CAFFEINE INGESTION AND ISOKINETIC STRENGTH

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ABSTRACT

The purpose of this study was to investigate the effects of caffeine on maximum voluntary contractions of the dominant knee extension and flexion muscles in 12 male intercollegiate track sprinters. Caffeine (5 mg.kg⁻¹) and placebo (225 mg methylcellulose) gelatin capsules were administered orally in randomly assigned order. Muscle function was measured isokinetically by a Cybex II dynamometer interfaced with a data reduction computer. Six repetitions maximum of the extensors and flexors were performed at three sequential ordered speeds (30°, 150° and 300°s⁻¹) with a one-minute rest between varying velocities. Peak torque and power were then assessed after treatment conditions, as well as a fatigue index calculated from a series of 60 repetitions maximum at 150°s⁻¹. Results of the 2 × 3 ANOVA and paired t-test indicated no difference in measures of peak torque and power at the varying contracting velocities and fatigue index after caffeine ingestion. These findings indicate the ingestion of caffeine in a small dose exerts no ergogenic effect on muscle function under anaerobic conditions.

Key words: Caffeine, Peak torque, Power, Fatigue index.

INTRODUCTION

It has been established that caffeine (1, 3, 7-trimethylxanthine) enhances muscle tension in vitro (Yamaguchi, 1975; Weber and Herz, 1968; Wood, 1978) and potentiates the contractile capacity of fatigued muscle stimulated in situ (Bianchi and Narayan, 1982; MacIntosh et al, 1981). The effect of caffeine on muscle function is due to its action on the sarcoplasmic reticulum, thus increasing calcium permeability and making it readily available for the contraction mechanism (Caputo, 1983). It has been claimed that caffeine is widely used by weight-lifters and throwers as an ergogenic aid to enhance strength and power (Brooks and Fahey, 1984). Presently, only one study known to the authors has investigated the effects of caffeine on human skeletal muscle contractile properties in vivo (Lopes et al, 1983). Lopes and associates failed to show a difference in maximal tension obtained with electrical stimulation at 100 Hz or maximal voluntary static contraction between placebo and caffeine. However the tension developed with electrical stimulation at lower frequency increased significantly with caffeine ingestion. Most movement patterns in athletic performance involve dynamic contraction of the muscle rather than static contraction. Therefore a further concern would be the effect of caffeine on maximal tension generated during a complete range of motion. Recent advancements in isokinetic testing have provided relatively simple, yet accurate methods for measuring tension production during a complete range of motion. Barnes (1980) reported during an isokinetic contraction that the integrated electromyographic activity per second decreased as the isokinetic speed increased. This finding, along with the findings of a significantly increased tension with lower electrical stimulation after caffeine ingestion by Lopes et al (1983), may suggest that ingestion of caffeine would produce greater tension during a maximal voluntary contraction at a high speed rather than at a lower contracting speed.

No study has investigated in vivo the effect of caffeine on muscle function during a dynamic contraction in relation to varying contracting velocities. The purpose of this study was to investigate the effects of caffeine ingestion on peak torque and power in man during low, moderate, and high speeds of contraction. A further purpose was to investigate the effect of caffeine on muscle function as a rate of decline in force.

METHODS

Twelve male intercollegiate track sprinters ($\bar{X}$ age = 20 ± 0.78 yr, $\bar{X}$ weight = 71 ± 9.1 kg, $\bar{X}$ height = 180 ± 6.5 cm) who were non-caffeine users volunteered as subjects in the present study. All were informed of the procedures and purpose of the study, any known risks, and each signed a statement of informed consent.

Prior to testing, all subjects participated in two practice sessions which consisted of the exercise protocol utilised during the testing sessions. Anhydrous caffeine (5 mg.kg⁻¹) or placebo (225 mg methylcellulose) was placed in gelatin capsules and assigned randomly to ingestion order before each test.

