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ORIGINAL ARTICLE

Time of day effects on aerobic capacity, muscle glycogen content and performance assessment in swimming rats

Effets de l'heure de la journée sur la capacité aérobie, le contenu musculaire en glycogène et la performance de nage chez des rats

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KEYWORDS
Forced swimming;
Time to exhaustion;
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Lactate minimum test

Summary
Objective. — The aims of this study were to analyze the time of day effects on aerobic capacity, time to exhaustion at this intensity and skeletal muscle glycogen concentration in swimming rats.
Methods. — Initially, 80 animals were divided in four groups handled and tested at 12:00 and 20:00 h and subjected to a lactate minimum test. For 12:00 and 20:00 h, the lactate minimum intensity was successfully determined in 65 vs 85% of the animals, respectively, and no significant differences ($P = 0.15$) were found between groups for this variable (4.95 ± 0.40 vs 4.83 ± 0.48% body weight, respectively). Forty-eight hours after, exercised groups (at 12:00 h or 20:00 h) performed an exhaustive swim bout at lactate minimum intensity.

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Results. — Time to exhaustion was significantly greater ($P = 0.03$) for rats exercised in the dark vs light period (108.89 ± 46.33 vs 77.96 ± 30.81 min, respectively). In addition, higher skeletal muscle glycogen concentrations were found in control group at 20:00 h when compared to all other groups, probably playing an important role on time to exhaustion. These results suggest that although rat's aerobic capacity is not affected by the time of day, swimming performance is improved in the dark when compared to light period.

MOTS CLÉS
Nage forcée ;
Temps limite à l'épuisement ;
Capacité aérobie ;
L'heure du jour ;
Test de lactate minimum

Résumé
Objectifs. — Investiguer les effets de l'heure du jour sur la capacité aérobiée, le temps d'épuisement à capacité aérobie, et la concentration de glycogène du muscle squelettique chez des rats lors d'un exercice de nage.
Matériels et méthodes. — Initialement, 80 animaux ont été divisés en quatre groupes, testés à 12:00 et 20:00 et soumis à un test de lactate minimum. Pour 12:00 et 20:00 h l'intensité de lactate minimum a été déterminée avec succès pour 65 et 85 % des animaux, respectivement, et aucune différence significative ($p = 0,15$) n'a été observée entre les groupes pour cette variable (4,95 ± 0,40 vs 4,83 ± 0,48 % du poids corporel, respectivement). Quarante-huit heures après, les groupes qui ont fait les exercices à 12:00 h ou 20:00 h ont effectué un exercice de temps limite à l'épuisement de nage à l'intensité de lactate minimum.
Résultats. — Le temps à l'épuisement a été significativement plus élevé ($p = 0,03$) pour les rats qui ont fait les exercices le soir comparativement à ceux qui ont fait les exercices à la lumière du jour (108,89 ± 46,33 vs 77,96 ± 30,81 min, respectivement). En outre, les concentrations de glycogène du muscle squelettique ont été plus élevées dans le groupe témoin (sans exercice), à 20:00 h, comparées à celles des autres groupes, probablement jouant un rôle important sur le temps d'épuisement. Ces résultats suggèrent que même si la capacité aérobie des rats n'est pas affectée par l'heure de la journée, la performance de nage est améliorée dans l'obscurité par rapport à la lumière du jour.

1. Introduction

Swimming tests until exhaustion have been long and broadly employed in experimental exercise research [1—3]. Placing rats to swim until some sign of failure, usually related to their inability to remain on the water surface for an arbitrary period [3,4], can be considered an attempt to mimic endurance-like task in humans.

Despite the stressful (and usually conveniently ignored) nature of such activity [5], swimming has been thought to present several advantages over current exercise models for laboratory animals (for reviews see [1,2]). Rats are highly motivated to achieve a high level of performance in order to escape or avoid drowning when exhaustion is imminent [1]. This is supported by the observations that unweighted rats can swim for a long time (i.e., 1.5 to 4 hours) [6,7], which in turn can be considered as a practical limitation [3].

A common procedure to shorten time to exhaustion (T_{EX}) and homogenize the work load to which animals are submitted is to add weights to their bodies [8]. This practice allows assessment and prescription of exercise intensity for each rat. Alternatively, increasing attention has been devoted to the lactate minimum intensity (LMI) [9—12], that seems to provide individual estimates of the maximal load in which an equilibrium exists between lactate appearance and disappearance in the blood, i.e., the maximal lactate steady-state [12]. Whether such intensity provides relatively homogeneous T_{EX} in laboratory, rodents however are unknown.

Another relevant issue regarding exercising rats is to what extent their exercise performance is affected by the light-dark cycle. Regardless of the well-known fact that common used laboratory rodent species are nocturnal [13], exercise routines are mostly, if not solely, conducted during any daytime probably due to convenience. Since this is their natural resting (or sleeping) phase in which characteristic behavioral [14] and physiological [15—18] changes took place, it is plausible that rat's exercise tolerance would be hindered in the light period. In fact, attention to the effects of circadian rhythms in rodent's exercise related research has been claimed by different authors [2,19,20], but to our knowledge, data on the influence of light-dark cycle in rat's exercise capacity is rather scarce and to some extent controversial [10,19,21]. Whereas Manchado-Gobatto et al. [21] and Beck and Gobatto [10] recently reported a higher performance scores in Wistar rats evaluated in dark vs light phase, the other only study addressing T_{EX} at different periods in swimming rats [19] found it to be 39% greater in animals exercised at 7:00 (light) vs 19:00 h (dark period).

Additional results from Clark and Conlee [19] were that although both liver and skeletal muscle glycogen contents were greater at 7:00 h in control non-exercise animals, only the former was virtually depleted by exercise. It should be argued however, that specific time points (i.e., 7:00 and 19:00 h) in the above study were scheduled based in a previous work [22] showing them to correspond to the peak and nadir of skeletal muscle glycogen content. The same investigation yet showed liver glycogen to reach its highest