

Level of hamstrings damage depending on force-generating capacity and creatine kinase activity

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Introduction

Although direct evidence of muscle damage is histological, in the sports context, easy measurable proxy markers are needed. According to Paulsen et al. (2012), muscle function measured as force-generating capacity (e.g., maximal isometric strength) is considered to be a reliable marker of the degree of muscle damage:

- **'mild exercise-induced muscle damage'** corresponds with a decline in force-generating capacity of no more than 20% and recovery within 48 hours.
- **'moderate exercise-induced muscle damage'** corresponds with a 20-50% decline in force-generating capacity, and/or full recovery between 48-168 hours.
- **'severe exercise-induced muscle damage'** corresponds with a decline in force-generating capacity of more than 50%, and/or recovery of force-generating capacity exceeds 168 hours.

Furthermore, serum creatine kinase (CK) activity may be used to separate subjects with **mild muscle damage** (< 1,000 IU/L) and **severe muscle damage** (> 10,000 IU/L) (Clarkson and Newham, 1995).

Aim

The aim of the present study was to categorize the eccentric exercise-induced hamstrings damage by using easy measurable markers such as force-generating capacity and serum creatine kinase activity

Methods

Participants

Thirteen young and healthy recreational sport practisers (21.3 ± 0.5 yrs; 74.6 ± 4.1 kg, 178 ± 1.7 cm) with no previous hamstring injuries one year before the study.

Eccentric exercise

Each participant performed 6 x 10 eccentric unilateral hamstring curls at 120% of their 1-repetition maximum (Kubota et al., 2007; Mendiguchía et al., 2013).

Procedures

Force-generating capacity

Force-generating capacity was measured as maximum voluntary contractions (MVCs) (maximal isometric strength); i.e. average force in a 1-s window once a force plateau had been established. MVC of the knee flexor muscles were measured with a force gauge connected to an A/D converter system (MuscleLab™, Ergotest AS, Langesund, Norway). Subjects were prone with the hip joint at 40° of flexion, with the knee joint at 30° of flexion. Measurements were done at baseline (Pre), and at 24, 48, 72 and 168 hours post-exercise. The leg which showed the greater loss of MVC was used for further analyses.

Creatine kinase

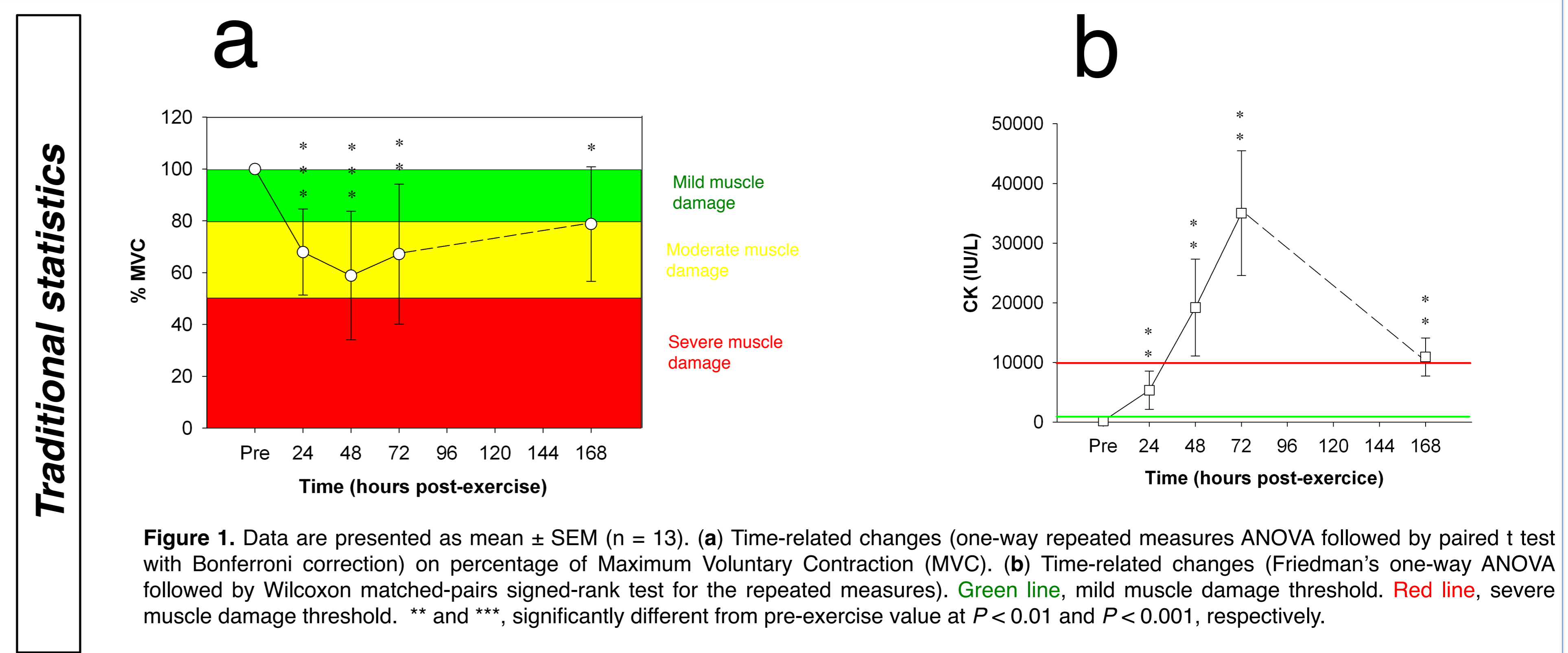
8mL blood samples were obtained at the baseline (Pre), and at 24, 48, 72 and 168 hours post-exercise for the later analysis of CK activity in serum. CK was used as a biomarker of fibre membrane disruptions (Baird et al., 2012) induced by the eccentric exercise.

