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Material

Changes in Physiological Responses to Tandem Bicycle Exercise during the 5 Hour Endurance Race in Okayama International Circuit

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Key words: tandem bicycle, relative exercise intensity, heart rate, blood pressure, RPE

1. Introduction

A previous report has stated that the front saddle cyclist on the tandem bicycle exercise requires physical strength (arm strength)[1]. Our previous study investigated the changes in relative exercise intensity in a 2-h endurance tandem bicycle race[2]. As for the results, we defined an evident association between a front saddle cyclist and a rear saddle cyclist in terms of physiological stress.

In our previous study, the relative exercise intensity of the front and rear saddle cyclists appeared to be different in the latter half of the 2-h race. However, upon further analysis there seemed to be a difference requiring some additional research. Therefore, we compared the rating of perceived exertion (RPE) during the first half with that during the second half of the tandem bicycle race. During the latter half, the RPE of the front and rear saddle cyclists was the same (as indicated by the same numerical value). Thus, we speculated that the physiological stress of the front and rear saddle cyclists is the same (as indicated by the same numerical value) at the end of a race with a longer time period, for example, a 5-h race.

Therefore, in the present study, we aimed to elucidate the changes in heart rate and RPE during a 5-h endurance tandem bicycle race to determine whether or not the physiological stress of the front saddle cyclist would remain the same or increase during a race with a longer time period.

2. Methods

Two healthy male subjects (front saddle cyclist: age, 27 years; height, 172 cm; body weight, 60 kg; and

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peak oxygen uptake ($\dot{V}O_{2peak}$), 32.7 mL/kg/min and rear saddle cyclist: age, 25 years, height, 173 cm; body weight, 88 kg; and $\dot{V}O_{2peak}$, 40.9 mL/kg/min) volunteered for this study. All procedures were approved by the Ethics Committee of the Kawasaki University of Medical Welfare and conformed to the Declaration of Helsinki (#306).

During the race, heart rate (RS800CX; POLAR, Sweden), RPE[3], and blood pressure (501; KENZMEDICO, Japan) were measured every three laps. Subjects were allowed a short rest (10 minutes) after every three laps. Urinary catecholamine (adrenaline, noradrenaline, and dopamine; creatinine correction) levels were measured before and after the race. $\dot{V}O_{2peak}$ for the subjects was measured using the Douglas bag method with a bicycle ergometer from four months before the race at the laboratory of Kawasaki University of Medical Welfare. Relative exercise intensity was calculated using $\dot{V}O_{2peak}$ values and the average heart rate of one lap. This study was performed on an approximately 3.7-km long track for 5 h (Cycle Endurance Race 2016 in OKAYAMA International Circuit, October 10, 2016)[4] (Figure 1, OKAYAMA International Circuit Japan). A global positioning system was used to track the location of the cyclists. Temperature and humidity were 18° C and 40%, respectively.

