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Engineering implications on physiological measurements using a Monark rope braked ergometer

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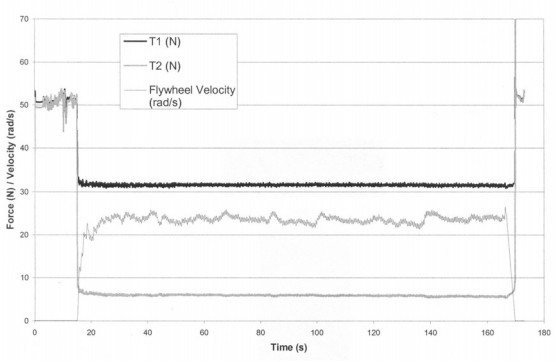
The Monark rope-braked ergometer is widely used by physiologists to determine the work and power output from subjects or for physiological measurements to be made at a predetermined level of effort. The power is determined by taking the product of the pedal rate (rpm) and the brake mass (kg). The brake mass is suspended in a basket attached to a pulley. A rope is connected to the pulley and is wound around the ergometer flywheel to provide resistance. MacIntosh et al. (2002) directly measured the rope tension and found that the tight and slack side tensions were 95.5% and 6.71% of the applied load. These results contradict the traditional assumption that the slack side tension is zero. There is, however, a discrepancy in these results as the moments applied to the pulley are not in equilibrium. Gordon et al. (2004) give a detailed theoretical analysis of the brake system and validated the theory with experimental results. The ratio of tension in the rope is given by,

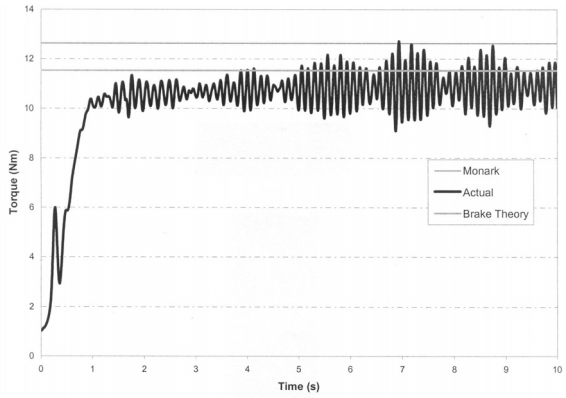
$T_1/T_2=e^{\mu\theta}$

where T_1 is the tight side tension (N), T_2 the slack side tension (N), μ is the coefficient of friction and θ is the angle of lap (radians). It is difficult to obtain values for the coefficient of friction to determine the theoretical brake load and hence direct measurement of the rope tension was used. Figure 1 shows the measured tensions and the flywheel velocity of a subject pedalling against a resistance of 3kg at a constant velocity. This shows that prior to and at the end of the subject pedalling the tight and slack side tensions are equal. Therefore, the forces on the flywheel are in equilibrium. During the period when the subject is pedalling both the tight and slack side tension is reduced but remains constant. The tight side tension is 32.3N (SD 0.19) and the slack side tension is 5.92N (SD 0.17). This gives a brake load of 26.38N compared with the value of 29.43N, which would be traditionally used. This is an error of 10.4%. This error is then carried into the calculations of brake torque, work done and power. Figure 2 shows the directly measured brake torque for a Wingate Anaerobic Test (WAnT) and compares it with the theoretical brake torque and that assumed by Monark (Constant). This shows that far from being constant the brake torque varies during this test. The error is increased as the moment of inertia of the flywheel is calculated using an inaccurate measure of the brake torque.

In conclusion the oversimplification in the analysis of the brake system leads to an overestimation of the work and power generated. In tests that use the brake torque to determine the moment of inertia of the flywheel the error is compounded.



Tight (T1) and slack side (T2) rope tensions and flywheel velocity for a subject pedalling against a 3kg resistance.



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Where applicable, the experiments described here conform with Physiological Society ethical requirements.

C136

The identification of inaccuracies of measured and calculated parameters during a Wingate high intensity exercise test using Taguchi method

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The purpose of this study was to establish the effects of inaccurate measurements and different methods of calculations of four parameters for a Wingate High Intensity Exercise Test (WAnT). This study used the standard WAnT procedure and compared two sets of data collected simultaneously and analysed in different ways. The difference in the results generated by the different methods of data collection and processing was identified and the influence of the individual parameters on the results was isolated. The

results gathered during the WAnT were work done, maximum power and average power for the subject over a 30 s period.
Data was collected using Wingate Measurement system and software manufactured by Cranlea Ltd and used by physiologists and this was compared with data collected simultaneously using alternative data collection methods and analysis techniques devised from research into rope braked ergometry (Gordon et al. 2004). Data was compared using a design of experiments method known as the Taguchi method (Peace, 1993). Four parameters were required to obtain WAnT results for peak power, mean power and work done during a 30 s test. These were flywheel speed, braking force, moment of inertia of the flywheel and time period over which work and power were calculated. Only one subject who had provided informed consent was used to generate the data as this was a comparison of data collection techniques.
It was found that, although the values of inertia, flywheel velocity and brake force were higher using the Cranlea system, the overall values of work done, peak power and average power were higher using the alternative system. This was due to the choice of time period over which the data was analysed and this has been discussed by Hibi et al. (1996) and quantified by this study as a crucial factor. Much work has been carried out on inertial effects in WAnT (Lakomy 1986), with 31.7% difference in the peak power (Reiser et al. 2000) but the importance of the time step seems to have been not so widely investigated. While the other factors have an influence on the results, the time over which the data is averaged is the most important giving a 9.8% increase on work done with Cranlea providing 18839.7J and the alternative system 20891J. The Cranlea system gave a peak power value of 843.57W while the alternative system gave a value of 1423.047W which gave a 40.75% increase. The average power calculated by the Cranlea system was 627.99W while the alternative system provided 722.65W which is a 13.1% increase.

