e-ISSN 1734-2260 from 2005

OFFICIAL JOURNAL OF POLISH SOCIETY OF SPORTS MEDICINE

ISSN 1429-0022 from 1997 till 2004
Indexed in: SportDiscus; EMBASE/Excerpta Medica; Index Copernicus

Medicina Sportiva 2008 vol. 12 Issue 2

The relationship between circulating leptin and plasma female sex hormone levels in physically active regularly menstruating premenopausal women with ovulatory and anovulatory menstrual cycles
Anna Kęska, Elżbieta Skierska, Grażyna Lutosławska, Joanna Tkaczyk pp: 25-30
Read article »

Monitoring of the autonomic nervous system activity during post-marathon recovery By spectral analysis of heart rate variability: A case study
Michal Botek, Pavel Stejskal, Filip Neuls pp: 31-35
Read article »

The influence of reliability in measuring skinfolds on the reliability of result Of endomorphic and mesomorphic components of somatotype
Petr Kutáč, Vojtěch Gajda pp: 36-40
Read article »

Changes in relative and absolute force measured during powerlifting after a 4-week training using the weightlifting method and stick isometric (mixed) method
Marek Kruszewski, Artur Kruszewski, Bartłomiej Kruszewski pp: 41-45
Read article »

Abnormal p wave morphology in the electrocardiogram of a hurdle runner with A history of presyncope – a case report
Małgorzata Poręba, Robert Skalik, Rafał Poręba, Paweł Gać, Witold Pilecki, Ludmiła Borodulin-Nadzieja, Małgorzata Sobieszczańska, Ryszard Andrzejak pp: 46-48
Read article »

On the problem of detecting low burden atrial fibrillation in healthy athletes Comments on: „Abnormal p wave morphology in electrocardiogram in a hurdle runner with a history of presyncope -a case report"
Don R. Swanson pp: 49-50
Read article »

Medicina Sportiva
Med Sport 12 (2): 25-30, 2008
DOI: 10.2478/v10036-008-0005-y

THE RELATIONSHIP BETWEEN CIRCULATING LEPTIN AND PLASMA FEMALE SEX HORMONE LEVELS IN PHYSICALLY ACTIVE REGULARLY MENSTRUATING PREMENOPAUSAL WOMEN WITH OVULATORY AND ANOVULATORY MENSTRUAL CYCLES

Anna Kęska[1(A,B,C,D,E,F)], Elżbieta Skierska[1(A,B,C,D,E,F)], Grażyna Lutosławska[2(C,D,E,F)], Joanna Tkaczyk[1(B,C)]

[1]Department of Biology, University of Physical Education, Warsaw, Poland
[2]Department of Biochemistry, University of Physical Education, Warsaw, Poland

Abstract

Introduction: Leptin is an important metabolic signal affecting the brain energy balance. However, it is also suggested that leptin is involved in the regulation of hypothalamic-pituitary-gonadal axis, thus possibly play an important role in reproduction.

Aim of the study: The purpose of the present study was to examine the relationship between circulating leptin and plasma sex hormone levels in regularly menstruating premenopausal females with ovulatory and anovulatory menstrual cycles.

Methods: From 60 prospective females who monitored their basal body temperature (BBT) through 6 months 47 females provided complete BBT records and took part in the study. All the women were regularly menstruating, healthy non-smokers, not taking any medication on regular basis. In last observed menstrual cycle plasma estradiol (E_2), progesterone (P), follicle-stimulating hormone (FSH), luteinising hormone (LH) and testosterone (T) as well as leptin concentrations were determined twice per cycle – between the 5th and 8th day of the cycle and again between the 19th and 22nd day of the cycle.

Results: Women with ovulatory and anovulatory menstrual cycles didn't differ with respect to age, anthropometric characteristics and cycle length. However, in non-ovulating women plasma leptin levels between days 19-22 of the cycle was significantly higher and between days 5-8 tended to be higher than in ovulating ones. In addition, exclusively in ovulating women plasma leptin to body fat (kg) ratio was significantly and positively ($r=0.348$, $P<0.05$) correlated with circulating estradiol levels.

Conclusions: Our results indicate that anovulatory menstrual cycles in premenopausal females are characterized by elevated plasma leptin levels and the lack of the relationship between circulating leptin and estradiol and support the suggestion concerning a close relationship between leptin and reproductive function.

***Key words**: young females, gonadal hormones, menstrual status, leptin*

Introduction

The normal rhythm of the menstrual cycle requires the precise stimulation of ovarian hormone secretion by the pulsatile release of the pituitary gonadotrophic hormones – follicle-stimulating hormone (FSH) and luteinising hormone (LH) (1). In turn gonadotrophins secretion is stimulated by the pulsatile release of gonadotrophin-releasing hormone (GnRH) from GnRH neurons in the arcuate nucleus of the hypothalamus (2).

Numerous studies have indicated that many metabolic substrates and hormones play a key role as a metabolic signal to the functionality of the reproductive axis (3). Recent studies have indicated a special role of leptin in the regulation of the reproductive system in both animals and humans (4-6).

Leptin is a peptide secreted with circadian rhythm mainly by subcutaneous adipose tissue, but also by placenta, stomach and skeletal muscle (7-10). Leptin secretion is regulated by many factors including insulin, sex hormones and glucocorticoids (11-13).

Leptin receptors have been localized at all levels of the hypothalamic–pituitary-gonadal axis, including the GnRH neurons, the ovary, and other neuronal cells that impinge on GnRH neurons (14). So leptin has been investigated as a mediator between the adipose tissue and the reproductive system. Various sets of data indicate that leptin may serve as a signal to the central nervous system with information on the critical amount of body fat stores necessary for GnRH secretion (15,16). Leptin also acts at the periphery, directly on the ovary where it controls steroidogenesis (17).

It has been suggested that leptin has a dual effect on reproduction and that the major site of action differs depending on its level in the blood.

In obese subjects leptin central receptors, which are sensitive to extremely low plasma leptin levels, are protected from hyperleptinemia by the saturable transport system of the blood-brain barrier, whereas peripheral leptin receptors are directly exposed to high leptin concentrations, with possible negative effects on gonadal steroidogenesis.

Conversely, in subjects with very low body fat it has been observed that low plasma and cerebrospinal fluid leptin concentrations are associated with low and apulsatile gonadotrophins secretion (18,19). A wealth of studies have indicated that under conditions of inadequate body fat reserves, low leptin provides a signal to the brain concerning insufficient energy stores necessary to maintain normal reproductive function (20-23).

Undoubtedly, leptin is a permissive factor for the menstrual cycle, with a regulatory role exerted at hypothalamic, pituitary and gonadal levels, but the mechanisms subserving leptin's effects on the reproductive axis still remain elusive. Additionally, the most studies which focused on the association between circulating leptin and menstrual disturbances were performed in women either with very low or very high body fat (24).

Therefore, this study was undertaken to evaluate circulating plasma leptin in normal weight females with ovulatory and anovulatory menstrual cycles. This purpose was accomplished by the comparison of plasma leptin levels in the middle of follicular and luteal phases of the menstrual cycle and by searching for the relationship between circulating leptin and gonadal hormones.

Materials and Methods

Subjects

A total of 60 non-obese women (BMI 19-23 kg/m^2) aged 19-21 years volunteered to participate in the study. All the subjects were university students recruited on the basis of advertisement in students' dormitories and oral information provided before lectures. All participants were physically active and their weekly physical activity was approximately 9 h. All the participants reported regular menstrual cycles for at least 12 months preceding the study. All the subjects were healthy with no medical problems and were taking no medications or used hormonal contraception. Written consent was obtained from all the subjects prior to the study. The study protocol was approved by the Ethics Commission at the University of Physical Education.

