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ORIGINAL ARTICLE

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Energy expenditure of horse riding

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Abstract Oxygen consumption ($\dot{V}O_2$), ventilation ($\dot{V}_E$) and heart rate (HR) were studied in five recreational riders with a portable oxygen analyser (K2 Cosmed, Rome) telemetric system, during two different experimental riding sessions. The first one was a dressage session in which the rider successively rode four different horses at a walk, trot and canter. The second one was a jumping training session. Each rider rode two horses, one known and one unknown. The physiological parameters were measured during warm up at a canter in suspension and when jumping an isolated obstacle at a trot and canter. This session was concluded by a jumping course with 12 obstacles. The data show a progressive increase in $\dot{V}O_2$ during the dressage session from a mean value of 0.70 (0.18) $l \cdot min^{-1}$ [mean (SD)] at a walk, to 1.47 (0.28) $l \cdot min^{-1}$ at a trot, and 1.9 (0.3) $l \cdot min^{-1}$ at a canter. During the jumping session, rider $\dot{V}O_2$ was 2 (0.33) $l \cdot min^{-1}$ with a mean HR of 155 beats $\cdot min^{-1}$ during canter in suspension, obstacle trot and obstacle canter. The jumping course significantly enhanced $\dot{V}O_2$ and HR up to mean values of 2.40 (0.35) $l \cdot min^{-1}$ and 176 beats $\cdot min^{-1}$, respectively. The comparison among horses and riders during the dressage session shows differences in energy expenditure according to the horse for the same rider and between riders. During the jumping session, there was no statistical difference between riders riding known and unknown horses. In conclusion these data confirm that riding induces a significant increase in energy expenditure. During jumping, a mean value of 75% $\dot{V}O_{2max}$ was reached. Therefore, a good aerobic capacity seems to be a factor determining riding performance in competitions. Regular riding practice and additional physical training are recommended to enhance the physical fitness of competitive riders.

Key words Heart rate · Jumping · Oxygen uptake · Riding

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Introduction

Several studies have addressed the physiological demands of riding (Westerling 1983; Trowbridge et al. 1995; Bojer et al. 1998). In a previous study, Westerling (1983) demonstrated that oxygen uptake varies according to different equine gaits, ranging between 40% and 80% of the rider's maximal aerobic power. Indirect measurements of energy expenditure by heart rate (HR) monitoring indicate that maximal HR and probably maximal aerobic power are reached by professional jockeys during horse racing (Trowbridge et al. 1995). All these studies were conducted with the same horse, and the variability in the energy costs of riding induced by different horses remains to be evaluated.

It is well known that all horses are different and have individual technical characteristics. Some of them are lethargic, and must be always pushed; others are lively and must be restrained. Consequently, each rider must adjust their technique to the particular horse they are riding. The main aim of our study was to investigate how the energetic costs of riding vary according to the horse.

Methods

Subjects

A total of five experienced riders were studied (three women and two men). Subjects rode, on average, 7 h per week. They were similarly experienced and participated in jumping competitions at the regional level. None of them trained intensely, and their occupational activities were not physically demanding.

Experimental design

The study consisted of three parts:

A. Bicycle ergometer test: determination of maximal oxygen uptake. The bicycle ergometer test was performed using an electrically braked ergometer (Orion, France). The power was incremented by 25 W every 2 min until exhaustion. Exercise at the maximal load was interrupted when the subjects had reached subjective exhaustion, which occurred at a HR equal to or higher than the predicted maximal values. Oxygen uptake (VO_2), ventilation (V_E) and HR were measured with a portable telemetric system (Cosmed K2, Rome). The exhaled gas was collected in a mask composed of a turbine (for V_E measurement) and a sample gas collection system (by pump for O_2 determination). This system has been validated by Bigard and Guezennec (1995).
B. Measurement of VO_2, HR and pulmonary ventilation during riding at a walk, trot and canter. VO_2, V_E and HR were measured with the portable telemetric oxygen analyser (K2-Cosmed) during riding at a walk, trot and canter. The gas parameters were collected and calculated as mean values for each 30 s. Each subject rode four different horses. On each horse, subjects performed 4 min of walking followed by 4 min of trotting and finally 4 min of cantering. Recordings lasted, therefore, 12 min for each horse. VO_2, V_E and HR data were calculated as the average of each gait (lasting 4 min).
   During this session, riders rode four horses with different dispositions: horses one and three needed pushing while horse three was the most lethargic. Horse two was an easy one and horse four was a nervous animal that had to be restrained.
C. Measurement of VO_2, HR and pulmonary ventilation during jumping. The same parameters as above were recorded during jumping sessions performed several days after the dressage session. The jumping session comprised 4 min of cantering in suspension, 3 min of rest at a walk, followed by the jumping of five small obstacles at a trot with a mean duration of 5 min and 3 min of rest at a walk. Then, the riding programme continued with the jumping of five obstacles at a canter for 5 min followed by 3 min of rest at a walk. Finally, the subjects jumped 12 obstacles (height between 1 m and 1.10 m), and the time for this jumping course ranged from 1 min to 1 min 30 s.

