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Lactate and catecholamine responses in male and female sprinters during a Wingate test

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Abstract. A total of six male and six female sprinters at the same national competition level and aged 18–20 years performed a force/velocity test and a 30-s supramaximal exercise test (Wingate test) on 2 different days, separated by a maximal interval of 15 days. The maximal anaerobic power (W_{max}) was determined from the force/velocity test, and the mean anaerobic power (W) from the Wingate test. Immediately after the Wingate test, a 5-ml venous blood sample was drawn via a heparinized catheter in an antebrachial vein for subsequent catecholamine (adrenaline and noradrenaline) analysis. After 5 min recovery a few microlitres of capillary blood were also taken for an immediate lactate determination. Even expressed per kilogram lean body mass, W_{max} and W were significantly lower in women. The lactate and adrenaline responses induced by the Wingate test were also less pronounced in this group whereas the noradrenaline levels were not significantly different in men and women. Above all, very different relationships appeared between lactate, adrenaline, noradenaline and W according to sex. Thus, as reported by other authors, the adrenergic response to a supramaximal exercise seemed to be lower in women than in men. Nevertheless a different training status between the two groups, even at same national competition level, could not be excluded and might contribute, at least in part, to the gender differences observed in the present study.

Key words: Supramaximal exercise – Lactate – Catecholamines – Sex – Sprinters

Introduction

Many differences have been shown between anaerobic and aerobic exercises concerning catecholamine and lactate responses (Kindermann et al. 1982; Näveri et al. 1985). Indeed, both catecholamine, especially adrenaline (A), and lactate levels have been found to reach higher values during the former than the latter type of exercise (Kindermann et al. 1982). All these findings have been established in men. However, divergences in the sex pattern could be found concerning the exercise-induced catecholamine responses. During a dynamic exercise, a 15-min ergocycle test at 80% $\dot{V}O_{2max}$, Favier et al. (1983) observed no difference for these hormones between untrained men and women. The same conclusion was drawn from the results of a 5-min isometric exercise (Sanchez et al. 1980). However, in that study, the A kinetics pattern varied according to sex, since higher A values were measured in men than in women, at the 1st min only. Similarly, higher A levels were obtained in physically fit men than in women after repetitive 10×6s supramaximal bouts (Brooks et al. 1990). These few data suggest a gender difference in the supramaximal exercise-induced sympathoadrenergic response. The aim of the present study was then to investigate the catecholamine responses both in male and female sprinters during a 30-s supramaximal Wingate test.

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Methods

The entire procedure was approved by the Ethical Committee of Rennes 1.

Subjects. A total of six male and six female sprinters, specialists in 100–200 and 400 m races, volunteered to participate in this study. They were all competing at national level and had trained for at least 4 years. They were thoroughly familiarized with all testing equipment and procedures before the study. They visited the laboratory on 2 different days, D1 and D2, separated by 8–15 days. The morphological characteristics determined on D1 are shown in Table 1. The percentage of body fat was estimated from four skinfold thicknesses according to the method of Durnin and Rahaman (1967).

Procedure. On D1, the force/velocity test (F/v test) was performed using the technique of Vandewalle et al. (1985). This test, using an Ergomeca cycle, consists in a succession of many supramaximal bouts of about 6 s duration against loads increasing by 1 kg for each bout. A 5-min test allowed complete recovery be-

Table 1. Morphological characteristics of subjects

	Age (years)	Weight (kg)	Fat (%)	Height (cm)
Men	19.5	70.4	11.2	178.3
	0.7	1	0.7	2
Women	18.3	56.4	20.6	168.2
	0.7	2.2	1.4	2.4

Data are mean (SEM), $n=6$ for each gender

tween successive bouts. The velocity was recorded using a photoelectric cell fixed on the wheel of the cycle and connected to a computer. Only the highest speed value was kept for each level of the test. By multiplying the F and v measured, the power (W) could be calculated at each step with the maximum defined as the maximal anaerobic power (W_{max}). The corresponding load (L, the individual optimal workload) was used for the Wingate test which was performed on the same day after a 30-min recovery, so as to reduce the stress which might appear during the second part of the experiment.