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Where applicable, the experiments described here conform with Physiological Society ethical requirements.

C137

Prediction of maximal oxygen uptake from a perceptually regulated graded exercise test

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As the relationship between the ratings of perceived exertion (RPE, Borg 1998), oxygen uptake (VO_2) and heart rate (HR) during a graded exercise test (GXT) is high ($r>0.90$), the RPE is often used to prescribe various levels of exercise intensity. The relationship between RPE and VO_2 may also facilitate the prediction of maximal oxygen uptake (VO_2max). However, it is unknown if it is possible to predict VO_2max from sub-maximal effort production levels. This would be a useful application, particularly as the production of a given RPE is often used as a guide to exercise intensity regulation. The purpose of this study was to assess the validity of predicting VO_2max from sub-maximal VO_2 values elicited during a perceptually-regulated GXT. We hypothesized that the strong relationship between RPE and VO_2 would enable VO_2max to be predicted and that this would improve with practice.
Ten physically active men (23.6±2.1 years, 79.6±10.2 kg, 1.81±0.05 m) performed four exercise tests: a GXT to establish VO_2max (starting at 50 W and increasing by 50 W every 3 min until exhaustion), and three sub-maximal RPE production trials on an electromagnetically braked cycle ergometer, each separated by 48 h. The resistance on the cycle was manipulated within ±1 W, independent of pedal speed. VO_2 and HR were monitored continuously. Physiological and exercise intensity information were concealed from the participant.
In each production trial, participants exercised at five self-regulated RPE levels (9, 11, 13, 15 and 17) prescribed in an incremental fashion for 4 min. The RPE Scale was mounted in full view of the participant. At the beginning of each RPE increment, 2-3 min was allowed to adjust the resistance until the participant was sure that the resistance equated with the prescribed RPE. No further intensity adjustments were made after the initial 2-3 min. Each bout was separated by 50 W active recovery for four more minutes, before commencing the next RPE production. Cadence was maintained at 50 —80 rpm.
Correlations between RPE and VO_2 were in the range 0.92 to 0.99 across the three trials. There were no significant differences between measured VO_2 (mean ± SD, 48.8 ± 7.0 ml kg^{-1} min^{-1}) and predicted VO_2max values (47.3 ± 10.0, 48.6 ± 8.1 and 49.9 ± 7.4 ml kg^{-1} min^{-1}, for trials 1, 2 and 3, respectively) when VO_2max was predicted from RPE values of 9—17 ($P>.05$) The same was observed when VO_2max was predicted from RPE 9—15. Limits of agreement (LoA) analysis on actual and predicted VO_2max values (from RPE 9—17) were (bias ±1.96 x SDdiff) 1.5±7.3, 0.2±4.9 and −1.2±5.8 ml kg^{-1} min^{-1}, for trials 1, 2 and 3, respectively. Corresponding LoA values for actual and predicted VO_2max (from RPE 9—15) were 5.4±11.3, 4.4±8.7 and 2.3±8.4 ml kg^{-1} min^{-1}, respectively.
The data suggest that a sub-maximal, perceptually-guided, GXT provides acceptable estimates of VO_2max which are further improved with practice in fit young males. The method may have potential in groups where maximal tests are not desirable.

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Where applicable, the experiments described here conform with Physiological Society ethical requirements.

C138

Continuous exercise and intermittent games activity reduce postprandial triacylglycerol concentrations in adolescent boys

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The process leading to coronary atherosclerosis is initiated in childhood (Mc Gill *et al.* 2000) and so reducing postprandial tri-

acylglycerol (TAG) concentrations, even in young people, could potentially slow atherogenic progression. This study sought to investigate if continuous exercise and intermittent games activity would reduce postprandial TAG concentrations in adolescent boys. Nineteen participants took part in this study and were randomly assigned to either a continuous exercise group ($n = 10$, age 15.3 ± 0.1 years, height 177.1 ± 1.7 cm, body mass 63.4 ± 1.1 kg and pubic hair maturity 4 ± 1; mean ± S.E.M.) or an intermittent games activity group ($n = 9$, age 15.4 ± 0.1 years, height 177.5 ± 1.2 cm, body mass 59.8 ± 1.0 kg and pubic hair maturity 4 ± 1; mean ± S.E.M.) and underwent two 2-day trials. Trials were performed a minimum of 7 days apart in a randomised, counterbalanced order consisting of a rest and exercise trial. Participants were asked to control their physical activity levels and diet before each trial. The study had ethical approval and prior to testing, written informed consent was obtained from parents/guardians. Maturity was self-assessed (Tanner, 1962). In the rest trial participants took no exercise on day 1. On day 1 of the exercise trials participants completed four blocks (approximately 15 min per block) of uphill treadmill walking (continuous group) or intermittent games activity (intermittent games group). On day 2, participants came to the laboratory after an overnight fast and finger prick blood samples were obtained in the fasted state. Participants then ingested a test meal (1.25 g fat, 1.07 g carbohydrate, 0.20 g protein, and 67 $kJkg^{-1}$ body mass). Further finger prick samples were collected at 30 and 45 min and 1, 3, 4 and 6 h. Plasma samples were analysed for TAG. Data were assessed using Student's t test for correlated means. Triacylglycerol data were logarithmically transformed prior to statistical analysis to achieve normality. Statistical significance was accepted at the 5% level. The total area under the TAG versus time curve was lower in the exercise compared with the rest trials in both groups (continuous exercise group: 7.26 ± 0.82 versus 8.39 ± 0.75 mmol l^{-1} $(6\ h)^{-1}$, exercise versus rest, respectively, reduced by 14%, $P = 0.050$; intermittent games activity group: 6.92 ± 0.79 versus 9.38 ± 1.25 mmol l^{-1} $(6\ h)^{-1}$, exercise versus rest, respectively, reduced by 26%, $P = 0.002$, no difference when groups compared). Both continuous exercise and intermittent games type activity reduce postprandial TAG concentrations in adolescent boys.

