INFLUENCE OF TRUNK EXTENSION TECHNIQUE ON PERFORMANCE AND CORE STABILITY DURING ERGOMETER ROWING

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The purpose of this study was to evaluate the impact of using a different timing of trunk extension on performance parameters and on core stability during ergometer rowing. 16 expert rowers took part in this study. Each subject rowed with 3 different trunk extension timings on a RowPerfect 3. An early trunk extension technique was detrimental to performance and induced more activity of trunk extensors. The usual legs-trunk-arms kinematics sequence seems to be more performant despite not being the least demanding on core stability.

KEYWORDS: trunk extension, rowing technique, electromyography, ergometer, power

INTRODUCTION: Power produced by the rower at the handle is the key performance parameter on ergometer rowing (Buckeridge et al., 2016; Hofmijster et al., 2018). Rowing technique is a specific movement sequence that produces force on the foot stretcher by legs extension closely followed by trunk extension to transfer the produced force and then finished by an arm pull to produce as much power as possible through the handle (Hofmijster et al., 2007). The trunk plays a crucial role in the sequence since it's supposed to transfer the force from the legs and produce force itself (Kleshnev, 1996; Buckeridge et al., 2016). Efficiency of the trunk in this sequence depends on core stability which is the capability to control the trunk in order to optimize its placements and force transfer (Kibler, Press & Sciascia, 2006).
In rowing, the trunk has already been investigated based on range of motion and neuromuscular activity parameters, with respect to materials manipulation such as the seat height (Vinther et al., 2013; Buckeridge et al., 2016). They demonstrated that material manipulation could influence the range of motion and neuromuscular recruitment leading to technique variations.
Different techniques are observed in rowing, yielding different trunk power profiles with specific power production from each segment (Kleshnev, 2016). These different techniques influence force transfer and production. To our knowledge, only one study further investigates the influence of technical manipulation, such as early trunk extension, on rowing biomechanics (Lintmeijer et al., 2018). This technical manipulation induced changes in the hip contribution to the acceleration of the boat. But there is no study that evaluated the impact of trunk extension techniques on performance and core stability during ergometer rowing. So, the purpose of this study was to evaluate the impact of different types of trunk extension timing on these parameters in ergometer rowing. We hypothesized that performance would be lessened, and core stability altered with early and late trunk extension techniques.

METHODS: 16 healthy and voluntary high-level rowers were recruited (5 women, 11 men, 20 ± 2 years old, 1.82 ± 0.05m, 76,8 ± 4.4 kg) part of the Elite, U23 and University categories of the French rowing federation.
After a free warm-up of 10 minutes, each rower was instructed to row on RowPerfect 3 (RP3®, Care RowPerfect BV, Hardenberg, The Netherlands) during 3 conditions with different trunk extension techniques. Each condition consisted of rowing at 20 stroke per minutes and then we registered 6 movements. The rationale for this stroke rate was to use a common warm up cadence for the rowers, enabling technique manipulation in safety. Indeed, such low stroke rate would avoid too intense repetitive motions related to back injury risks (Caldwell, McNair & Williams, 2003). The first condition was the usual way of rowing with their ecological legs-trunk-

arms sequence. In the second condition, rowers had to extend their back later than usual. For the third condition they had to open it at the beginning of the movement. They always followed this order of conditions to avoid any disturbance of the usual way of rowing in the first condition. The mobile rowing ergometer was equipped with BioRow Catch Training System (BioRow Tech, London, United Kingdom) registering force data, at the handle and at the foot stretcher, and positions of the seat, trunk and handle. All these parameters were measured at 25Hz.
In addition, 3D trunk and pelvic kinematics were measured at 100Hz, using two inertial units (iSen, STT Systems, Spain) placed in the back between the two scapulas (trunk) and between the two posterior superior iliac spines (pelvis). Surface electromyography (Trigno™, Delsys, Natick, MA, USA) recordings of core muscles, sampled at 2000 Hz and synchronized with the motion analyzis system, were obtained from the rectus abdominis, the external obliques, the erector spinae, the tensor fasciae latae and the gluteus maximus of the right and left sides.
In order to determine the timing of trunk extension, i.e. when the trunk started its extension, a 15° threshold was defined.
Performance variable such as power were calculated from Biorow Data by this formula: Handle power(W) = handle force * handle speed.
The positions were derived to obtain velocities. Technique variables, illustrated by power production at the different levels of the kinetic chain, were calculated following Kleshnev's formulas (2000):

