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LEG-KICK CONTRIBUTION IN THE 200 M FRONT CRAWL SWIMMING

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SUMMARY

The aim of this study was to assess changes in leg-kick frequency during a 200 m front crawl swimming event, performed at maximal intensity, as well as its influence to 200 m front crawl performance. Ten male swimmers performed 200 m front crawl at maximal intensity. Six video cameras (two aerial and four underwater) were used to record four complete non-breathing cycles, one for each 50 m lap (APASystem was used for processing). Kick frequency was the inverse of the time to complete one kick cycle, defined as the period between two consecutive maximum vertical coordinates of the right foot. Repeated measures one-way ANOVA, linear regressions, and within and between subjects correlation were computed. This study evidenced a decreased in kick frequency with velocity and further increase in response to fatigue, highlighting a greater importance of the leg-kick contribution to propulsion.

INTRODUCTION

The contribution of the lower limbs to the total propulsion in front crawl is known to be low. Data reported in the literature indicate that in terms of speed and power output, the contribution of the legs to propulsion is about 10 to 15% [1,2]. However, when the small muscle groups of the arms and shoulders become fatigued, the less-efficient larger muscle groups of the legs begin to work harder, increasing the energy cost of swimming. In accordance with this, Zamparo and Swain [3] showed an increase of the contribution of the lower limbs to the total power output during an incremental protocol, until 50% of contribution, in a special swimming ergometer.

The kick plays an important role in providing stability for the whole stroke by facilitation of body position, optimizing propulsion and minimizing resistance [4]. It also contributes to an economical body roll, as it is linked to the hydrodynamic forces [5], implying physiological changes (e.g. oxygen consumption) [6]. In addition, proper kicking is required as a foundation for development of good coordination in the global front crawl technique [7]. In this way, changes that might occur in the lower limbs actions during high-intensity swim should be taken into account, as well as its contribution in fatigue conditions.

Therefore, the aim of this study was to assess changes in kick frequency during a 200 m front crawl event, performed

at maximal intensity, as well as its influence to 200 m front crawl performance.

METHODS

Ten high level male swimmers volunteered to participate in this study (average (SD)): age 21.6 (2.4) yrs; height 185.2 (6.8) cm; arm span 188.7 (8.4) cm; body mass 76.4 (6.1) kg. All swimmers (mean performance in a 200 m race = 91.6 (2.1)% of the 25 m pool world record) had 11.0 (3.5) yrs experience as competitive swimmers. All subjects gave their written informed consent before participation.

Swimmers performed a 200 m front crawl simulated race, at maximal intensity. Six synchronised video cameras (Sony® DCR-HC42E) were used to record the event (four under and two above water). Three-dimensional reconstruction of twenty-one body landmarks digitised (50 Hz) was computed using DLT [8], a calibration frame (3 x 2 x 3 m for the horizontal, vertical and lateral directions; 30 calibration points) and a 6 Hz low pass digital filter. Twenty-one body landmarks, 7th cervical, mandible (mental protuberance), humeral heads, ulnohumeral joints, radiocarpal joints, 3rd dactylions, trochanter major of femurs, tibiofemoral joints, talocrural joints, calcanei and acropodion, and the Zatsiorsky anatomical model adapted by de Leva [9] were used. The calibration setup has been described and the accuracy and reliability of the calibration procedures and digitisation have been established by Figueiredo et al. [10]. One complete arm stroke cycle, at mid-pool and without breathing, for each 50 m of the 200 m front crawl was recorded. Test sessions took place in a 25 m indoor pool.

Data analysis

Kinematical data analysis was done using APAS (Ariel Dynamics, Inc.). The mean horizontal velocity was calculated by dividing the swimmer's mean whole-body centre of mass horizontal displacement by the time spent to complete one stroke cycle. Kick frequency (KF) was the inverse of the time to complete one kick cycle, defined as the period between two consecutive maximum vertical coordinates of the right foot. The y displacement of the first phalanx tip was representative of the foot's vertical motion, which was referenced to an external point.

Mean (\pm SD) computations for descriptive analysis were obtained for all variables selected (data normal distribution verified with Shapiro-Wilk's test). A one-way repeated

measures ANOVA was used to compare the variables along the 200 m event. When a significant F-value was achieved, Bonferroni post-hoc procedure was performed to locate the pairwise differences. Linear regressions between the velocity and the kick frequency were computed, as well as their coefficients of determination for each lap. To further analyse this relationship over the 200 m, since involves a repeated measurements design, a within subjects correlation coefficient was reported, as well as a between subjects correlation coefficient [11,12].

All statistical analysis was performed using STATA 12.1 (StataCorp, USA) and the level of statistical significance was set at $P \leq 0.05$. Effect size was computed with Cohen's f [13].

