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A 4-week endurance training program improves tolerance to mental exertion in untrained individuals

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Abstract

Objectives: The aim of this study was to investigate whether 4 weeks of endurance training could improve tolerance to mental exertion in untrained participants. **Design:** Longitudinal training study. **Method:** Twenty untrained young adults (14 F, 6 M; 27.6±6.2 years) completed a 4-week training protocol in a randomised and counterbalanced order. Baseline and follow-up assessment were conducted over three sessions in the week preceding and following the training period. During session 1, participants completed an incremental maximal ramp test. During sessions 2 and 3 participants completed a 15 min cycling time trial preceded by either a mental exertion or control conditions. Following baseline assessments, participants were randomised into a physical training or placebo group that completed the training intervention thrice weekly over four weeks. **Results:** The physical training resulted in increases in VO_2peak relative to the placebo group (p=0.003). Linear mixed models utilising the control condition time trial performance as a covariate found the physical training group increased their time trial distance following the mental exertion condition to a greater extent than the placebo group (p=0.03). RPE during the time trial and perceptual measures of mental exertion did not significantly change between groups (all p>0.10) although interaction effects were observed when considering the RPE-power output relationship during the time trial. **Conclusions:** Four weeks of endurance training increased tolerance to mental exertion in untrained participants during a subsequent physical performance, but not during prolonged cognitive performance. This finding suggests that the ability to tolerate mental exertion is trainable in at least some contexts and highlights the far-reaching benefits of endurance training.

Keywords: mental fatigue, endurance training, resilience, brain adaptations, cycling

Practical implications

- The ability to tolerate mental exertion appears to be trainable, highlighting that endurance training could have potential benefit not only in sports, but also in many sporting, occupational, and military settings.
- A reduction in mental fatigue could improve physical work capacity and, consequently, encourage the use of physical exercise as a good practice in many occupational contexts.

Introduction

Endurance exercise training results in adaptations to the neuromuscular, metabolic, cardiovascular, respiratory and endocrine systems as reflected in improvements in key parameters of aerobic fitness, exercise economy and lactate/ventilatory threshold[1]. Aside from these traditional, peripherally-based adaptations, endurance exercise is linked to cognitive benefits[2,3] as well as structural[4] and functional changes in the brain[5]. These observations appear consistent with adaptations that, among other benefits, would confer improved efficiency and/or capacity for mental work. Brain adaptations to physical training could therefore also be important in our resistance to mental fatigue.

Acute mental fatigue is defined as a psychobiological state that may arise during or after prolonged cognitive activities; it is characterized by feelings of tiredness or exhaustion, and a decreased commitment and increased aversion to continue the current activity[6]. Acute mental fatigue has an adverse effect on cognitive function[7,8] and endurance performance[9]. Mental fatigue appears to impair endurance performance through an increased perception of effort during subsequent physical exercise[9]. However, a physiological reason for an increase in perceived exertion has, to date, only been postulated[10]. Beyond the physiological mechanism of mental fatigue, it is important to understand whether the ability to resist mental fatigue is associated with a genetic predisposition or displays a trainable phenotype. In a recent study, we observed an impairment of endurance performance (measured as distance covered during a cycling time trial) after mental exertion in recreational and under 23 but not in professional cyclists[11,12]. In addition, the professional cyclists performed better during the cognitive challenge than recreational athletes, suggesting a potential association between resistance to mental fatigue and cognitive capacity in this context. This observational snapshot of cohorts does not, however, distinguish between heritability and trainability.

To date, no studies have investigated the effect of endurance training on the ability to tolerate mental exertion. Therefore, the primary aim of this study was to determine whether 4 weeks of endurance training could improve tolerance to mental exertion, as determined by the difference in time trial cycling performance after a mental exertion task compared to a control condition, in previously untrained participants. We also sought to investigate if this physical training would have a measurable impact on cognitive function. The physical training group was compared to a placebo intervention group that watched a series of documentaries with recall questions to replicate the contact time of the training group, but not the physical demands.

