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EFFECTS OF CAFFEINE ON EXERCISE PERFORMANCE, LACTATE, F.F.A., TRIGLYCERIDES, PROLACTIN, CORTISOL AND AMYLASE IN MAXIMAL AEROBIC EXERCISE

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ABSTRACT

In this study the effect of caffeine (5 mg/kg) on maximal power output, lactate, blood FFA, triglyceride, amylase, prolactin and cortisol hormones was examined during a 20 m. progressive shuttle-run test at the same time of day, one week apart. Subjects were twenty male, elite, long distance athletes aged between 19-30. In each of the trials, solutions were given one hour prior to testing by Appling a single blind experimental design. Statistical analysis was carried out on the relevant data using Student's T-tests. Caffeine trial was compared with the placebo. MaxVO$_2$ values, which reflects sportive performance of the sportsman, during exercise and all parameters before exercise were not significantly different between caffeine and placebo trials (P>0.05). After exercise (6min.), values were as fallows. Systolic blood pressure values were found to be significantly higher (P=0.02) whereas blood lactic acid values were lower (P=0.01) in the caffeine trials. Heart rate, diastolic blood pressure, FFA, triglycerides, amylase, cortisol, and prolactin concentrations were not significantly different between the trials (P>0.05). As a conclusion these results suggest that orally taken caffeine amounts of 5 mg/kg or less does not affect exercise performance and are not effective as a doping substance.

Introduction

Endurance athletes are constantly interested in ways of aiding and improving their performance, whether by nutritional aids, training techniques, or drugs. The use of either caffeine or glucose has been shown to be of benefit. Caffeine has been reported to delay the onset of exhaustion when ingested prior to exercise, due to a stimulation of F.F.A. mobilization, leading to a glycogen-sparing effect (7, 18).

Invitro studies have suggested that caffeine may inhibit phosphorylase a and stimulate intramuscular triglyceride breakdown directly. Caffeine ingestion results in an increased FFA mobilization 1-2h post ingestion due to central nervous system stimulation and inhibition of phosphodiesterase activity (7).

International Olympic Committee (IOC) has banned the use of high levels of caffeine. However, since caffeine is commonly found in many foods that are taken as part of the normal diet, when testing for the drug the banned level is set above 15 μg ml^{-1} urine which is reported to represent the ingestion of 500-600 mg of caffeine (five or six cups of coffee) in a 1-2 hour period. Therefore in practical terms this dosage is only likely to be exceeded through the use of tablets, injection, suppositories or the deliberate ingestion of large amounts (20, 22).

However, there is some evidence to suggest that the amount of coffee found in a strong cup of coffee, while not exceeding the limits set by the IOC, may be more than enough to enable an athlete to experience the physiological benefits available from caffeine (22).

Recent investigations have found that caffeine enhances performance during sub maximal cycling performance but not running or treadmill performance. Bond et al. found that caffeine did not exert any beneficial effects during incremental bicycle ergometry (21). Caffeinated-beverage deprivation was associated with decreased vigour and increased fatigue and with symptoms including headache. No changes in psychomotor performance were observed (13).

As an ergogenic agent, caffeine may improve simple movement speed and long-term endurance, but similar benefits have not been found for short, exhaustive forms of exercise (11).

However, caffeine ingestion may also produce adverse effects for the endurance performer. Relatively modest doses (3-5mgkg^{-1}) have been shown to induce an increased blood lactate level. This is probably due to a stimulation of glycolysis via the cAMP mechanism, which is also responsible for the lypolytic stimulation (1). The intake of caffeine, which increases FFA, which in turn decreases glycolysis, also inhibits the production of lactate, thus the athlete is able to perform either more work or to work at a greater intensity (9, 15). However, Gaesser and Rich found that ingestion of a 5mgKg^{-1} dose of caffeine did not delay, and might even accelerate the onset of blood lactate accumulation (6).

Much of the belief that caffeine aids performance is based on its direct actions on isolated tissues. Included among caffeine's actions are stimulation of the central nervous system and of cardiac muscle, relaxation of smooth muscle and mobilisation of free fatty acids. There exists a large body of evidence suggesting that caffeine also has marked effects on skeletal muscle function (24).