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Where applicable, the experiments described here conform with Physiological Society ethical requirements.

C139

Effects of alcohol and hypoxia on driving simulator performance and visual acuity in normal, young subjects

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Alcohol and hypoxia are known to affect performance, but their combined effects are poorly understood.

We have studied the effects of (1) control (air + no alcohol), (2) blood alcohol concentration (BAC) - 0.8mg/ml, (3) hypoxia (80-85% O_2 saturation) and (4) alcohol and hypoxia combined using a divided attention driving simulator (DADS, Stowood Scientific, Oxford) and the Bodmann visual acuity test [1].

Following a practice session using the DADS system, 10 normal subjects (4 male; median age 21 years, range 20-22 years) completed 4 study sessions, each at the same time of day in the afternoon, in a randomized order. At each session, subjects consumed a 570ml drink of 50:50 cranberry juice:grapefruit juice and waited 30 min before starting the DADS test, which lasted for 20 min. This was followed immediately by the Bodmann test. BAC was calculated for each subject using Forrest's algorithm of the Widmark equation [2], rearranged to obtain the volume of 100% ethanol required to achieve a BAC of 0.8mg/ml.

Data from the DADS was analysed for reaction times, off road events, the ability to follow the centre of the road and the ability to turn the wheel in relation to the curve of the road. The Bodmann test was analysed for the time to complete the test. Data were analysed using Friedman's ANOVA with Dunn's multiple comparison test and are given as median (interquartile range).

Hypoxia was maintained at levels between 80-85% saturation throughout each study. There were significant differences between (alcohol + hypoxia) and control for off-road events, absolute error and standard deviation of the curve and reaction time (Table 1). There were no significant differences between sessions for the Bodmann test or the standard deviation off the centre.

In normal young subjects the combined effects of alcohol at a BAC of 0.8 mg/ml and hypoxia at 80-85% O_2 saturation appear to impair the ability of subjects to undertake tasks requiring fine motor co-ordination and quick reactions, whereas hypoxia or alcohol alone at the levels studied do not.

Table 1. Summary of significant results

	Control	Alcohol	Hypoxia	Alcohol + Hypoxia
Mean reaction time (s)	1.34 (1.23–1.935)	1.71 (1.48–2.43)	1.39 (1.18–1.86)	2.04 (1.58–2.84)‡
SD on curve	0.29 (0.26–0.42)	0.32 (0.25–0.43)	0.32 (0.25–0.41)	0.40 (0.37–0.53) †
Absolute error on curve	0.20 (0.19–0.31	0.23 (0.18–0.32	0.24 (0.18–0.29)	0.28 (0.25–0.39) †
SD off the centre	0.24 (0.15–0.30)	0.23 (0.18–0.29)	0.27 (0.16–0.31)	0.34 (0.20–0.46)
Off road events	1.5 (0–6.5)	0.5 (0–3.5)	3.0 (0–8.0)	8.0 (1.5–20.5) †
Bodmann test	5.13 (4.4–6.4)	5.32 (4.5–7.3)	5.39 (4.4–6.7)	6.06 (5.4–6.9)

Mean reaction time, measure of complex reaction time; SD on curve, standard deviation of difference between steering angle and road angle; Absolute error, total difference between steering angle and road angle; SD off the centre, standard deviation of the centre of the car from the centre of the road; Off road events, number of times the car left the road. $p < 0.05$ vs control; $p < 0.01$ vs control.

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Where applicable, the experiments described here conform with Physiological Society ethical requirements.

C140

Changes in serum levels of reactive oxygen species, antioxidants and nitric oxide during normal pregnancy

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The changes in maternal physiology support the diverse needs of the developing fetus and prepare the gravida for the parturition. The aim of our study was to determine the serum levels of the products of reactive oxygen species, antioxidants and nitric oxide in healthy pregnant women at different gestational ages. The study has the approval of ethics committee of University of Medicine and Pharmacy, Cluj-Napoca and the approval of patients. We included in our study 30 healthy pregnant women (aged between 17 and 28 years) with single pregnancy that presented at the Department of Obstetrics Cluj-Napoca, for prenatal visits. We took blood samples from these patients at 6-8 weeks of gestation, 12-15 weeks, 20 weeks and at term before the onset of labor. As controls, we selected for our study 30 healthy non-pregnant women aged between 19 and 34 years. We established the serum level of the products of reactive oxygen species for all patients: lipid peroxides-Satoh method (1) and the carbonyl content of proteins-Reznik method (3). We also established the hydrogen donating ability of serum (that reflects the serum antioxidant capacity)-Hatano method (1) and the serum level of nitrate and nitrite (products of nitric oxide degradation in organism)-Griess reaction (4). All results are expressed as the mean ± S.D. The comparison between each group of pregnant women and the group of non-pregnant women was carried out using Student's t test. A p value <0.05 was considered significant. We found that serum products of reactive oxygen species in healthy pregnant women of 6-8 (lipid peroxides 1.8±0.05 nmol/ml and serum carbonyl content of proteins 1.22±0.07 nmol/mg protein) and of 12-15 weeks (lipid peroxides 1.82±0.08 nmol/ml and serum carbonyl content of proteins 1.28±0.08 nmol/mg protein) do not differ significantly from those of healthy non-pregnant women (lipid peroxides 1.8±0.07 nmol/ml and serum carbonyl content of proteins 1.25±0.07 nmol/mg protein). In contrast, in women at 20 weeks we found significantly higher values ($p<0.01$) of these parameters (lipid peroxides 2.15±0.11 nmol/ml and serum carbonyl content of proteins 1.78±0.07 nmol/mg protein) and this increase was maintained until the end of the pregnancy. In addition, the hydrogen donating ability of serum was significantly increased ($p<0.01$) at 20 weeks (50.1±2.4%) compared with non-pregnant women (39.7±1.9%). The levels of nitrates and nitrites increased significantly ($p<0.01$) beginning at 12-15 weeks (19.9±1.8 μmol/ml) compared with the levels in non-pregnant women (12.2±1.04 μmol/ml) and was maintained until the end of the pregnancy (20.1±1.6 μmol/ml). We conclude that there is a new oxidative status in healthy pregnant women. The mother produces reactive oxygen species in greater quantities from 20 weeks until the end of the pregnancy but also has stronger antioxidant mechanisms. On the other hand, nitric oxide, known to produce relaxation of vascular and non-vascular smooth muscle (2), is increased earlier, namely from the beginning of the second trimester.

