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## Development of a force-endurance model able to describe the muscle fatigability in the severe domain and validation of the RACLET test. \*

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**Introduction.** Muscle fatigability corresponds to the decrease in the ability of muscles to generate force. The Critical Power ( $P_c$ ) concept [1] predicts the point at which fatigue develops, in such a way that the required constant intensity will no longer be sustainable ( $W'$  reserve is emptied). During all-out tests the power plateau reached at the end of the test and the work done above this value have been numerically and conceptually related to  $P_c$  and  $W'$ , respectively. These two mathematical models, characterizing similar phenomena but based on very different exercises (steady state versus all-out) have not been directly linked. Thus, the aims of this study were to *i*) develop an integrative model of exercise fatigability and *ii*) propose a submaximal test based on this model to determine critical intensity.

**Methods.** From Mortons 3–parameters model [2] one can make the assumption that fatigability is proportional to the impulse accumulation above the critical force ( $F_c$ ) so:

$$F_{\max}(t) = -\frac{1}{\tau} \int_0^t (F(T) - F_c) dT + F_i \quad (1)$$

Since the model can be applied to any exercise, a specific Ramp Above Critical Exhaustion Test (RACLET) was proposed. The test was designed so that the target intensity starts above the critical intensity and decreases below it, before exhaustion of  $W'$ , so before the exhaustion of the participant. It was tested for a cycling task with a 300s ramp test decreasing from 40% to 5% of initial force ( $F_i$ ), where maximal capacities ( $F_{\max}$ ) were assessed every 30s from 6-pedal-strokes sprints. Twenty participants realized 5 experimental sessions: 2 RACLET and 3 time to exhaustion (TTE). A custom friction regulated instrumented cyclo-ergometer was developed to measure crank torque and velocity. Each  $F_{\max}$  was used to adjust the model's parameters. The model's reliability and validity were tested by determination of individual parameters  $F_c$  and  $\tau$  by adjusting the model to  $F_{\max}$  and time data from RACLET and TTE tests.

**Results.** The model's goodness of the fit on RACLET test experimental data was excellent (median adjusted  $R^2=0.95$ ; RMSE=3.4% $F_i$ ). Mean $\pm$ SD  $F_c$  and  $\tau$  were 29.6 $\pm$ 7.2% $F_i$  and 22.7 $\pm$ 13.9s, respectively.  $F_c$  parameter in RACLET demonstrated good relative (ICC=0.9) and absolute reliability (SEM=4.5%). The comparison of  $F_c$  between RACLET and reference TTE method was acceptable ( $R^2=0.8$ , SEM=5.8%).

**Discussion.** The proposed model fits very well with the experimental data obtained during the RACLET. The latter showed very good test-retest reliability. Moreover, the fitted parameters were very similar to those obtained with the gold standard method TTE. The present results show that it is possible to determine individual model parameters ( $F_i$ ,  $F_c$ , and  $\tau$ ) from experimental data obtained from the proposed RACLET. As this test does not lead to the participants' exhaustion, it could be interesting for athletes monitoring training, or patients with pathologies that make it difficult to use traditional methods (TTE and all-out tests).

[1] H Monod and J Scherrer. The work capacity of a synergic muscular group. *Ergonomics*, 8(3):329–338, 1965.

[2] R Hugh Morton. A 3-parameter critical power model. *Ergonomics*, 39(4):611–619, 1996.