Each subject was tested on separate days at approximately the same time with a one week interval between experiments. Upon entering the study the subjects were instructed to abstain from products containing caffeine for one week prior to the study and not to participate in any physical activity 48 hours prior to the test. After ingestion of the caffeine or placebo capsule, the subjects rested in a sitting position for 60 minutes to allow for peak absorption (Axelrod and Reichenenthal, 1953; Bellet et al, 1968; Robertson et al, 1981). At the end of this period, a venous blood sample was collected and analysed for caffeine concentration by high pressure liquid chromatography (Orcutt et al, 1977). The subjects were then tested for dominant knee extension and knee flexion. Functions of the knee extension and knee flexion muscles were tested with a dual channel Cybex II isokinetic dynamometer connected to a Cybex II data reduction computer. The isokinetic dynamometer was calibrated prior to the testing sessions. The subjects were seated with the

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hip between 65° and 90° of flexion and the knee in 90° of flexion. The axis of rotation of the Cybex II was aligned with the anatomical axis of the subject's knee. The Cybex II lever arm was attached to the subject's shank at a point approximately 70 per cent of the distance between the medial condyle of the femur and the medial malleolus to allow for a standardised and comfortable attachment site. The subject's thigh was stabilised with a strap attached to the table (Rothstein et al, 1983).

The test session began with the subject's hands across the chest and moving the leg at three velocities presented in the following order: 30°s⁻¹ (low contracting speed), 150°s⁻¹ (moderate contracting speed), and 300°s⁻¹ (high contracting speed). At each speed, the subject performed six consecutive maximal repetitions. A repetition constituted moving the leg from a 90° flexed position to full extension and back again. The subjects were allowed 60-second rests between velocities. After completing a total of 18 trials at 30°, 150°, and 300°s⁻¹, the subjects rested for two minutes and then performed a series of 60 maximal repetitions at 150°s⁻¹. The data from the isokinetic tests was then analysed to obtain values for peak torque, power and a fatigue index. The highest point on the torque curve was accepted as peak torque and power was calculated as the total work produced over six repetitions, divided by the actual contraction time. The fatigue index was defined as the ratio of total work performed during the last 20 repetitions to that performed during the first 20 repetitions of the 60 contractions at 150°s⁻¹.

To ascertain the treatment effects, a two-way (2 × 3) (treatment × velocities) ANOVA and paired t-test was used in analysing the fatigue index. The Newman-Keuls post hoc procedure was used to identify significantly different group means. An $\alpha = 0.05$ probability level was used for all tests of statistical significance.

RESULTS AND DISCUSSION

Mean plasma concentration after ingestion of placebo and caffeine were 0.04 and 5.71 $\mu\text{L}\cdot\text{mg}^{-1}$ respectively. Peak torque values for knee extension and flexion after placebo and caffeine are depicted in Table I.

TABLE I

Peak torque (Newton metres) for knee extension and flexion at velocities of 30°, 150°, and 300° per second after placebo and caffeine ingestion

		Placebo	Caffeine
Knee extension	30° s ⁻¹	226 ± 42	223 ± 46
Knee extension	150° s ⁻¹	154 ± 26	155 ± 24
Knee extension	300° s ⁻¹	87 ± 12	80 ± 20
Knee flexion	30° s ⁻¹	146 ± 33	132 ± 33
Knee flexion	150° s ⁻¹	123 ± 23	119 ± 20
Knee flexion	300° s ⁻¹	87 ± 16	85 ± 18

As the isokinetic velocity increased, the torque decreased with a marked difference in linearity between knee extension and flexion. The present study found no significant effects of caffeine ingestion on knee extension and flexion isokinetic force exerted at 30°, 150°, and 300°s⁻¹. This finding is in agreement with the work of Lopes and others (1983) who reported no difference in maximum voluntary contraction of the abductor pollicis muscle after caffeine ingestion.

The mean power values for knee extension and flexion at different speeds of contraction after ingestion of caffeine and placebo are presented in Table II.

TABLE II

Isokinetic power (Watts) for knee extension and flexion at velocities of 30°, 150°, and 300° per second after placebo and caffeine ingestion

		Placebo	Caffeine
Knee extension	30° s ⁻¹	68 ± 10	72 ± 13
Knee extension	150° s ⁻¹	278 ± 52	285 ± 69
Knee extension	300° s ⁻¹	324 ± 116	336 ± 106
Knee flexion	30° s ⁻¹	40 ± 11	41 ± 11
Knee flexion	150° s ⁻¹	211 ± 61	220 ± 55
Knee flexion	300° s ⁻¹	272 ± 74	286 ± 64

The power values for extension and flexion followed the same general pattern with an increase in power as the speed of contraction increased. There were no significant effects of caffeine ingestion on knee extension and flexion isokinetic power across contracting speeds. However, the data was in the direction of the hypothesis, in which the power increased as the contracting velocity increased with caffeine ingestion.