Materials and methods

Twenty initially untrained participants completed the study. Although twenty-two originally volunteered, two participants withdrew due to personal reasons after the first visit. Participants confirmed that they were not involved in regular vigorous physical activities (≤ 2.5 hours of moderate/vigorous physical activity per week) and completed a pre-exercise screening (Exercise and Sport Science Australia Adult Pre-Exercise Screening Tool) before entering the study. Participants were excluded from enrolling in the study if they declared any medical condition or injury that would prohibit them from completing the physical components of the study, had a diagnosed sleep disorder, known colour-vision impairments, or were shift-workers. The study design and procedures were approved by the University of Canberra Human Research Ethics Committee (HREC-2018-76) and followed the ethical principles for medical research involving human participants set by the World Medical Association Declaration of Helsinki. Participants were provided with written instructions outlining the procedures and risks associated with the study and gave informed written consent.

A randomised counterbalanced design was used. Group, physical training or placebo group, and order of the experimental treatments, mental exertion or control conditions, were randomly assigned based on balanced permutations generated by a web-based computer program. While participants were aware of their allocation to the physical training or placebo group, they were blinded to the true aims of the study. Participants were told the study sought to compare the effects of a physical and a mental training program on cycling time trial performance.

An overview of the experimental protocol is shown in Figure 1. Participants attended the laboratory on eighteen occasions over six weeks. During baseline (week 1) and follow up (week 6), participants completed the same three sessions. During the first session, weight and height were assessed before participants completed an incremental maximal test on an SRM cycle ergometer (High-Performance Ergometer, Schoberer Rad MeBtechnik, Germany) to determine peak oxygen consumption and heart rate. The test began with a 3 min stage at 50 W, then increased by 25 W every minute to volitional exhaustion. Participants were then familiarised with the procedures and measures employed during the next two sessions. During the second and third visits participants completed either the mental exertion or control condition in a randomised counterbalanced order. During the mental exertion condition, participants completed a cognitive task which aimed to assess cognitive performance, induce a state of mental fatigue, and provide manipulation checks. This task consisted of 90 min of computerised cognitive tasks presented on a laptop using specialist software (E-Prime, Psychology Software Tools Inc., United States). The task was divided into three parts: a) an initial 45-min cognitive battery assessing cognitive domains including working memory, response inhibition and task-switching; b) a 40-min modified incongruent Stroop colour-word task [11]; and c) 5-min of the same task-switching (flanker) task as in the cognitive battery. The 45-min cognitive battery comprised four different tasks: 1) 15-min of the flanker task[13]; 2) 10-min of a go/no-go task[14]; 3) 10-min of a 2-back task[15], and; 4) 10-min of a working memory task[16]. Further details of the cognitive tasks and assessments are available in the supplementary material (Supplementary material 1). After the mental exertion condition, participants recorded their subjective sensation of mental fatigue and motivation toward the upcoming physical endurance test using a visual analogue scale (VAS). Participants marked their response on a 10 cm line anchored by 0 (no mental fatigue at all) and 100 (maximal mental fatigue), and 0 (no motivation at all) and 100 (maximal motivation) for the mental fatigue and motivation scales respectively. Participant responses were measured from the left anchor and expressed in mm. Participants recorded subjective workload of the mental exertion condition using the National Aeronautics and Space Administration Task Load Index scale (NASA-TLX)[17]. Participants completed the NASA-TLX immediately after the other perceptual scales.

During the control condition participants watched a white screen for 15 min. At the end of the task, they were required to record their subjective sensations of mental fatigue, motivation and workload, as described following the mental exertion condition.

Within 10 min of the completion of the mental exertion and control conditions participants performed a 3 min standardised cycling warm-up followed by a 15 min time trial using an SRM cycle ergometer. The ergometer was setup to replicate the participants' preferred bike position in the initial session and replicated thereafter. Participants were instructed to cover as much distance as possible during the 15 min. A timer was placed in front of participants and remained visible during the time trial. Participants were blinded to all other performance and physiological data. A member of the research team who was blind to the experimental treatment received by the participants provided standardised verbal encouragement during the time trial. Heart rate was recorded at the end of the warm-up, and during the final 15 s of every 3rd minute throughout the time trial using a heart rate monitor. At the same time points, a rating of perceived exertion (RPE) was recorded using the Borg 6-20 scale[18]. Mean values for power, speed and cadence were calculated for each 3 min block of the time trial, and the total distance calculated using the speed recorded by the ergometer.