The five subjects rode one horse with which they were familiar and another one which they had never ridden.

Statistical analysis

All the values are expressed as means (SD). The statistical evaluation was carried out by applying two-way repeated-measures ANOVA. Post hoc differences were tested by Student's *t*-test. Statistical significance was set at an alpha level of 0.05.

Results

The individual values for VO_2, V_E and HR obtained during the ergometer test are presented in Table 1. The mean VO_2 ($l \cdot min^{-1}$), V_E ($l \cdot min^{-1}$) and HR ($beats \cdot min^{-1}$) measured in the two riding sessions cumulated for the overall time spent in each gait for the horse/rider couple are given in Table 2: a progressive significant increase in VO_2, HR and V_E is observed from walk to canter in suspension ($P < 0.05$). The parameters measured during canter in suspension, obstacle trot and obstacle canter were not statistically different, but jumping significantly increased VO_2, V_E and HR compared to all other situations ($P < 0.01$).

Figure 1 presents the VO_2 curves obtained from each 30-s collection period for each gait and jumping course. Whereas a steady state is attained during walking, after 1 min of trotting and when cantering, VO_2 rapidly increased during jumping without reaching steady state. The energy expenditure achieved at the end of the jumping course reached 75% of the VO_{2max} measured on ergocycle for 92% of maximal HR.

Comparison of the data observed for each horse during the dressage riding session (Table 3) indicates that VO_2, V_E and HR differ significantly according to

Table 1 Maximal oxygen uptake (VO_{2max}, $l \cdot min^{-1}$), maximal heart rate (*HR*, $beats \cdot min^{-1}$), and maximal pulmonary ventilation (V_E, $l \cdot min^{-1}$) at maximal exercise during the ergocycle test

Rider	VO_{2max} ($l \cdot min^{-1}$)	HR ($beats \cdot min^{-1}$)	V_E ($l \cdot min^{-1}$)	Age (years), sex	Height (m)	Mass (kg)
1	3.57	156	84	35, M	1.81	77
2	4.15	195	114	19, M	1.73	54
3	2.23	197	90	29, F	1.78	58
4	2.51	189	83	23, F	1.61	48
5	3.58	201	90	24, F	1.65	54
Mean	3.20	187	92	26	1.716	58.2
SD	0.75	7	10	6.16	0.08	11.1

Table 2 Mean VO_2, V_E and HR data during the dressage and the jumping sessions. The data are presented as means values cumulated over 4 min for the dressage session and canter in suspension, 5 min for the obstacle trot and canter, and 1 min for jumping

	VO_2 ($l \cdot min^{-1}$)		HR ($beats \cdot min^{-1}$)		V_E ($l \cdot min^{-1}$)	
	Mean	SD	Mean	SD	Mean	SD
Walk	0.70	0.18	106	15	19.39	3.57
Trot	1.47	0.28	131	20	29.57	4.60
Canter	1.90	0.30	144	18	40.5	6.75
Canter in suspension	2.17	0.33	155	22	47.75	8.95
Obstacle trot	2.02	0.27	156	24	43.24	5.21
Obstacle canter	2.02	0.30	159	26	43.38	8.15
Jumping course	2.25	0.35	176	24	59.11	8.30