Study protocol

The study was started by the interview, which allowed to collect data about health condition, using hormonal contraception and the regularity of the menstrual cycles. The prospective subjects (n=60) monitored their basal body temperature (BBT) through six menstrual cycles (25). Thirteen women who provided incomplete records were excluded from the next steps of the study. In 47 subjects who provided complete BBT records, in last observed menstrual cycle anthropometric measures were made and blood samples were taken twice per cycle, between days 5 and 8 and between days 19 and 22 of the cycle. In 26 women with biphasic BBT pattern plasma progesterone levels exceeded 19.0 nmol·l^{-1} between days 19 and 22 of the cycle. These women were classified as ovulating (26). In 21 women monophasic BBT and plasma progesterone levels lower than 19.0 nmol·l^{-1} was found between days 19 and 22 of the menstrual cycle. These subjects were classified as non-ovulating.

Anthropometric measurements

Body height and weight were measured and body mass index (BMI) was calculated. Body fat was estimated from the sum of three skinfolds thickness (abdominal, subscapular, triceps) according to the nomogram established for female subjects (27). Skinfolds measures were made in duplicate using Harpenden caliper and mean values were taken for calculation of body fat.

Blood samples

Fasting blood samples were drawn from the antecubital vein into lithium heparin tubes using disposable syringes and needles under aseptic conditions. Blood was taken between 8:00 and 9:00 a.m. Plasma was separated by centrifugation (10min/3000 rpm, 4^{0}C) and stored at -70^{0}C until analysis.

Hormone assays

Plasma levels of FSH, LH, estradiol (E_2), progesterone (P) and testosterone (T) were determined by standard radioimmunoassay methods and commercial kits purchased from OBRI-POLATOM (Poland). Intra- and inter-assay coefficients of variations (CV) for FSH were 4.0% and 6.0%, for LH – 4.0% and 7.0%, for E_2 – 3.8% and 7.9%, for P - 4.3% and 5.0%, for T – 5.3% and 5.4%, respectively. Leptin plasma concentrations were measured by radioimmunoassay method and Linco Research commercial kits (USA). Intra- and inter-assay coefficients of variations (CV) for leptin were 4.5% and 5.0%, respectively.

Statistical analysis

Data distribution was evaluated using the Shapiro-Wilk test. The comparison of normally distributed data was performed by use of Student t-test for paired and unpaired data. Mann-Whitney U test and Wilcoxon matched-pairs test were used for comparison of unpaired and paired data which were not normally distributed. Pearson product-moment correlation was also calculated. All analysis were made using Statistica 6.0 (Statsoft, USA). Data are presented as means ± SD. Significance level was set at $P<0.05$.

Results

Subjects characteristics are presented in Table 1. Anthropometric data of ovulating and non-ovulating

Table 1. *Subject characteristics (mean ± SD)*

	Ovulating women (n=26)	Non-ovulating women (n=21)
Age (years)	20.4 ± 1.2	20.2 ± 0.8
Age at menarche (years)	13.1 ± 1.2	13.1 ± 1.2
Body height (cm)	171.9 ± 6.9	170.0 ± 7.1
Body mass (kg)	62.8 ± 7.6	62.2 ± 8.2
Fat (kg)	15.1 ± 2.8	15.3 ± 3.6
Fat (%)	23.9 ± 1.8	24.4 ± 3.1
FFM (kg)*	47.7 ± 5.0	46.9 ± 5.0
Menstrual cycle length (days)	27.5 ± 2.5	30.2 ± 11.8

* FFM – fat free mass

Table 2. *Plasma hormones and leptin levels in ovulating and non-ovulating women (mean ± SD)*

	Ovulating women (n=26)		Non-ovulating women (n=21)	
	Days 5-8	Days 19 - 22	Days 5-8	Days 19 - 22
FSH ($IU \cdot l^{-1}$)	5.6 ± 1.1	2.8 ± 1.3*	5.1 ± 1.9	4.6 ± 2.6 $^{\#}$
LH ($IU \cdot l^{-1}$)	5.1 ± 1.6	5.2 ± 1.9	4.5 ± 2.7	9.5 ± 9.2 $^{\wedge\,\#}$
E_2 ($pmol \cdot l^{-1}$)	192.1 ± 100.6	509.8 ± 121.9*	98.4 ± 86.9 $^{\#}$	309.8 ± 232.7 $^{\wedge\,\#}$
P ($nmol \cdot l^{-1}$)	2.1 ± 0.7	41.7 ± 15.2*	2.1 ± 0.6	3.8 ± 3.2 $^{\wedge\,\#}$
T ($nmol \cdot l^{-1}$)	2.6 ± 0.8	2.6 ± 1.1	2.7 ± 1.0	2.4 ± 0.9
Leptin ($ng \cdot ml^{-1}$)	6.9 ± 2.9	7.9 ± 3.9*	9.6 ± 5.4	10.6 ± 5.3 $^{\#}$

*,^ -P<0.05-significantly higher vs. respective values between days 19-22; $^{\#}$ P<0.05- significantly different vs. ovulating women

women did not differ significantly. Moreover, no difference between groups was observed in the mean menstrual cycle length.

In ovulating subjects FSH levels markedly (by 50%) decreased in the middle of luteal phase in comparison with follicular phase of the cycle (Table 2). The mean plasma E_2, P, and leptin levels were significantly higher between days 19 and 22 than between days 5-8 of the cycle (by 165.4 %, 1885 % and 14.4% for E_2, P and leptin, respectively) Plasma LH and testosterone levels did not differ between follicular and luteal phase of the menstrual cycle.

In non-ovulating subjects there were no differences in plasma FSH, testosterone and leptin levels between days 5-8 and 19-22 of the cycle, whereas LH levels were significantly higher (by 111%) between days 19-22 than between the days 5-8 of the menstrual cycle. Plasma E_2 and P concentrations between days 19-22 were markedly higher than between days 5-8 (by 214.5% and 80.9% for E_2 and P, respectively).

However, in non-ovulating women plasma FSH, LH and leptin concentrations between days 19-22 were significantly higher than in their ovulating counterparts (by 64.3%, 82.7% and 34.2%, respectively). On the contrary, circulating E_2 and P between days 19-22 in non-ovulating women were markedly lower than in ovulating ones (by 39.2% and 997.4%, respectively).

Leptin to fat ratio [(ng/ml)/fat mass (kg)] calculated for collected data of follicular and luteal phases of the menstrual cycle in ovulating women (0.489 ± 0.203) was markedly lower than in non-ovulating counterparts (0.642 ± 0.298, P<0.005) Fig. 1).