The fatigue index during knee extension and flexion at 150°s⁻¹ did not differ significantly between caffeine and placebo ingestion (Table III). This finding may be considered an extension of the work of Lopes and associates who demonstrated that the drug has no effect on fatigue production in situ during a static contraction (Lopes et al, 1983).

TABLE III

Fatigue index (%) for knee extension and flexion over 60 repetitions at 150° per second after ingestion of caffeine and placebo

		Placebo	Caffeine
Knee extension	150° s ⁻¹	45 ± 5.6	40 ± 9.9
Knee extension	150° s ⁻¹	40 ± 10.8	38 ± 12.0

In conclusion, our data suggest caffeine in a small dose exerts no influence on muscle function at low, moderate, and high contracting velocities tested in vivo. Since caffeine ingestion is a practice among athletes and very little research has investigated its effect on muscle function, a recommendation is to extend the present study by utilising a larger dose of caffeine.

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BOOK REVIEW

Title: PROGRESS IN ERGOMETRY, QUALITY CONTROL AND TEST CRITERIA
Authors: H. Loellgen and H. Mellerowicz (Eds.)
Publisher: Springer-Verlag, Berlin. 1985
Price: £19.00 **Paperback** **ISBN 0-540-13570-7**

Not all papers included in these proceedings have obvious relevance to the title of the seminar at which they were presented. Nevertheless some contributions do represent work towards one of the goals for the progress of ergometry in medicine as set out by Mellerowicz in his preliminary remarks. The paper by Loellgen consists of sound, practical advice on quality control and is an excellent source of references for the use of probability theory in exercise testing. Two chapters deal with evaluation of relatively new techniques; Stegemann and Essfeld's description of problems encountered with breath-by-breath expired air analysis systems and possible solutions is informative and opens up many possibilities; the accuracy of constant load electromagnetic cycle ergometers is examined by Landry and co-workers who have some reservations concerning the stability of the braking power of such ergometers over time and usage. Problems exist too with pedal speed-dependent ergometers, as shown by Cramer in his short but informative paper.

Measurement of blood lactate concentration is frequently undertaken as an index of muscle metabolism during exercise. Terry Graham cautions against a simplistic view of lactate metabolism and, in straightforward language, provides help with standardisation of methodology and interpretation. Jan Karlsson and co-workers document their experience of determining the onset of blood lactate accumulation (OBLA) in athletes and patients. The haemodynamic response to exercise receives attention; Heck and colleagues provide some 'normal values' for blood pressure in cycle ergometry whilst Thadani reminds readers of the influence of posture on blood pressure. Ruddel and co-authors show that if exercise intensity is very light blood pressure is influenced by factors other than the exercise test itself. Surprisingly, habituation of naive subjects to the procedures of ergometry is not suggested by these authors as a means of overcoming this problem.

An appendix includes a reprint of the American Heart Association's (AHA) checklist for operation of an exercise testing laboratory and a checklist for quality control arising from deliberations at the Seminar. The latter also relies heavily on the recommendations of the AHA and lacks detail. The text comprises 275 pages, including 104 Figures and 88 Tables.

Adrianne E. Hardman

BOOK REVIEW

Title: HOW TO RUN A MARATHON
Authors: Tony Benyon and Kevin Macey
Publisher: New English Library, Sevenoaks, Kent. 1986
Price: £6.95 (UK Edition) **120 pages. 57 whole page cartoons** **ISBN 0-450-06151-5**

My locum, knowing my almost obsessional interest in sports medicine and exercise physiology, gave me this book as a birthday present to bring me down to earth, and I can recommend it strongly to any wife/husband, girl/boy friend, parent or child of an equally obsessional runner as a suitable gift for the same purpose.

Chapters on what to wear, including pantomime horse costumes, how to train, effects of running (including the devastation of the sex life), types of runners and the race itself are all mentioned and each page of text is faced by an amusing but often only too true a cartoon. Serious runners will be amused at what they see illustrative of what their less dedicated friends do, and those with a more amateur approach will laugh at the dedicated. This is a book to dip into, to keep in the bathroom or waiting room (but it will soon be pinched) or to read at a single session, for example while waiting for the athlete to return home from his twenty mile jog on a cold winter's evening.

H. E. Robson