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Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC177

Effect of chronic ethanol feeding, during sexual maturation, on 24-hour rhythms of mitogenic responses and lymphocyte subset populations in thymus and spleen of male rats

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This work analyzes the effect of chronic ethanol feeding on the 24-h variation of mitogenic responses and lymphocyte subset populations in thymus and spleen. Animals were maintained under a 12:12 h light/dark photoperiod and they received a liquid diet for 4 weeks, starting on day 35 of life. The ethanol-fed group received a similar diet to controls except for that maltose was isocalorically replaced by ethanol. Ethanol replacement provided 36% of the total caloric content of the diet. Rats were humanely killed at 6 time intervals around the clock, beginning at Zeitgeber time (ZT) 1 (ZT 0 = lights on). Under ethanol intake, both splenic and thymic weights decreased. Also, mean values of thymic, but not of splenic T cell number decreased, and mean values of thymic and splenic CD8+ and CD4+-CD8+ number augmented. Consequently, thymic T/B ratio and thymic and splenic CD4+/CD8+ ratio decreased in ethanol-fed rats. These findings coexisted with a significant increase in thymic cells response to LPS. The ethanol diet modified 24 h rhythmicity of thymic and splenic T, B and CD4+-CD8+ cells, thymic CD4+ and splenic CD8+ cells, thymic and splenic T/B and CD4+/CD8+ ratios, as well as of mitogenic responses in both tissues. Chronic ethanol administration presumably affects the endogenous clock that modulates the circadian variation of immune responsiveness in growing rats.

Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC178

OXIDANT AND DNA DAMAGING EFFECTS OF ACUTE EXPOSURE TO HIGH DOSES OF TAMOXIFEN

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Background: Reactive oxygen species are believed to contribute to the development of several diseases by causing oxidative stress and oxidative damage. The tryphenylethylene drug Tamoxifen, widely used for breast cancer therapy, demonstrated some serious side effects, among which liver disease and liver cancer (1). We have investigated the effects of acute exposure to high doses of Tamoxifen on the oxidative stress parameters and DNA damage in rat liver.

Materials and methods: Female Wistar rats were dosed with Tamoxifen 35 mg/kg body weight and 150mg/kg body weight by oral gavage for 2 days and were humanely killed on the 3rd day of the experiment. Lipid peroxides (2) and protein carbonyls (3), as markers of oxidative stress, and hydrogen donating ability (4), as a measure of non-enzymic antioxidant capacity, were measured in liver homogenates. For assessing the DNA damage, single cell gell electrophoresis (5) was performed on liver cells. All data are presented as mean values *plusmn* SD. The data were analysed using the unpaired Student's T-test for comparing the groups. The 0.05 level of significance was chosen.

Results: The levels of lipid peroxides (LPx) and protein carbonyls (PC) were significantly higher, while hydrogen donating ability (HAD) was lower in the liver homogenate of Tamoxifen treated rats, for both doses, as compared to controls (Tam 35 mg/kg body weight vs. controls LPx $t(11)=5.79$, $p<0.001$, PC $t(11)=6.43$, $p<0.001$, HAD $t(11)=-4.52$, $p<0.001$; Tam 150 mg/kg body weight vs. controls LPx $t(11)=7,22$, $p<0.0001$, PC $t(11)=6.11$, $p<0.001$, HAD $t(11)=-4.69$, $p<0.001$). The tailfactor (TF) and score of lesion (SL) in the comet assay, as a measure of DNA damage, were significantly higher in the study groups as compared to controls, for both doses (Tam 35 mg/kg body weight vs. controls TF $t(11)=7.06$, $p<0.001$, SL $t(11)=5.42$, $p<0.001$; Tam 150 mg/kg body weight vs. controls TF $t(11)=3.24$, $p<0.01$, SL $t(11)=3.64$, $p<0.01$). While oxidative stress parameters were similar for both doses of tamoxifen, we found more pronounced DNA lesions in 35 mg/body weight treated animals.

Conclusions: Acute exposure to high doses of Tamoxifen produces oxidative stress and DNA damage in female rat liver. The oxidant effects of tamoxifen are similar for the two doses used in the experiment. The DNA damaging effect is more pronounced for the lower dose.

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Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC180

Zero magnetic field and oxidative stress in pregnant rats

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The natural magnetic field influences the physiological and pathological processes of the body. The authors have followed the modifications of the reactive oxygen species and of the antioxidants in the serum of pregnant rats exposed to zero magnetic field. White pregnant Wistar rats, 200-250 g weight, were divided into two groups, with 9 animals in each group: group I, control pregnant rats 2 weeks in natural magnetic field; group II, preg-

