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Material

Changes in Physiological Stress of Tandem-bicycle Cyclists and a Single-bicycle Cyclist during a Three Hour Endurance Race

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

Abstract

This study aimed to clarify the changes in physiological stress of a tandem bicycle (front and rear cyclist) and a single bicycle (single cyclist) during a 3-h endurance bicycle race. Three healthy Japanese adult males participated in a 3-h endurance race held at Okayama International Circuit (3.7 km around). The tandem-bicycle cyclists were keeping the same pace with the single-bicycle cyclist for 3-h. During the race, heart rate, rating of perceived exertion (RPE), blood pressure and urinary catecholamine were measured. Relative exercise intensity was calculated using the $\dot{V}O_2$peak and average heart rate values were obtained during each lap. The exercise intensity of the tandem-bicycle cyclists was higher for uphill than downhill riding. In contrast, the exercise intensity of the single-bicycle cyclist was higher for downhill than uphill riding. Going uphill, the tandem bicycle has a load of two people while the single bicycle has a load of one person. Conversely, going downhill, the weight of the two cyclists on the tandem bicycle increases the speed, whereas the single-bicycle cyclist must pedal to catch up with that speed. Urinary catecholamine levels tended to increase after the race. Exercise intensity shows force results in the opposite directions for tandem and single-bicycle cycling both uphill and downhill.

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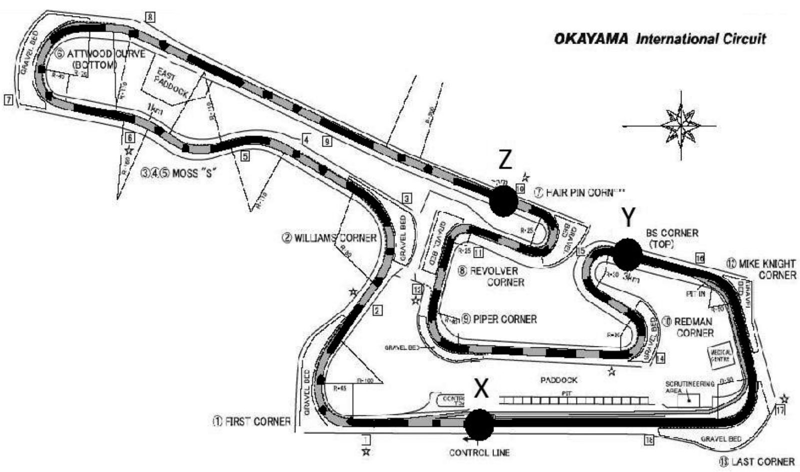
1. Introduction

A tandem bicycle is a two-saddle bicycle in which the front and rear cyclists work together to propel the bicycle[1]. In our previous study, we found that the relative exercise intensity between the front and rear cyclists appeared to differ during the latter half of a 2-h race, such that the intensity was higher in the front cyclist than in the rear cyclist[2,3]. We speculated that the physiological stress of a single-bicycle cyclist during uphill riding is higher than that during downhill riding when compared with a tandem bicycle. We thus aimed to clarify the changes in physiological stress of a tandem bicycle (front and rear cyclist) and a single bicycle (single cyclist) during a 3-h endurance bicycle race.

2. Methods

Three healthy Japanese adult males (tandem bicycle: front saddle cyclist: age, 27 years; height, 172 cm; body weight, 63 kg; and peak oxygen uptake ($\dot{V}O_2$peak), 39.4 ml/kg/min; rear saddle cyclist: age, 26 years; height, 174 cm; body weight, 91 kg; and $\dot{V}O_2$peak, 33.4 ml/kg/min; and single-bicycle cyclist: age, 23 years; height, 174 cm; body weight, 59 kg; and $\dot{V}O_2$peak, 44.6 ml/kg/min) participated in a 3-h endurance race held at Okayama International Circuit (3.7 km around). All procedures were approved by the Ethics Committee of the Kawasaki University of Medical Welfare and conformed to the Declaration of Helsinki (#306). The tandem-bicycle cyclists were keeping the same pace with the single-bicycle cyclist for 3-h. During the race, heart rate was recorded from start to finish using a heart rate monitor (M400; POLAR, Sweden). Additionally, heart rate, rating of perceived exertion (RPE)[4] and blood pressure (501; KENZMEDICO, Japan) were measured every three laps. The participants were allowed a short rest (10 min) after every three laps. Urinary catecholamine (adrenaline, noradrenaline and dopamine; creatinine correction) levels were measured before and after the race. The $\dot{V}O_2$peak was measured using the Douglas bag method with a bicycle ergometer four months before the race at a laboratory at Kawasaki University of Medical Welfare. Relative exercise intensity was calculated using the $\dot{V}O_2$peak and average heart rate values were obtained during each lap. The racetrack was approximately 3.7 km in length (Cycle Endurance Race 2017 in Okayama International Circuit) (Figure 1, Okayama International Circuit Japan[5]) and the temperature and humidity were 26.6° C and 58.4%, respectively. A global positioning system was used to track the cyclists' locations during the race.