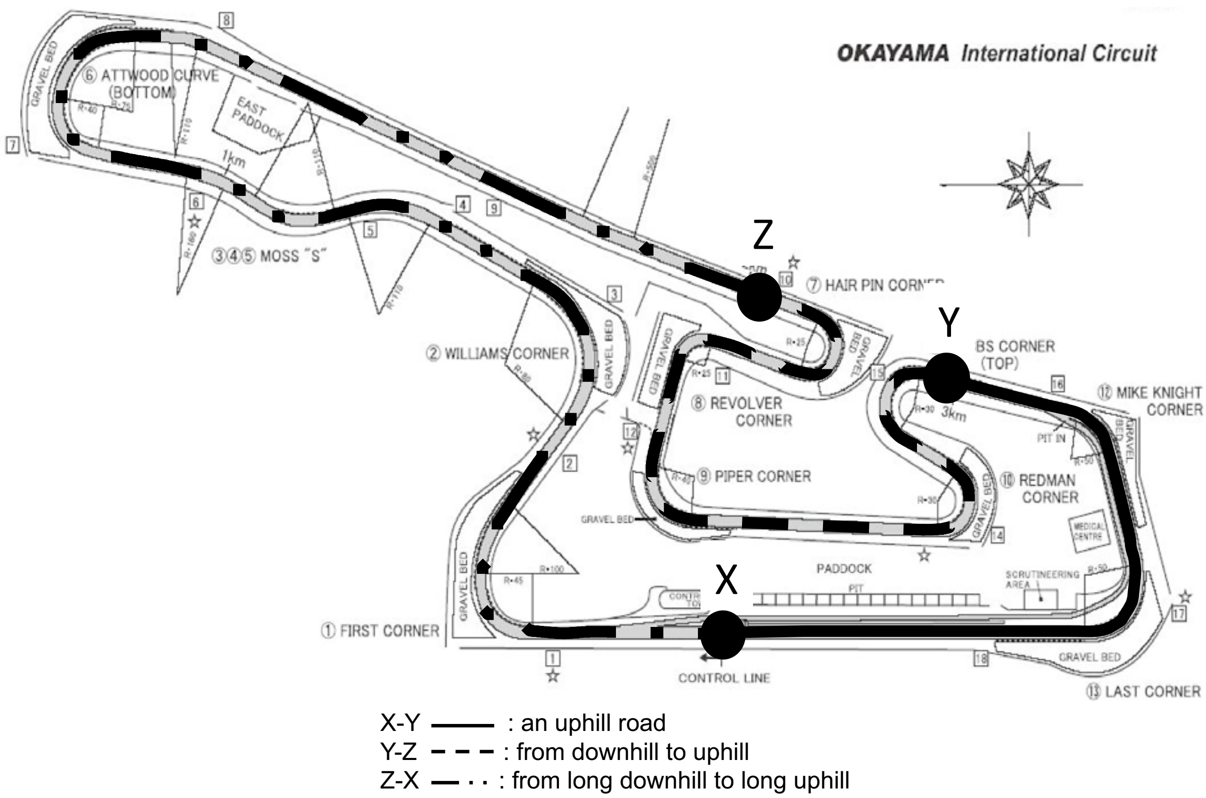

Figure 1 Okayama International Circuit (3.7km)[4]

3. Results and Discussion

Table 1 summarizes the average speed of the tandem bicycle for each lap. The average speed was 20.3 ± 2.0 km/h for each lap throughout the race. The average speed decreased gradually after 3 h of riding, which is generally attributed to fatigue.

Table 1 Lap time and average speed of tandem bicycle riding for each lap

/Lap	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th
Time (min. sec.)	9'20	9'45	9'50	9'53	10'44	10'53	10'36	10'09	10'27	9'58	10'32
Speed (km/h)	23.8	22.8	22.6	22.5	20.7	20.4	20.9	21.9	21.2	22.3	21.1

/Lap	12th	13th	14th	15th	16th	17th	18th	19th	20th	21st	22nd
Time (min. sec.)	10'43	10'19	11'29	11'56	11'34	12'18	12'20	13'37	12'30	12'50	11'22
Speed (km/h)	20.7	21.5	19.3	18.6	19.2	18.0	18.0	16.3	17.8	17.3	19.5

Figure 2 (X-Y: an uphill road), Figure 3 (Y-Z: from downhill to uphill), and Figure 4 (Z-X: from long downhill to long uphill) represent average relative oxygen uptakes (%$\dot{V}O_{2peak}$) in the trials between front and rear saddle cyclists. The differences in %$\dot{V}O_{2peak}$ between the front and rear saddle cyclists were as follows: X-Y, 8.3%; Y-Z, 5.4%; and Z-X, 2.3%. However, these differences disappeared after about 2 h of riding. This also indicates the changes in relative exercise intensity at Y and Z points. The differences in relative exercise intensity between the front and rear saddle cyclists also disappeared after about 2 to 3 h of riding. We presumed that the main causative factor for these decreases in the differences might be the fatigue for the front saddle cyclist and the increased support for the rear saddle cyclist after approximately 2 to 3 h of riding[5,6].

Blood pressure and RPE were measured at the paddock for every three laps. The blood pressure values of the front saddle cyclist were as follows: 104/78 mm Hg (rest), 160/76 mm Hg (third lap), 138/72 mm Hg (sixth lap), 140/76 mm Hg (ninth lap), 120/68 mm Hg (twelfth lap), 128/68 mm Hg (fifteenth lap), 104/66 mm Hg (eighteenth lap), and 108/56 mmHg (final lap). The blood pressure values of the rear saddle cyclist were as follows: 122/62 mm Hg (rest), 132/60 mm Hg (third lap), 140/72 mm Hg (sixth lap), 144/72 mm Hg (ninth

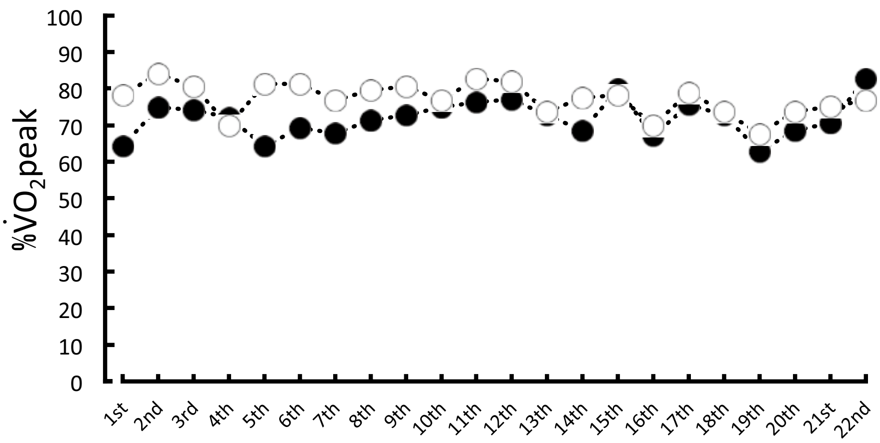

Figure 2 Comparison of relative oxygen uptakes (%$\dot{V}O_2$peak) between front and rear saddle cyclist during A: X-Y (an uphill road)
○ : Front saddle cyclist ● : Rear saddle cyclist

