SHORT-TERM PLYOMETRIC TRAINING IMPROVES ALTERED NEUROMOTOR CONTROL DURING RUNNING AFTER CYCLING IN TRIATHLETES

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INTRODUCTION: Cycling has a direct negative effect on some highly-trained triathletes' ability to execute optimal neuromotor strategies specific to running (Chapman et al., 2008). The presence of altered neuromotor control when running off-the-bike has been associated with exercise-related leg pain (Chapman et al., 2010). Accordingly, identification of training interventions that could minimise this interference may aid in prevention of injury and augmentation of performance during running following cycling. Plyometric training is a specific form of strength training that has been reported to improve running economy by enhancing neuromuscular function (Paavolainen et al., 1999). The primary aim of this study was to examine the effect of plyometric training on triathletes neuromotor control and running economy in those in which neuromotor control is aberrant during running after cycling.

METHOD: A randomised control trial of an 8 week plyometric intervention program was conducted. Running economy and neuromotor control of fifteen well-trained triathletes (height, 175 ± 7 cm; weight, 65 ± 9 kg; VO_2max, 62 ± 6 ml.min^{-1}.kg^{-1}) were determined by measuring submaximal VO_2 and lower limb electromyography (EMG) for 4 min at 12 km.hr^{-1} during a control run (no prior cycling) and a run after 45 min of cycling (transition run). EMG data was collected from the tibialis anterior, gastrocnemius lateralis, rectus femoris and biceps femoris muscles of the right leg. Triathletes who exhibited altered neuromotor control in any muscle during running after cycling at baseline were included for further participation in the study. The criteria for altered neuromotor control was that the mean difference in EMG amplitude between control-and-transition runs exceeded 10% and that the 95% confidence intervals for EMG waveforms were not overlapping for ≥ 10% of the stride.

Subjects were randomly assigned to either a control or plyometric intervention program for a period of 8 weeks. Both groups continued their regular endurance training. Triathletes in the plyometric group also participated in 3 x 30 min plyometric training sessions per week. (see Table 1 for example of exercises and increasing difficulty of the program over the 8 weeks).

Table 1. Plyometric program (Weeks 1 & 8 given as an example of progression of program).

Week	1		6-8		
Session	1	2	1	2	3
Squat	2 x 6		5 x 8		
Countermovement jumps	1 x 6		3 x 6		
Knee lifts (technical)	1 x 20		3 x 20		
Ankle jumps	1 x 10		3 x 10		
Hamstring Curls	1 x 10		3 x 10		
Alternate leg bounds		1 x 10		6 x 10	4 x 10
Skip for height		1 x 30m		4 x 30m	5 x 20m
Single-leg ankle jumps		1 x 20m		4 x 20m	
Continuous hurdle jumps					5 x 5
Scissor jumps for height					5 x 8

Primary outcome measures of neuromotor control were (i) the EMG waveform; (ii) mean EMG amplitude; (iii) coefficient of multiple correlation *(CMC)*; and (iv) root mean square error (RMSE). Secondary outcome measure was running economy. Outcome measures were analysed with an independent samples t-test, with group allocation as a fixed factor. Standardised mean differences (SMD) were calculated using pooled standard deviations.

RESULTS: Eight triathletes exhibited altered neuromotor control at baseline testing and were randomly allocated into control or plyometric groups. There were no significant differences between groups at baseline for all measures (Table 2). There were significant differences between groups at 8 weeks that favoured plyometrics for the primary neuromotor outcomes of mean EMG amplitude and RMSE ($p = 0.043$, SMD = 1.2 and $p = 0.008$, SMD = 2.9, respectively – see Table 2). Altered neuromotor control was corrected at 8 weeks in 100% triathletes in the plyometric group, compared to 40% in the control group. Running economy was not significantly different between groups at 8 weeks ($p \geq 0.17$).

Table 2. Mean (SD) pre and post data for the control and plyometric groups and mean difference (95% confidence intervals) between groups for primary and secondary outcomes measures at 8 weeks.

	Mean (SD)		Mean (95% CI) difference
	Pre	Post	
Primary Outcome Measures			
Mean EMG amplitude (%)			
Control	-14.5 (3.7)	-9.2 (5.9)	-9.1 (-17.8 to -0.4)*
Plyometric	-14.3 (6.6)	-0.5 (1.5)	
CMC			
Control	0.64 (0.15)	0.81 (0.08)	-0.11 (-0.2 to 0.01)
Plyometric	0.64 (0.18)	0.92 (0.03)	
RMSE (%)			
Control	11.7 (3.3)	8.1 (1.1)	3.0 (1.1 to 4.9)*
Plyometric	12.4 (3.1)	5.1 (0.9)	
Secondary Outcome Measure			
Running economy ($ml.min^{-1}.kg^{-1}$)			
Control	-0.2 (1.7)	1.24 (1.6)	1.8 (-1.0 to 4.5)
Plyometric	-0.64 (1.6)	-0.53 (1.4)	

DISCUSSION: The addition of plyometric exercises to regular endurance training corrected the presence of altered neuromotor control when running off-the-bike. Following the intervention period, all triathletes in the plyometric group exhibited muscle recruitment patterns during running after cycling that closely resembled the recruitment patterns used during an isolated run. Despite the improvements in neuromotor control, 8 weeks of plyometric training did not enhance or impede running economy off-the-bike.

CONCLUSION: Combined plyometric and endurance training corrected neuromotor control in those triathletes in which it was previously aberrant. The favourable neuromotor outcomes did not translate into improved or impaired running economy, but may have utility in the prevention of injury and/or rehabilitation.

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