This study was approved by the Ethics Committee of the Catalan Autonomous Government (Sports Council)

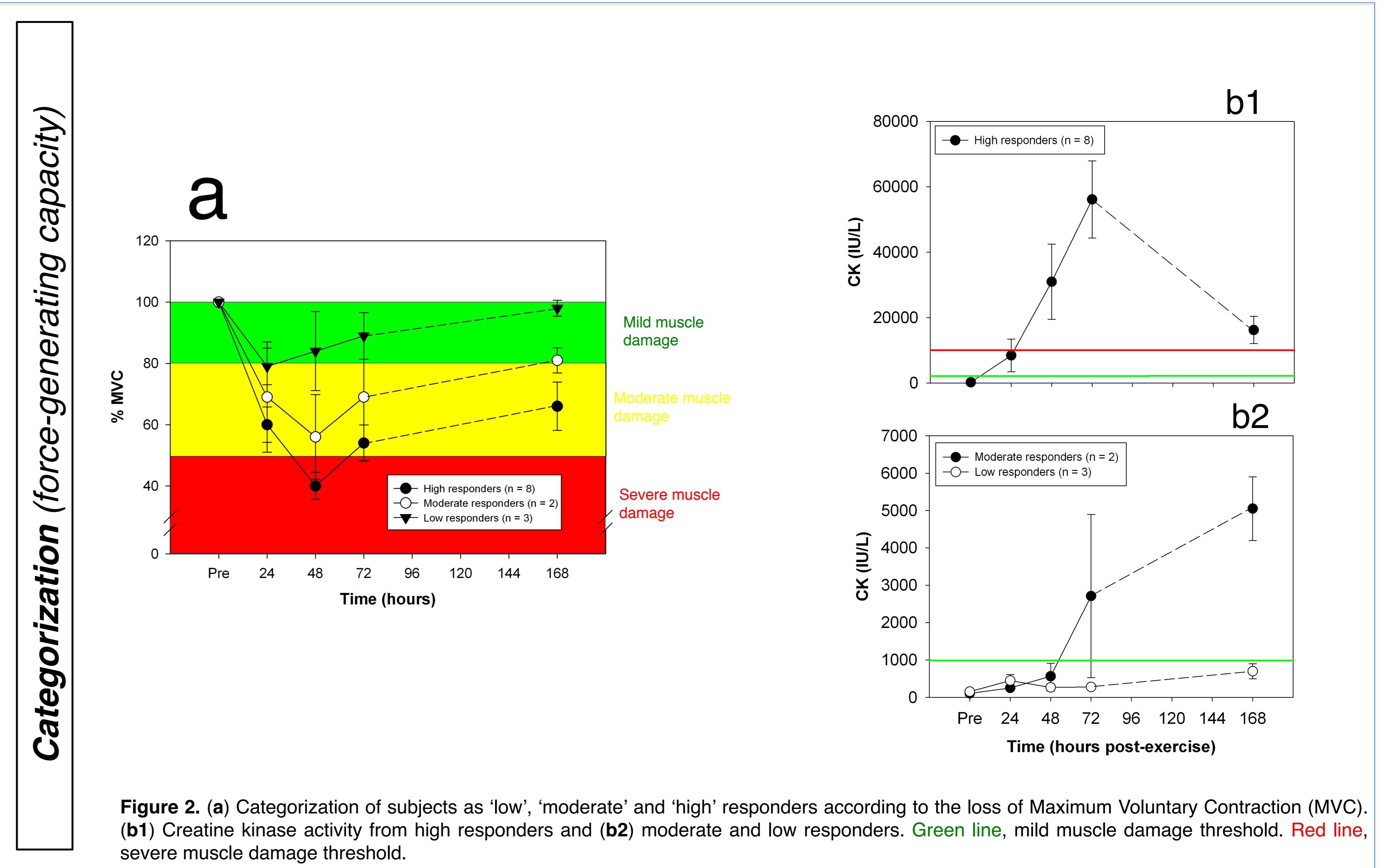
References

- Baird MF, Graham SM, Baker JS, Bickerstaff GF. Creatine kinase and exercise-related muscle damage implications for muscle performance and recovery. *J Nutr Metab.* 2012; 2012:960363.
- Clarkson PM, Newham DJ. Associations between muscle soreness, damage, and fatigue. *Adv Exp Med Biol.* 1995; 384: 457-469.
- Kubota J, Ono T, Araki M, Torii S, Okuwaki T, Fukubayashi T. Non-uniform changes in magnetic resonance measurements of semitendinosus muscle following intensive eccentric exercise. 2007; 101: 713-20.
- Mendiguchía J, Garrues MA, Cronin JB, Contreras B, Los Arcos A, Malliaropoulos N, Maffulli N, Idoate F. *J Strength Cond Res.* 2013; 27: 574-81.
- Paulsen G, Mikkelsen UR, Raastad T, Peake JM. Leucocytes, cytokines and satellite cells: what role do they play in muscle damage and regeneration following eccentric exercise? *Exerc Immunol Rev.* 2012; 18: 42-97.

Results



"We would like to emphasize that using traditional statistics to describe the response to eccentric exercise can mask important and interesting observations. We recommend to classify subjects as 'low', 'moderate' and 'high' responders because this will allow for better presentation and interpretation" (Paulsen et al., 2012)



Conclusions