The possibility that caffeine or methylxanthines could improve performance during sports events and prolonged effort aroused great interest and was the basis for numerous studies. However, this hypothesis remains extremely controversial, undoubtably because of a lack of standardization among the various experimental procedures. Furthermore this type of study is complicated by the fact that caffeine effects vary with the corpulence of the individual, the type, intensity and duration of the given exercise, the dose of caffeine used, habituation to the methylxanthines and with environmental conditions during exercise. In fact, caffeine might act directly on the central nervous system by stimulating release of β-endorphins and hormones that modify perception of pain and discomfort caused by physical effort (17).

Some researchers suggest that only well-trained athletes can utilise caffeine with benefit. On the other hand, Casal and Leon have suggested that caffeine only has a positive effect on athletes who are not of the elite nature since they have not increased lipolytic enzyme activity, mitochondrial density or size that endurance activities bring about. Similarly athletes with high amounts of caffeine in their normal diet have been found to build up a tolerance to the substance which prevents caffeine from having its purported ergogenic effect (5).

Materials and Methods

Subjects, participated in this research, were twenty elite male long distance athletes aged between 19-30 (22.2 ± 3.22) They all were active club sportsman.

TABLE 1

Changes on Lactate, F.F.A, Triglycerides & Amylase during maximal exercise (with placebo)

	Lactate (mmol / L)		F.F.A. (µEg / L)		Trigliserides (mg/dl)		Amylase (IU / L)	
Subjects	Before exercise	After exercise	Before exercise	After exercise	Before exercise	After exercise	Before exercise	After exercise
1	3.39	15.99	101	146	112	120	85	84
2	2.65	9.37	1146	1070	102	100	97	89
3	4.22	15.85	345	172	215	226	64	62
4	4.66	13.06	367	575	58	75	62	59
5	3.99	17.07	79	185	69	99	58	45
6	5.32	15.59	327	500	57	41	67	63
7	3.60	15.85	60	66	87	111	48	63
8	2.29	13.80	110	168	63	56	60	55
9	5.83	15.42	203	203	245	191	48	53
10	5.60	18.67	110	132	57	52	30	25
Average Value ± S.D.	4.15 ± 1.20	15.14 ± 2.59	248.8 ± 324.60	321.7 ± 310.36	106.5 ± 68.26	107.1 ± 60.11	61.90 ± 18.91	59.80 ± 18.14

Range of the normal lactate value between 0.63 - 2.44 (mmol / L)
Range of the normal F.F.A. value between 100 – 600 (µEg / L)
Range of the normal trigliserides value between 0 - 160 (mg / dl)
Range of the normal amylase value between 0 – 90 (IU / L)

In this research:

- Age, length, and weight of subjects were measured for placebo and caffeine trials.
- Bohringer Mannheim kit is used for lactate measurements.
- Randox kit was used for F.F.A measurements.
- Randox kit was used for triglycerides measurements.
- Teco diagnostics kit was used for amylase measurements.
- Bohringer Mannheim 4010 model spectrophotometer was used for lactate, F.F.A., triglycerides and amylase measurements.
- Bio data diagnostic kits were used for cortisol and prolactin measurements.
- Mini Instruments Ltd’s game counter was used for hormone tests.
- Blood pressure was measured by pressure monitor.
- Heart rate was measured by heart rate monitor.

Shuttle-run test was applied two times with one week interval. At first study, placebo with an artificial sweet (saccharine) was given (250 ml hot water + 4gr. coffee without caffeine) and test protocol was applied according to the (16, 18).

In the study, a week after ,5 (mg / kg) dust caffeine was put in the placebo , at the same quantity and drunk to the sportsman. In both placebo and caffeine trial solutions were given one hour prior to the exercise. While one blind test protocol was applied, any information about caffeine intake was not given to the sportsman.

Venous blood was with drawn preexercise and 6min. after recovery. These samples were analized for lactate, free fatty acid, triglycerides, amylase, prolactin and cortisol hormones.

Results and Discussion

The results of the measured values on placebo and caffeine trails when compared with each other are as below.