For both the physical training and placebo groups, the intervention took place during weeks 2-5 (lasting 4 weeks). The physical training group completed 3x60 min sessions per week on an air-braked cycle ergometer (Wattbike Pro Trainer, Wattbike Ltd, United Kingdom). Each week training consisted of: a) 1x60 min at 65-70% of the peak heart rate recorded during the incremental maximal ramp test; b) 1x20 min at 65-70%, plus 6x3 min at 85-90% of the peak heart rate, with 2 min of active rest between repetitions; and c) 1x20 min at 65-70% followed by 40 min at 75-80% of the peak heart rate. During each session, heart rate, power output and cadence were recorded, and participants provided a session RPE (Supplementary material 2). The placebo group attended the laboratory on the same number of occasions and for the same duration as the physical training group. However, participants watched an assortment of documentaries lasting approximately 50-60 min sourced from local free-to-air broadcasting. The documentaries were viewed by the research team prior to the start of the study and were chosen so that they were interesting but not likely to generate strong emotive responses. To ensure that the participants attended to the documentary, at the end of each viewing participants were asked to answer four simple questions pertaining to the content of each video (participants' maximum mistake rate was 1 out 4).

All the testing and intervention sessions were performed in an isolated air-conditioned room (20±1 °C). Prior to each visit, participants were instructed to sleep for at least 7 h, refrain from the consumption of alcohol and caffeine, and avoid any vigorous exercise the day before visiting the laboratory. Participants were also instructed to avoid any mentally demanding tasks on the day of the training and testing sessions. Each participant carried out the sessions individually and at the same time of day (within 1 h period, between 9:00 and 13:00).

Statistical analysis was conducted with R version 3.4.2[19]. The mean and standard deviation of the outcome measures at baseline and follow up were calculated for each group. Group differences in baseline characteristics were assessed with Chi-square tests for categorical data and t-tests for continuous data. To investigate intervention effects, data were analysed by General Linear Mixed Models with a random intercept fitted for participants to take into account the repeated measures nature of the data and interindividual variability using the lme4 package[20]. For each model, the dependent variable was the outcome measured during the mental exertion condition. The independent variables were time (baseline and follow up) and group (training and placebo) with the corresponding control condition outcome as a covariate. The interaction terms between group and time were included in each model. A significant interaction term indicated the change from baseline to follow up was different by group. Visual inspection of QQ-plots generated for each model showed no obvious deviations from normality. Statistical significance was accepted at $p<0.05$.

Results

Participants were similar between groups at baseline regarding anthropometric characteristics, VO_{2peak} and distance covered during the time trial (Table 1). At baseline, participants completed significantly less distance following the mental exertion condition compared to the control condition (mean diff: -

223 m; 95% CI: -137 to -309; $p<0.001$). Using the NASA-TLX scale, participants reported that the mental exertion condition was more mentally demanding (mean diff: 6.4; 95% CI: 5.5 to 7.4; $p<0.001$) than the control condition. The VAS scales showed mental fatigue (mean diff: 53 mm; 95% CI: 42 to 65; $p=0.001$) was significantly greater, while motivation (mean diff: -3 mm; 95% CI: -12 to 7; $p=0.55$) was not significantly different, following the mental exertion condition compared to the control condition.

There was a group*time interaction for VO_{2peak} ($F_{18,1}=11.29$; $p=0.003$), such that the physical training group improved significantly more than the placebo group ($b=3.8$ ml·min^{-1}·kg^{-1}; 95% CI: 1.6 to 6.0).

The primary outcome measure was time trial distance following the mental exertion condition. Distance covered in the control condition was included in the model as a covariate to account for differences in time trial performance between groups following the intervention period. There was a significant group*time interaction ($F_{19,1}=5.66$; $p=0.03$; Figure 2) and examination of the fixed effects showed the physical training group improved time trial distance in the mental exertion condition significantly more than the placebo group ($b=264$ m; 95% CI: 211 to 476).