nant rats exposed to zero magnetic field for 2 weeks. All animals were humanely killed at the end of the experiments.
The exposure was made at the National Institute of R&D for Isotopic and Molecular Technology. Rats housed in wooden cages were placed into a device that compensated the natural magnetic field. The device consisted of Helmholtz coils with a 1.2 m diameter and oriented in a North-South direction and along the local magnetic field lines. The field inside the coils was in the range of 200-400 nTesla and it was conventionally named 'zero magnetic field'.
The serum determinations were made in the Laboratory of the Physiology Department U.M.Ph 'Iuliu Hatieganu' Cluj-Napoca. Blood samples were collected through venous puncture of all rats. Serumal ceruloplasmine was measured using the Ravin method (1), carbonylated proteins through the Reznick method (2) and malondialdehyde (MDA) by the colorimetric method with TBA (thiobarbituric acid). The results obtained were compared against each other and also to the control group. The serum ceruloplasmine presented increased values in group II (zero magnetic field): 41.39 ± 6.61 mg % compared to the control group I: 26.56 ± 3.2 mg %. The values of the carbonylated proteins were lower in group II: 1.28 ± 0.059 mmol/ml than the contol group I: 1.87 ± 0.42 mmol/ml. Malondialdehyde presented decreased values in group II: 1.29 ± 0.12 mmol/ml in comparison with the control group I: 2.28 ± 0.17 mmol/ml.
The animals exposed to zero magnetic field presented significantly decreased values of the malondialdehyde and of the carbonylated proteins, probably because of some lesions in the lipid and protein strata and the serum ceruloplasmine presented increased values in this group (II).

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Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC181

Effect of nicotine administration on weight and histology of some vital visceral organs in female albino rats

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Cigarette smoking is known to have many deleterious effects on visceral tissues in women. These effects are usually attributed to nicotine but this is not the only toxic substance in cigarettes (Oyebola & Adetuyibi, 1977; Alada 2001). The present work represents an initial step in developing an animal model in which to test whether administration of nicotine alone produces the same effects on the viscera of rats as cigarette smoking produces in women. Investigation of the toxicity of nicotine is particularly relevant since it is an important constituent of the cow urine concoction, a local treatment for convulsions in Nigeria.
24 female rats with regular oestrous cycle and in the same phase of the cycle by the commencement of the experiment were divided into two groups. 12 rats from each group received 0.5mg/kg nicotine and 0.9% normal saline S.C. daily respectively. Pair feeding was carried out throughout the experimental period. Weekly growth rate was monitored and there was no significant difference between the nicotine treated and the control animals. All the rats survived to the end of the study and none were culled for reasons of distress.
6 rats from each group were killed by cervical dislocation after 30 and 60 days treatment. The ovary, uterus, pituitary, adrenal, heart, liver, brain and the kidney were removed, weighed and histological study carried out. Body weights of each rat were recorded daily before and throughout the experiment. Statistical analysis was carried out using the Student's t test.
Weights of the ovary, uterus, kidney, brain and pituitary were significantly reduced in the nicotine (0.5mg/kg) treated group when compared with the control rats ($P<0.05$.).
Histological sections showed necrosis in the brain and pituitary, congestion in kidney, fibrosis and follicular degeneration in ovary, ischemia and endometrial degeneration in uterus. After 30days treatment with nicotine (0.5mg/kg) and 0.9% normal saline, the weight of the heart decreased significantly from 0.614 ± 0.012g in normal saline treated rats (control) to 0.563 ± 0.005g in nicotine treatment rats ($P<0.05$). However, maintaining nicotine treatment for 60 days, showed a significant increased ($P<0.05$.) in the weight of the heart from 0.618 ± 0.0097g in control to 0.668 ± 0.008g in treated rats, with the appearance of cartilaginous cells. 30 days nicotine (0.5mg/kg) administrations produce no significant change ($P>0.05$) in the weight of the liver, 60 days treatment increases the weight significantly from 6.10 ± 0.229g in control rats to 7.39 ± 0.050g in treated rats ($P<0.05$). Administration of nicotine (0.5mg/kg) for 30 and 60 days produces no significant effect on the weight of the adrenal. There was no significant difference in growth rate of both control and nicotine treated rats.
Although cigarette smoking is not always synonymous with nicotine administration, these results showed that nicotine has deleterious effects on some vital visceral organs in female rats which are similar to what obtains in women smokers.

Alada ARA (2001). Afr J Biomed Res 4, 47-50.

Oyebola DDO & Adetuyibi A (1977). Trans R Soc Trop Med Hyg 71, 349-350.

Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC214

Progressive resistance training temporarily alters hamstring torque-angle relationship in humans

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Single bouts of muscle contractions with an eccentric or lengthening component have been observed to result in a shift in limb angle-torque relationship (Brocket et al. 2001). The aim of this study was to examine the persistence of this change after eccentric and concentric progressive resistance training. Thirty young adults (19 female, 11 male, aged 18 to 24 years, height 168.7±8.3 cm, body mass 65.9±11.4 kg, all data are mean ± S.D.) were randomly allocated into three groups of 10, control (CONT), eccentric training (ECCE) and concentric training (CONC). Volunteers completed informed consent documents and all procedures were approved by University of Limerick Research Ethics Committee. The ECCE and CONC groups performed seven sessions over 3 weeks of progressive resistance training of the right hamstrings muscle, using a standard barbell and a leg curl machine. Load was set at 2 sets of 8 repetition max at each session. Right leg hamstrings to quadriceps torque ratio was measured during isometric contraction before training and 4, 8 and 11 days after training; subjects were seated with knee angle of 90 deg. Torque-angle relationship was measured at the same time points. For this measurement, isometric torque was recorded at seven equally spaced knee angles, from 20 to 80 deg from full extension with volunteers lying prone. All measurements were recorded on an isokinetic dynamometer (Con Trex, Switzerland). Hamstring-quadriceps torque ratio did not change in any group. In the CONC group, the angle of peak isometric torque increased from 46.0±5.2 deg pre-training to 53.0±14.9 deg on day 4 following training cessation (repeated measures ANOVA, $P<0.05$), with no significant strength gains. In the ECC group, peak torque was increased over baseline on day 4 and day 11 post-training ($P<0.05$) The angle at which peak torque occurred was decreased on day 4 (50.0±8.2 deg pre-training, 29.0±7.4 deg on day 4) and on day 11 (34.0±9.7 deg) (both $P<0.01$), but was similar to baseline 18 days after training. The control group knee angle-torque relationship did not change during the study. Therefore, both training methods induced a temporary change in torque-angle relationship. Concentric training increased and eccentric training decreased the knee angle at which peak torque was measured. Torque-angle changes in both groups were reversed by day 18 after training.