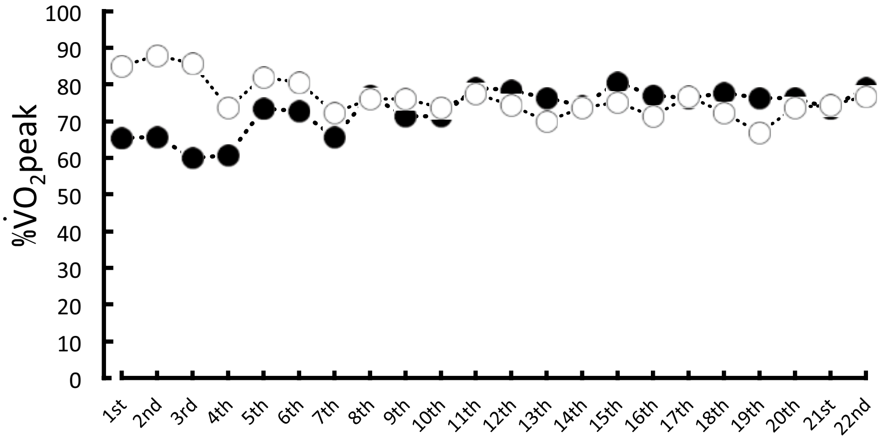

Figure 3 Comparison of relative oxygen uptakes (%$\dot{V}O_2$peak) between front and rear saddle cyclists during B: Y-Z (from downhill to uphill)
○ : Front saddle cyclist ● : Rear saddle cyclist

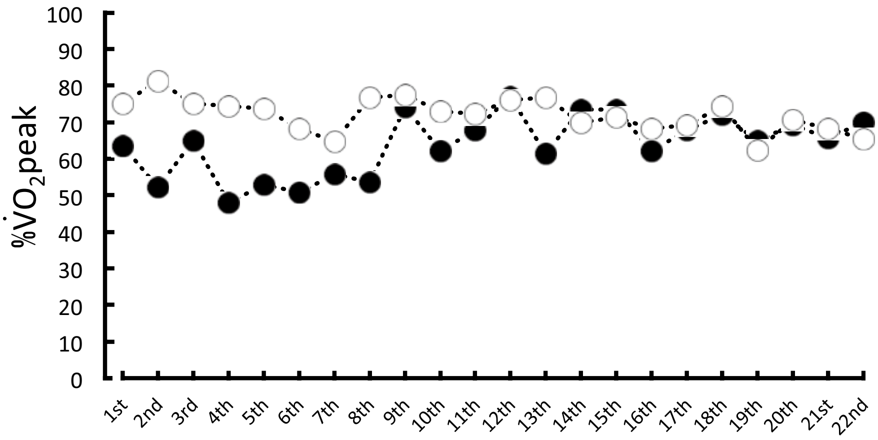

Figure 4 Comparison of relative oxygen uptakes (%$\dot{V}O_2$peak) between front saddle cyclist and rear saddle cyclist during C: Z-X (from long downhill to long uphill)
○ : Front saddle cyclist ● : Rear saddle cyclist

lap), 146/72 mm Hg (twelfth lap), 140/72 mm Hg (fifteenth lap), 132/72 mm Hg (eighteenth lap), and 136/70 mm Hg (final lap) (Figure 5). RPE values of the front saddle cyclist were as follows: 6 (rest), 16 (third lap), 15 (sixth lap), 15 (ninth lap), 16 (twelfth lap), 16 (fifteenth lap), 16 (eighteenth lap), and 15 (final lap). RPE values of the rear saddle cyclist were as follows: 6 (rest), 14 (third lap), 14 (sixth lap), 15 (ninth lap), 16 (twelfth lap), 17 (fifteenth lap), 17 (eighteenth lap), and 18 (final lap) (Figure 6). Blood pressure of the front saddle cyclist increased after 2 h of riding, whereas RPE increased in the rear saddle cyclist. We obtained both subjective (RPE) and objective (blood pressure) data at the same time. However, subjectivity (RPE) and objectivity indexes (blood pressure) did not necessarily agree. It has been established that RPE agrees with heart rate. However, it does not always agree with blood pressure.

