Influence of non-circular chainrings on muscular activity during stationary and outdoor cycling

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Abstract

Power production in cycling varies during one crank revolution due to the limitation of pedal force occurring normal to the crank (Fonda & Sarabon, 2010). Non-circular chainrings (NCC) should extend the pushing phase where most of the power is generated and shorten the time spent at the dead spots (Bini & Dagnese, 2012). However, research has failed to reproduce the benefits so far. The purpose of this work is to investigate muscular activity of the lower limb when cycling with NCC in comparison to a circular chainring (CC). A second purpose is to compare muscular activity when cycling indoors on a stationary trainer to the results when cycling outdoors on the road.

Five experienced male cyclists cycled in four test conditions (2 W/kg and 4.5 W/kg, indoor and outdoor, each at a self-selected cadence) with a Rotor Q-Ring (Madrid, Spain; ovality = 12.5%) in three chainring positions (NCC 1-3) and a circular chainring. All measurements were done on a cyclocross bike, which was mounted on a stationary trainer for the laboratory measurements. The outdoor measurements were executed on a straight and flat tarmac section. Muscular activity of six muscles of the right leg (m. gluteus max., m. rectus fem., m. biceps fem., m. vastus lat., m. tibialis ant., m. gastrocnemius med.) was measured by surface electromyography (sEMG) at a sampling rate of 2000 Hz. Considered parameters were maximum activation, activation time, integrated EMG (iEMG) and a frequency analysis using wavelet transforms.

The results showed no significant differences in terms of the maximum activation, the starting point, the end point and duration of muscular activity for m. gluteus max., m. biceps fem., m. rectus fem., m. vastus lat. and m. tibialis ant. between the CC and the different NCC set-ups (Figure 1). This was shown for all measurement conditions. Considering the activation time of the muscles, only for m. gastrocnemius med. significant differences occurred at the end point and hence the duration of the activation when cycling outdoor at low and high intensity. In these cases, m. gastrocnemius med. showed a significantly longer duration when cycling with the CC in comparison to the NCC set-ups. All other muscles showed no significant differences in terms of the activation time when using a NCC in comparison to a CC. Regarding the iEMG, the statistical analysis showed no significant differences for all test conditions between the CC and NCC set-ups, neither in the iEMG data during the whole crank cycle nor in the iEMG data during the pushing phase. The frequency analysis by wavelet transforms, however, indicates some differences. M. gluteus max., m. biceps fem., m. rectus fem., m. vastus lat. and m. gastrocnemius med. show higher intensities at lower frequencies of the EMG-spectrum in at least two of the NCC set-ups than in the CC-condition. No significant differences in muscular activity between cycling indoors and outdoors were found.

The results suggest that cycling with NCC has small to no influence on muscular activity. Alterations due to the ovality seem to be compensated by the motion of the ankle, as the only differences were found at m. gastrocnemius med. The finding, that only m. gastrocnemius med., which transfers the generated power from the other muscles to the pedals, seems to be affected, supports the suggestion that the cyclists keep up their accustomed movement pattern and also the way they generate power only by changes at the ankle. An interesting finding of this study was that there are indications that the muscles act at lower EMG-frequencies when cycling with NCC in comparison to a CC, which can lead to benefits in terms of muscle fatigue. There was no previous study found which examined the frequencies of the EMG-spectrum when cycling with NCC. Especially because of the small sample size

in this study, it has to be noted, that these are only indications and further detailed investigations have to be done. Summing up, it can be stated that although there are no changes in terms of amplitude, magnitude and timing of the muscular activity, results indicate alterations regarding the frequencies of the EMG-spectrum and hence possible effects on fatigue cannot be ruled out.

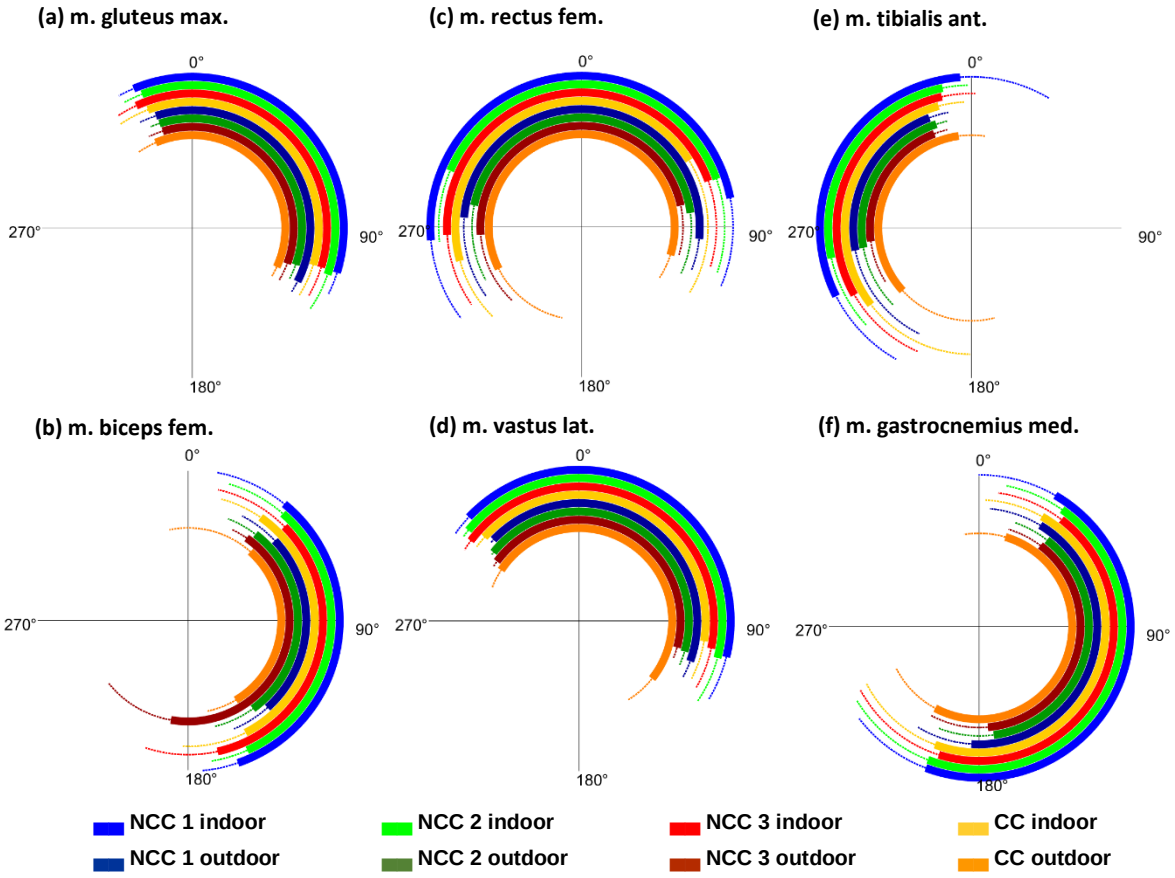

Figure 1: Activation pattern of cycling at high intensity (4.5 W/Kg) for (a) m. gluteus max., (b) m. biceps fem., (c) m. rectus fem., (d) m. vastus lat., (e) m. tibialis ant. and (f) m. gastrocnemius med. for all test conditions.

References:

Bini, R. R. & Dagnese, F., 2012. Noncircular chainrings and pedal to crank interface in cycling: aliterature review. Revista Brasileira de Cineantropometria & Desempenho Humano, 14(4),pp.470–482.

Fonda,B.& Sarabon, N., 2010. Biomechanics of cycling.SportScience Review, 19(1-2),pp.187–210.

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