

ORIGINAL INVESTIGATION (ARTIGO ORIGINAL)

## **DURING AN INCREMENTAL EXERCISE CYCLISTS IMPROVE BILATERAL PEDALING SYMMETRY**

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### **ABSTRACT**

CARPES, F. P.; ROSSATO, M.; FARIA, I. E.; MOTA, C. B. During an incremental exercise cyclists improve bilateral pedaling symmetry. *Brazilian Journal of Biomotricity*, v. 2, n. 3, p. 155-159, 2008. This study evaluated the pedaling asymmetry in six cyclists performing an incremental maximal test. The main hypothesis based in a previous research was that increasing workload the asymmetry would decrease, which was here confirmed. However, there were evidences of significant pedaling asymmetry at lower exercise intensities. The asymmetry was related to lower limb dominance. This results must be confirmed in a larger sample, but suggest that during most time of training session and some competitions where moderate to low intensity is sustained the athletes produce torque asymmetrically and the increase of intensity and fatigue process lead the cyclists to equality of torque output between limbs.

**Keywords:** Crank torque, bilateral asymmetry, laterality, limb coordination, and limb dominance.

### **INTRODUCTION**

In our study bilateral asymmetry was computed considering the magnitude of crank peak torque output within limbs. In studies considering bilateral asymmetry in running, the bilateral asymmetries in the ground reaction force may vary as much as 35% to 45% between the lower limbs (CHAVET et al., 1997; CHAVET et al., 1997; HAMILL et al., 1984; HERZOG et al., 1989; HERZOG et al., 1989). For cycling, the differences between limbs may vary

from 0.5% to 42% (CARPES et al., 2007; CAVANAGH, 1974; DALY et al., 1976).

Sanderson (SANDERSON et al., 2000) investigated the effect of changing cadence (60, 80, and 100 rpm), and power output (100 and 235W) on the pedal forces asymmetry, and found average asymmetries ranging from 8% to 9%. The asymmetry of work output was higher (maximal asymmetry indexes about 21%) for the lower power ratio (100W), mainly when the low power output was combined with the highest cadence (100 rpm). Even so the pedaling asymmetry was evaluated for different workloads, the changes during incremental exercise reaching higher workloads was not addressed. This study was designed to analyze bilateral pedaling symmetry related to the propulsive crank torque during an incremental maximal cycling test in order to verify the effects of different exercise intensities based on the mechanical workload on the pedaling asymmetry. In this regard, the identification of intensities of effort where the athlete may cycle symmetrically or not can be useful when looking for training protocols with respect to bilateral deficits, as well as in attempt to avoid injuries and improvement of pedaling technique.

## METHODS

**Subjects** - Six male amateurs and experienced competitive cyclists volunteered for this study (mean  $\pm$  SD age 20  $\pm$  3 years, height 180  $\pm$  0.7 cm, body mass 71.9  $\pm$  12.1 kg, VO<sub>2</sub>peak 56.3  $\pm$  4.6 ml/kg/min<sup>-1</sup>, peak power output 400  $\pm$  66 W and power/mass ratio 5.64  $\pm$  0.5 W/kg). The analysis of the pedaling symmetry was not explained to the volunteers so as not to influence the pedaling mechanics. The procedures were in agreement with the local Committee of Ethics in Research with Humans. All subjects signed a written consent form prior to take part in the investigation.

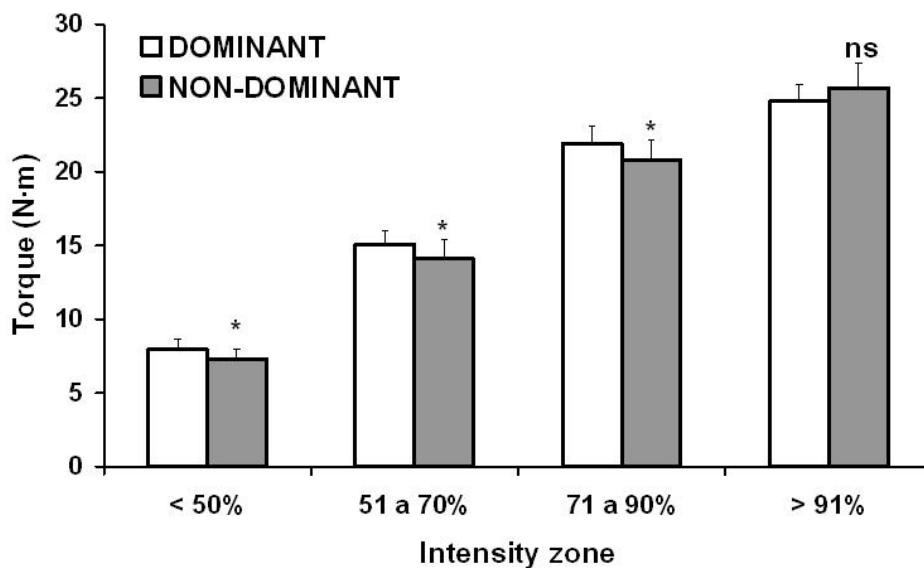
**Measurements** - A VO<sub>2</sub>peak cycling test was performed on a SRM® Training Systems cycle ergometer scientific model (SRM Science, Welldorf, Germany). The initial workload of 100 W was increased 25 W every minute. Exhaustion was defined as the point when the subject was no longer capable of maintaining 90 rpm. The VO<sub>2</sub>peak (ml.kg<sup>-1</sup>.min<sup>-1</sup>) was defined as the highest VO<sub>2</sub> observed in 20 s during the progressive cycling test. VO<sub>2</sub> and CO<sub>2</sub> production were determined every 20 s during the test via an open-circuit indirect calorimetry system (TEEM 100 Metabolic System, Aerosport Inc., Ann Arbor, MI). Prior to each test, all the devices were calibrated as suggested by the manufactures.

