Physical exercise facilitates motor processes in simple reaction time performance: An electromyographic analysis

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Abstract

The aim of the current study was to assess the effects of physical exercise on simple reaction time performance. Participants performed a simple reaction time task twice, one time during physical exercise and another time without exercise. Electromyographic signals were recorded from the thumb of the responding hand to fraction reaction time in pre-motor and motor time. The results showed that exercise shortened motor time but failed to affect pre-motor time. This pattern of findings is consistent with previous studies examining the effects of physical exercise on choice reaction time.

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Choice reaction time (RT) is generally been shown to be shorter when the task is performed simultaneously with an acute sub-maximal exercise (e.g. [6]). The fractionating of choice RT, using the onset of voluntary electromyographic (EMG) activity to dissect RT into pre-motor and motor time, has shown that exercise (i) interacts with visual stimulus intensity on the pre-motor time (PMT), which suggests that this variable affects retinal processing, and (ii) shortens the motor time (MT) [7], thereby revealing that this variable affects the contraction of the response agonists [10,14]. Exercise, therefore, alters the peripheral sensory and motor processes implemented during choice RT. Since exercise influences peripheral processes during choice RT, it seemed relevant to also test the influence of the exercise during simple RT. Direct assessment of the motor command in simple and choice performances revealed that the descending volley is more phasic in simple than in choice reactions (e.g. [3,4]). Given that peripheral motor processes differ across these procedures, it seems worthwhile to further assess the effects of exercise on simple RT.

Previous studies yielded inconsistent findings (for a review, see [13]). Physical exercise has been observed to exert a facilitating, detrimental, or no effect on simple reaction time performance (e.g. [9,1,5]). The objective of the present study was to assess the effects of exercise on simple RT using the same EMG analysis and the same stimulus intensity manipulation than those used by Davranche and Audiffren [6] in choice RT. In this aim, simple RT was fractionated into PMT and MT, with respect to the voluntary activity of the response agonists, in a manual task performed either concurrently with a pedaling task or at rest.

Factors affecting the same processes generally interact [12], visual stimulus intensity was manipulated so as to determine whether exercise also affects the early sensory processes involved in simple RT task.

Twelve experienced players in decision-making sports 1 (five females and seven males, aged 22–50 (M=27 years; S.D. = 8)) were tested. Informed consent was obtained from the participants. The maximal oxygen uptake (\( \dot{V}O_2 \text{max} \): \( M = 44 \text{ ml kg}^{-1} \text{ min}^{-1} \); S.D. = 8), the power at maximal oxygen uptake (\( P_{\dot{V}O_2 \text{max}} \): \( M = 279 \text{ W} \); S.D. = 61), maximal heart rate (\( HR_{\text{max}} \): \( M = 183 \text{ beats min}^{-1} \); S.D. = 10) and the power at ven-

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1 In decision-making sports as opposed to other sports (e.g. swimming, athletics), players are accustomed to simultaneously handle physiological and cognitive loads simultaneously (e.g. team sports, fighting sports and racket sports).
exercise intensity and duration in order to have an optimal energetic rate. This result suggests that subjects adapt their pedal rate according to visual stimulus intensity as within-subject factors show that mean RT was shorter during exercise (217 ms, S.D. = 20) than at rest (225 ms, S.D. = 17) (F(1, 11) = 5.3, p < 0.05, η² = 0.11). RT was longer to weak intensity signals (231 ms, S.D. = 17) than to strong intensity signals (213 ms, S.D. = 16) (F(1, 11) = 233.59, p < 0.05, η² = 0.61). In addition, an under-additive interaction between exercise and visual intensity was observed (F(1, 11) = 5.41, p < 0.05, η² = 0.007). Indeed, Newman–Keuls post hoc test shows that the effect of exercise was larger in the strong visual intensity (−10 ms, S.D. = 11) compared to the weak visual intensity (−6 ms, S.D. = 15) (Fig. 1a).

For pre-motor time, statistical analysis only revealed a significant effect of visual intensity (F(1, 11) = 213.21, p < 0.05, η² = 0.73). The mean PMT was longer in the weak visual intensity (152 ms, S.D. = 13) than in the strong visual intensity (133 ms, S.D. = 10). Main effect of exercise was absent (F(1, 11) = 2.04, p = 0.18, η² = 0.03), but the interaction between exercise and visual intensity was marginally significant on mean PMT (F(1, 11) = 3.57, p = 0.08, η² = 0.005) (Fig. 1b).

Newman–Keuls post hoc test suggests that there was a deleterious effect of exercise on pre-motor processes in the weak visual intensity condition (p < 0.05; +6 ms, S.D. = 12). Moreover, the PMT distribution analysis reveals a marginal interaction between exercise and decile (F(9, 99) = 1.84, p = 0.07, η² = 0.02). Newman–Keuls analysis reveals that exercise lengthened the PMT of the two last deciles (ninth decile: p < 0.05; +9 ms, S.D. = 22; tenth decile: p < 0.05; +15 ms, S.D. = 33).

Mean MT was shorter during exercise (72 ms, S.D. = 17) than at rest (85 ms, S.D. = 18; F(1, 11) = 24.87, p < 0.05, η² = 0.68) and this facilitative effect was present for all deciles. Indeed, the MT distribution analysis reveals a main effect of exercise (F(1, 11) = 24.51, p < 0.05, η² = 0.63) and no significant interaction was observed between exercise and decile (F(9, 99) = 1.36, p = 0.21, η² = 0.02). MT was not influenced by signal intensity (F(1, 11) < 1) (Fig. 1c).

The EMG burst, measured through the α angle, was steeper during exercise than at rest (F(1, 11) = 10.53, p < 0.05, η² = 0.44; p < 0.05). This result suggests that subjects adapt their pedal rate according to exercise intensity and duration in order to have an optimal energetic rate.
Fig. 2. Grand average of rectified electromyographic (EMG) activity during exercise (thick line) and rest (thin line).

$M = 37^\circ$, S.D. = 15 versus $M = 30^\circ$, S.D. = 16, Fig. 2, but the angle was not affected by signal intensity ($F < 1$).

The present study clearly indicates that exercise improves simple RT performance. Reaction time fractioning reveals that physical exercise improves late motor processes. The analysis of the EMG burst suggests that the motor unit discharge is better synchronized during exercise, thereby extending the results obtained for choice RT [7].

In addition, distributional analyses show that the effect of exercise consists of a shift of the whole MT-distribution. The benefit effect was consistent throughout all the deciles of the MT-distribution (10–14 ms) which suggests that these two factors affect at least a process in common [12]. However, this interaction being only marginally significant on PMT, conclusions regarding this interaction should be taken with caution.

The benefit effect was consistent throughout all the deciles of the MT-distribution (10–14 ms), which suggest that exercise shortens RT without affecting its variance. Furthermore, it must be noted that visual intensity only affects PMT. The interaction between exercise and visual intensity on mean RT may suggest that these two factors affect at least a process in common [12]. However, this interaction being only marginally significant on PMT, conclusions regarding this interaction should be taken with caution.

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