Some Physiological Changes in Female Athletes During and After Exercise: Investigating the Use of a New, Low-invasive Sampling Method (Electrosonophoresis)

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ABSTRACT

The purpose of this study was to monitor cardiovascular and endocrine changes in sedentary and training females during a six week period, and to assess the accuracy of a new, low-invasive sampling methodology (electrosonophoresis). Changes in fitness were measured using oxygen consumption (VO_2). The impact on VO_2 of sleep quality, sleep duration and alcohol consumption (recorded in sleep logs) was assessed. Cortisol, testosterone and growth hormone levels in plasma were monitored for acute changes following fitness tests, and chronic changes related to training, oral contraceptive use or alcohol consumption. Hormone concentrations in blood and saliva samples were compared to those in interstitial fluid (obtained using electrosonophoresis) to investigate the accuracy of electrosonophoresis.

Mean VO_2 increased by 3.3 ± 1.3mL/kg/min between Week 1 and Week 5 and the changes detected in heart rate (HR) during the fitness tests suggest that aerobic fitness of the training participants increased across the study. No significant associations between sleep quality, sleep duration or alcohol consumption and VO_2 were detected. No acute changes in plasma hormone concentrations following fitness tests were detected. No chronic changes in plasma cortisol or testosterone concentrations were detected, although a non-significant trend towards increased plasma GH levels in training participants was detected. Resting plasma cortisol levels were significantly lower in oral contraceptive users compared with non-users. Plasma testosterone and growth hormone levels were unaffected by oral contraceptive use. Alcohol consumption had no acute detectable effects on plasma concentrations of the three hormones. Plasma testosterone levels were higher in participants who abstained from alcohol, and higher plasma growth hormone levels were detected in heavy drinkers. These results contrast with published reports. Concentrations of the three hormones in interstitial fluid and plasma exhibited highly significant positive correlations ($r^2 > 0.98$) with an interstitial fluid:plasma concentration ratio of about 1:10 in each case. Equations to predict plasma concentrations of cortisol, testosterone and growth hormone from interstitial fluid concentrations have been derived. The electrosonophoretic method apparently provides an accurate, painless, low-invasive method for prediction of the plasma levels of these three hormones. This technology has far-reaching implications for research in human, animal and biomedical fields.

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Greek Letters

α	Slope
α_0	Slope for cortisol
α_1	Slope for testosterone
α_2	Slope for growth hormone
α-MSH	Alpha-melanocyte-stimulating hormone
β	y-axis intercept
β_0	y-axis intercept for cortisol
β_1	y-axis intercept for testosterone
β_2	y-axis intercept for growth hormone
μL	Microlitre

English Letters

a.m.	*Ante meridiem*
ACTH	Adrenocorticotropic hormone
ADH^1	Anti-diuretic hormone
ADH^2	Alcohol dehydrogenase
ALDH	Aldehyde dehydrogenase
ANOVA	Analysis of variance
AT	Anaerobic threshold
AVP	Arginine vasopressin
bpm	Beats per minute
BIA	Bioelectric impedance analysis
BMI	Body mass index
BMR	Basal metabolic rate
CO	Cardiac output
CO_2	Carbon dioxide
CRH	Corticotrophin-releasing hormone
CVD	Cardiovascular disease
DHEA	Dehydroepiandrosterone
e.g.	For example
et al.	*et alii*
etc.	*et cetera*
EEG	Electroencephalogram
ELISA	Enzyme-linked immunosorbent assay
EOG	Electrooculogram
ESOP	Electrosonophoresis
FSH	Follicle-stimulating hormone
GABA	Gamma-aminobutyric acid
GH	Growth hormone
GHRH	Growth hormone-releasing hormone
GnRH	Gonadotropin-releasing hormone
GO_x	Glucose oxidase
hr	Hour
HDL	High-density lipoproteins
HPA	Hypothalamic-pituitary-adrenal
HPG	Hypothalamic-pituitary-gonadal
HPLC	High performance liquid chromatography

HR	Heart rate
HR_{max}	Maximum heart rate
i.e	*Id est*
IF	Interstitial fluid
IGF	Insulin-like growth factors (–I or –II)
IGFBP	Insulin-like growth factor binding protein
kD	KiloDalton
kg	Kilogram
km	Kilometre
L	Litre
LDL	Low-density lipoproteins
LH	Luteinizing hormone
max	Maximum
min	Minute
mL	Millilitre
n	Number
n_p	Number of participants
n_s	Number of samples
ng	Nanogram
nmol	Nanomolar
NAD^+	Nicotinamide adenine dinucleotide (oxidized form)
NADH	Nicotinamide adenine dinucleotide (reduced form)
NB	*Nota bene*
NIDDM	Non-insulin-dependant diabetes mellitus
NOC	Not on oral contraceptives
O_2	Oxygen
OC	Oral contraceptives
p	Probability statistic
pg	Picogram
pp	Pages
p.m.	*Post meridiem*
P	Plasma
PGO	Ponto-geniculo-occipital
PCO_2	Partial pressure of carbon dioxide
PO_2	Partial pressure of oxygen
r	Correlation coefficient
r^2	Coefficient of determination
RAS	Reticular activating system
REM	Rapid eye movement
RER	Respiratory exchange ratio
RIA	Radioimmunoassay
RNA	Ribose-nucleic acid
RPE	Ratings of perceived exertion
sd	Standard deviation
S	Saliva
S1	Stage 1
S2	Stage 2
S3	Stage 3
S4	Stage 4
SC	Stratum corneum

SEM	Standard error of the mean
SD	Sleep duration
SCN	Suprachiasmatic nucleus
SG	Sedentary group
SQR	Sleep quality rating
T	Testosterone
TG	Training group
TRH	Thyrotropin-releasing hormone
VO_2	Oxygen consumption
VO_{2max}	Maximal oxygen consumption
V_E	Mean expiratory flow
VCO_2	Carbon dioxide production
X	Concentration of hormone in interstitial fluid
Z_1	Indicator variable for testosterone
Z_2	Indicator variable for growth hormone

Symbols

/	Per
°C	Degrees Celsius
%	Percent
±	Plus or minus sign