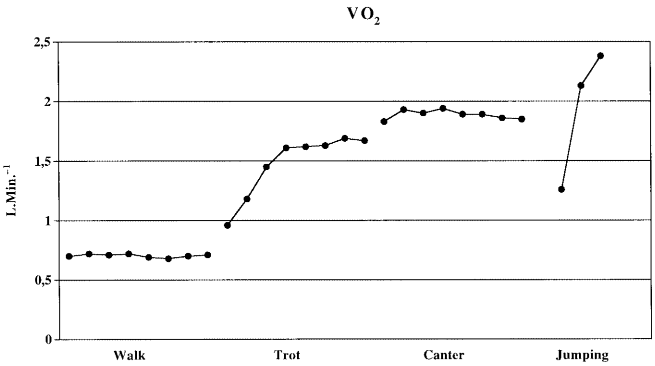

Fig. 1 Oxygen consumption averaged over each 30-s period during the 4-min walk (*W*), trot (*T*) and canter (*C*). During jumping (*J*), the first point was obtained before the start; only two values were collected after the start

the horse being ridden [respectively $F(3,12) = 5.122$, $F(3,12) = 6.882$, $F(3,12) = 4.459$, $P < 0.05$]. The comparison between means indicates a lower energy expenditure when the riders were cantering on horses two and four. Table 4 shows that there were significant differences between riders in the energy expenditure calculated while riding the four horses in the dressage session.

Table 5 shows that riding an unknown horse results in a tendency to enhance energy expenditure but only the difference induced by cantering is suspension reaches statistical significance ($P < 0.05$).

Discussion

The results of the energetic cost measurements agree with those of Westerling (1983). Energy expenditure during horseback riding ranged from $0.5 \text{ l} \cdot \text{min}^{-1}$ at a walk to $2 \text{ l} \cdot \text{min}^{-1}$ during jumping.

The main result of this study is to highlight the variability in rider energy expenditure according to the horse being ridden. There was an important variability in rider energy expenditure between horses during the dressage and jumping sessions. Moreover, the results varied greatly among subjects, especially in jumping. In dressage sessions, the horse's nature was found to be a source of variability. Indeed, our results confirm that the horse that had to be pushed the most was the one that required the highest metabolic cost by the rider. The observed differences in $\dot{V}O_2$ according to rider and horse raise questions about the relationship between the energy expenditure of the rider and the horse. It has been shown recently that part of the horse's energy expenditure is internal work required to maintain the center of mass and speed (Minetti et al. 1999). Therefore, the movement of the rider on the horse's back could increase the horse's internal work through its action on gait biomechanical parameters. The horse-dependent differences in energy expenditure observed among riders may be related to differences in the riders' movements. It is not clear the extent to which riders' movements can

Table 3 $\dot{V}O_2$, $\dot{V}_E$ and HR during the dressage session with four different horses. The data presented are means values cumulated over 4 min for each gait

Horse	Walk						Trot						Canter					
	$\dot{V}O_2$		HR		$\dot{V}_E$		$\dot{V}O_2$		HR		$\dot{V}_E$		$\dot{V}O_2$		HR		$\dot{V}_E$	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	0.64	0.27	107	18	17.5	4.62	1.37	0.36	135	21	31.95	4.64	1.86	0.33	154	25	47.49	8.18
2	0.64	0.13	107	18	15.6	2.91	1.35	0.29	131	18	28.28	4.6	1.62	0.32	139	18	35.72	5.31
3	0.79	0.17	107	14	16.6	3.15	1.64	0.3	133	17	30.32	5.69	2.16	0.29	146	15	42.18	6.75
4	0.75	0.16	102	10	15.9	3.66	1.55	0.18	126	15	27.73	3.64	1.97	0.27	137	15	36.60	6.76

Table 4 VO_2 and $\%VO_2$ in the dressage session according to the rider

Rider	Walk		Trot		Canter	
	VO_2	$\%VO_2$	VO_2	$\%VO_2$	VO_2	$\%VO_2$
1	1.00	28.22	1.85	51.8	2.115	59.1
2	0.56	13.49	1.4	33.73	2.01	48.43
3	0.72	32.51	1.55	69.5	1.86	83.4
4	0.6	23.9	1.165	46.41	1.61	64.14
5	0.64	17.87	1.425	39.8	1.925	53.77
Mean	0.70	23%	1.48	48%	1.9	62%
SD	0.17	7.66	0.25	13.69	0.19	13.44

influence the amount of mechanical work the horses need to do. It may be that different gaits require more energy expenditure by the rider because they need to work harder to maintain their center of mass. Further studies are needed to understand the reciprocal influences that riders and horses have on energy expenditure.