RPE, power, and power relative to RPE, measured at each 3-min split during the time trial following mental exertion was then investigated (Supplementary material 3). To account for the structure of this data, time trial split was initially included in the models as a three-way interaction with group and time, with the control condition outcomes included as a covariate. Non-significant interaction terms were dropped from the final models for ease of interpretation. Firstly, there were no significant group*time*split interactions for RPE, power or power relative to RPE (all $p>0.70$). For RPE there were no significant two-way interaction effects (all $p>0.20$). For power, the physical training group improved during the mental exertion time trial to a greater extent than the placebo group (group*time: $F_{181,1}=20.86$; $p<0.001$; $b=16.12$ watts; 95% CI: 8.76 to 22.82). Finally, the physical training group increased power relative to RPE at iso-time (group*time: $F_{179,1}=39.91$; $p<0.001$; $b=1.60$ watts/RPE; 95% CI: 1.08 to 2.08) to a greater extent than the placebo intervention, indicating that participants in the physical training group produced a higher power output for the reported RPE following the mental exertion condition.

For the NASA-TLX scale, there were no significant group*time interactions for the mental demand ($F_{18,1}$=2.20; p=0.16), temporal demand ($F_{18,1}$=1.39; p=0.25), physical demand ($F_{18,1}$=1.98; p=0.18), performance ($F_{18,1}$=0.05; p=0.81), effort ($F_{18,1}$=0.04; p=0.85), or frustration ($F_{18,1}$=0.16; p=0.69) subscales. For the VAS, there were no significant group*time interactions for sensation of mental fatigue ($F_{17,1}$=1.17; p=0.29) or motivation ($F_{18,1}$=0.54; p=0.47) prior to completing the time trial in the mental exertion condition.

There were no significant group*time interactions for the cognitive performance outcomes (Supplementary material 4).

Discussion

The main finding of this study was that a 4-week physical endurance training program increased tolerance to mental exertion, showing an improved physical performance after a mental exertion condition compared to a placebo group. Further, power output during the time trial was higher for the reported RPE after the intervention period in the mental exertion condition, suggesting central as well as peripheral adaptations to the physical training. No other differences were found between the physical training and placebo groups for other perceptual or cognitive performance measures.

As expected, the endurance training protocol was effective in improving VO_2peak and performance in the cycling time trial. This improvement was accompanied by an increase in mental exertion tolerance in the physical training group, reflected in an almost negligible time trial performance decrement after the mental exertion condition following the physical training intervention. In the placebo-based intervention the mental exertion condition induced a similar reduction in time trial performance at both time points. Although this study was relatively small (n=10 in each group), our primary interaction effect has a large effect size (effect size calculated from F value, Cohen’s d=1.122) and thus its practical meaning appears robust. To our knowledge, our study is the first to show that a physical endurance training program can increase resilience to prior mental exertion in this manner. We suggest that given subjective reports of mental fatigue did not change, that is, participants still reported high mental fatigue scores after the mental exertion condition, this result reflects an increased tolerance to mental exertion. Increased tolerance to mental exertion may come about through the pursuit of effortful tasks, such as endurance training. Indeed, cognitive control is often used to describe the processes, or capacity, by which individuals manage goal-orientated behaviours against distractions, disincentives, habitual tendencies or in the face of many choices[21,22], and is thought to increase with the pursuit of effortful behaviours. Unfortunately, we did not record how effortful participants perceived the different interventions, but a change in tolerance was apparent and could be supported mechanistically within our results. We observed an increase in the power output relative to RPE in the physical training group during the training protocol (Supplementary material 2) and the time trials (Supplementary material 3). Whereas this may just reflect a general adaptation to the physical training stimulus, the physical training group increased power relative to RPE at iso-time following the mental exertion condition relative to placebo suggesting that central adaptations were also generated. We have previously proposed[10] how adenosine-reducing changes in cerebral fuel stores (e.g.,[23]) and/or neural recruitment patterns (e.g.,[24]), perhaps reflecting altered mental efficiency, could account for this increased tolerance. Hence there are possible physiological mechanisms that may explain our data suggesting that - at least to some extent - resilience to mental exertion is a trainable trait. Our recent research seems to support this hypothesis, showing that tolerance to mental exertion is higher in elite athletes than in recreational ones, but also that sub-elite athletes have an intermediate ability to tolerate mental exertion compared to elite and recreational[11,12].