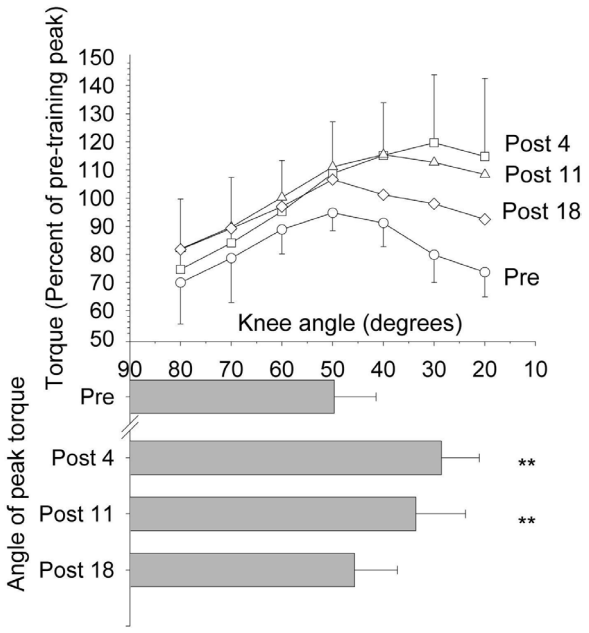

Figure 1. The torque-angle relationship in eccentrically-trained hamstring muscle group (mean ± S.D., N=10). Open circles are pre-training. Squares denote four days post-training; triangles and diamonds are 11 and 18 days after cessation of training, respectively. ** $P<0.01$ compared to pre-test.

Brockett et al. (2001). Med Sci Sports Exerc 33, 783-790.

Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC215

Complexity measurements of event-related potential recordings for single and dual tasks in man

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The purpose of this study is to investigate the application of sample entropy (SampEn) measures (Richman and Moorman, 2000) to electrophysiological studies of single and dual tasking performance. It has been proposed that cognitive control mechanisms are required to orchestrate performance of more than one task at a time. If this is the case then it is expected that the entropy values should be changed in the multiple task condition compared with the single task condition.

The subjects were 13 healthy individuals from the general population both males and females, aged between 18 and 45 years. Each participant took part in all three of the tasks (auditory task and motor tasks 1 and 2). Brain potentials were recorded using a Scan electrophysiological acquisition system (EAS) (Neuroscan Medical Systems, Virginia, USA). All channels were amplified with a gain of ×150 and bandpass filters of 0.01–100Hz were employed. The signals were digitized using a 16-bit analogue-to-digital converter and sampled at 500Hz. The complexity and regularity of short-duration (~s) epochs of averaged, stimulus-

locked electroencephalographic data were analysed using SampEn along with the method of surrogate data. Signals were collected under single and dual tasking conditions. Individual tasks consisted of an auditory discrimination task and two motor tasks of varying difficulty. Dual task conditions were combinations of one auditory and one motor task. Data, mean ± SEM, were compared using the Students t–test with significance taken at P∠0.05. Local ethical approval was obtained for the study.
For rare tone stimuli in the single auditory task and the dual auditory and motor task 1, the entropy values for all electrodes in the auditory single task condition were significantly higher than those for the auditory dual task condition (P ∠ 0.05 – 0.001). Comparisons between data for rare auditory stimuli of the single auditory task and the dual auditory and motor task 2 shown that, entropy measurements were significantly higher for single task compared with dual task performance (P ∠ 0.05 – 0.001) for all recorded electrodes.
In conclusion, the findings of this study have demonstrated that use of entropy measurements, such as sample entropy, could be alternative nonlinear approaches for analyzing event–related brain potential signals using short term time series. The methods show further promise as a quantitative measure of nonlinear dynamic systems behavior in relation to psychological changes, such as transitions between single and dual task challenges, situations for which the validity of traditional nonlinear dynamical approaches such as estimations of correlation dimension and Lyapunov exponents has recently been challenged.

Richman JS, Moorman JR, Am J Physiol, 2000, 278:H2039-H2049

This work was partly supported by the National Natural Science Foundation of China (30370386, 30470453)

Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC216

Ceruloplasmin as a marker of inflammatory and antioxidant status in acute coronary syndrome

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Ceruloplasmin (CP) is an essential plasma α2-globulin that participates in the inflammatory acute-phase reaction, and is also involved in oxidative stress. It has been acknowledged that during acute coronary ischemic episodes there is a lack of balance between the production of reactive oxygen species and the development of antioxidant systems, resulting in oxidative stress. At the same time, a proinflammatory status is also known to be involved in acute coronary ischemic episodes as a risk factor that acts independently from the activation of coagulation or the endothelial dysfunction. It is thus reasonable to assume that CP might be a key player in the acute coronary ischemic syndrome.
The objectives of the present paper focused on the determination of plasma CP and its correlation with plasma oxidative stress and acute-phase reaction markers on patients with acute myocardial infarction. A group of patients with acute myocardial infarction (N = 28) and a control group were included in our study. All patients agreed to participate in the study and the protocol was in compliance with the Declaration of Helsinki. We assayed the plasma concentrations of malondialdehyde (MDA), CP, uric acid, as well as the concentrations of plasma α2-globulin and fibrinogen, at four intervals post infarction (1, 3, 7, 10 days p.i.). The results indicated a progressive increase of the MDA concentration in the acute myocardial infarction group reaching a maximum during the third day p.i. (from 3.1 mM/ml on day 1 p.i. to 4.75 ± 1.02 mM/ml on day 3 p.i., $p < 0.001$ compared to controls, Student's t test). The concentrations of CP and uric acid, taken here as indicative of the antioxidant reaction, also progressively increased (CP: from 57.78 mg% on day 3 p.i. to 60.61 ± 2.16 mg% on day 7 p.i., $p < 0.01$ compared to controls; uric acid: from 5.4 mg% on day 3 p.i. to 6.38 ± 0.92 mg% on day 7 p.i., $p < 0.01$ compared to controls), but this increase was observed with a 4 day delay relative to the peak of MDA, being synchronized with the increase of inflammatory markers, that is, α2-globulin (from 11% on day 3 p.i. to 12% on day 7 p.i., $p < 0.001$ compared to controls) and fibrinogen (from 490 mg% on day 3 p.i. to 520 ± 91 mg% on day 7 p.i., $p < 0.05$ compared to controls). We concluded that there was an increase of the oxidative stress in acute myocardial infarction. However, future studies should try to specifically determine in what way the increase of plasma CP in acute coronary syndromes relates to inflammatory and antioxidant processes in acute coronary syndromes.