The propulsive peak crank torque was monitored employing the SRM® crank dynamometer (CARPES et al., 2007) every minute during 10 consecutive crank cycles. The crank torque peak for the right and left lower limbs was defined as the largest crank torque observed for each leg between 0° and 180° of the left and right crank cycle corresponding to the propulsive phase. The pedaling asymmetry was analyzed in accordance with the intensity zones of <50%, 50 to 70%, 70 to 90%, and >90% of the maximal peak oxygen uptake (%VO<sub>2</sub>peak) (FERNANDEZ-GARCIA et al., 2000).

Statistical Analysis - The dominant limb (DO) leg was characterized by the kick leg (SMAK et al., 1999). The peak crank torque in the DO and ND lower limb was compared for each intensity zone by a two-way ANOVA (4x2). Post hoc analysis where main effects or interactions were significant subsequently was performed using Tukey's HSD post-hoc test ( $p$  value set at 0.05).

## RESULTS

The Figure 1 depicts the crank torque peak, in DO and ND leg achieved for each intensity zone and the significant pedaling asymmetry.



**Figure 1** - Plot of the propulsive crank torque peak at different exercise intensity zones. (\*indicates significant statistical difference,  $p < 0.05$ , between DO and ND crank torque peaks; 'ns' indicate no statistical differences found).

The cyclists showed significant statistical difference in the peak crank torque among the lower limbs in the intensity zones lesser than 90% of the  $VO_2$  peak ( $p < 0.05$ ). Pedaling asymmetry was considered when the difference between limbs was not statistically significantly. Considering the asymmetry indexes, the lower intensity elicits bilateral differences lower than 10% (Figure 1). At the exercise intensity  $> 90\% VO_2$  peak a pedaling symmetry index higher than 25% was observed.

## DISCUSSION

The main finding of this study was that pedaling asymmetry decreases and it was not significant during the highest exercise intensity as measured by  $\%VO_2$  peak.

Smak et al. (SMAK et al., 1999) have examined the influence of the different

cadences (60, 75, 90, 105 and 120 rpm at the work rate of 250 W) on the pedaling symmetry showing that the cyclists considered as a group (average) demonstrate relatively symmetric technique in their pedaling pattern. However, the data on each subject revealed substantial differences between the DO and ND legs. In the present study, the results of asymmetry for crank peak torque production can not be explained by fluctuations in the cadence because it presented a low variation during the test ( $94 \pm 2$  rpm). The hypothesis that the DO leg, as identified by kicking, would contribute more to average power and torque than the ND leg is supported by previous reports from Smak et al. (CARPES et al., 2007; SMAK et al., 1999).

Considering that competitive cycling events are characterized by high exercise intensity (IMPELLIZZERI et al., 2005), and the most of prolonged cycling races present moderate and low intensities (FERNANDEZ-GARCIA et al., 2000), this preliminary results suggest the pedaling asymmetry during training and competition is frequently, which supports a previous investigation during simulated time-trial cycling (CARPES et al., 2007). Golich & Broker (GOLICH et al., 1996) using the SRM<sup>®</sup> Powermeter showed that during the Tour Dupont of 1994 for 50% of the total race time, the power output was below 150 W, and 25% of the time cyclists generated power outputs between 240 and 360 W. Higher power outputs (> 360 W) corresponding to higher intensities were observed only during 1% of the total race time.

If confirmed this hypothesis, our study suggest that main of cyclists may develop their training sessions with higher effort of dominant limb in comparison to other one during the torque generation. This observation is converging with a previous published study where asymmetry in the crank peak torque output was found during 40 km simulated cycling time-trial (CARPES et al., 2007). The authors report that highest asymmetry indexes (percent of differences between lower limbs) occurred during intermediate stages of the simulated race where the exercise intensity was lower compared to start and finish of the simulated race. This observation should be careful considered due the lack of studies addressing this topic.

## CONCLUSION

To the best of our knowledge, this study was the first to examine pedaling symmetry during cycling exercise at different exercise intensity zones. Our findings demonstrate that pedaling symmetry is influenced by the exercise intensity. Previous studies showed prolonged cycling races under low to moderate intensity during most of time. Our results suggest that pedaling asymmetry during training and prolonged competition can be frequently observed.

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