- Legs power (W): Plegs = stretcher force * seat speed
- Trunk power (W): Ptrunk = handle force * (trunk speed- seat speed)
- Arms power (W): Parms = handle force (handle speed – (trunk speed – seat speed))

For Core Stability variables, sagittal range of motion (ROM), catch angle and finish angle for pelvis and trunk were extracted from IMU data. A positive angle represents an extension with respect to trunk and pelvis verticality. RMS of the whole drive phase were calculated from EMG data of each pair of muscles. For each subject, a mean rowing cycle for every condition was determined from the 6 registered cycles. All our analyzes were focused on drive phase going from catch to finish linked to minimal and maximal handle position. Repeated measures ANOVAs and post-hoc (Fisher's LSD) were used for the variables with significance level of 0.05. The magnitude of the changes was assessed with effect size calculated by Cohen's d.

RESULTS: The 15° threshold was exceeded significantly earlier in the early condition (30,1% ± 8.9) compared to the usual condition (34.7% ± 5.7, $p<0.05$) and the late condition (36.6% ± 6.8, $p<0.01$) (Figure 1).

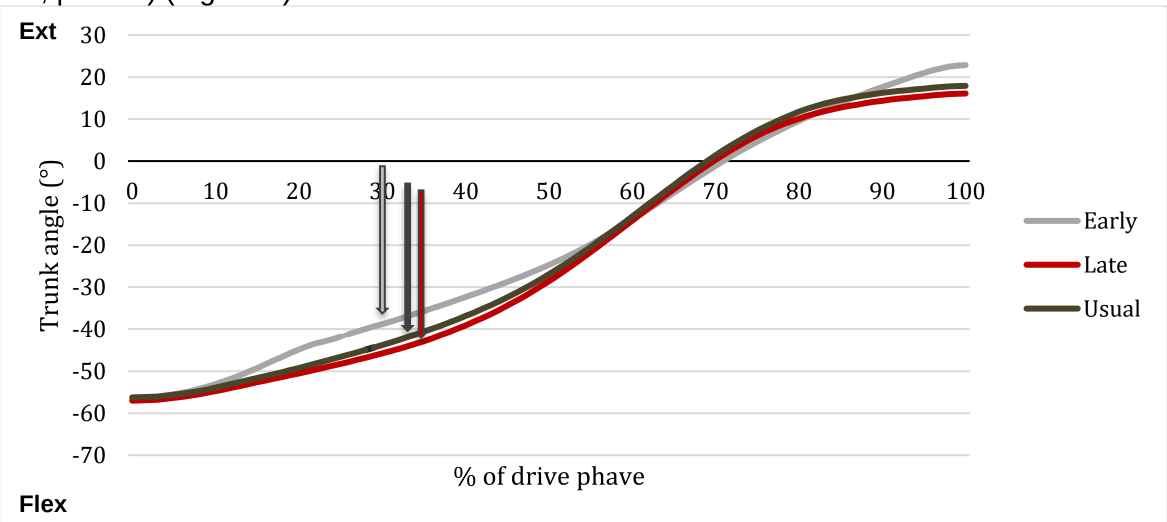

Figure 1: Mean group trunk flexion (-) -extension (+) angle during drive phase. Standard deviations are omitted for visualization purposes. Arrows depict when the 15° threshold was exceeded.

The performance parameter, i.e. mean handle power, was significantly lesser in the early condition (563W ± 157) compared to the usual condition (625W ± 164, $p<0.01$, d=1.04). The was no significant difference with respect to the late condition (590W ± 155).

The influence of trunk extension technique on Core Stability and Technique variables is presented in Table 1 and 2 below.

Table 1: Technique variables.