In systolic pressure values, before exercise, showed no significant difference for placebo and caffeine trials (11.65±0.5mm Hg;

TABLE 2

Changes on Sistole & Diastole Heart rate MaxVO$_2$ during the exercise with placebo

	Sistole (mmHg)		Diastole (mmHg)		Heart Rate (Pulse*min^{-1})		MaxVO$_2$ (ml.kg^{-1}.dak.$^{-1}$)
Subjects	Before exercise	After exercise	Before exercise	After exercise	Before exercise	After exercise	During exercise
1	11	14	6	9	52	174	58.7
2	12	17	7	6	46	180	64.8
3	12	14	8	6	56	180	56.5
4	12	15	7.5	6	56	187	58.2
5	12	15	8	8	52	175	65.6
6	12	16	8	6	60	194	62.7
7	12	13	8	7	58	190	59.0
8	10.5	13	7	6	56	191	59.8
9	11	14	7	7	60	200	62.2
10	12	18	8	6	55	173	65.9
Avarage Value ± S.D.	11.65 ± 0.57	14.9 ± 1.66	7.45 ± 0.68	6.7 ± 1.05	55.1 ± 4.22	184.4 ± 9.32	61.34 ± 3.35

12.05±1.2mmHg respectively). However, after exercise, the systolic pressure values were 14.9±1.60 in placebo trials and 16.7±1.5 in caffeine trials. Therefore, systolic pressure values were found significantly higher in caffeine trials than in placebo trials (P=0.02).

The diastolic pressures, before and after the exercise, showed no significant difference for both placebo and caffeine trials. However, Titlow et al. showed an elevation in systolic and diastolic blood pressure after caffeine ingestion, before 60min. treadmill running (21).

Caffeine consumptions resulted in significant increases in both systolic and diastolic blood pressure at rest and during exercise. The elevation for systolic blood pressure during exercise was 7-8 mmHg at all three exercise intensities; however, for diastolic blood pressure there was only a significant elevation (4 mmHg) at the highest exercise intensity. No differences were noted between those men who regularly consume and those who regularly abstain from caffeine (12). Our results in diastolic blood pressure agree with these findings whereas in systolic blood pressure, do not.

Although, before and after exercise, heart rate in caffeine trials against placebo trials increased in minimal levels; the difference was not significant.

Superko Hr et all's findings also agree with our trails (20).

Durıng exercise, Max VO2 levels under caffeine conditions were approximately the same with the placebo conditions. Titlow et al. reported that 200mg caffeine enhances 60 min. sub maximal exercise performance (21). William JH et al. in the study on 9 young men, reported that 7 mg /kg caffeine does not effect maximal power increase and delaying exhaustion during 15min. short-termed, dynamic high intensity exercise (24). Trice I, Haymes EM reported that caffeine increases time to exhaustion when trained subjects cycled intermittently at high levels of intensity (22). The combination of caffeine and ephedrine significantly prolonged exercise time to exhaustion compared to placebo, while neither caffeine nor ephedrine treatments alone significantly changed time to exhaustion (1). In conclusion, while some of these findings agree with our results few others disagree.

Neither placebo nor caffeine ingestion, before exercise, showed any effect on lactate levels (P>0.05).

TABLE 3

Changes on prolactin & cortisol level during the maximal exercise (with placebo)

	Prolactin (µg / ml)		Cortisol (ng / ml)	
Subjects	Before Exercise	After exercise	Before exercise	After exercise
1	10	32	44.64	55.05
2	4.2	16	89.28	110.11
3	13	33	113.09	133.92
4	16.2	28	52.08	113.09
5	11	28.4	98.21	163.69
6	5.3	9	43.15	86.3
7	13	12	65.47	83.33
8	13.8	14	49.1	72.91
9	12.1	16	81.84	107.14
10	9	28.9	62.13	94.9
Average Value ± S.D.	102.04 ± 31.15	10.76 ± 3.76	21.73 ± 9.12	69.90 ± 24.4

TABLE 4

Changes on prolactin & cortisol level during the maximal exercise (with Caffeine)

	Prolactin (µg / ml)		Cortisol (ng / ml)	
Subjects	Before exercise	After exercise	Before exercise	After exercise
1	3.8	19	44.64	55.05
2	3.25	17.9	89.28	110.11
3	18.1	30	113.09	133.92
4	12.2	24.8	52.08	113.09
5	9	38	98.21	163.69
6	6.8	12.3	43.15	86.3
7	12.3	12.8	65.47	83.33
8	10.9	18	49.1	72.91
9	6.8	23.3	81.84	107.14
10	9	27.5	62.13	94.9
Average Value ± S.D.	9.22 ± 4.43	22.36 ± 8.02	70.76 ± 25.74	102.04 ± 31.15

