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The influence of a taurine containing drink on cardiac parameters before and after exercise measured by echocardiography

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Summary. To determine the effect of the taurine containing drink "Red Bull" on cardiac parameters thirteen endurance trained subjects performed an exhaustive bout of endurance exercise at three different times. Prior to the exercise the original "Red Bull" drink, a similar drink without taurine, containing caffeine, and a "placebo" drink without caffeine and without taurine were ingested by the subjects in a double-blind cross-over design. Echocardiographic examinations were performed before the drinks, 40 minutes after the drinks prior to the exercise and in the regeneration period after exercise. Stroke volume was significantly influenced only in the "Red Bull group" (80,4 ± 21,4 ml before drink vs. 97,5 ± 26,2 ml in the regeneration period), mainly due to a reduced endsystolic diameter and volume. Furthermore in this group the peak late diastolic inflow (V_A) in the regeneration period was significantly higher compared with the pre-exercise levels. This observation was also made in the caffeine group but without any consequences on ventricular function. The results of the present study show an influence of the original caffeine and taurine containing drink (Red Bull) on parameters of the cardiac contractility.

Keywords: Amino acids – Taurine – Caffeine – Exercise – Echocardiographic measurements

Introduction

The use of caffeine as an energiser is widespread both in leisuretime and trained athletes. For some years the drink Red Bull has been frequently used by athletes since they feel a stimulating effect upon their performance. In contrast to other energy drinks which are currently available, Red Bull contains taurine. Previous double – blind trials have shown an effect upon various physiological parameters during and after exercise with reference to an increased endurance performance; at a given submaximal workload, both heart rate and noradrenaline content were lower after the administration of a

taurine containing drink (Geiß et al., 1994). The beneficial effects of taurine supplementation upon the heart have been described, both in healthy circumstances (for review see Satch and Sperelakis, 1998) and the failing heart (Azuma et al., 1992). The biochemical explanations for such beneficial effects of taurine include its effect upon cAMP concentration in the brain with a decreased central nervous activity, or a modulated Ca^{++} metabolism in myocardial myofibrillar protein with an inotropic effect (Bousquet et al., 1998). In cats with cardiomyopathy this effect could be observed by M-Mode echocardiography (Atkins et al., 1990).

The aim of this present study was to determine whether taurine administration, as a constituent of Red Bull, would have an effect upon functional cardiac parameters, especially ventricular function.

Subjects and methods

Thirteen trained endurance athletes (7 triathlons, 4 cyclists, 2 runners who trained more than 11 hours per week of endurance exercise for 6 years) participated in the study. Their mean age was 26 ± 4 years, mean height was 1.80 ± 0.06 m and mean body mass was 73.6 ± 4.6 kg. All subjects were volunteers, healthy and drug free. After information about the study to be undertaken, written consent was obtained. The study was conducted during a twelve week period when the subjects training schedules were held at a constant level. In the days prior to the exercise test no training, alcohol or stimulants were allowed. Three hours before the exercise the subjects received a standardised breakfast without caffeine (bread, butter, mineral water = 50 g carbohydrate, 18 g fat, 8 g proteins = 395 kCal) (Geiß et al., 1991). Forty minutes before the test exercise one of the three drinks under investigation, D1, D2 or D3, was consumed.

Echocardiographic examinations were performed before the ingestion of the test drink, immediately prior to the exercise and in the regeneration period, when the heart rate had declined to about 70 beats per minute. The exercise intensity was determined about one week before the scheduled research: The subjects started at a workload of 50 W with the workload subsequently increasing stepwise by 50 W every 6 minutes until exhaustion (= Watt max). Blood lactic acid (Bla) was measured in hyperemized ear lobe capillary blood samples at the end of each step (Boehringer Laktat®).