The second part of the study took place on D2 in the absence of any competition or exhaustive physical activity. The subjects were asked to consume no food containing biogenic amines on the day before nor on the morning of the test, as these constituents alter the catecholamine analysis. The experiment started for all the subjects at about 0900 hours, i.e. 2 h after a standardized breakfast. On arrival, each subject lay down on a bed and a heparinized catheter was inserted into an antecubital vein. Thirty minutes later, the subject sat on the cycle and the first blood sample was drawn (5 ml). A warm-up was allowed for 5 min at a submaximal load of about 50–60 W and a very low velocity. Finally, the Wingate test was performed. During this exercise, the athlete was required to pedal for 30 s on the same bicycle, as fast as possible, against the previously determined load L. The velocity was again recorded throughout the time. The power produced could then be calculated at each time and also the mean power developed over the 30 s (W).

Immediately pedalling stopped venous blood was again sampled (5 ml). Then, after a 5-min recovery, a small needle was used to take a few microlitres of capillary blood from a finger tip as well.

Blood analysis. Lactate was immediately determined enzymatically in the capillary blood sample, using a lactate analyser (microzym, Cetrix). Plasma from the venous blood samples was separated by centrifugation at $3000 \times g$ and stored at $-80°$ C for subsequent catecholamine analysis. Thereafter, plasma A and noradrenaline (NA) concentrations were estimated by high-performance liquid chromatography, according to the method of Koubi et al. (1991).

Statistical tests. Data were expressed as means ($\bar{x}$) and standard errors (SEM). The methods used for the statistical analysis included coefficients of correlation and two-way analysis of variance. A value of $P \leq 0.05$ was accepted as the minimal level of statistical significance. The Fisher test was used as a post-hoc test.

Results

Maximal anaerobic power (W_{max}) and mean anaerobic power (W)

W_{max} and W in male and female athletes are summarized in Table 2. Even when normalized for body mass or lean body mass, all these values were significantly greater in men, meaning that male sprinters performed better in supramaximal laboratory exercises.

Lactate and catecholamine responses

At rest, NA values in both sexes were identical, whereas significantly lower levels of A were found in women than in men (Table 3).

Then, as expected, the supramaximal exercise induced great changes in lactate and catecholamine responses. Lactate, A and NA concentrations were 5-, 3- and 8-fold respectively higher in women and 6-, 4- and 12-fold respectively higher, in men than basal concentrations. Indeed, as shown in Table 3, the Wingate test revealed significant gender differences since both lactate and A were significantly lower in women than in men. Moreover, very different relationships appeared

Table 2. Performance of male and female sprinters in the Wingate test

		Men	Women
W_{max}	W	1138 (41.6)***	634 (38.2)***
	W·kg^{-1}	16.2 (0.7)**	11.5 (0.7)**
	W·kg LBM^{-1}	18.2 (0.7)**	14.3 (0.8)**
W	W	781.5 (19.5)***	474.2 (19.2)***
	W·kg^{-1}	11.1 (0.3)**	8.4 (0.3)**
	W·kg LBM^{-1}	12.5 (0.5)**	10.6 (0.3)**

Data are mean (SEM). W_{max}, Maximum anaerobic power; W, mean anaerobic power. Power values are also referred to body mass and lean body mass (LBM)
** $P<0.01$, *** $P<0.001$

Table 3. Metabolic and catecholamine responses of male and female sprinters to the Wingate test

	Rest		Exercise	
	Men	Women	Men	Women
Lactate (mM)	2.4 (0.3)	2.2 (0.4)	14.9 (2.4)*	11.4 (3)*
Adrenaline (ng/ml)	1.2 (0.4)*	0.7 (0.2)*	4.7 (1.9)**	2.0 (1.3)**
Noradrenaline (ng/ml)	1.37 (0.24)	0.97 (0.36)	9.6 (4.3)	7.2 (3.3)

Data are mean (SEM). Lactate was measured in capillary blood at rest and 5 min after completing the exercise; catecholamines were measured in venous plasma at rest and immediately on competition of the exercise.
* $P<0.05$, ** $P<0.01$