Neither in ovulating nor in non-ovulating participants leptin to fat ratio was correlated with circulating FSH, LH, P and T. However, in ovulating subjects but

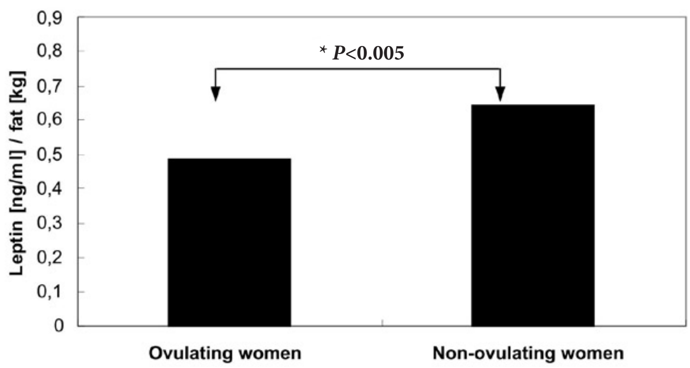


Fig.1. *Leptin to fat ratio for collected follicular and luteal phases of the menstrual cycle in ovulating and non-ovulating women*

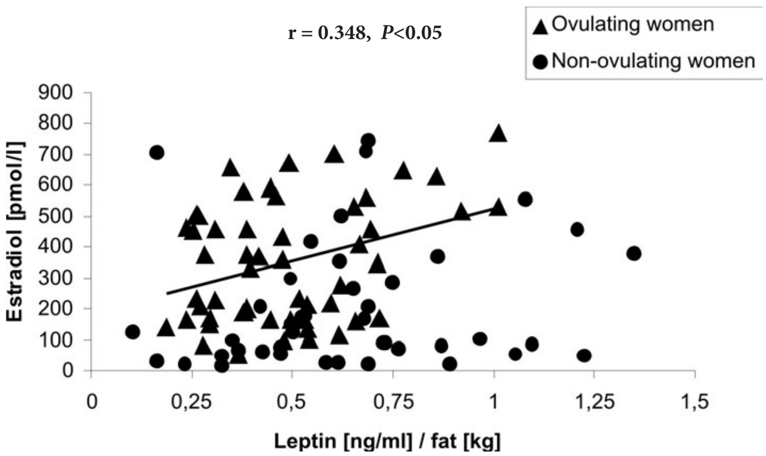


Fig.2. *The relationship between leptin to fat ratio and estradiol plasma levels in ovulating and non-ovulating women*

not in non-ovulating ones significant and positive association was noted between leptin to fat ratio and circulating estradiol (Fig. 2).

Discussion

Numerous data have suggested that many physically active young women experience a wide spectrum of menstrual irregularities such as luteal phase deficiency, anovulation, oligomenorrhoea and even amenorrhoea. Functional abnormalities of the reproductive axis have been associated with the age, age at menarche, extremes of body fat, abnormal dietary practices, psychological stress and pathologic conditions including androgen excess, hyperprolactinaemia or ovarian failure (28).

The results of the current study enable precisely define the reason for disturbed ovulation in some of regularly menstruating participants. However, at least androgen excess has to be excluded as a potential reason since in ovulating and non-ovulating women circulating testosterone did not differ and in both groups were within physiological range.

Similarly, BMI values and body fat content in women accepted for the participation possibly exclude low body fat stores as a possible reason of anovulation. However, it is worthy to note that in females fat stores are preserved due to depressed resting metabolic rate even in the face of energy deficit (29). Thus, normal BMI values and body fat of our subjects did not provide reliable information concerning energy balance. Taking into account that the participants of the present study were physically active it could not be excluded that at least part of them were characterized by energy deficiency which is known to depress reproductive system (30).

Current data concerning the differences in circulating FSH, LH, E_2 and P levels between ovulating and non-ovulating women are in agreement with other findings (31-33). Similarly, significantly higher plasma leptin levels in the luteal than in the follicular phase of the menstrual cycle in ovulating women of the present study has been noted in previous studies (34-36). In addition, it has been postulated that the ovulatory rise in plasma leptin is probably due to the elevation in circulating estradiol during the luteal phase of the menstrual cycle (37,38). This assumption has been indirectly supported by Hong et al. (39) who have indicated that circulating leptin - E_2 correlation exist exclusively in premenopausal but not in post-menopausal women.

Our data even further support the above findings indicating that in non-ovulating participants characterized by low plasma E_2 levels no changes in plasma leptin concentration due to menstrual cycle phase has been observed. Additionally, we have noted that in non-ovulating subjects, in contrast to ovulating ones, leptin production by adipose tissue expressed as leptin levels/body fat ratio is not correlated with circulating estradiol.

On the other hand, our study has revealed that in non-ovulating women plasma leptin levels between days 19-22 of the menstrual cycle was markedly higher and between days 5-8 tended to be higher than in ovulating ones despite lower estrogen levels and similar body fat in both groups. In consequence, leptin production in adipose tissue of non-ovulating subjects briefly assessed as leptin concentration expressed per kilogram of body fat in non-ovulating women is higher than in ovulating ones. The reason of this finding is unknown and could be only speculated.

It has been documented that ovarian hormones contribute to the regulation of insulin sensitivity and their disturbed secretion brings about depressed insulin sensitivity or even insulin resistance resulting in higher plasma insulin levels (40,41). In addition, significant and positive correlation between plasma leptin and insulin concentrations has been demonstrated (42-44). Taking all the above together it seems feasible that non-ovulating participants of the present study were characterized by diminished insulin sensitivity, increased its plasma level and subsequent elevated leptin secretion.

However, data concerning insulin sensitivity in non-ovulating women are not available but it is worthy to note that Lutosławska et al. (45) have found slightly altered circulating islet hormone levels and impaired their action on plasma glucose in non-ovulating women vs. ovulating ones. Therefore, the contribution of impaired insulin secretion and/or sensitivity due to anovulatory menstrual cycles could not be excluded as a possible reason of elevated plasma leptin levels found in non-ovulating subjects of the present study.

Moreover, another reasons for elevated plasma leptin in non-ovulating women have to be taken into consideration as for example elevated circulating cortisol and/or prolactin (46-48). The study concerning this issue is in progress.

Summing up, our study revealed that in premenopausal regularly menstruating females subtle disturbances in circulating sex hormones and subsequent anovulation possibly contribute to similar circulating leptin in both cycle phases as well as to elevated leptin production by adipose tissue and to the lack of correlation between leptin production and circulating estradiol.

This study was supported by grant DS-42 from the University of Physical Education in Warsaw