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Reena TR et al. (2004). Indian Heart J 56, 72.

Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC217

Training, rate of force development and tendon stiffness

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Previous studies have shown that the rate of force development (RFD) has a significant relationship with sporting events requiring high power output (Wilson & Murphy, 1995; Young et al. 1995). Traditional methods used to develop RFD favour plyometric techniques. However, due to the nature of the loading (short duration, high impact forces) there is a risk of musculotendinous injury (Humphries et al. 1995). Other training regimens such as isometric loading may induce similar benefits to that of plyometric training in terms of RFD with a reduced risk of injury. No attempt to compare the efficacy of plyometric vs. isometric resistance training with respect to RFD has previously been made. The aim of this study was therefore to examine changes in rates of force development of the plantar flexors in response to training. In addition, as the rate at which force can be developed is influenced by the tendon stiffness (Kubo et al. 2001), changes in the gastrocnemius tendon stiffness were measured using B-mode ultrasonography as in Maganaris & Paul (2002). Two groups

(n=11) were trained for 6 weeks (3 times per week plyometric vs. isometric). The investigation was approved by the Salford University Institutional Ethics Committee and all subjects gave their written informed consent to participate in the study which conformed with the principles of the World Medical Associations Declaration of Helsinki. Student's t tests were used to analyse data, alpha values were set to p=0.05.

Significant increases in the gastrocnemius tendon stiffness were seen, with increments of 51.2 % (p=0.03) and 65.8 % (p=0.04) for the plyometric and isometric groups, respectively (Fig. 1). Concentric rate of force development (initial 150 ms from onset of force) showed trends for improvements after training of 24.4 % (p=0.06) and 60.7 % (p=0.21) in both the plyometric and isometric groups, respectively (Fig. 2). No significant differences were found between the groups for changes in either tendon stiffness or rate of force development.

The results suggest that isometric training can be effectively utilised to bring about similar changes in rates of force development and tendon stiffness to that of plyometric training without the additional risks of injury normally associated with the plyometric methods.

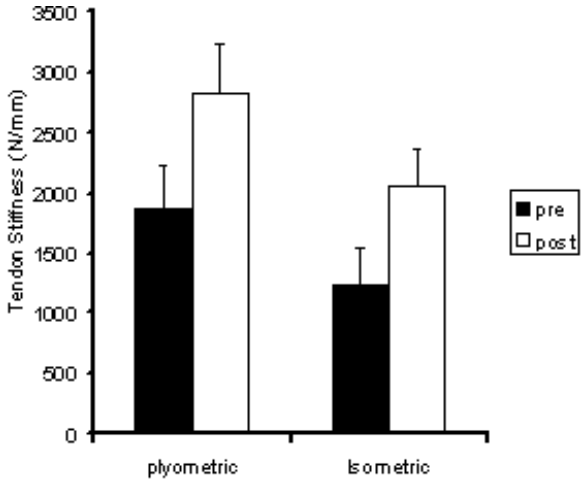

Figure 1. Gastrocnemius tendon stiffness before and after 6 weeks of training. *Significantly different (p = 0.03 and 0.04) stiffness compared with pre-training values for the plyometric and isometric groups respectively. Data are mean ± S.E.M.

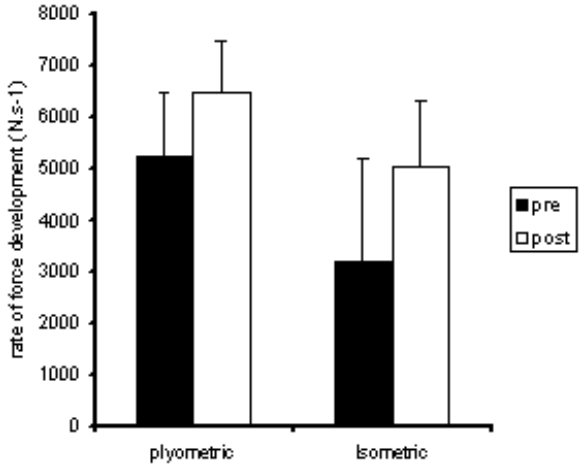

Figure 2. Influence of training regimen on rate of concentric force development. Data are mean ± SEM.

Humphries BJ, Newton RU & Wilson GJ. (1995). Int J Sports Med 16, 129-33.

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Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC219

Indices of variation in leg movements during free-style walking

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Accelerometers allow sensitive and inexpensive measurement of dynamic postural movements under natural conditions of walking (Moe-Nilssen 1998b; Kavanagh 2004). However, the best approach to analysis of these data is not clear. This preliminary study investigated variability in unconstrained walking in young and older people using a protocol approved by King's College Research Ethics Committee.

Ten subjects, five healthy older adults (aged 71±4years, BMI 24.2±1.8, ±SD) and five younger adults (aged 27±6years, BMI 24.6±1.8), were compared. Vertical and mediolateral accelerations at the ankle during an 18 metre walk were recorded using ADXL250 accelerometers and DataqCF2 pocket PC data collection at 300Hz. Stride analysis using feature filtering allowed the total variance of the acceleration to be separated into variance of the mean stride and the residual variance, i.e. the deviations of each stride from the mean stride. A comparison was also made of the effect of transforming the timescale of each stride to a fixed number (200) of points: this reduced the residual SD of mediolateral accelerations by 22% and vertical accelerations (which have sharper transients) by 38%.