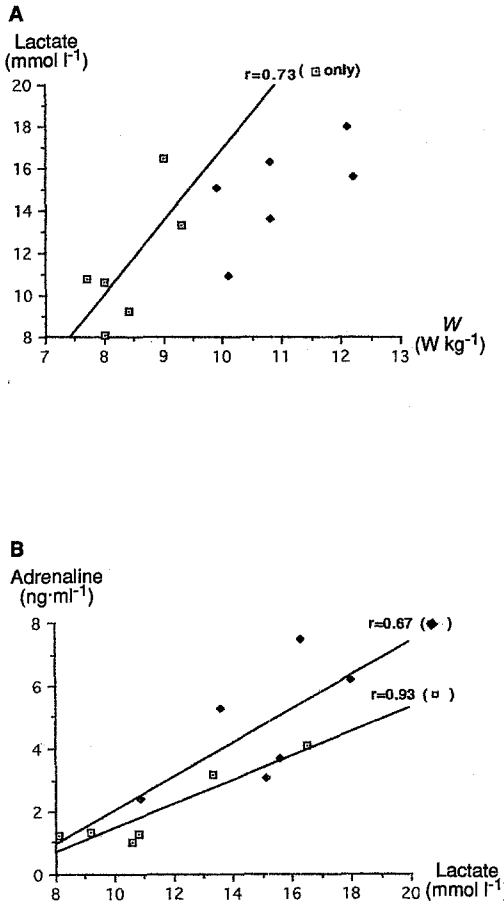

Fig. 1. A Relationship between lactate concentration measured 5 min after the Wingate test and mean aerobic (W) power. **B** Relationship between plasma adrenaline measured immediately at the end of the exercise and plasma lactate. ◆ Men, □ women

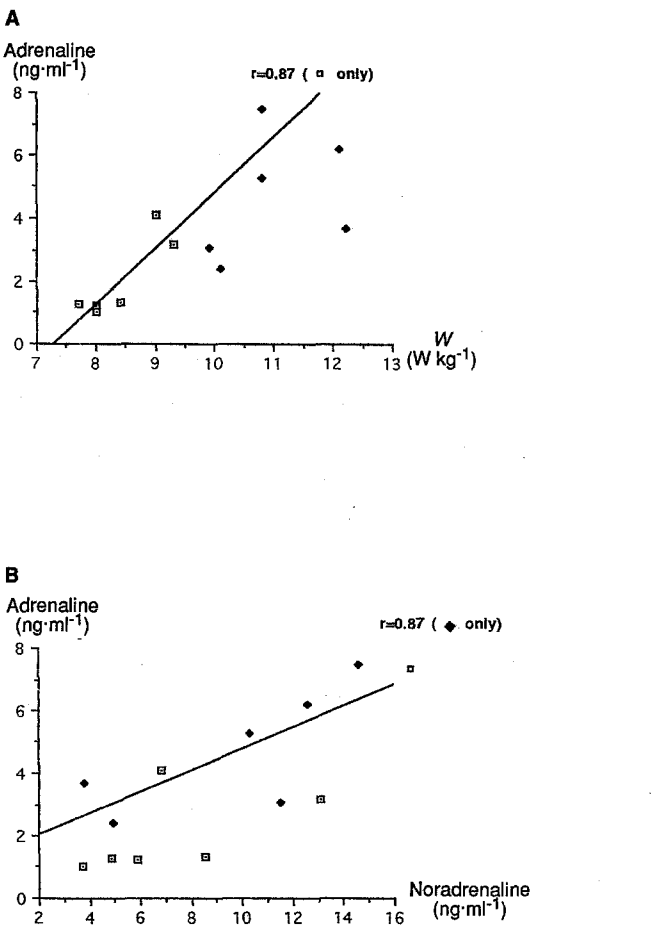

Fig. 2. A Relaionship between plasma adrenaline and W. **B** Relationship between plasma concentrations of adrenaline and noradrenaline. Concentrations measured immediately after the Wingate test. ◆ Men, □ women

between lactate, A, NA and W according to gender. Thus the relation between A and NA was statistically significant in men only (Fig. 2B). Nevertheless, in women significant relationships could be observed between lactate and W (Fig. 1A), A and lactate (Fig. 1B) as well as between A (Fig. 2A) or NA (Fig. 3) and W.

Discussion

W_{max} values

To reach a peak power value during the Wingate test as close as possible to W_{max}, we employed the individually determined optimal workload (L), determined by the F/v test. This point is of fundamental importance in this study, the aim of which was to obtain, for each subject, both the highest values of lactate and catecholamines which could be induced by a supramaximal exercise in the laboratory. On the whole our results were close to previous data. Whereas in the present study the W_{max} values of both men and women were slightly higher than the respective values measured by Mercier