We found no change in cognitive performance in our untrained, yet high-functioning healthy adult participants. Exercise training interventions that target cognitive performance in young and healthy adults are rare in the literature (e.g.,[25]) although there is both cross-sectional[26] and randomized controlled trial[27] evidence that cognitive performance does benefit from exercise training in this population. The relative paucity of evidence, at least compared to investigations in older adults, may be due to the typical high cognitive performance in this population, and this may explain the lack of cognitive improvements in our university-student based cohort. Future studies could confirm our findings using more demanding or prolonged cognitive tasks, or technologies such as electroencephalography to evaluate changes in neural processing and not just overt behavioural outcomes.

A possible limitation of this study was that we chose to include a placebo intervention which replicated the time spent by the training group, but not the physical demands. In doing so however, we were conscious that cognitive and/or emotional control effort may have its own training effect and thus chose relatively emotionally neutral, although reasonably interesting content. Although we believe this met the aim of creating a placebo, we did not ask participants their expectations, nor about the effort required for either intervention (outside RPE in the physical training group). Furthermore, we acknowledge the limitation of the small sample size of the present study, however no studies have been published on the effect of a training program on tolerance to mental fatigue. Therefore, we based our numbers on a practical solution that we thought we could achieve from a recruitment and compliance perspective, and sought to inform future research of the effect sizes.

Conclusions

Four weeks of endurance training increased tolerance to mental exertion in untrained young adults during a subsequent physical task, with relative subjective ratings suggesting that central changes may account for this improvement. Cognitive performance assessments did not indicate any improvements in cognitive function as a result of endurance training.

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References

1. Jones AM, Carter H. The effect of endurance training on parameters of aerobic fitness. *Sports Med*. 2000;29(6):373-86.
2. Etnier JL, Salazar W, Landers DM, Petruzzello SJ, Han M, Nowell P. The influence of physical fitness and exercise upon cognitive functioning: A meta-analysis. *J Sport Exerc Psychol*. 1997;19(3):249-77.
3. Gomez- Pinilla F, Hillman C. The influence of exercise on cognitive abilities. *Compr Physiol*. 2013;3(1):403-28.
4. Wood KN, Nikolov R, Shoemaker JK. Impact of long-term endurance training vs. guideline-based physical activity on brain structure in healthy aging. *Front Aging Neurosci*. 2016;8:155.
5. Pensel M, Daamen M, Scheef L, et al. Executive control processes are associated with individual fitness outcomes following regular exercise training: blood lactate profile curves and neuroimaging findings. *Sci Rep*. 2018;8(1):4893.
6. Boksem MA, Tops M. Mental fatigue: costs and benefits. *Brain Res Rev*. 2008;59(1):125-39.
7. van der Linden D, Frese M, Meijman TF. Mental fatigue and the control of cognitive processes: effects on perseveration and planning. *Acta Psychol (Amst)*. 2003;113(1):45-65.
8. Lorist MM, Boksem MA, Ridderinkhof KR. Impaired cognitive control and reduced cingulate activity during mental fatigue. *Brain Res Cogn Brain Res*. 2005;24(2):199-205.
9. van Cutsem J, Marcora S, De Pauw K, Bailey S, Meeusen R, Roelands B. The effects of mental fatigue on physical performance: a systematic review. *Sports Med*. 2017;47(8):1569-88.