References

1. Dueck ChA, Matt KS, Manroe MM. et al. Treatment of athletic amenorrhoea with a diet and training intervention program. *Int J Sport Nutr* 1996; 6: 24-40.
2. Loucks AB, Thuma JR. Luteinizing hormone pulsatility is disrupted at a threshold of energy availability in regularly menstruating women. *J Clin Endocrinol Metab* 2003; 88: 297-311.
3. Wade GN, Jones JE. Neuroendocrinology of nutritional infertility. *Am J Physiol Regul Integr Comp Physiol* 2004; 287: 1277-96. DOI: 10.1152/ajpregu.00475.2004
4. Baldelli R, Dieguez C, Casanueva FF. The role of leptin in reproduction: experimental and clinical aspects. *Ann Med* 2002; 34: 5-18.
5. Caprio M, Fabbrini E, Isidori AM, Aversa A, Fabbri A. Leptin in reproduction. *Trends in Endocrinol Metab* 2001; 12: 65-72. DOI: 10.1016/S1043-2760(00)00352-0
6. Welt CK, Chan JL, Bullen J. et al. Recombinant human leptin in women with hypothalamic amenorrhoea. *N Engl J Med* 2004; 351: 987-97.
7. Bado A, Lavasseur S, Attoub S. et al. The stomach is a source of leptin. *Nature* 1998; 394: 790-2. DOI: 10.1038/29547
8. Senaris R, Garcia-Caballero T, Casabiel X. et al. Synthesis of leptin in human placenta. *Endocrinol* 1997; 138: 4501-4.
9. Wang J, Lin R, Hawkins M. et al. A nutrient-sensing pathway regulates leptin gene expression in muscle and fat. *Nature* 1998; 393: 684-8.
10. Zhang Y, Proenca R, Maffei M. et al. Positional cloning of the mouse obese gene and its human analog. *Nature* 1994; 372: 425-32. DOI: 10.1038/372425a0
11. Trayhurn P, Hoggard N, Mercer JG. et al. Leptin: fundamental aspects. *Int J Obes* 1999; 23: 22-8.
12. Van Gaal LF, Wauters MA, Mertens IL. et al. Clinical endocrinology of human leptin. *Int J Obes* 1999; 23: 29-36.
13. Wauters M, Considine RV, Van Gaal LF. Human leptin: from an adipocyte hormone to an endocrine mediator. *Eur J Endocrinol* 2000; 143: 293-311.
14. Karlsson C, Lindell K, Svensson E. et al. Expression of functional leptin receptors in the human ovary. *J Clin Endocrinol Metab* 1997; 82: 4144-8.
15. Takeuchi T, Tsutsumi O. Basal leptin concentration in women with normal and dysfunctional ovarian conditions. *Int J Gynaecol Obstet* 2000; 69: 127-133. DOI: 10.1016/S0020-7292(00)00178-8
16. Thong FSL, McLean C, Graham TE. Plasma leptin in female athletes: relationship with body fat, reproductive, nutritional, and endocrine factors. *J Appl Physiol* 2000; 88: 2037-44.
17. Moschos S, Chan JL, Mantzoros CS. Leptin and reproduction: a review. *Fertil Steril* 2002; 77: 433-444. DOI: 10.1016/S0015-0282(01)03010-2
18. Mantzoros C, Flier IS, Lessem MD. et al. Cerebrospinal fluid leptin in anorexia nervosa: correlation with nutritional status and potential role in resistance to weight gain. *J Clin Endocrinol Metab* 1997; 2: 1845-51.
19. Mitchell M, Armstrong DT, Robker RL. et al. Adipokines: implications for female fertility and obesity. *Reproduction* 2005; 130: 583-97. DOI: 10.1530/rep.1.00521
20. Chan JL, Mantzoros CS. Role of leptin in energy-deprivation states: normal human physiology and clinical implications for hypothalamic amenorrhoea and anorexia nervosa. *Lancet* 2005; 366: 74-85. DOI: 10.1016/S0140-6736(05)66830-4
21. Cunningham MJ, Clifton DK, Steiner RA. Leptin's actions on the reproductive axis: perspectives and mechanisms. *Biol Reprod* 1999; 60: 216-22.
22. Kopp W, Blum WF, von Prittwitz S. et al. Low leptin levels predict amenorrhoea in underweight and eating disordered females. *Mol Psychol* 1997; 2: 335-40.
23. Manore MM. Dietary recommendations and athletic menstrual dysfunction. *Sports Med* 2002; 32: 887-901.
24. Di Carlo C, Tommaselli GA, De Filippo E. et al. Menstrual status and serum leptin levels in anorectic and in menstruating women with low body mass indexes. *Fertil Steril* 2002; 78: 376-82. DOI: 10.1016/S0015-0282(02)03221-1
25. McConnell HJ, O'Connor KA, Brindle E. et al. Assessing reproductive function in exercising women: validity of ovulation detections algorithms. *Med Sci Sports Exerc* 2002; 34: 1836-44.
26. Broocks A, Pirke KM, Schweiger U. et al. Cyclic ovarian function in recreational athletes. *J Appl Physiol* 1990; 68: 2083-6.
27. Piechaczek H. The assessement of total body fat by means of anthropometric and densitometric methods. *Mat Prace Antrop* (in Polish) 1975; 89: 3-48.
28. Cumming DC, Cumming CE. Estrogen replacement therapy and female athletes. *Sports Med* 2001; 31: 1025-31.
29. De Souza MJ, Lee DK, VanHeest JL. et al. Severity of energy-related menstrual disturbances increases in proportion to indices of energy conservation in exercising women. *Fertil Steril* 2007; 88: 971-5. DOI:10.16/j.fertnstert.2006.11.171
30. Waldrop J. Early identification and interventions for female athlete triad. *J Pediatric Health Care* 2005; 19: 213-20. DOI: 10.1016/j.pedhc.2005.02.008
31. De Cree C. Sex steroid metabolism and menstrual irregularities in the exercising female: a review. *Sports Med* 1998; 25: 369-406.
32. De Souza MJ. Menstrual disturbances in athletes: a focus on luteal phase defects. *Med Sci Sports Exerc* 2003; 35: 1553-63. DOI: 10.1249/01.MSS.0000084530.31478.DF
33. Williams NI, McArthur J, Turnbull BA. et al. Effects of follicular phase exercise on luteinizing hormone pulse characteristics in sedentary eumenorrhoeic women. *Clin Endocrinol* 1994; 41: 787-94.
34. Łukaszuk K, Liss J, Kusiak E. et al. Serum leptin concentration increase during luteal phase in healthy premenopausal women. *Horm Metab Res* 1998; 30:172-4.
35. Riad-Gabriel MG, Jinagouda D, Sharma A. et al. Changes in plasma leptin during the menstrual cycle. *Eur J Endocrinol* 1998; 139: 528-31.
36. Ludwig M, Klein HH, Diedrich K. et al. Serum leptin concentrations throughout the menstrual cycle. *Arch Gynecol Obstet* 2000; 263: 99-101.

37. Paolisso G, Rizzo MR, Mone CM. et al. Plasma sex hormones are significantly associated with plasma leptin concentration in healthy subjects. *Clin Endocrinol* 1998; 48: 291-7. DOI: 10.1046/j.1365-2265.1998.00383.x
38. Messinis IE, Papageorgiou I, Milingos S. et al. Oestradiol plus progesterone treatment increases serum leptin concentrations in normal women. *Human Reprod* 2001; 16: 1827-32.
39. Hong SC, Yoo SW, Cho GJ. et al. Correlation between estrogens and serum adipocytokines in premenopausal and postmenopausal women. *Menopause* 2007; 14: 835-40.
40. Marsden PJ, Murdoch AP, Taylor R. Adipocyte insulin action following ovulation in polycystic ovarian syndrome. *Human Reprod* 1999; 9: 2216-22.
41. Gambineri A, Pelusi C, Manicardi E. et al. Glucose intolerance in a large cohort of Mediterranean women with Polycystic Ovary Syndrome. *Diabetes* 2004; 53: 2353-8.
42. Gonzalez-Ortiz M, Martinez-Abundis E, Balcazar-Munoz BR. Serum leptin concentrations in young insulin-sensitive and insulin-resistant volunteers. *Horm Metab Res* 2000; 32:273-6.
43. Steinberger J, Steffen L, Jacobs DR et al. Relation of leptin to insulin resistance syndrome in children. *Obesity Res* 2003; 9: 1124-30.
44. Hung YJ, Chu NF, Wang SC. et al. Correlation of plasma leptin and adiponectin with insulin sensitivity and beta-cell function in children – the Taipei Children Heart Study. *Int J Clin Pract* 2006; 12: 1582-7. DOI: 10.1111/j.1742-1241.2006.00909.x
45. Lutosławska G, Skierska E, Kęska A. et al. Plasma insulin and glucagon concentrations and biochemical variables in regularly menstruating females with ovulatory and anovulatory menstrual cycles. *Horm and Metab Res* 2003; 35: 444-50. DOI: 10.1055/s-2003-41627
46. Ling C, Billig H. PRL receptor –mediated effects in female mouse adipocytes: PRL induces supressors of cytokine signaling expression and suppresses insulin-induced leptin production in adipocytes in vitro. *Endocrinol* 2001; 142: 4880-90.
47. Viengchareun S, Bouzinba-Segard H, Laigneau JP. et al. Prolactin potentiates insulin-stimulated leptin expression and release from differentiated brown adipocytes. *J Mol Endocrinol* 2004; 33: 679-91. DOI: 10.1677/jme.1.01563
48. Weise M, Abad V, Considine R et al. Leptin secretion in Cushing's Syndrome: preservation of diurnal rhythm and absent response to corticotrophin-releasing hormone. *J Clin Endocrinol Metab* 1999; 6: 2075-79.