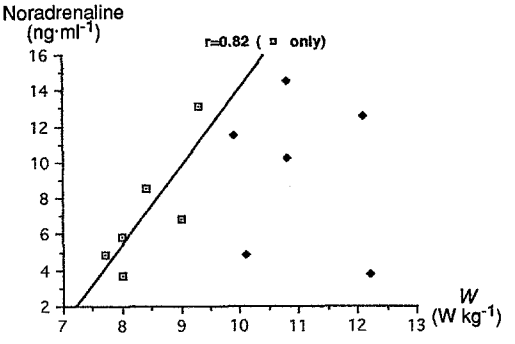

Fig. 3. Relationship between plasma noradrenaline concentrations measured immediately after the Wingate test and W. ◆ Men, ⊡ women

et al. (1991) in different sportsmen or by Jacobs et al. (1983) in physically fit men and women, Cheetham et al. (1986) found greater levels of W_{max} in female sprinters compared with our group. This discrepancy could probably be explained by the younger age of our subjects. The gender differences in W_{max} or W were not surprising: Vandewalle et al. (1985) or Froese and

Houston (1987) have reported similar findings. Like these authors, we observed that the differences between men and women for both W_{max} and W decreased when these parameters were expressed per kilogram body weight and decreased even further when referred to lean body mass (LBM, Table 2). Nevertheless, a small but significant difference remained. To explain this, differences in the structural (Bruce et al. 1992) or metabolic properties of the female skeletal muscles have been proposed, among them a lower glycogen content (Taylor and Peronnet 1981) and lower levels of anaerobic enzymes (Nygaard 1981; Taylor and Peronnet 1981; Komi and Karlsson 1978) than in men. In fact, as training is known to enhance muscle glycogen content and enzyme activities, this factor can never be entirely excluded in explain gender differences even in athletes. Indeed, among children Gilliam et al. (1982) have pointed out that girls were spontaneously less active than boys during their respective games. In adults also, the females are less involved in activities with a high energy cost. Above all, even in olympic athletes, the training level of women remained below the training level of men at the same competition level (Pollock 1977).

Lactate and catecholamine responses

As also observed in the earlier studies of Sanchez et al. (1980) and Brooks et al. (1990), the lactate increase induced by exercise was found to be less substantial in women than in men. Of course, as the lactate clearance was not analysed in this study, a faster lactate elimination in women can not be excluded. Nevertheless, a lower lactate production in women is a more likely explanation since the workload sustained by the female sprinters, and thus their total energy output, were also smaller. Moreover the ratio between lactate and W expressed per kilogram LBM was the same in men and women (1.19 and 1.08 respectively).

With respect to the catecholamine responses, our data indicate an obvious gender difference in the exercise-induced A and NA changes. The peak values of A measured at the end of the supramaximal exercise were significantly lower in women. The NA concentrations also tended to be lower in women but the difference was not statistically significant. In accord with the previous results of Sanchez et al. (1980) or Brooks et al. (1990), we might conclude that the adrenergic response to a supramaximal exercise is lower in women than in men. Of course, the influence of the sex steroid hormones might be involved to explain these gender differences. In this respect the earlier data of Zuspan and Zuspan (1973) are relevant. These suggested that the sex hormones might exert different effects on A and NA secretion levels. If this is the case, the absence of correlation between A and NA maximum levels in our female sprinters might be similarly explained. However, this hypothesis seems unlikely to account for all our results. Especially in male sprinters, the relative independence of the metabolic and hormonal responses, i.e. lactate A, NA maximum concentrations, from the produced workload remains to be clarified. Thus, no relation was found in this group between lactate and W (Fig. 1a) as if the performance of men in the Wingate test were independent of the glycolytic pathway. Nor could a relation be established in male sprinters between the catecholamine values and W (Figs. 2, 3). In fact, all these paradoxical results are similar to those of Ohkuwa et al. (1984). In that study, the relation between blood lactate levels and performance during a 400-m speed race in sprinters and long-distance runners seemed to be dependent on the training status. Whereas a significant relation between these two parameters could be observed in the latter group, this relation was absent in the sprinters. These results suggested to the author that, in sprinters, the anaerobic alactic pathway might make a greater contribution than the glycolytic pathway to the performance in a supramaximal test. Moreover, other factors than A have been involved in such exercise in the control of muscle glycogenolysis among them the rise of inorganic phosphate. If the utilization of the muscle phosphagen content plays a primary role in the performance of elite sprinters in a supramaximal exercise, as Cheetham et al. (1986), Schnabel et al. (1984) and Hirvonen et al. (1987) have claimed, then it is possible that muscle glycolysis partially escapes from adrenergic control in highly trained sprinters. This might explain the lack of correlation between the lactate and catecholamine responses in our male sprinters.

Finally, sympathoadrenergic responses to supramaximal exercise have been found to increase after anaerobic training (Okhuwa et al. 1984). Together with possible differences in training status between male and female sprinters at the same national competition level, this factor might also contribute, at least in part, to the gender differences in catecholamine responses observed in the present study.

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