After exercise, in placebo ingestion, mean lactate value was 13.11±3.6mmol/lt whereas in caffeine ingestion it was 8.19±4mmol/lt. In caffeine consumers lactate values after the exercise showed a significant decrease (P=0.01). In literature caffeine, ephedrine and their combination significantly increased lactate levels (1). During a brief intense exercise, blood lactate concentrations were not affected significantly by caffeine ingestion, but during the exercise bouts muscle lactate concentration was significantly increased by caffeine (10). Some studies show that the intake of caffeine which increase FFA, which in turn decreases glycolysis, also inhibits the production of lactate thus the athlete is able to perform either more work or to work at a greater intensity (9, 15). However, Gaesser and Rich found that ingestion of a 5mg/Kg dose of caffeine did not delay, and might even accelerate the onset of blood lactate accumulation (6)

Before exercise, FFA values under the placebo conditions were 284.8±324µEq/ml whereas in caffeine trials it was 325±229µEq/ml. Hence, in placebo and caffeine trials there was no significant difference (P>0.05).

After exercise, FFA values were 321±310µEq/ml in placebo and 454±154µEq/ml in caffeine trials. FFA values after exercise caffeine consumers were higher than non-consumers. But this difference was not significant. Bell D. et all's studies also agree with these findings (1).

Prior to exercise, triglyceride values in placebo and caffeine trials (106.5±68mg/dl; 100±56mg/dl respectively) were close to each other. And so, there was no significant difference.

After exercise, triglyceride values were 107±60mg/dl in placebo trials and 84.19±30mg/dl in caffeine trials. Although mean triglyceride values in caffeine trials were found to be diminished, the difference was not significant. On the other hand Casal DC and Leon AS showed that triglyceride values were increased post caffeine ingestion and after exercise but the increase was also not significant (3, 4).

Before and after exercise both in placebo and caffeine trials, the amylase values

TABLE 5

Changes on Lactate, F.F.A, Triglycerides & Amylase during maximal exercise (with caffeine)

	Lactate (mmol / L)		F.F.A. (µEg / L)		Trigliserides (mg /dl)		Amylase (IU / L)	
Subjects	Before exercise	After exercise	Before exercise	After exercise	Before exercise	After exercise	Before exercise	After exercise
1	3.25	6.06	236	208	174.5	121	44	46
2	4.32	9.09	280	425	92.0	74.8	50	55
3	4.10	8.67	250	491	94.2	82.8	27	32
4	4.32	6.14	157	189	35.6	38.2	65	49
5	5.48	16.41	933	634	82.8	75.1	64	59
6	4.95	13.20	143	416	96.8	66.2	48	60
7	3.81	8.31	380	462	66.2	81.5	64	71
8	4.03	14.46	254	625	34.3	56.4	60	58
9	5.42	16.23	212	518	212.7	136.3	75	68
10	3.96	15.32	409	578	115.9	109.6	71	68
Average Value ± S.D.	4.36 ± 0.71	11.30 ± 4.14	332.2 ± 233.41	434.6 ± 162.27	100.5 ± 56.28	84.19 ± 30.01	56.80 ± 18.91	56.60 ± 18.14

Range of the normal lactate value between 0.63 - 2.44 (mmol / L)
Range of the normal F.F.A. value between 100 – 600 (µEg / L)
Range of the normal triglycerides value between 0 - 160 (mg / dl)
Range of the normal amylase value between 0 – 90 (IU / L)

TABLE 6

Changes on Systole & Diastole, Heart rate, MaxVO$_2$ during the exercise (with caffeine)

	Systole (mmHg)		Diastole (mmHg)		Heart Rate (Pulse*min^{-1})		MaxVO$_2$ (ml.kg^{-1}.dak.$^{-1}$)
Subjects	Before exercise	After exercise	Before exercise	After exercise	Before exercise	After exercise	During exercise
1	14	17	8	6	54	180	59.3
2	11	17	7.5	7	48	181	63.6
3	11.5	14	8	7	58	193	59.0
4	14	19	9	8	54	192	59.8
5	12	16	8	8	58	170	65.7
6	12	16	8	6	64	200	62.7
7	11	16	7	8	68	194	62.2
8	11	17	7	7	65	191	59.8
9	11	16	7	8	68	200	61.9
10	13	19	8	7	64	175	65.6
Average Value ± S. D	12.05 ± 1.21	16.8 ± 1.47	7.75 ± 0.64	7.2 ± 0.78	60.1 ± 6.74	187.6 ± 10.42	61.95 ± 2.47

showed no difference Many studies show that amylase values were increased in saliva during and after the exercise (3, 4 and 14). But no studies looking at human pancreatic amylase were found man. However, a study on rats showed that pancreatic enzymes (both amylase and lipase) were increased with physical endurance exercise (16).