The same intensive eccentric exercise protocol induced different levels of muscle damage. According to the categorization proposed by Paulsen et al. (2012) based on the loss of force-generating capacity, the eccentric exercise induced severe muscle damage in 8 of the 13 subjects. Those subjects, categorized as high responders, also showed the greatest CK activity at every time point analyzed.

Interestingly, 2 subjects were moderate responders since they showed a loss of the force-generating capacity between the 20 and 50% of the MVC. However, the fact that the force-generating capacity was not fully recovered 1 week after the exercise and the CK showed a clear increasing trend (serum peak at 168 hours post-exercise), suggested a more severe muscle damage process.

Surprisingly, 3 subjects were low responders since they showed a slight decrease of the force-generating capacity (< 20% MVC) and were recovered one week after the exercise. Moreover, the CK serum activity at every time point analyzed were the lowest in this group (< 1,000 IU/L). Nevertheless, in low responders, CK peaked at 24 hours post-exercise and at 168 hours post-exercise showing a very different time course and magnitude of changes than the rest of the participants.

Once the traditional statistics have been performed, the categorization of subjects according to its loss in force-generating capacity seems to allow for better interpretations. While in high responders the time course of force-generating capacity and CK activity showed a similar recovery trend, in moderate and low responders only the force-generating capacity showed a recovery trend.

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