X-Y ——— : an uphill road
Y-Z – – – : from downhill to uphill
Z-X — · · : from long downhill to long uphill

Figure 1 OKAYAMA International Circuit (3.7km)[5]

3. Results & Discussion

Table 1 summarizes the average speed of both bicycles for each lap. The average speeds of the tandem and single bicycle were 20.9 ± 1.7 km/h and 20.6 ± 1.7 km/h for each lap, respectively. Figure 2 (A: X-Y, uphill road), Figure 3 (B: Y-Z, downhill to uphill) and Figure 4 (C: Z-X, long downhill to long uphill) show the

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

/ Lap		1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	12th	13th	14th	15th
Time	Tandem	8'32	9'38	10'00	9'56	9'59	9'41	10'24	10'29	10'37	10'45	10'47	10'59	11'01	11'50	10'55
	Single	8'32	9'39	10'00	10'02	9'59	9'41	10'26	10'29	10'38	10'44	10'46	11'04	11'06	11'50	10'55
Speed	Tandem	25.6	22.4	21.6	21.9	21.6	22.2	20.7	20.8	20.2	20.1	20.2	19.5	19.5	18.3	19.7
	Single	25.3	22.1	21.3	21.3	21.4	22.1	20.4	20.4	20.0	19.2	20.0	19.3	19.2	18.0	19.6

(Time : min.'sec., Speed : km/h)

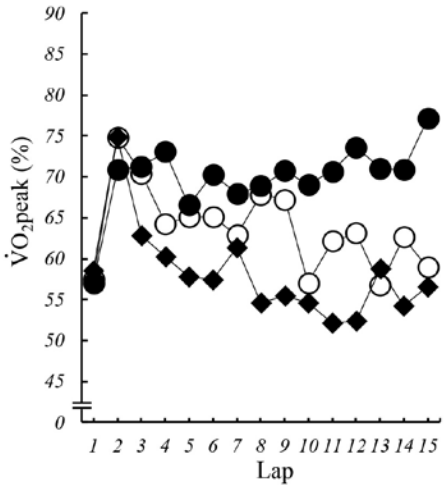


Figure 2 Changes in relative oxygen uptake (%$\dot{V}O_2$peak) between each cyclist during A: X-Y (an uphill road)
○ : Front saddle cyclist, ● : Rear saddle cyclist, ◆ : Single cyclist

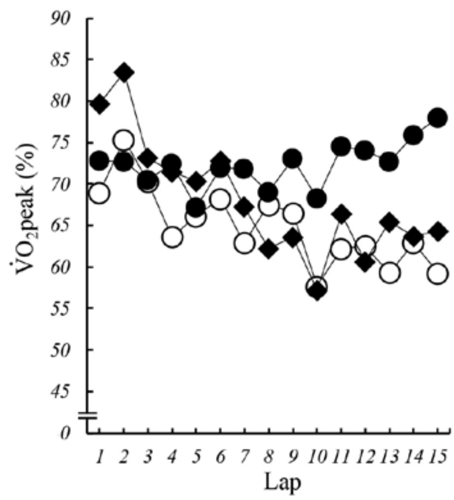


Figure 3 Changes in relative oxygen uptake (%$\dot{V}O_2$peak) between each cyclist during B: Y-Z (from downhill to uphill)
○ : Front saddle cyclist, ● : Rear saddle cyclist, ◆ : Single cyclist

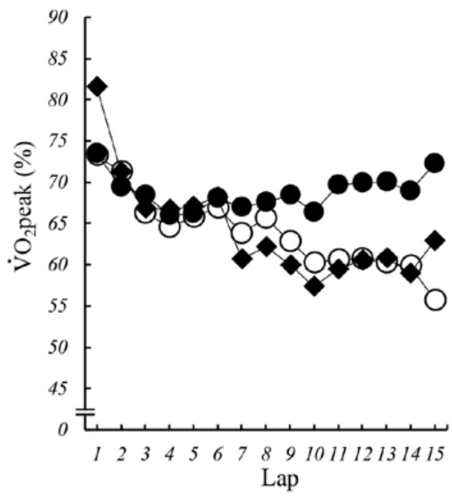


Figure 4 Changes in relative oxygen uptake (%$\dot{V}O_2$peak) between each cyclist during C: Z-X (from long downhill to long uphill)
○:Front saddle cyclist, ●:Rear saddle cyclist, ◆: Single cyclist

average relative oxygen uptake (%$\dot{V}O_2$peak) in the trials between the cyclists. The average %$\dot{V}O_2$peak at A was 63.7% for the front cyclist, 69.9% for the rear cyclist and 58.1% for the single cyclist; at B the average %$\dot{V}O_2$peak was 64.9% for the front cyclist, 72.3% for the rear cyclist and 68.1% for the single cyclist; at C the average %$\dot{V}O_2$peak was 63.8% for the front cyclist, 68.8% for the rear cyclist and 64.3% for the single cyclist. The value tended to be higher for the rear cyclist relative to the other cyclists.

