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ORIGINAL ARTICLE

Changes of vertical jump height in response to acute and repetitive fatiguing conditions

Intérêt de la variation de la hauteur de saut vertical comme marqueur de la fatigue en réponse à des conditions répétitives

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KEYWORDS
Metabolic fatigue;
Exercise-induced muscle damage;
Cognitive and emotional fatigue;
Cumulative training stress

Summary
Purpose. — The purpose of the study was to assess value of jump height variation as an indicator of neuromuscular fatigue in response to three acute interventions: (1) incremental leg cycling until volitional exhaustion, (2) 70 drop jumps, (3) 24 hours sleeplessness; and (4) during 6-week period within a basketball competition season.
Material and methods. — The typical markers of metabolic fatigue (blood lactate), exercise-induced muscle damage (muscle soreness, decrease in torque, increased blood creatine kinase activity), cognitive and emotional fatigue (information-processing speed and mood state) and volume of playing time of basketball players were analyzed in relation to changes in jump height.
Results. — The findings of the study were: (1) metabolic exercise caused a major drop in jump height, which was correlated with blood lactate accumulation, and the recovery of both was rapid; (2) the jump height drop was associated with the muscle-damage condition, although the reduction in jump height was much smaller and the recovery was longer compared with that observed after metabolic exercise; (3) jump height did not change significantly after 24 h of sleeplessness, regardless of the fact that cognitive and emotional fatigue was evident; and (4) jump height variations did not accompany the stress magnitude of players during the basketball competition period. Jump height carries some value as a neuromuscular fatigue indicator in certain acute circumstances, but has limited value in estimating cumulative stress caused by extended basketball training or competition.

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MOTS CLÉS
Fatigue métabolique ;
Lésions musculaires induites par l'exercice ;
Fatigue cognitive

Résumé
But. — Le but était d'évaluer la valeur de la variation de hauteur de saut comme indicateur de la fatigue neuromusculaire, après trois types d'intervention : (1) pédalage sur cyclo-ergomètre jusqu'à épuisement volontaire, (2) 70 *drop jumps*, (3) 24 heures de privation de sommeil ; et (4) après une période de 6 semaines au cours d'une saison de compétition de basket-ball.
Matériel et méthodes. — Les marqueurs typiques de la fatigue métabolique (lactate dans le sang), dommages musculaires induits par l'exercice (douleur musculaire, diminution du couple, augmentation de la créatine kinase dans le sang), la fatigue cognitive et émotionnelle (vitesse de traitement de l'information et humeur) et le volume de temps jeu des joueurs de basket-ball ont été analysés en fonction des changements de hauteur de saut.
Résultats. — Les résultats de l'étude étaient les suivants : (1) l'exercice métabolique a causé une baisse importante de la hauteur de saut, qui était corrélée avec l'accumulation de lactate dans le sang, et la récupération de ces deux paramètres était rapide ; (2) la diminution de hauteur de saut était constamment associée aux dommages musculaires, bien que cette réduction fut moins marquée et la récupération meilleure comparée à celle observée après une charge métabolique ; (3) la hauteur de saut n'a pas changé de façon significative après 24 h de privation de sommeil, indépendamment du fait que la fatigue cognitive et émotionnelle fut évidente ; et (4) les variations de hauteur de saut n'étaient pas associées au niveau de stress des joueurs au cours de la période de compétition de basket-ball. La hauteur de saut présente une certaine valeur en tant qu'indicateur de la fatigue neuromusculaire dans certaines circonstances, mais a une valeur limitée pour estimer le stress cumulatif lié à l'entraînement ou la compétition.

1. Introduction

The decline in performance during physical workload reflects fatigue and depends on both central and peripheral mechanisms [1,2]. Blood-flow impairment, energy-source depletion, and metabolite build-up, as well as disturbance of excitation—contraction coupling and exercise-induced muscle damage, have been suggested to play roles in the development of peripheral fatigue [3,4]. Central activation failure contributes to the decline of the activation and recruitment of the working muscles [5]. Prolonged and/or intense stimulation of the central nervous system may produce conscious awareness of fatigue, which contributes to cognitive and emotional disturbances [6,7] and induces alterations of the central motor command [8]. The dominance of peripheral and central fatigue depends on the type, intensity, and duration of the exercise and on the duration of the recovery period between bouts of exercise [9]. Furthermore, fatigue might be induced or amplified by insufficient rest as a result of travel, illness or lack of sleep [10,11].

In the training process, selection of optimal physical load is essential for desired adaptation and injury risk reduction [12]. If the selected load is too low, it does not cause the desired effect, nor an improvement in results. However, training and competition loads that exceed optimal workloads can produce long-lasting exercise-induced fatigue, which leads to decline in athletic performance [13]. To avoid overstrain it is necessary to obtain objective information on the effect of physical loads on the body and its regeneration.

Different variables have been related to the detection of the actual physiological strain in training [13,14]. Questionnaires regarding sleep disorders and mood state have been used simultaneously with blood analyses and tests of reaction time and performance until exhaustion [13,14]. In overtrained athletes, exercise tests reveal reduced time-to-exhaustion, respiratory exchange ratio, lactate production and maximum heart rate [13].

Monitoring jump height decline as a marker of fatigue has become increasingly popular among athletes, bearing in mind that this test is simple to manage and induces minimal additional fatigue [15]. It is well known that central and peripheral fatigue have a negative impact on speed, strength, and coordination [13,16], which are essential for jumping. Consequently, if high training volume and intensity persist for extensive periods, athletes with greater stress magnitude are expected to exhibit decline in jump height, which would be a signal of threatened destruction of stress-regeneration balance. Hence, daily jump height monitoring potentially can provide essential information necessary for immediate correction of a training plan. However, previous attempts to detect fatigue using jump height variations have produced contradictory results [15,17]. Edouard et al. [17] have shown that jump height is a sensitive measure of the extent of fatigue experienced by rugby league players, while drop in jump height was not observed after decathlon competitions [15]. Lack of understanding of the associations between different fatigue origins and jump height can produce a number of potential misinterpretations and false recommendations related to training strategies.

Therefore, the main aim of this study was to assess the value of jump height variation as an indicator of neuromuscular fatigue in various circumstances. This study included four substudies that evaluated jump height changes:

- after metabolic physical load;
- after exercise-induced muscle damaging physical load;
- after 24 h of wakefulness-induced cognitive and emotional fatigue;
- in basketball players during a 6-week period within a basketball competition season.

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