Received: November 27, 2007
Accepted: March 31, 2008

Address for correspondence:
Anna Kęska, PhD
Department of Biology
University of Physical Education
00-968 Warsaw 45, box 55
e-mail: Anna.Keska@awf.edu.pl

Medicina Sportiva
Med Sport 12 (2): 31-35, 2008
DOI: 10.2478/v10036-008-0006-x

MONITORING OF THE AUTONOMIC NERVOUS SYSTEM ACTIVITY DURING POST-MARATHON RECOVERY BY SPECTRAL ANALYSIS OF HEART RATE VARIABILITY: A CASE STUDY

Michal Botek[1(A, C, D, E, F)], Pavel Stejskal[2(C, D, E, G)], Filip Neuls[1(A, B, D)]

[1]Centrum for Kinantropological Research, Faculty of Physical Culture, Palacký University, Olomouc, Czech Republic
[2]Department of Functional Anthropology and Physiology, Faculty of Physical Culture, Palacký University, Olomouc, Czech Republic

Abstract

Introduction: Vigorous physical exertion, such as a marathon, evokes long lasting changes in the autonomic cardiac regulation and peripheral fatigue.

Aim of the study: We investigated changes in the autonomic nervous system (ANS) activity simultaneously with the subjective feeling of fatigue from the 67 hours following a race (42.195 km) in 31-year-old male amateur athlete.

Methods: The ANS activity was assessed by spectral analysis of heart rate variability (SA HRV) during orto-clinostatics maneuvers. Both frequency-domain measures and age-dependent complex indexes of the SA HRV were used. Post-race ANS activity was assessed at the beginning of the 7th, the 19th, the 34th, the 44th, the 58th, and the 67th hour of the recovery period.

Results: At the 19th hour after the race, the overall spectral power had risen above the initial level, primarily owing to the prevailing sympathetic activity over the increasing vagal activity. By the 44th hour, a further significant increase in ANS activity had occurred, this time due to the overriding vagal activity. A high level of subjectively perceived fatigue persisted throughout the entire recovery period monitored.

Conclusion: This work demonstrated that the ANS activity was completely restored by the 44th hour of post-marathon recovery. The high level of subjectively perceived fatigue persisted throughout the entire recovery period monitored and was not correlated to the ANS activity.

Key Words: *heart rate variability, exercise, marathon, recovery, supercompensation, fatigue*

Introduction

The autonomic nervous system (ANS) activity plays an important role in the regulation of both the cardiovascular system and internal organs in ensuring of optimal function during various activities (1). A monitoring of R-R variations to quantify autonomic cardiac regulation, for example by SA HRV, enables feedback assessment of the amount of internal changes induced particularly by training and non-training stimuli (2). It has been presented that vigorous physical exertion, such as a marathon, evokes long lasting changes in the autonomic regulation persisting several hours after the end of the exercise (3). The performance during exercise is limited by chemical factors acting either in the brain or in the working muscles producing either "central" or "peripheral" fatigue, respectively (4). Botek (5) has observed some discrepancies between the dynamics of both ANS activity and the subjective feeling of the fatigue during athletic preparation. In the present work, we investigated changes in the ANS activity simultaneously with the subjective feeling of fatigue during the 67 hours after the marathon.

Material and Methods

The work is conceived as a case study. The physical activity of the tested athlete was according to habitual activity. He had never run a marathon (42.195 km) before. His training preparation lasted three months, and his training load level is presented in table 1.

Before the testing, the subject had been investigated to preclude any medical or health limitations to perform the maximal exertion test. Each testing protocol and situation was clearly and precisely described to him. The study protocol was approved by the ethics committee of the Faculty of Physical Culture, and the athlete gave written informed consent. The subject underwent basic anthropometric measurements (height [cm], weight [kg]) and a maximal exertion running test two weeks before the start of the study in the exercise laboratory. The maximal running test was performed

Table 1. *Distribution of the training sessions and the load within the pre-marathon phase*

Number of TU	TL·week^{-1}	Total TL (February – May, 2007)	Training Intensity	Mean Exercise Intensity [% MHRR]
54	30 – 50 km	460 km	5:00 – 6:00 min·km^{-1}	70 – 80

TU – training units; TL – training load; % MHRR – percent of the maximal heart rate reserve [(HRrunning – HRrest)/(HRmax – HRrest)]x100

Table 2. *Basic characteristic of the subject*

Age [years]	Gender	BMI [kg·m^{-2}]	HRrest [beat·min^{-1}]	HRmax [beat·min^{-1}]	$\dot{V}O_2$max [ml·kg·min^{-1}]
31	male	25.2	51	176	50.7

$\dot{V}O_2$max – maximal oxygen uptake; HRrest – resting heart rate; HRmax – maximal heart rate; BMI – Body Mass Index

Table 3. *Assessment of the subjective feeling of the fatigue during post-marathon*

Point(s)	0	1	2	3	4	5
Description	No fatigue	Low fatigue	Moderate fatigue	Somewhat high fatigue	High fatigue	Very high fatigue

on a Lode Valliant treadmill (Netherlands). The test started with a warm up phase: 4 minutes (min) at 8 km·h^{-1} and 10 km·h^{-1}, respectively. Immediately after the warm-up, the inclination of the treadmill increased from 0 % to 5 %, and speed remained at 10 km·h^{-1}. Then the speed increased every 1 min by 1 km·h^{-1} till exhaustion. During the test, the subject breathed in a mask: ventilation and both O_2 and CO_2 exchange were analyzed by a ZAN 600 Ergo USB (Germany). Resting heart rate (HR) was measured in standard conditions using monitor HR Polar 810 (Finland): in the morning, immediately after waking up, the subject lay five minutes in bed in the quiet room. The record was assessed and from this the mean HR was established.

Electrocardiograph data were collected during active standardized orto-clinostatics maneuver of lying-standing-lying by the VarCor PF7 system (6), which requests for HRV analysis 256 artifact free subsequent R-R intervals for each position.

Frequency domain analyses were performed according to the methods described by Salinger et al. (7). Amplitude density of the collected signal was estimated using the Fast Fourier Transform method with a partly modified Coarse-Graining Spectral Analyses algorithm (8). Total spectral power (P_T) and power of mean spectral components were calculated by integrating the area under the power spectral density curve in the frequency ranges according to Salinger et al. (7): P_T from 0.02 to 0.5 Hz; power very low frequency (P_{VLF}) from 0.02 to 0.05 Hz; power low frequency (P_{LF}) from 0.05 to 0.15 Hz; power high frequency (P_{HF}) from 0.15 to 0.5 Hz. Frequency-domain measurements were calculated from the power estimates, including P_T, P_{VLF}, P_{LF}, P_{HF}, and ratios P_{VLF}/P_{HF} and P_{LF}/P_{HF}, respectively. The autonomic activity was also expressed by complex indexes of SA HRV (9): the complex index of the vagal activity (VA), the complex index of the sympathovagal balance (SVB) and the complex index of the total score (TS). The reference values of SA HRV indexes range from -5.0 to +5.0 points. The physiological values have been established for both VA and SVB in range from -2.0 to +2.0 points for TS from -1.5 to +1.5 points (10).