The exercise intensity of the tandem-bicycle cyclists was higher for uphill than downhill riding[6,7]. In contrast, the exercise intensity of the single-bicycle cyclist was higher for downhill than uphill riding. Going uphill, the tandem bicycle has a load of two people while the single bicycle has a load of one person. Conversely, going downhill, the weight of the two cyclists on the tandem bicycle increases the speed, whereas the single-bicycle cyclist must pedal to catch up with that speed. This is considered to be a burden on the single-bicycle cyclist.

Figure 5 presents the changes in blood pressure. Diastolic blood pressure tended to decrease with each lap. This result speculates that the diastolic blood pressure during the race was influenced by exercise intensity exercise for each lap. Figure 6 shows the changes in RPE. RPE tended to increase with each lap. Table 2 shows the comparison of urinary adrenaline, noradrenaline and dopamine concentrations before and after the race. Adrenaline and noradrenaline tended to increase after the race. Urinary catecholamine is a stress hormone that is metabolized from dopamine to noradrenalin and then to adrenaline. Urinary noradrenaline is associated with psychological stress, and adrenaline is associated with physical stress[6]. Urinary adrenaline and noradrenaline levels increased in all cyclists, indicating similar levels of physiological and psychological stress. It is thought that this supports the increase of psychological stress after racing,

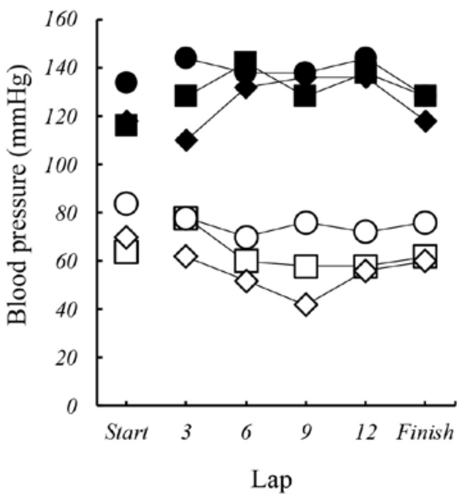


Figure 5 Changes in the blood pressure of each cyclist
■ : Front saddle cyclist SBP, ● : Rear saddle cyclist SBP, ◆ : Single cyclist SBP
□ : Front saddle cyclist DBP, ○ : Rear saddle cyclist DBP, ◇ : Single cyclist DBP

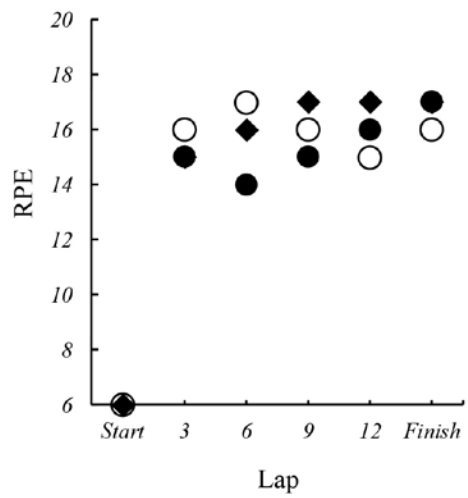


Figure 6 Changes in the RPE of each cyclist
○ : Front saddle cyclist, ● : Rear saddle cyclist, ◆ : Single cyclist

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

	Adrenaline		Noradrenalin		Dopamine	
	pre	post	pre	post	pre	post
Front saddle cyclist	9.86	19.68	69.83	139.43	453.09	276.51
Rear saddle cyclist	10.11	30.32	89.92	218.01	411.41	416.20
Single cyclist	28.03	22.08	88.75	147.34	439.37	380.72

(ng/mgCr)

because the increase of urinary noradrenaline levels is in agreement with the increase of RPE. Further study will require at least 7 to 8 samples for each group of cyclists in order to demonstrate statistically that there is no difference.

4. Conclusion

Exercise intensity shows force results in the opposite directions for tandem and single-bicycle cycling both uphill and downhill.

Conflicts of Interest

The authors declare that there are no conflicts of interest regarding the publication of this article.

Acknowledgement

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