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Short communication

Development of a specific index to detect malnutrition in athletes: Validity in weight class or intermittent fasted athletes

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Abstract

Fasted or weight-category athletes manage their training under strict diet conditions that could impair the stress-recovery balance and result in acute or chronic fatigue. However, to date, no validated biomarker are available to quantify this phenomena. The aim of this study was to assess the validity of a specific index combining plasma albumin and weight change to detect nutrition-related risks of fatigue increase and under-performance in athletes experiencing particular nutritional conditions.

An athlete's nutrition risk index (ANRI) equation, based on data from lightweight and heavyweight rowers, was developed using relationship between plasma albumin concentrations combined to weight changes with sport performance and overtraining scores and was tested by odds ratio for failure. The accuracy and sensitivity of this former specific equation was subsequently tested on runners observing the Ramadan-fasting as well as on boxers after a short weight-loss period.

Independently of training and performance, lightweight rowers presented lower nutritional parameters than heavyweight (albumin: 37.4 ± 2.7 *vs* 39.9 ± 1.8 $g \cdot L^{-1}$, $P < 0.05$; weight state: 94.5 ± 1.8 *vs* $99.9 \pm 0.9\%$, $P < 0.01$). In lightweight, ANRI was related with overtraining score ($R^2 = 0.21$, $P < 0.01$), risks for failure in competition were enhanced when ANRI increased (OR:2.5, $P = 0.03$). Relationship of ANRI with overtraining score tended to be also significant in runners ($R^2 = 0.32$, $P = 0.06$) but not in boxers ($P = 0.4$).

Albumin concentrations combined to weight loss appeared relevant to delineate nutrition-related risks of fatigue and/or competitive failure associated with mid-term diets (about 30 days) as observed in rowers and Ramadan-fasted runners. ANRI may benefit to athletes monitoring by delineating effects of their weight loss program.

Keywords: Albumin; Weight loss; Physical conditioning

1. Introduction

The nutrition status can be considered as the regulation of a homeostatic process which allowing to keep the body at a constant state with respect to physiological functions and with optimal energy stores. However, there are several situations characterized by an impairment of this equilibrium (*i.e.* linked to a decrease in nutrients intake or a high increase of nutrient

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expenditure) which usually lead to malnutrition. That is classically observed in patients with protein energy malnutrition (like elderly people) or in intensive care unit patients [1]. For these patients, some indexes were developed to set protein energy malnutrition diagnosis and to assess nutritional status [2]. These markers are well validated and extensively used in clinical practice for their reliability to predict patients' outcome. Although largely underestimated, athletes' population, because of its high daily energy expenditure, may be also at risk of malnutrition [3]. Hence, despite the benefic effects of regular exercise on health, marked increases of physical training may be associated with physiological systems alterations (*i.e.*: muscular damages; metabolic pathways impairments; dysimmunity) [4–6]. Although nutrition plays an important role in the recovery of the exercise-induced physiological stress, trained individuals frequently present imbalance between caloric intake and expenditure [7]. Finally, over their competitive period, athletes competing in weight classes have to combine reduced diet with strenuous training that could result in energy homeostasis imbalance increasing their risks for underperformance and alterations of the immune systems [8–10].

It could be obviously assumed that tool classically used in malnourished patients are not appropriate to discriminate a possible impairment of nutritional status in athletes [2,11]. The nutritional risk index (NRI) has been reported to accurately determine nutrition-related risks in hospitalized young and aged patients, and to describe nutritional status in healthy subjects [12–15]. However, to our knowledge, there is no tool to evaluate the nutritional status of athletes [2,16]. This lack of specific tools for the monitoring of athletes nutritional status should be related to the specific situations associated with this particular population [17]: i) high variability of training and competition context, ii) variability of diet duration and type, iii) difficulty to determine parameters as outcomes of nutritional status, iv) difficulty to collect and analyze biological parameters in the sport competitive context, and v) inadequacy of the body mass index, which is usually > to 25 or 30 in strength conditioned athletes.

The aim of this study was to develop a new index called athlete's NRI (ANRI: developed from NRI) to detect nutrition-related risks of failure in athletes experiencing particular nutritional conditions.

2. Materials and methods

An ANRI equation, based on data from lightweight rowers, was developed using relationship between plasma albumin concentrations combined with weight changes and overtraining scores, and was tested by odds ratio for failure. The accuracy and sensitivity of this former specific equation was therefore tested on two confirmation groups: runners observing the Ramadan-fasting and boxers after a weight loss period. In the three groups, blood samples, weight and overtraining questionnaires were collected in similar conditions at the beginning of the diet (weight) and onset of the sport event (rowers and boxers) or end of the Ramadan fast (runners; blood samples, weight, overtraining questionnaires). Results of NRI and ANRI were also compared to absolute and relative performance indicators.

2.1. Subjects

Men rowers competing at the similar sport level were recruited for the study, they competed as lightweight rowers (LW; $n = 23$; 23.6 ± 0.8 years old) having to achieve a weight limit or as heavyweight rowers (HW; $n = 22$; 24.2 ± 1.1 years old) without weight limit. LW were observed after a weight loss diet period of 33.4 ± 4.3 days preceding a national level multi-races competition (three races for each subjects). All the rowers competed in similar boats (coxless pairs) providing methodological advantages: i) reduced delays between races and unique classification scale; ii) limit for the average weight was 70 kg for the crew (72.5 max individually) increasing weight losses when compared to single scull or ergometer races; iii) coxless pairs described individual performance compared to other crew boats.

Groups of Ramadan-fasted runners and boxers were also recruited to test the equation developed based on LW rowers. Eight middle-distance runners participated in the study (25.0 ± 1.3 years old), they were trained for 8.2 ± 0.6 h per week during the study. Runners observed the Ramadan-fasting, abstaining from food and liquids from approximately 05.00 to 19.00 h for 30 days [18]. Eight elite boxers composed the third group (21.4 ± 1.4 years old) and were trained for 7.4 ± 1.6 h during the study. Boxers observed a 10 days pre-competitive weight loss diet to achieve individual weight limit. After explaining the risks and benefits of the study, subjects gave their written informed consent to participate in the study which was carried out according to the ethical guidelines of the University of Paris Descartes-Cochin (Paris, France).

2.2. Nutritional risk index and nutritional status

The NRI was calculated as previously described using albumin serum concentrations and weight state:

$$\mathrm{NRI} = [1.519 \times \text{albumin}\ (\mathrm{g \cdot L^{-1}})] + [0.417\ (\text{weight state})]$$
[13].

In line with previous studies on NRI [12–14] we set actual weight/usual weight = 1 when actual weight exceeded usual weight.

Based on previous studies, 4 grades of nutrition-related risk have been defined: 1-major risk (NRI < 82), 2-moderate risk (NRI: 82 to 92), 3-low risk (NRI: 92 to 97.5), and 4-no risk (NRI>: 97.5) [14].

The specific ANRI equation was calculated using the relationship between rowers plasma albumin concentrations combined with weight changes and overtraining scores:

$$\mathrm{ANRI} = [-0.7915 \times \text{albumin}\ (\mathrm{g \cdot L^{-1}})] - [1.2810\ (\text{weight state})] + 169.85.$$

Weight state was calculated using comparison of the weight at the competition onset (rowers and boxers) or fast end