Based on this pretest, in the test exercise the subjects cycled with the following intensity and duration:

1. Ten min warm-up with Bla levels lower than 2 mmol/l (27 ± 6% Wmax)
   – pausing ten min
2. Six min with BLa levels at 2 mmol/l (44 ± 5% Wmax)
3. Six min with BLa levels at about 3 mmol/l (60 ± 5% Wmax)
4. Six min with BLa levels at about 5–6 mmol/l (77 ± 4% Wmax)
   – pausing ten min
5. Six min with BLa levels about 8 mmol/l (near exhaustive exercise, (94 ± 4% Wmax)

The test design was planned double-blind and cross-over, therefore during the experimental phase of the study neither the subjects nor the investigators knew which drink was consumed in each trial. The drinks were of the same taste and colour with the following compositions:

D1: "Red Bull" without taurine, without glucuronolacton, without caffeine, with glucose (10,5 g), with saccarose (43 g) (500 ml, "*Placebo*")
D2: "Red Bull" without taurine, without glucuronolacton, with caffeine (160 mg), with glucose (10,5 g), with saccarose (43 g) (500 ml, "*Control*")

D3: "Red Bull" original drink containing taurine (2 g), glucuronolacton (1,2 g), with caffeine (160 mg), with glucose (10,5 g/l), with saccarose (43 g) (500 ml, "*Verum*")

D1 and D2 were also manufactured by Red Bull company in a comparable fashion is that of D3 but without several components specially for this study. Heart rate was registered continuously with polar pulse tester, blood pressure with conventional cuff method during the last minute of each step, blood lactate was measured at the end of each step, blood ammonia (ammonia checkerl II, Nobis Labordiagnostika Germany), at rest and 3 min after steps 4 and 5.

Echocardiographic methods

All subjects were examined by M-Mode, 2-dimensional and pulsed wave Doppler echocardiography on a Hitachi (model EUB 525) ultrasound machine. M-mode measures were obtained according to the American Society of Echocardiography guidelines, using "leading edge to leading edge" method (Quinones et al., 1978). Because of the rapid decrease of circulatory activation after exercise in endurance trained persons, measurements must be done in a quick and accurate manner. Therefore systolic and diastolic left ventricular volumes were calculated from the Teichholz formula (Teichholz et al., 1976), also the stroke volume. Fractional shortening (FS) was calculated as LVEDD – LVESD/ LVEDD (LVEDD left ventricular end-diastolic diameter, LVESD left ventricular end-systolic diameter). Doppler examination of the diastolic left ventricular inflow was performed from an apical 4-chamber view, the sample volume was placed between the mitral leaflet tips. The ultrasound beam was lined up parallel to left ventricular inflow to minimize the angle between beam and inflow. The angle was lower than 25 degrees in all examinations. Left ventricular inflow during three subsequent heart beats was measured. Peak early diastolic inflow (E-wave) and peak late diastolic inflow (A-wave) were calulated from the results (mean of three measurements).

Statistics

The significance of the data was validated by the Friedmann (nonparametric analysis of variance) and Wilcoxon test (post-hoc test), using a significance level of $p \leq 0.05$ as significant. Results are given as mean and standard deviation.

Results

Metabolic and peripheral circulation measurements showed the same physiological increase after exercise after administration of any of the three drinks. Only the systolic blood pressure was not significantly lower at submaximal exercise loads. The blood ammonia concentration, although increased was not significantly higher after the last step in the placebo trial. In other regards, neither the heart rate nor the echocardiographic measurements, by Friedmann tests, showed any significant differences between the three trials (Table 1). In the group administered Verum, after exercise the late peak diastolic inflow velocity (V_A) increased significantly above resting levels, which was also evident in the group administered caffeine alone (Control) but to a lower extent (Fig. 1). The early peak diastolic inflow velocity (V_E) was not influenced by any of the three drinks administered (Table 1). While exercise after administration of the Verum drink significantly

Table 1. Echocardiographic parameters in a group of athletes after administration of Verum, Control or Placebo (B: at rest before drink; A: at rest after drink; E: after exercise)