10. Martin K, Meeusen R, Thompson K, Keegan R, Rattray B. Mental fatigue impairs endurance performance: A physiological explanation. *Sports Med*. 2018;48(9):2041–51.
11. Martin K, Staiano W, Menaspà P, et al. Superior inhibitory control and resistance to mental fatigue in professional road cyclists. *PLoS One*. 2016;11(7):e0159907.
12. Filipas L, Gallo G, Pollastri L, La Torre A. Mental fatigue impairs time trial performance in sub-elite under 23 cyclists. *PLoS One*. 2019;14(6):e0218405.
13. Eriksen BA, Eriksen CW. Effects of noise letters upon the identification of a target letter in a nonsearch task. *Percept Psychophys*. 1974;16(1):143-9.
14. Nieuwenhuis S, Yeung N, Cohen JD. Stimulus modality, perceptual overlap, and the go/no- go N2. *Psychophysiology*. 2004;41(1):157-60.
15. Jaeggi SM, Buschkuehl M, Perrig WJ, Meier B. The concurrent validity of the N-back task as a working memory measure. *Memory*. 2010;18(4):394-412.
16. Vogel EK, McCollough AW, Machizawa MG. Neural measures reveal individual differences in controlling access to working memory. *Nature*. 2005;438(7067):500.
17. Hart SG, Staveland LE. Development of NASA-TLX (Task Load Index): Results of empirical and theoretical research. *Advances in Psychology*. 52: Elsevier; 1988. p. 139-83.
18. Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*. 1982;14(5):377-81.
19. R Core Team. R: *A language and environment for statistical computing*. R Foundation for Statistical Computing. ISBN 3-900051-07-0; 2013.
20. Bates D, Mächler M, Bolker B, Walker S. Fitting linear mixed-effects models using lme4. *Journal of Statistical Software*. 2014;67(1):1-48.
21. Badre D, Nee DE. Frontal Cortex and the Hierarchical Control of Behavior. *Trends in Cognitive Sciences*. 2018;22(2):170-88.
22. Norman DA, Shallice T. Attention to action: Willed and automatic control of behaviour. In: Davidson RJ, Schwartz GE, Shapiro D, editors. *Consciousness and Self-Regulation*. New York, USA: Springer; 1986. p. 1-18.

23. Matsui T, Ishikawa T, Ito H, et al. Brain glycogen supercompensation following exhaustive exercise. *J Physiol*. 2012;590(3):607-16.

24. Chong TT-J, Apps MA, Giehl K, Hall S, Clifton CH, Husain M. Computational modelling reveals distinct patterns of cognitive and physical motivation in elite athletes. *Sci Rep*. 2018;8(1):11888.

25. Smith PJ, Blumenthal JA, Hoffman BM, et al. Aerobic exercise and neurocognitive performance: a meta-analytic review of randomized controlled trials. *Psychosom Med*. 2010;72(3):239-52.

26. Guiney H, Lucas SJ, Cotter JD, Machado L. Evidence cerebral blood-flow regulation mediates exercise-cognition links in healthy young adults. *Neuropsychology*. 2015;29(1):1-9.

27. Stroth S, Hille K, Spitzer M, Reinhardt R. Aerobic endurance exercise benefits memory and affect in young adults. *Neuropsychol Rehabil*. 2009;19(2):223-43.

Figure legends

Figure 1. Schematic of the 6-week experimental design.

Figure 2. Time trial distance during the mental exertion condition. The change in control condition time trial distance was subtracted from the post intervention data to reflect the inclusion of this variable as a covariate in the Linear Mixed Models. Physical training group improved time trial distance in the mental exertion condition significantly more than the placebo group. Data are presented as mean ± 95% Confidence Intervals.

Table 1. Baseline characteristics of the study sample by group allocation.

	Training group (n = 10)	Placebo group (n = 10)	p
Females, n (%)	7 (70)	7 (70)	1.00

Age, y	27.6 (6.3)	27.5 (6.0)	0.97
Height, cm	169.4 (6.8)	169.5 (9.6)	0.98
Weight, kg	69.6 (18.4)	68.7 (14.3)	0.91
$VO_{2peak,}$ $ml \cdot min^{-1} \cdot kg^{-1}$	32.9 (6.9)	32.8 (5.6)	0.98
TT in control condition, m	6823 (715)	6762 (701)	0.85

Note: Data are presented as mean (SD) or number of participants.