Urinary adrenaline, noradrenaline, and dopamine of the front saddle cyclist were 13.2 ng/mgCr, 73.1 ng/mgCr, and 474.6 ng/mgCr before and 38.2 ng/mgCr, 178.1 ng/mgCr, and 468.0 ng/mgCr after the race, respectively. These values for the rear saddle cyclist were 11.0 ng/mgCr, 95.8 ng/mgCr, and 472.7 ng/mgCr before and 24.4 ng/mgCr, 180.1 ng/mgCr, and 336.0 ng/mgCr after the race, respectively (Table 2). After the race, there was an increase of 189% in adrenaline, 144% in noradrenaline, and 1% in dopamine levels in the front saddle cyclist and a change of +122% in adrenaline, +88% in noradrenaline, and -29% in dopamine levels in the rear saddle cyclist.

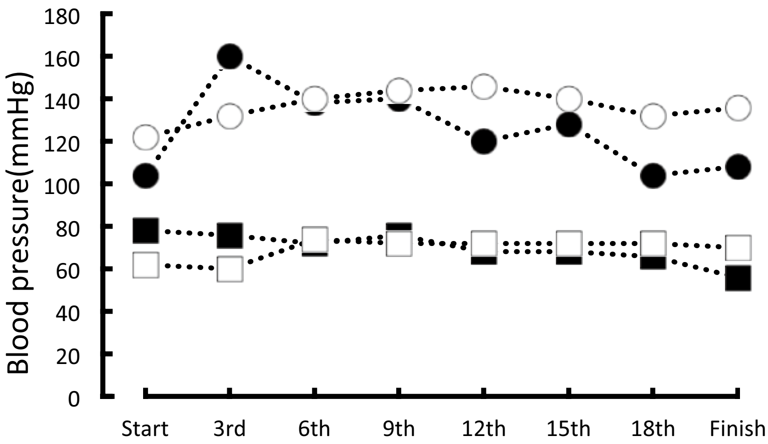

Figure 5 Changes in the blood pressure on front saddle cyclist and rear saddle cyclist, respectively
○ : Front saddle cyclist (SBP) ● : Rear saddle cyclist (SBP)
□ : Front saddle cyclist (DBP) ■ : Rear saddle cyclist (DBP)

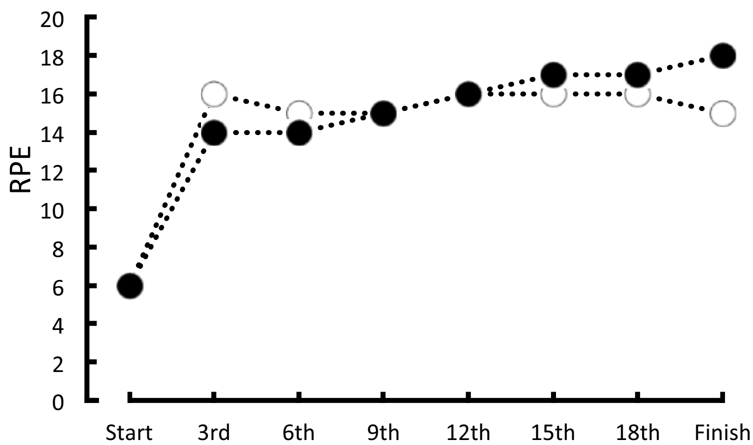

Figure 6 Changes in the RPE on front saddle cyclist and rear saddle cyclist, respectively
○ : Front saddle cyclist ● : Rear saddle cyclist

Table 2 Changes in urinary adrenalin, noradrenalin and dopamine concentrations between the before and after of the trial

	Ad		NorAd		Dop	
	Rest	Final lap	Rest	Final lap	Rest	Final lap
Front	13.9	27.2	97.7	169.3	330.0	355.2
Rear	15.9	24.2	152.8	168.3	797.2	632.9

(ng/mgCr)

The study results support our speculation: higher relative exercise intensity, blood pressure, and RPE in the front saddle cyclist are attributed to the handle, brake, and gear operations as well as stronger wind pressure[5,6]. Further, the differences between the relative exercise intensities during the 2-h and 5-h endurance races were attributed to different time durations[2]. The relative exercise intensity of the front saddle cyclist was higher than that of the rear saddle cyclist during the first half of a 5-h endurance tandem bicycle race. However, the differences between the front and rear saddle cyclists disappeared after approximately 3 h of riding. Further study will require at least 7 to 8 samples for each group of front and rear saddle cyclists to demonstrate statistically that there is no difference.

4. Conclusion

These results support the study speculation. The physiological stress of the front and rear saddle cyclists appeared to be the same after 3 h of tandem bicycle riding.

Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

Acknowledgements

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