 and 3.

Walking data

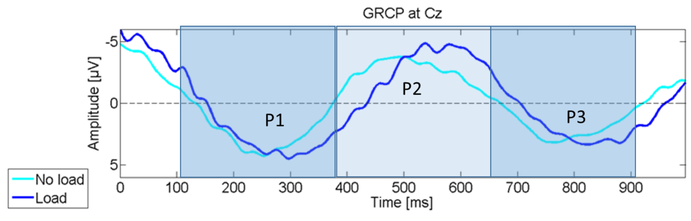
- Speed, cadence and stride length calculated

Affective data

- RPE, subjective experience.(distress, positive, fatigue)

Results

GRCP: No difference in amplitude or latency across conditions



	P1	P2	P3
AMPLITUDE	M (SE)	M (SE)	M (SE)
Load	4.31 uV (1.73)	-4.11 uV (2.12)	2.99 uV (1.52)
No load	4.42 uV (1.75)	-4.53 uV (1.95)	2.88 uV (1.48)
Difference	0.11 uV	0.42 uV	0.11 uV
LATENCY			
Load	247.17 ms (15.24)	522.35 ms (17.27)	790.82 ms (16.01)
No load	232.35 ms (11.00)	490.58 ms(16.81)	776.23 ms (15.82)
Difference	14.82 ms	31.77 ms	14.59 ms

Walking parameters: faster walking and longer strides under load

	Load	No Load
Speed	*M* = 6.35 kmph *SE* = 0.19	*M* = 5.92 kmph *SE* = 0.13*
Cadence (steps per min)	*M* = 120.78 spm *SE* = 0.05	*M* = 120.77 spm *SE* = 0.04
Stride length	*M* = 1.75 m *SE* = 0.05	*M* = 1.63 m *SE* = 0.04*

* $p < 0.05$

Affective experience: greater exertion and fatigue reported following load

	Load	No Load
RPE	*M* = 12.88 *SE* = 0.69	*M* = 7.94 *SE* =0.41*
Subjective Experiences		
Positive	*M* = 17.24 *SE* = 1.23	*M* = 17.71 *SE* = 1.30
Distressed	*M* = 6.59 *SE* =0.64	*M* = 5.88 *SE* =0.54
Fatigue	*M* = 12.71 *SE* = 1.15	*M* = 9.76 *SE* = 1.07*

* $p < 0.05$

Discussion

The GRCP was identified during 'natural' walking and was similar in characteristics to that reported by [1]. The GRCP showed no significant variance attributable to load carriage in either peak amplitude or peak latency, but a small effect ($n_G^2 = 0.02$) of later peak latencies in the load condition was found, reflective of longer strides taken to accommodate the load. Further, carrying a load during a 3 minute walk resulted in a 35 % increase in levels of perceived exertion and 10 % increase in levels of fatigue than walking without load. This may be due to the 0.43 kmph increase in speed found during load carriage. Load carriage had minimal effects on brain activity in this short assessment, but walking strategies differed. This may be due to the relative inexperience of participants with heavy load carriage.

Conclusion

Load carriage had minimal additional influence on the GRCP over a short duration of time in a natural environment.

However, it is possible to characterise the gait cycle in 'natural' environments with mobile EEG.

References
[1] Knaepen, K., Mierau, A., Tellez, H. F., Lefeber, D., & Meeusen, R. (2015). Temporal and spatial organization of gait-related electrocortical potentials. *Neuroscience Letters*, *599*, 75–80. https://doi.org/10.1016/j.neulet.2015.05.036

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