TRIATHLON CYCLE-RUN TRANSITION: SEATED VERSUS ALTERNATING SEATED AND STANDING CYCLING

Randall L. Jensen[1,2], Brian Cunniffe[2], Andrew J. Harrison[2], Brian Phelan[2], Amir Shafat[2]

Dept. HPER, Northern Michigan University, Marquette, MI, USA[1]
Dept. Sport and Exercise Science, University of Limerick, Limerick, Ireland[2]

Nine experienced triathletes completed two trials of a cycle to run transition. During the last three minutes of a 30 minute cycling bout (at power output equal to lactate threshold) subjects either remained seated (SEAT), or alternated seated and standing cycling (30 s at a time) (ALT). Minimum and maximum knee angle and stride frequency were obtained at the end of a three minute control run (C) and at minutes 0, 2, & 4, of running after cycling transition. The only difference found by Two-Way Repeated Measures ANOVA (condition X minute) was that C was significantly different than minute 0 of the transition for stride frequency ($p < 0.05$). The findings of the current study indicate that there is a change in stride length following cycling, however, the ALT strategy did not change the kinematic variables during running following cycling when compared to SEAT.

KEYWORDS: bicycling, running, knee angle, stride frequency

INTRODUCTION: Triathletes often report discomfort and awkwardness during the first few minutes of running following the cycle to run transition. Apparently this feeling is not imagined as previous studies have shown increased oxygen uptake (Hue et al. 1998), decreased ventilatory efficiency (Hue et al., 1999, 2002), alterations in stride length (SL) (Bernard et al., 2003; Garside and Doran, 2000; Gotschall and Palmer, 2000) and stride frequency (SF) (Bernard et al., 2003; Garside and Doran, 2000; Gotschall and Palmer, 2000; Hausswirth et al., 1997) all of which ultimately may impact performance (Bernard et al., 2003).

To avoid this apparently disadvantageous condition, triathletes have tried a number of different strategies. Garside and Doran (2000) found that increased seat tube angle of the bicycle (81º vs. the normal 73º) resulted in increased SL and SF and faster running speed of the first 5 km of a 10 km run with no changes in physiological variables other than an increased heart rate. They suggested that alteration in the cycling phase might evoke a "residual effect" that improved performance in the subsequent running phase. These "alterations" might be due to changes in body position resulting in different recruitment of muscles or a better simulation of running.

Cedaro (1999) has advocated alternating standing and seated cycling just prior to the transition to running rather than remaining seated for the cycle portion of the triathlon. He suggests that this approach will allow the muscles to more quickly adapt to the movements of running. However, no data was presented to support this contention and a search of the literature provides no studies to corroborate or refute this argument.
Therefore the purpose of this study was to examine the effect of varying cycling position (alternating seated and standing vs. remaining seated) on stride kinematics during the subsequent running phase of a triathlon transition.

METHODS: Subjects were nine (seven male and two female) recreational or sub-elite triathletes (Age = 27.7±6.0 y; Height = 168.2±7.3 cm; Weight = 66.5±8.5 kg; T_{LA} = 181.0±26.5 W) as classified according to previously reported triathlon population data (O'Toole and Douglas 1995). Each subject provided written voluntary consent and the study was approved by the local institutional review board and ethics committee.

Testing took place on four days with a minimum of one day between each testing day. On the first day subjects were weighed on a balance beam scale to the nearest 100 g and stature was determined by stadiometer to the nearest 5 mm. Subjects were allowed to self select the seat height of the ergometer, but once selected the same standardized height was used for all subsequent trials They then cycled for five minutes at a self selected workload after which they were asked to run on the treadmill at a pace that approximated their running speed for the running portion of a triathlon. During this familiarization trial the speed which the subject felt best approximated their running speed was noted and used for the running portion of all later test sessions. For the three subsequent testing sessions subjects were asked to refrain from training for 24 hours prior to reporting for data collection and to treat the testing session as a race.

On the second day of testing, following a five minute warm-up at 50 W, subjects performed a lactate threshold test using the cycle ergometer and pedaling at a cadence of 90 rpm. Initial power output was 50 W for three minutes, after which power output was increased by 25 W every three minutes until lactate threshold was achieved. Capillary blood samples were obtained from the fingertip in 50 µl heparinized capillary tubes during the last 30 sec of each stage. Blood lactate concentration was assayed with a YSI-1500 Sport Lactate Analyzer (Yellow Springs, Ohio). Lactate threshold was defined as consecutive stage increases ≥1 mmol · l^{-1} in the obtained lactate value. Power output was then determined relative to the power production at which lactate threshold was attained. This power output was maintained during each of the following cycle exercise bouts.

On the following two days subjects cycled for 30 minutes at the power output achieved at lactate threshold and were then asked to run at their previously self selected running pace. On one day subjects were asked to maintain cadence at 90 rpm and remain seated for the entire 30 minute cycle bout. On the other day subjects remained seated for the first 27 minutes, but for the final three minutes were required to alternate between standing and being seated (ALT) every thirty seconds, while maintaining a cadence of 90 rpm. The order of trials (SEAT vs. ALT) was randomly assigned. Subjects were provided with verbal feedback in order to help them maintain the proscribed cadence. For both days following the cycling portion of exercise a 30 second transition period took place, after which the subjects began running on a treadmill. The previously self selected running pace was reached within 30 seconds of beginning the run.