		Placebo	Control	Verum
Heart rate [1/min]	B	53 ± 8	53 ± 11	54 ± 12
	A	49 ± 5 *** **	49 ± 7 *** ***	50 ± 7 *** ***
	E	65 ± 15	70 ± 11	70 ± 15
FS [%]	B	35.2 ± 7.5	37.4 ± 7.1	34.3 ± 6.6
	A	38.5 ± 7.0	39.1 ± 8.8	37.2 ± 3.7 **
	E	39.1 ± 6.2	37.0 ± 6.3	39.3 ± 7.2
LVEDD [mm]	B	51.7 ± 4.2	52.6 ± 4.8	50.7 ± 5.4
	A	52.8 ± 4.1	52.4 ± 3.8	52.5 ± 3.8
	E	52.3 ± 5.3	52.6 ± 4.7	52.6 ± 4.0
LVESD [mm]	B	33.4 ± 3.9	33.0 ± 5.8	33.3 ± 4.2
	A	32.4 ± 4.0	32.0 ± 5.6	33.8 ± 4.5 *
	E	30.4 ± 5.9	33.1 ± 4.8	31.6 ± 4.9
VE [m/s]	B	0.69 ± 0.11	0.65 ± 0.11	0.69 ± 0.17
	A	0.68 ± 0.10	0.69 ± 0.08	0.68 ± 0.15
	E	0.61 ± 0.07	0.63 ± 0.14	0.65 ± 0.1

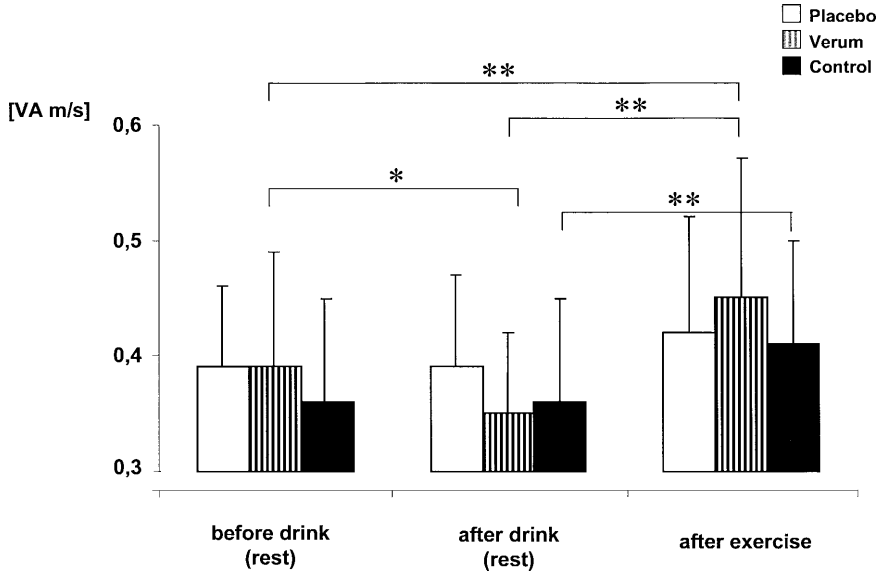

Fig. 1. Increase in the late peak diastolic inflow velocity (*VA*) from rest to post exercise in trained athletes after consumption of Verum, control or placebo. A significant increase is observed in the group administered taurine + caffeine, Verum, $P < 0.01$, while a similar effect is also observed in the group administed only caffeine, control, $P < 0.01$

decreased the left ventricular end systolic diameter (LVESD) no significant changes were evident after administration of either the Control or Placebo drinks. The fractional shortening increased significantly only in the Verum administered subjects after exercise. A significant increment in the stroke volume was evident in the Verum administered subjects after exercise, (a

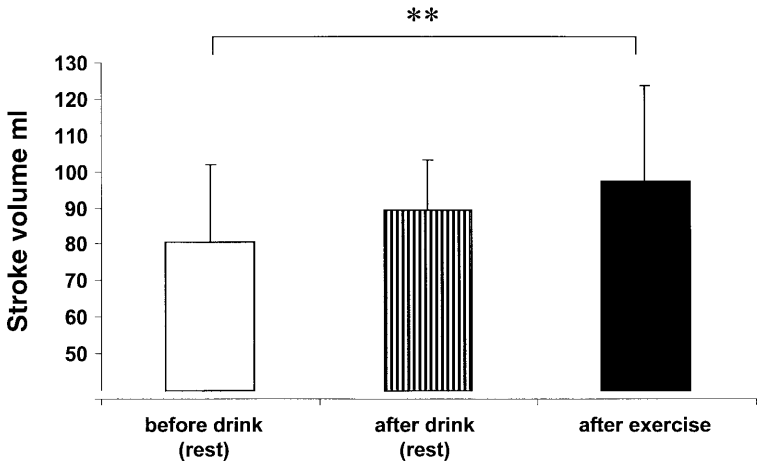

Fig. 2. Stroke volume (ml) before, after consumption of drink and after exercise in the group administered Verum, caffeine + taurine drink

parameter of contractility) due to the higher FS (fractional shortening) and lower end-systolic volume (Fig. 2), while there were no significant alterations in the groups administered either Control or Placebo.