The athlete was instructed to avoid coffee, tea, and food minimally 2 hours before the measurement of ANS activity. All these measurements were conducted in a quiet room. During measurement, the athlete closed his eyes and was listening to relaxing music. The assessment of ANS activity started twelve training sessions before the marathon, whereas the training intensity was optimized according to morning ANS activity described by both Šlachta et al. (11) and Stejskal (12). The last assessment of the ANS activity took place two hours before the marathon race. Start of the marathon took place at the 9:00 a.m., and the athlete finished the competition at the 1:26 p.m. In the recovery period, the ANS activity was assess at the beginning of the 7th, the 19th, the 34th, the 44th, the 58th, and the 67th hour after the race. Both the mean values and standard deviations of all used parameters were calculated from the results of the twelve measurements of the ANS activity, which were taken before the race. These values were established as the pre-marathon level of the ANS activity. During the race, HR was sampled by a HR Polar 810 monitor (Finland). The feeling of fatigue was assessed by the athlete himself each time before the assessment of ANS activity. The level of subjective feeling of fatigue ranged from 0 to 5 point(s) (see table 3). This scale was established only for this project, therefore it was not validated. Database, tables, and graph were performed by software MS Excel 2003.

Results

The average HR value of the athlete during the run was 157.0 ± 6.1 beats·min^{-1}, which represented 85.0 ± 4.8 % of his maximal heart rate reserve (MHRR). The athlete completed the marathon in 4 hours 26 minutes.

The HRV measures of spectral power returned and in the same time exceeded their initial values at the start of the 19th hour of recovery. In the case of P_{HF} and P_T the same effect occurred another 25 hours later. As shown in table 4, the ratios P_{VLF}/P_{HF} and P_{LF}/P_{HF}, respectively, reached their initial levels about 15 hours later then spectral measures.

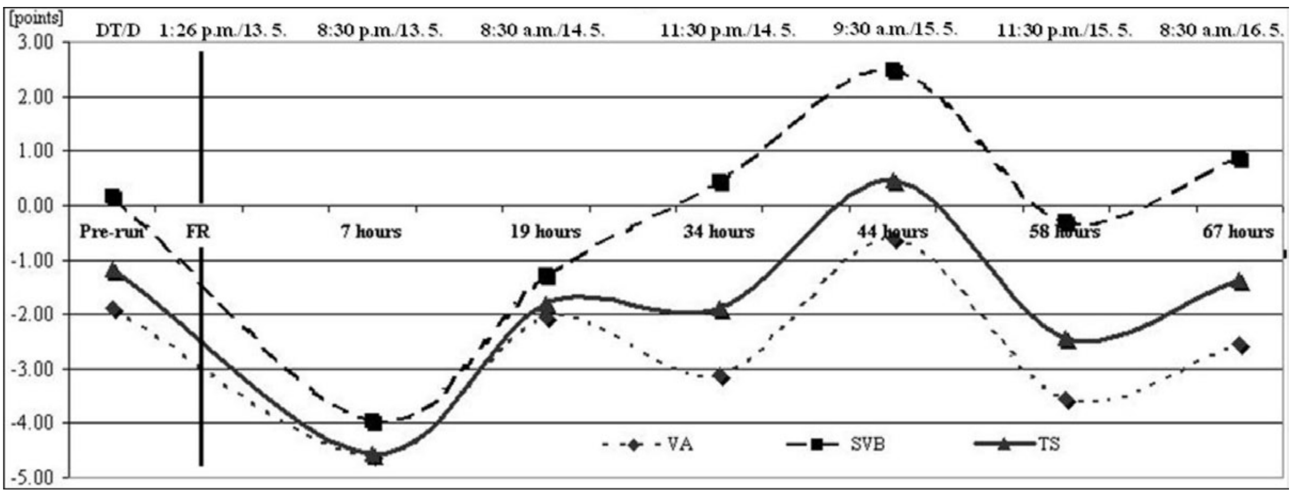
A decrease in the values of P_{VLF}/P_{HF} and P_{LF}/P_{HF} ratios below the initial level was detected repeatedly when measured at the beginning of the 34th and 44th hour after completing the race, while during the second measuring the decrease was even more marked. The initial level of SVB, VA and TS, was attained between the 34th and the 44th hour of the recovery period. Figure 1 shows that the values of complex SA HRV indexes maximally exceeded those of the pre-start level at the beginning of the 44th hour of recovery.

Throughout the entire recovery period fatigue was reported as very high by the athlete with the exception of one test situation which occurred at the start of the 67th hour of recovery when the fatigue was classified as only high.

Table 4. *The time course of the monitored HRV parameters during recovery period*

Assessed parameter	Pre-run value M ± SD	8:30 p.m. 13. 5.	8:30 a.m. 14. 5.	11:30 p.m. 14. 5.	9:30 a.m. 15. 5.	11:30 p.m. 15. 5.	8:30 a.m. 16. 5.
		the 7th h post-run	the 19th h post-run	the 34th h post-run	the 44th h post-run	the 58th h post-run	the 67th h post-run
P_T [ms^2]	2013.26 ± 416.70	404.83	2761.69	854.81	2610.92	654.40	1011.71
P_{VLF} [ms^2]	316.71 ± 141.12	178.12	928.39	75.73	158.84	135.27	189.21
P_{LF} [ms^2]	950.27 ± 294.14	178.86	1048.08	428.34	851.00	263.41	262.32
P_{HF} [ms^2]	746.29 ± 190.39	47.85	785.23	350.75	1601.08	255.73	560.17
P_{VLF}/P_{HF}	0.48 ± 0.28	3.72	1.18	0.22	0.10	0.53	0.34
P_{LF}/P_{HF}	1.31 ± 0.36	3.74	1.33	1.22	0.53	1.03	0.47
BF [breath·min^{-1}]	13.3 ± 0.8	14.5 ± 1.1	13.5 ± 1.2	13.7 ± 1.4	12.4 ± 0.3	13.1 ± 1.2	12.6 ± 0.6

P_T – total spectral power; P_{VLF} – very low frequency power; P_{LF} – low frequency power; P_{HF} – high frequency power; BF – breath frequency; M – mean value; SD – standard deviation; h – hour



VA – the complex index of the vagal activity; SVB – the complex index of the sympathovagal balance; TS – the complex index of the total score; DT/D – daily time/date of the measurement; FR – finish of the race

Fig. 1. *The dynamics of the complex indexes of SA HRV during post-marathon recovery*

Table 5. *Assessment of the subjective feeling of the fatigue during post-marathon period*

Time/date	8:30 p.m. 13. 5. 2007	8:30 a.m. 14. 5. 2007	11:30 p.m. 14. 5. 2007	9:30 a.m. 15. 5. 2007	11:30 p.m. 15. 5. 2007	8:30 a.m. 16. 5. 2007
Recovery	the 7th hour	the 19th hour	the 34th hour	the 44th hour	the 58th hour	the 67th hour
Fatigue [points]	5	5	5	5	5	4
Fatigue description	exhaustion fever weakness walk-painful joints stiffness muscle soreness breathlessness	weakness walk-painful joints stiffness muscle soreness breathlessness	weakness muscle soreness neck ache physical fatigue mental fatigue sweating walk-painful	physical fatigue joints stiffness muscle soreness neck ache walk-painful	weakness general fatigue joints stiffness muscle soreness walk-painful	persisted fatigue walk-painful

Discussion

We have several basic findings as a result of this work: 1) according to the TS, the ANS activity returned to its initial level by the beginning of the 44th hour after the marathon, 2) during recovery, the initial level in all individual HRV and complex SA HRV indexes were exceeded, 3) a high level of subjectively perceived fatigue persisted for almost the whole duration of the recovery period monitored.