RESULTS AND DISCUSSION

Swimming velocity decreased significantly from 1.57 to 1.35 $\text{m}\cdot\text{s}^{-1}$ (first to the last lap) ($F_{(3,27)} = 24.58$, $P < 0.001$, $f = 1.26$), which is in agreement with previous studies [14,15]. Kick frequency decreased significantly from 2.02 Hz in first lap to the third lap (1.85 Hz) ($F_{(3,27)} = 2.80$, $P = 0.05$, $f = 0.26$), increasing afterwards, probably as a response to fatigue, mainly in the upper limbs as shown by the muscle activity [16].

Figure 1 presents the linear regressions between velocity and kick frequency for each 50 m lap of the 200 m front crawl, meaning that the subject with higher velocities in the second half (third and fourth lap) of the effort had also a higher kick frequency, suggesting a higher leg-kick contribution, as referred by Zamparo and Swain [3] for an incremental protocol (without fatigue). These authors reported, at the end of their protocol, a 50% contribution of the legs to the total power output.

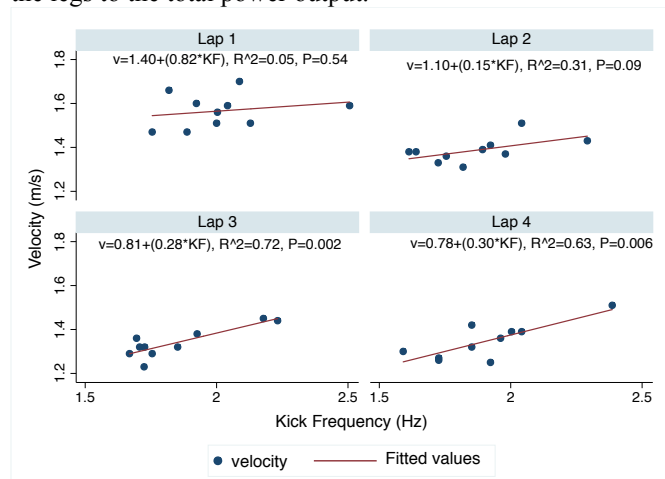


Figure 1: Velocity (v , m/s) as a function of kick frequency (KF, Hz) in the four laps of the 200 m front crawl.

To further study the relationship of the velocity and the kick frequency throughout the 200 m front crawl event, within

and between subjects correlation coefficients were calculated, being $R = 0.66$ ($P < 0.001$) and $R = 0.66$ ($P = 0.037$), respectively. Concomitant with the linear regressions results for each 50 m lap, results suggest that leg-kick increase its contribution, along the 200 m effort. Since the velocity remained stable in the last three 50 m laps, this means that kick frequency is increased as fatigue evolves, as previously reported also for the stroke frequency [14,15]. As arms and legs have a strong coordination in front crawl [16], this kick frequency increase was already hypothesized.

These study findings have suggested implicitly that the leg-kick could not be relegated to a position of secondary importance for propulsion. In other words, the role of leg-kick cannot be limited to keeping the body in a good position in the water; rather it has influence on the whole-body velocity, when speed is changed or when fatigue becomes evident.

CONCLUSIONS

This study evidenced that leg kick contribution to the performance in front crawl increases with velocity, but also with fatigue.

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REFERENCES

1. Deschodt VJ, et al. *Eur J Appl Physiol.* **80**:192–199, 1999.
2. Hollander AP, et al. *Swimming Science.* Human Kinetics, Champaign, 39–43, 1988
3. Zamparo, P., et al. *J Appl Physiol.* **113**:584-594, 2012.
4. Maglischo EW. *Swimming fastest.* Human Kinetics, Champaign, 2003.
5. Yanai T. *J Biomech.* **36**:53–62, 2003.
6. Ogita F, et al. *Acta Physiol Scand.* **157**: 435-441, 1996.
7. Sanders RH. *J Sports Sci.* **25**:213–227, 2007.
8. Abdel-Aziz Y, et al. Proceedings of the symposium on close-range photogrammetry, Illinois, 1-18, 1971.
9. de Leva P. *J Biomech.* **29**:1223-1230, 1996.
10. Figueiredo P, et al. *Int J Sports Med.* **30**:779-781, 2009.
11. Bland JM, et al. *BMJ.* **310**:446, 1995.
12. Bland JM, et al. *BMJ.* **310**:633, 1995.
13. Cohen J. *Statistical Power Analysis for the Behavioral Sciences.* Lawrence Erlbaum Associates, Hillsdale, 1988.
14. Alberty M, et al. *Int J Sports Med.* **26**:471-475, 2005.
15. Craig AB, et al. *Med Sci Sports.* **11**:278-283, 1979.
16. Figueiredo P, et al. *Int J Sports Med.* **34**:49-55, 2013.