BOOK OF ABSTRACTS **Open Access**

Relation between maximal power in sprint cycling, pedal force orientation and strength of the lower limb muscles in elite sprint cyclists

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Purpose:

Maximal power (Pmax) in sprint cycling is related to muscle strength and especially that of knee extensors (Driss et al., 2002; Kordi et al., 2017). However, the power output produced during the flexion phase of the pedalling cycle is also related to the capacity to effectively orientate the force on the pedals, as shown in a novice population (Dorel et al., 2010). The first aim of this study was to determine, in a high-level population, how the maximal power produced during the two main phases of the pedalling cycle relates to: i) the capacity to orient the pedal force, and ii) the force-generating capacity of the six main muscle groups of the lower limb. A second aim was to examine whether this relationship is improved by using specific velocity conditions during single-joint strength measurements.

Methods:

19 high level sprint cyclists (8 women and 11 men; age 21.4±3.7 years; height 174.5±8.6 cm; mass 76±12.1 kg) performed a 4-s isokinetic sprint at optimal velocity (Dorel et al., 2010) on a cycle ergometer (Excalibur Sport, Lode®) equipped with instrumented pedals (VélUS group; Sherbrooke). Index of mechanical effectiveness (IE) was calculated as the ratio between effective force and total force. Motion capture (Vicon) allowed to measure the mean velocity of each joint and to identify the extension and flexion phases. Maximal isometric and isokinetic strengths of extensors and flexors at the three main joints of the right lower limb were measured in a separated session (ergometer Con-Trex): ankle dorsi- and plantar-flexion (0, 30, 120, 210 and 300 $°.s^{-1}$), knee flexion and extension (0, 100, 200, 300 and 450 $°.s^{-1}$) and hip flexion and extension (0, 100, 200 and 300 $°.s^{-1}$). Torque value was averaged on the following ranges of motion: -10 to 20° for ankle (negative for dorsi-flexion), 30 to 90° for knee and 80 to 120° for hip joint (0° full extension).

Linear regression analyses were used to examine the relationship between Pmax and IE and between Pmax and the sum of single-joint maximal isometric torques (isometric), on both absolute ($Pmax_{Abs}$ in W and $\sum Mtot_{Abs}$ in N.m) and relative values ($Pmax_{Rel}$ in $W.kg^{-1}$ and $\sum Mtot_{Rel}$ in $N.m.kg^{-1}$). To investigate the effect of considering specific movement velocities during strength assessments, regressions were also performed with data obtained during isokinetic conditions (isokin-spe) at velocities close to those observed during pedalling: 120, 300 and 200 $°.s^{-1}$ for ankle, knee and hip joints, respectively (with 80, 353 and 170 $°.s^{-1}$ in pedalling). All analyses were done on sum of torque and cycling power over the entire cycle and on both flexion and extension phases separately. The coefficient of determination (R^2) was assessed ($P<0.05$ for level of significance).

Results & Discussion:

Pmax was strongly related to $\sum MTot_{Abs}$ produced during isometric condition ($R^2=0.82$, $P<0.001$), but this relation is moderate when considering relative values ($R^2=0.42$, $P<0.01$, Fig.1.). Interestingly, this relationship was even stronger with ∑MTot in isokin-spe condition when considering both absolute ($R^2=0.94$, $P<0.001$) and relative values ($R^2=0.84$, $P<0.001$). It suggests that assessing single-joint strength at specific velocities is more relevant.

When considering each phase separately, we observed a strong relationship between PmaxExt and ∑MExt for both absolute and relative values ($R^2=0{,}96_{Abs}$ and $R^2=0.86_{Rel}$, $P<0.001$, Fig.2(a)). For flexion, a good relationship was observed between PmaxFlex and ∑MFlex for absolute values ($R^2=0.74$, $P<0.001$, Fig.2(a)), which became smaller for relative values ($R^2=0.45$, $P<0.01$). Even if we observed a significant relationship between IE and Pmax (Fig.2(b)) during extension, R^2 values were low ($R^2=0.31_{Abs}$, and $R^2=0.21_{Rel}$, $P<0.05$) compared to flexion ($R^2=0.66_{Abs}$, and $R^2=0.7_{Rel}$, $P<0.001$). As a whole, these results show that Pmax in the extension phase is mainly determined by the

force-generating capacities of extensors in elite athletes, especially when these qualities are specifically assessed (in terms of force-velocity constraints). Although also related to single-joint muscle capacity, the power produced during the flexion phase (~4 to 21% of the total power), is largely influenced by the capacity to effectively orientate the force on the pedals; reinforcing the potential role of muscle coordination (Wakeling et al., 2010).

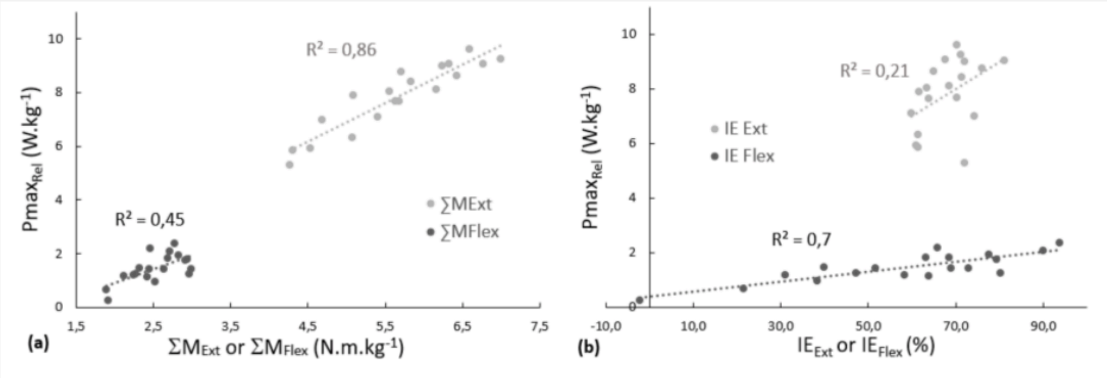

Figure 1. Relationship between sum of maximal isokinetic torques of ankle, knee and hip joints in extension (grey points) and flexion (black points) phases and maximal power in the same phases (a). Relationship between power output and index of effectiveness in flexion and extension phases separately (b).

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