Variable	Usual	Late	Early
Plegs mean (W)	186 ± 45	178 ± 46	162 ± 40*** °°
Ptrunk mean(W)	233 ± 73	211 ± 62	230 ± 77
Parms mean (W)	161 ± 44	157 ± 42	129 ± 34*** °°°

Table 2: Core Stability variables.

Variable	Usual	Late	Early
Trunk ROM (°)	74.2 ± 9.8	73.4 ± 9.6	79.4 ± 9.6** °°
Trunk catch angle (°)	-56.2 ± 8.9	-57.0 ± 8.9	-56.6 ± 9.8
Trunk finish angle (°)	17.9 ± 7.6	16.4 ± 9.1	22.8 ± 7.9*** °°°
Pelvis ROM (°)	43.2 ± 7.0	42.1 ± 7.1	45.1 ± 8.9
Pelvis catch angle (°)	-2.9 ± 8.3	-1.9 ± 9.7	-3.3 ± 8.9
Pelvis finish angle (°)	40.3 ± 9.9	40.2 ± 9.2	41.8 ± 10.7
Rectus Abdominis RMS (µV)	0.11 ± 0.08	0.10 ± 0.06	0.11 ± 0.07
External Oblique RMS (µV)	0.10 ± 0.09	0.09 ± 0.06	0.09 ± 0.05
Erector Spinae RMS (µV)	0.17 ± 0.08	0.14 ± 0.09	0.18 ± 0.10°°
Tensor fasciae latae RMS (µV)	0.05 ± 0.04	0.04 ± 0.03	0.04 ± 0.03
Gluteus Maximus RMS (µV)	0.13 ± 0.06	0.11 ± 0.06**	0.12 ± 0.06**

Significant difference with Usual condition ($p<0.05$, ** $p<0.01$, *** $p<0.001$)
°Significant difference with Late condition (° $p<0.05$, °° $p<0.01$, °°° $p<0.001$)
All significant differences had effect sizes larger than 0.5.

DISCUSSION: The early extension of the trunk induced a significant lower average final power production at the handle (large effect). This can be explained by the reduced power production from the arms and legs compared to the two other techniques. Extending the trunk too early could hinder the leg power production during the drive since the quicker trunk extension would move the center of gravity backwards on the seat, thus limiting the leg power output on the stretcher. However, later trunk extension did not influence performance during ergometer rowing. Given that this condition turned out to resemble the usual technique, it seems difficult for rowers to delay their trunk extension.
The reduced power production found for the early trunk extension might be explained by core stability variables. Indeed, the early extension induced a greater trunk range of motion due to the higher finish angle. Although the trunk worked over a larger amplitude, pelvis kinematics remained within the same range of motion. Thus, the trunk might need a stable pelvis base of support when changing the timing of extension, according to the core stability principle (Kibler, Press & Sciascia, 2006). However, these kinematics changes were not all associated with increased neuromuscular activations. According to the higher trunk extension, significantly enhanced erector spinae muscle activity has been reported (large effect). But, lower gluteus maximus activity has also been found. Even if the whole Core Stability was not more challenged, the increased trunk extension together with higher trunk extensors activity, would rather speak in favor of increased loading at the spine level (De Blaiser et al., 2018). Consequently, this must be considered, especially in rowing, where spine loading is already an issue due to high constraints and repeated movements (McGregor et al., 2002; Thornton et al., 2016).
This could be useful for coaches to make sure oarsmen avoid too early trunk extension for the sake of performance and injuries prevention. Moreover, an important focus on rowing

technique should be made as soon as possible for young athletes in order to learn an effective and safe technique of rowing.

In the present study, all parameters were averaged over the whole drive phase. Using statistical parametric mapping analyses could help to tease out more precise changes within the rowing cycle induced by the use of a different technique.

CONCLUSION: The study showed that an early trunk extension technique may be detrimental to performance and more demanding on core stability. According to the few differences between usual and late technique, it seems difficult to delay even more the trunk extension. Even if acute technique alterations were evaluated in the present study, training interventions based on earlier trunk extension seems not recommended or should be conducted more precisely by using trunk kinematics feedbacks for instance.

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