Discussion

The present study demonstrates an effect of an energy drink containing both caffeine and taurine on cardiac parameters after exercise which differed from a placebo and a control drink which contained caffeine alone. The late peak diastolic inflow velocity (V_A) depends mainly on the atrial pump function and was significantly increased from the resting state to the post exercise period only after administration of the taurine + caffeine drink (Verum) which indicated an increased contractiliy of the left atrium. The early peak diastolic inflow velocity, an indicator for the compliance of the left ventricle or for blood volume expansion, was unchanged. The stronger contraction of the left atrium could explain the slightly higher, but not significant, left ventricular end diastolic volume (LVEDV) in the Verum administered group. The stroke volume (SV) was significantly increased due to a higher LVEDV and a significantly decreased left ventricular endsystolic volume (LVESV), while the Fractional Shortening (FS) also increased significantly. The increase of SV and FS might be a consequence of the Frank-Starling mechanism after improved filling of the left ventricle alone or of additional improvement of contractility. To our knowledge in humans no comparable data about cardiac parameters after the administration of a taurine containing drink and exercise have been published. However previous studies have shown an increased VO_2max and performance after the intake of the same taurine and caffeine containing drink Verum. Furthermore in these studies a decreased heart rate during submaximal exercise, i.e. oxygen consumption, was registered (Geiß et al., 1994, Jester et al., 1997). These observations could now be explained by

the present results (higher SV and FS) because, at a given cardiac output, a higher SV is associated with a lower heart rate, and maximum heart rate at a higher SV improves VO_2max and maximal endurance performance which is dependent on a higher cardiac output. After the control drink (with caffeine alone) no changes in LVESD and FS were induced by exercise, while after placebo a small reduction of LVESD was measured, i.e. a small increase of FS which was not significant. Factor analyses (MANOVA) revealed no influence of caffeine habituation on the results. Therefore we conclude, that taurine alone or in combination with caffeine is responsible for the differences. In cats with cardiomyopathy a positive inotropic effect of taurine has been observed (Atkins et al., 1990). The underlying biochemical mechanisms may include modulation of storage capacity of Ca^{++} in the sarcoplasmatic reticulum (Huxtable and Bresser, 1973), a stimulation of the pumping rate of Ca^{++} activated ATPase pumps (Pasantes-Morales, 1982) or an influence on ion channels (Satoh 1998). These positive inotropic effects are comparable to the digitalis responses (Atkins et al., 1990). This might explain the positive effects of taurine in congestive heart failure and after acute myocardial infarction (Azuma et al., 1985, Chazov et al., 1974). Another underlying biochemical mechanism might be an increased turnover of cAMP in the heart by taurine-induced stimulation of the adenylate cyclase and phoshodiesterase (Mal'Chikova and Flizarova, 1981). If so, the inhibition of the phoshdiesterase by caffeine would be a superposing effect to the taurine actions. With respect to the missing caffeine effect on the heart rate and blood pressure in the verum trial, this may indicate that taurine acts upon central regulatory loops. Such influences at the brain level have been demonstrated by Wessberg and co-workers in several publications. Therefore a combined effect of taurine at the level of the heart and the central nervous system may be responsible for our results as well as an interaction between the substances in the Verum drink.

Most of the previous studies of the effect of taurine containing drinks upon performance and circulatory factors have investigated trained athletes. It may be that the effects of Verum are less obvious in such subjects by comparison to untrained individuals in whom the central circulatory capacity is often the performance limiting factor, such that the use of taurine in the latter group may be of more beneficial effect.

In conclusion after administration of the taurine and caffeine containing Verum drink the cardiac contractility, especially the left atrial contractility, after exercise was increased. This result might explain the improved maximal performance and lower heart rate at submaximal working intensity observed in previous studies. Evidence is given that this is an effect of the combination of taurine and caffeine and a combined effect at the level of the heart and the brain.

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