In this study, the prolactin level in the placebo group rose from (10.76 ± 3.76) prior to exercise to (21.73 ± 9.32) following exercise groups. Prolactin level in the caffeine group, rose (9.22 ± 4.43) prior to exercise to (22.36 ± 8.02) following exercise groups. Even though in both groups the prolactin level fallowing exercise has risen, there was no significant difference between caffeine and placebo groups (8).

Before exercise, cortisol value of caffeine users were higher than placebo users (in placebo 57.4±29.4mg/dl, in caffeine 73.9±26mg/dl). After exercise, a difference was also seen (in placebo 64.6±16mg/dl; in caffeine 77.8±15mg/dl). However, the difference between them was not at a significant level. Sung and et al have found that cortisol was increased post caffeine and throughout maximal exercise on caffeine days (19).

As a conclusion, after the exercise, in young male subjects, 5mg/kg caffeine ingestıon as compared with placebo decreased blood lactate values and increased blood pressures. A significant difference was not observed in free fatty acid, triglycerides, amylase, prolactin and cortisol hormones. All these results can be seen on **Table 1.**

REFERENCES

1. **Bell D.G., Jacobs I., Zamecnik J.** (1998) Eur. J. Appl. Physiologic, **77(5),** 427-433.
2. **Battram D.S., Shearer J., Robinson D., Graham T.E.** (2004) J. Appl. Physiol., **96**(3), 943-50.
3. **Calvo F. Chicharro J.L**. (1997) J. Appl. Physiologic, **22**(6), 553-561.
4. **Chatterton R.T., Jr Vogelsong K.M., Lu Y.C., Ellman A.B., Hudgens G.A.** (1996) Clin. Physiologic, **16(4),** 433-448.
5. **Flinn S., Gregory J., Mc Naighton L.R, Tristram S., Davies P.** (1990) Int. J. Sports Med., **11**, 188-199.
6. **Gaesser G.A., Rich R.G.** (1985) Int. J. Sports Med., **6,** 209-21.
7. **Giles D., Maclaren D.** (1984) J. Sports Sci., **2,** 35-46.
8. **Hockney A.C. Premo M.C., Mcmurray R.G.** (1995) J. Sports Sci., **13**(4), 305-311.
9. **Ivy J., Costill D.L., Van Handel P.J., Essi D., Lower R.** (1981) Int. J. Sports Med., **2,** 139-142.
10. **Jackman M., Wendling P., Friars D., Graham T.E.** (1996) J. Appl. Physiology., **81**(4), 1658-1663.
11. **Jacobson B.H., Webber M.D., Claypool L., Hunt L.E.** (1992) Br. J. Sp. Med., **26**(4), 276-279.
12. **Kaminsky L.A., Martin C.A., Whaley M.H.** (1998*)* J. Sports Med. Phys. Fitness, **38**(1), 53-58.
13. **Lane J.D.** (1997) Pharmacology Biochem. Behav., 203-208.
14. **Ljungberg G., Ericson T., Ekblom B., Birkhed D.** (1997) Scand. J. Med. Sci. Sports, **7**(4), 214-219.
15. **Magkos F., Kavouras S.A.** (2004) Sports Med., **34**(13), 871-89.
16. **Manios Y., Moschandreas J., Hatzis C., Kafatos A.** (1999) Preventive Medicine, **28,** 149-159.
17. **Nehling A., Debry G.** (1994) Int. J. Sports Med., **15,** 215-223.
18. **Paluska S.A.** (2003) Curr. Sports Med. Rep., **2**(4), 213-9.
19. **Sung B.H., Lovallo W.R., Pincomb G.A., Wilson M.F.** (1990) Am. J. Cardiol. Apr., **65**(13), 909-13.
20. **Superko H.R., Myll J., Diricco C., Williams P.T., Bortz W.M., Wood P.D.** (1994) Am. J. Cordial., **15,** 80-784.
21. **Titlow L.W., Ishee J.H., Riggs C.E.** (1991) J. Sports Sci., **9**, 15-22.
22. **Trice I., Haymes E.M.** (1995) Int. J. Sport Nutr., **5**(1), 37-44.
23. **Wiles J.D., Bird S.R., Hopkins J., Rileys** (1992) Br. J. Sp. Med., **26**(2), 116-120.
24. **Williams J.H., Signorile J.F., Borners W.S., Henrich T.W. (1998)** Br. J. Sports. Med., **22**(4), 132-134.