Data was collected prior to cycling at the end of a three minute (control run) and after the cycling bout at the beginning of each minute (0, 2, and 4 minutes) of running, once subjects attained the predetermined running speed For the control period prior to cycling, subjects ran for three minutes with data collected for three strides at the end of the three minute control run.

Kinematic variables including stride frequency and minimum and maximum knee angle were obtained via videotape at 50 Hz from the right side using a Panasonic AGDP800 camera to provide a 2D sagittal view of the exercise. Reflective markers were placed on the subject's right lateral malleolus, lateral epicondyle of the tibia, and greater trochanter of the femur. Kinematic analyses were performed at 50 Hz via the Peak Motus system (Englewood, CO). Stride frequency was estimated by determining the amount of time necessary for the three strides to take place (defined by heel contact) and extrapolating to a full minute. Maximum and minimum knee angle were determined as the greatest and least included angle of the knee joint (thigh to shank) for three strides.

Statistical analyses were performed using SPSS 13.0 for Windows. A Two-way (cycling position X minute) repeated measures ANOVA was used to compare cycling condition X time (p=0.05). If significant differences were noted, a Bonferroni's post-hoc test was performed.

RESULTS: Intraclass Correlation (IC) of maximum and minimum knee angles for three strides within a condition were found to be reliable, with IC Coefficients ranging from R = 0.81 to 0.95 and no significant differences between the strides ($p > 0.05$). Thus the data of the first stride was used for all further comparisons.

Values for minimum and maximum knee angles and stride frequency are displayed in Table 1 No significant differences were found for the minimum or maximum knee angles across cycling strategies or the time following cycle-run transition ($p > 0.05$). In addition, there were no significant interactions for either angle ($p > 0.05$). However there was a difference in stride frequency for minutes ($p < 0.05$), but not the type of cycling or the interaction of minute to cycling position ($p > 0.05$).

Table 1. Means ± SD for stride frequency and knee angles during running following the transition from cycling or a control condition of just running (n=9).

Minutes		**Maximum Knee angle º**	**Minimum Knee angle º**	**Stride Frequency · min^{-1}**
Control		162.6 ± 6.8	64.0 ± 9.6	80.9 ± 5.4 [a]
Seated	0	164.0 ± 6.3	63.1 ± 10.9	85.2 ± 3.4
	2	164.5 ± 5.2	63.6 ± 11.2	84.7 ± 5.1
	4	162.4 ± 5.8	62.8 ± 11.1	84.2 ± 4.1
Alternate	0	164.7 ± 5.8	61.3 ± 9.3	85.0 ± 3.7
	2	164.5 ± 5.4	62.8 ± 11.5	84.2 ± 5.8
	4	164.3 ± 5.9	63.5 ± 13.11	84.7 ± 6.0

[a] Significantly different from minute 0 of both (SEAT and ALT) conditions($p < 0.05$)

DISCUSSION: The findings of the current study agree with previous studies that have shown differences in running stride frequency following prior cycling exercise (Bernard et al., 2003; Garside and Doran, 2000; Gotschall and Palmer, 2000) but are in contrast to others who have found no differences (Hausswirth et al., 1997; Hue et al. 1998). However, as time progressed, running stride frequency in the current study again became similar to that of the control condition. This is in agreement with anecdotal reports of triathletes who state that the “awkward running feeling” immediately after cycling gradually subsides with time. It should be noted that the changes in stride frequency were true for cycling in a traditional seated position as well as for the alternating seated and standing position. Therefore it appears that the ALT method proposed by Cedaro (1999) does not appear to alter stride frequency during subsequent running when compared to seated cycling.

That maximum knee angles were not different from control running following either cycling condition is in agreement with Hausswirth et al (1997) who found no differences in running hip, knee, or ankle extension angles following cycling. The lack of difference in the minimum knee angles (the non-support phase) is in contrast to Hausswirth et al (1997) who found knee angle during an isolated run to be greater than the running portion of a simulated triathlon. Of interest to note is that while the maximum knee angles of the current study (162-164º vs. 168º) were similar to that of Hausswirth et al (1997), the minimum knee angles were significantly less in the current study (61-64º vs 77º). Furthermore, the values were even greater (86º) during the isolated run of Hausswirth and coworkers (1997). As noted above, the subjects of the current study were classified as recreational, or sub-elite triathletes; the subjects of Hausswirth and coworkers (1997) would also be included in this classification, but appeared to be training at a higher volume when compared to the current subjects.
Interestingly, when asked which position was best in terms of overcoming the uncomfortable feeling in the initial stages of running, 5 preferred the alternating standing and seated positions whilst 4 preferred the normal seated position. Thus from a comfort level there also appears to be minimal difference between the two strategies.

CONCLUSION: Although the strategies using different body positions seem quite different, the outcome of the variables in the present study reveal no differences between the two positions. The changes in running stride length following 30 minutes of cycling at anaerobic threshold are similar to those reported by previous authors and seem to reflect the anecdotal observations of triathletes concerning an "awkwardness" in running that disappears within a few minutes of beginning the running stage. The search for strategies to relieve this feeling appears to not yet be complete.

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