The data obtained here indicate the mean energy expenditure induced by different riding activities. The maximal aerobic power was measured, and we assume that the riders' mean energy expenditure when riding was between 25 and 70% of VO_{2max}. The question is how much does the physical training achieved when riding enhance the rider's aerobic capacity. It has been shown that continuous physical exercise at 60–70% VO_2max for several 30-min sessions per week enhances aerobic capacity (Pollock 1973). The riders canter for only a small part of a normal training session, the main training part consisting of walking and trotting. Consequently, riders should physically train for several hours per week in addition to their riding activities if they are to enhance their aerobic capacity. This is confirmed by the fact that professional riders, who spend several hours riding each day, have better aerobic fitness and strength in several muscle groups compared to recreational riders (Bojer et al. 1998). Assuming a cost of 20.22 kJ (4.83 kcal) per litre of oxygen consumption, it is possible to calculate the energy expended during a dressage training session. During a normal training session of 1 h the rider spends 10 min at walk, 20 min at canter, and 30 min at trot. So, the mean oxygen consumption values measured in this study yield an overall oxygen consumption of 77 l, representing an energy expenditure of 1553 kJ (371 kcal). Jumping could greatly enhance this value, for example 20 min of jumping training, as a normal training duration, could induce a caloric wasting above 837 kJ (200 kcal). However, jumping training is not performed more than twice a week. The metabolic cost of riding could be compared to that of training in other physical activities. It has been calculated that 1 h of running at 60% VO_{2max} for an adult male of 70 kg results in a mean energy expenditure ranging between 2500 and 3000 kJ (600 and 700 kcal). Nevertheless, riding is a metabolic cost that could help to maintain as good a physical constitution as achieved by aerobics or gymnastics.

Table 5 Mean VO_2, HR, and V_E calculated from the overall values obtained during the jumping session with the known and the unknown horse

	Canter in suspension						Obstacle trot						Obstacle canter						Jumping course					
	VO_2		HR		V_E		VO_2		HR		V_E		VO_2		HR		V_E		VO_2		HR		V_E	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Known horse	2.05	0.37	154	24	44	9.01	2.00	0.30	155	24	42.74	6.01	2.10	0.31	159	26	44.5	9.95	2.15	0.34	175	22	57.24	8.09
Unknown horse	2.35	0.29	156	20	51.5	8.95	2.05	0.25	158	25	43.73	4.42	1.95	0.30	159	27	42.3	6.39	2.30	0.37	177	27	60.98	8.52

Regular riding practice is thus recommended to improve the energy balance and reduce body fat.

In some subjects, jumping induces 100% $\dot{V}O_{2max}$ and maximal HR. So, $\dot{V}O_{2max}$ is probably a factor that limits performance. On the other hand, during jumping 94% of the mean maximal HR is obtained at only 75% $\dot{V}O_{2max}$. This discrepancy between HR and $\dot{V}O_2$ could be because steady-state oxygen consumption is not achieved during jumping, and ventilation and metabolism change rapidly according to the different jumping phase. So, the method used here could underestimate peak oxygen consumption. Therefore, even though oxygen consumption remained sub-maximal during jumping, unfit subjects could have their hearts stimulated to dangerous levels. This point highlights the necessity of regular medical examinations before participation in riding competitions and supports the movement that competitive riders should maintain a general physical fitness training programme.

In conclusion, this study emphasizes the variability in rider energy expenditure according to the horse and the rider. The mean $\dot{V}O_2$ achieved during the training sessions always remained under 75% $\dot{V}O_{2max}$. This level of energy expenditure is capable of developing high aerobic capacities, but, during jumping, any subject could reach, for a short duration, their $\dot{V}O_{2max}$. The performance of competitive riders is influenced by their aerobic capacity; therefore, it is in their interests to do additional aerobic fitness training.

References

Bigard AX, Guezennec CY (1995) Evaluation of the cosmed K2 telemetry system during exercise at moderate altitude. Med Sci Sports Exerc 27: 1333–1338

Bojer M, Lötzerich H, Trunz E (1998) A fitness-check for riders in consideration of a functional anatomy analysis of riding [Abstract]. J Sports Med 19: 56

Minetti AE, Ardigò LP, Reinach E, Saibene F (1999) The relationship between mechanical work and energy expenditure of locomotion in horses. J Exp Biol 202: 2329–2338

Pollock ML (1973) The quantification of endurance training programs. In: Willmore JH (ed) Exercise and sport sciences reviews. Academic Press, New York, pp 155–188

Trowbridge EA, Cotterill JV, Crofts CE (1995) The physical demands of riding in national hunt races. Eur J Appl Physiol 70: 66–69

Westerling D (1983) A study of physical demands in riding. Eur J Appl Physiol 50: 373–382