Data in the literature indicate that the period of ANS recovery after vigorous exertion depends on both the sport and the cardio-respiratory system performance (13). In our case, the relatively short training preparation together with the only slightly above average cardio-respiratory performance ($\dot{V}O_2max = 50.7\ ml{\cdot}kg{\cdot}min^{-1}$) allowed us to expect a slower return of the ANS activity to the level prior to the race than in endurance trained athletes. Bernardi et al. (14) suggested that in the trained athletes, the ANS activity returns back to the norm within 24 hours of completing a 46-kilometer race. However, Daniłowicz-Szymanowicz et al. (3) have described a prolonged increased sympathetic activity remaining 24 hours after the run.

In the case of our athlete, the following changes in the ANS activity occurred close to the 3 days of recovery. The evening assessmets of the ANS activity have shown a marked reduction in vagal activity together with sympathetic predominance (negative value of the SVB) at the 7th and the 58th hour recovery, respectively. In the second day of recovey period (34th hour recovery), a low level of vagal activity was detected again. However, the ANS regulation remainded on the vagal side (positive value of the SVB). Described changes in the ANS regulation could be a reflection of negative influence of routine stress stimuli during the working day (cicradian rhythm - 15) together with persistance of fatigue from the race. The measurements in the morning, the 19th and 44th hour of the recovery, revealed rebounds in ANS activity. The first "supercompensation" was due to a high level activity of both branches of the ANS with predominance of persisting sympathetic activity. The second significant increase in the ANS activity that exceeded the initial level was caused by the high vagal activity dominating over the sympathetic activity (pronounced increase in the VA and SVB). It is important to point out that all assesments of ANS activity during the early hours of the day (the 19th, 44th and 67th hours after the race) demonstrated the clear positive influence of sleep on the autonomic cardial regulation as demonstrated by the morning increase to the vagal activity, as was also observed by Kondo et al. (16).

As mentioned above, some kind of "supercompensation" of the ANS activity occurred during the recovery period. Similar results can be found in other studies, for instance Bernardi et al. (14) describes increased vagal activity expressed as baroreflex functions 24 hours after a prolonged race at a higher altitude. Also, Hautala et al. (13) found that around the 48th hour of recovery after a 75-km ski race at higher altitude the values rose to the pre-exercise level in particular in baroflex functions and spectral parameters influenced by vagal activities. It appears that the supercompensation of ANS activity enables the athlete to become temporarily more resistant and adaptable towards a variety of stress stimuli. In this connection, Pichot et al. (17) mention an improvement in homeostatic control which can favourably influence competative performance.

Subjectively experienced fatigue persisted to a high degree practically throughout the three days. Above all, the athlete complained of long-lasting muscle and joint pains. The literature does not present much information on the subjective assessment of a feeling of fatigue occurring after a race. The main expection is the paper of Noble et al. (18), in which a significantly increased value of subjective perceived exertion of 7 days after finishing a marathon race has been proven. The pre-started values were not again achieved until 13 to 15 days afterwards. As mentioned above, the ANS activity returned to its pre-starting level at the 44th hour of recovery, even though at this time the athlete still percieved heavy fatigue. So far, the interrelationships between muscle pain caused by ischemia and sympathetic neuromuscular activity have not been documented. Cook et al. (19) stated that the sensation of pain is carried through the spinal and supra-spinal tracts that are independent of sympathetic activity. Iellamo et al. (20) concluded that vagal reactivation and its stronger effect on the sinoatrial node leads to the fall in HR in the earlier phases of recovery, in spite of the persistent local muscle ischemia and the corresponding increased sympathetic activity.

We can state in conclusion that the prolonged exhausting exertion during the first few hours of recovery manifested itself as prevailing sympathetic activity. After 44 hours, a further significant increase in the ANS activity occurred mainly due to the prevailing vagal activity. The high level of subjectively perceived fatigue persisted throughout the entire recovery period monitored and did not influence the ANS activity.

The work is presented as a case-study and there is its main limit. The aim of the study was to show the changes in the ANS after an exhaustive marathon race, especially within meaning of the ANS supercompensation. However, the verification of these results calls for similar measurements in more athletes.

Grants: This article was conducted as a part of the following research project: Physical activity and inactivity of inhabitants of the Czech Republic in the context of behavioural changes MSM: 6198959221.

References

1. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. Heart rate variability. Standards of measurement, physiological interpretation, and clinical use. Special report. *Circulation* 1996; 93(5): 1043-65.
2. Aubert AE, Seps B, Beckers F. Heart rate variability in athletes. *Sports Med* 2003; 33(12): 889-919.
3. Daniłowicz-Szymanowicz L, Raczak G, Pinna GD, et al. The effects of an extreme endurance exercise event on autonomic nervous system activity. *Pol Merkuriusz Lekarski* 2005; 19(109): 28-31.
4. Noakes TD. The Central Governor Model of Exercise Regulation Applied to the Marathon. *Sports Med* 2007; 37: 374-7.
5. Botek M. Monitoring of autonomic nervous system activity using spectral analysis of heart rate variability in athletes. Thesis. Palacký University, Olomouc: Faculty of Physical Culture, 2007.
6. Salinger J, Gwozdziewicz M. Systémy používané pro vyšetření krátkodobé variability srdeční frekvence. In: Javorka K., ed. Variabilita frekvencie srdca: Mechanismy, hodnotenie, klinické využitie. Martin: Osveta, 2008: 57-60.
7. Salinger J, Opavský J, Stejskal P, et al. The evaluation of heart rate variability in physical exercise by using the telemetric variapulse TF3 system. *Acta Univ Palacki Olomuc Gymn* 1998; 28: 13-23.
8. Yamamoto Y, Hughson RL. Coarse - Graining Spectral Analysis: new method for studying heart rate variability. *J Appl Physiol* 1991; 71(3): 1143-50.
9. Stejskal P, Šlachta R, Elfmark M, et al. Spectral analysis of heart rate variability: New evaluation method. *Acta Univ Palacki Olomuc Gymn* 2002; 32(2): 13-8.
10. Stejskal P, Jakubec A, Přikryl P, et al. Vliv osmihodinového časového posunu po přeletu přes poledníky na východ na spektrální analýzu variability srdeční frekvence u špičkového sportovce (kasuistika). *Med Sport Boh Slov* 2004; 13(1): 2-10.
11. Šlachta R, Stejskal P, Elfmark M. Spektrální analýza variability srdeční frekvence u sportovců a modifikace tréninku pomocí spektrální analýzy. In: Salinger J., ed. Variabilita srdeční frekvence a její hodnocení v biomedicínských oborech – od teorie ke klinické praxi. Olomouc: Fakulta tělesné kultury, 2003: 134-9.
12. Stejskal P. Využití hodnocení variability srdeční frekvence ve sportovní medicíně. In: Javorka K., ed. Variabilita frekvencie srdca: Mechanismy, hodnotenie, klinické využitie. Martin: Osveta, 2008: 168-81.
13. Hautala A, Tulppo MP, Makikallio TH, et al. Changes in cardiac autonomic regulation after prolonged maximal exercise. *Clin Physiol* 2001; 21(2): 238-45.
14. Bernardi L, Passino C, Robergs R, et al. Acute and persistent effects of a 46-kilometer wilderness trail run at altitude: Cardiovascular autonomic modulation and baroreflexes. *Cardiovasc Res* 1996; 34(2): 273-80.
15. Bilan A, Witczak A, Palusinski R, et al. Circadian rhythm of spectral indices of heart rate variability in healthy subjects. *J Electrocardiol* 2005; 38(3): 239-43.
16. Kondo K, Matsubara T, Nakamura J, et al. Characteristic patterns of circadian variation in plasma catecholamine levels, blood pressure and heart rate variability in Type 2 diabetic patients. *Diabet Med* 2002; 19(5): 359-65.
17. Pichot V, Busso T, Roche F, et al. Autonomic adaptations to intensive and overload training periods: A laboratory study. *Med Sci Sports Exerc* 2002; 34(10): 1660-6.
18. Noble BJ, Maresh CM, Allison TG, et al. Cardio-respiratory and perceptual recovery from a marathon run. *Med Sci Sports* 1979; 11(3): 239-43.
19. Cook DB, O'Connor PJ, Ray CA. Muscle pain perception and sympathetic nerve activity to exercise during opioid modulation. *Am J Physiol Regul Integr Comp Physiol* 2000; 279(5): R1565-73.
20. Iellamo F, Pizzinelli P, Massaro M, et al. Muscle metaboreflex contribution to sinus node regulation during static exercise: insights from spectral analysis of heart rate variability. *Circulation*, 1999; 100(1): 27-32.