Vertical acceleration SD of the ankle (Table 1) was somewhat lower in the elderly (by 12%) but the residual SD was much less (35%). Side swing, i.e. the mediolateral SD of acceleration, was also lower in elderly (by 24%) but its residual was not significantly further reduced. This shows, as expected, that vertical power in the elderly is reduced during walking but also that the strides become more stereotypical. In contrast the stride-by-stride variations in lateral movements (the residuals) remain high in the elderly.

The high variability of lateral movements probably reflects the neural guidance of the legs during walking and may thus provide a useful index of control of balance. Further refinement of the index needs to relate this to the phase of the stride and its temporal relation to changes in body roll.

Table 1. Vertical and mediolateral acceleration in young and elderly subjects

	Vertical SD	Vert. Residual	Lateral SD	Lat. Residual
	$m.s^{-2}$	% variance	$m.s^{-2}$	% variance
Young, n = 5	8.42 Â± 0.54	22.7 Â± 5.1	5.95 Â± 1.05	37.1 Â± 3.5
Elderly, n = 5	7.41 Â± 0.81 *	14.1 Â± 3.9 *	4.49 Â± 0.58 *	33.3 Â± 7.2

Values expressed as root variance (SD) of data and as percentage of this variance remaining after subtraction of the mean stride from each of 12 consecutive strides. Mean ± S.D., *P<0.05 for 2-tail t test between groups

Kavanagh JJ, Barrett RS & Morrison S (2004). Gait and Posture 20 291-298.

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This work was supported by the Guy's, King's and St Thomas' Charitable Foundation.

Where applicable, the experiments described here conform with Physiological Society ethical requirements.

PC220

Effect of different bottled waters on human skeletal muscle performance

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We investigated whether Penta® water (ultra-purified, restructured, metastable bottled water, PW) enhanced muscle performance relative to other bottled water (BW) during a performance test (PT) completed after prolonged steady state (SS) exercise. The study received approval from London South Bank ethical committee, and was performed according to the Declaration of Helsinki.

Ten male recreational/well-trained cyclists (age: 34 ± 3 years, VO_2max: 4.05 ± 0.13 l min^{-1}, weight: 84.9 ± 4.6 kg, height: 1.81 ± 0.03 m) participated in 2 double blind trials separated by 2 weeks and allocated by systematic rotation (PW vs BW). Subjects were overnight fasted and had consumed the same diet and performed same training for 48h prior to each trial. Subjects completed 30 min cycling at 70 % VO_2max, followed by 3 x 50 s raised efforts (double 70% VO_2max work load) interspersed with 2 min rest; then 45 min cycling at 70% VO_2max (SS) prior to PT. During PT, subjects completed an individualised set volume of work, equal to 4 min at 95% Workmax. A 6ml kg^{-1} bolus was consumed immediately pre-exercise and then 2 ml kg^{-1} (PW or BW) every 15 min. Expired air (MSX, Ferraris UK) was analysed breath-by-breath and blood samples taken at regular intervals pre-, during and post-exercise. Biomechanical data were collected from Lode ergometer and vastus lateralis activity was assessed using surface electromyography (EMG, B&L Engineering, USA; CED, UK) throughout the protocol. 1 min averages for EMG and biomechanical data were calculated at beginning, middle and end of each SS period and for each 20% work completed during PT. Data were normalised against corresponding values during the first minute of SS and presented as mean ± S.E.M. Blood samples were analysed for plasma volume change (Dill et al. 1974), and plasma osmolality (osmometer, Roebling, UK) was measured.

There were no differences between trials (2 way ANOVA) in any of the measured variables during SS exercise (66 ± 2% VO_2max). However, subjects completed PT significantly faster for PW (258 ± 13 s) than BW trials (275 ± 7 s, P = 0.04, Student's paired t test). Neither plasma volume change nor osmolality were different between conditions although there were significant changes over time, indicative of dehydration (both $P < 0.05$).

The amplitude of the surface EMG (as an index of the muscle activation level) and the EMG power density spectrum (as an estimate of the action potential conduction velocity) are used to describe the recruitment and the pattern of motor units activity during a contraction (for a recent review see Farina et al. 2004). Therefore, for Penta® water trials, the EMG data indicate an ability to recruit a larger muscle mass and to sustain higher conduction velocities during the performance test, than for BW trials. This resulted in a higher power output and faster completion of the task during PW trials. The mechanism could be attributed to both neural control as well as peripheral factors, but it is not possible to differentiate between these two putative mechanisms with the current data.

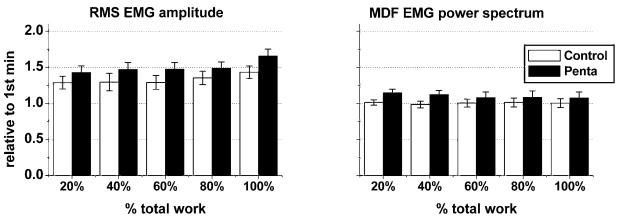

Figure 1. Normalised RMS EMG amplitude (P = 0.03) was higher and median frequency (MDF) of EMG power spectrum (P = 0.06) tended to be higher throughout the performance cycling test in Penta water (PW, filled bars) than in other bottled water (BW, open bars) trials (2 way ANOVA, n = 7; data from 3 subjects were excluded from the analysis due to technical reasons). Data are averaged over each 20% work completed during the performance test.

Dill DB & Costill DL (1974). J Appl Physiol 37, 247-248.

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This study was supported by Team Penta® UK.

Where applicable, the experiments described here conform with Physiological Society ethical requirements.