Received: March 31, 2008
Accepted: May 23, 2008
Published: June 03, 2008

Address for correspondence:
Michal Botek, Ph.D.
Centrum for Kinantropological Research
Faculty of Physical Culture Palacký University,
Třída Míru 115
Olomouc 771 40
Czech Republic
e-mail: michal.botek@upol.cz

Pavel Stejskal, Ph.D.: pavel.stejskal@upol.cz
Filip Neuls, Ph.D.: filip.neuls@upol.cz

Medicina Sportiva
Med Sport 12 (2): 36-40, 2008
DOI: 10.2478/v10036-008-0007-9

THE INFLUENCE OF RELIABILITY IN MEASURING SKINFOLDS ON THE RELIABILITY OF RESULT OF ENDOMORPHIC AND MESOMORPHIC COMPONENTS OF SOMATOTYPE

Petr Kutáč(A, B, E, F, G), **Vojtěch Gajda**(A, C, D)

Department of Physical Education, Pedagogical Faculty of Ostrava, Czech Republik

Abstract

Introduction: The somatotype has been identified as one possibility to qualify the physique of an individual through application of the anthropometric method to serve as a supplementary method to determine the individual´s physical composition.

Aim: The study aims to evaluate the impact of skinfolds measurement on the somatotype endomorphic and mesomorphic component determination by comparing the measurement results of individuals with little experience.

Methods: To carry out this study, we recruited students from the Department of Physical Education, Pedagogical Faculty. The group of workers with little experience consisted of four randomly selected students who attended a seminar serving the purpose of learning the skinfold measuring technique. An expert in this area was asked to lead the seminar. The individual calculations were carried out by means of the statistic product SPSS 15.0.

Results: The results of our investigation showed difficulty in skinfolds measurement accuracy, in particular, with respect to an experience and training in the applied methodology. They showed that the students measured reliably, but with a systemic error. While the measurement of skinfold suprailiac proved to be the least problematic, the measurement of skinfold on the calf showed to be most problematic.

Conclusion: The study showed that in the area of measuring the impact of the skinfold on the components of somatotype, the monitored faults of measurement do not influence the result of mesomorphy component value. As a result of the endomorphic component value, the mentioned faults are clearly visible (the differences in the result are statistically significant).

Key words: *body composition, somatotype, endomorphy, mesomorphy, measuring of skinfolds, reliability of measuring*

Introduction

The somatotype serves as one of the possibilities of measuring the physique of an individual by applying the anthropometric methods that serve as the supplemental methods for the physical composition (1,2). The evaluation is based on relationship among three morphological components the values of which are calculated from the anthropometric measurements. The first - endomorphy component relates to the relative obesity or slimness of the individual, the second – mesomorphy component relates to the relative muscle skeletal development in relation to the stature, and the third – ectomorphy component relates to the relative length of the parts of the body (3). The somatotype provides us with information on some somatic signs of the individual that we can use not only for following the ontogenesis of an individual at various age (4-8), but also for investigation of his/her somatic conditions for a given sports event at the selection of sports talents (9). The importance of somatic characteristics of an individual (somatotype) in sports is supported by earlier publications (10-14) and current studies (15-22) that focus on characteristics of the top sportsmen of the representation selections in various age categories. The P.T. students are an important monitored group as they follow a curriculum that requires a special sports performance. The authors mainly followed the somatic characteristic of these students in relation to the curriculum this population group followed (13, 23-25).

With respect to the applied measuring methodology (technology of measuring the skinfolds thickness and components calculation), the question of reliability of these measurements arises. Can the results of the measurements performed by various authors without proving their objectivity be compared? While the methodologies of measuring individual anthropometric parameters are accurately described and unified (including a sufficiently exact armamentarium), given our experience, certain abnormalities can appear when measuring the thickness of skinfolds. The exactness of skinfolds measurement does not only depend on the type of caliper used, but, predominantly, on the experience level of the person administering the measuring technique (localization and pulling out of skinfold). Therefore, we explored the question of reliability and objectivity regarding the measurement of the thickness of skinfolds in our study.

Due to the thickness of skinfolds measuring results influences the values of endomorphy and mesomorphy components, we will view the real significance of the obtained differences in relation to the changed values of relevant components (endomorphy and mesomorphy) of the somatotype of explored probands.

Aim

1. Based on the repeated measurements of four skinfolds (subscapular, suprailiac, on the triceps, and on the calf) with a caliper type Best by an expert (a worker with a substantial practical experience) to find out its reliability.
2. To verify the reliability of measuring at the choice of common academic population on the ground of comparing the results of measuring four skinfolds (identical with the measuring in point 1.) by an expert and workers with a short experience. In case of significant differences to evaluate the skinfolds influence on the values of endomorphy and mesomorphy components of somatotype.

Materials and Methods

For accuracy of skinfolds measurement rating (repeated measurement by an expert) we recruited first year students with a concentration in Leisure Time Management, at the Department of Physical Education, Pedagogical Faculty - KTV PdF OU. 32 students (18 men and 14 women) were administered this measurement procedure.

For the second aim – comparing the results of measuring four skinfolds by an expert and workers with a short experience, the 3rd year students majoring in the pedagogy study – TV specialization at KTV PdF OU (n = 25 students, 7 men and 18 women).

The group of workers with a short experience consisted of four randomly selected students of the seminar. The purpose of the seminar was to gain an experience in the skinfolds thickness measuring technique. Due to a great experience in this area, the seminar lecturer was asked to perform this position.

The measurement for the first aim accomplishment (repeated measurement by an expert) due to a higher number of students was carried out in two stages (16 students were measured in every stage). On Tuesday there was measured the first group and on Wednesday the same week there was measured the second group. The measurement was repeated within one week when every group again was measured on the same day and at the same time as in the first measurement.

The measurement for the second aim accomplishment (comparing the results of measuring by an expert and workers with a short experience) was carried out with the selected group of students on the same day.

The measurements were always carried out in the alphabetical order. The values of skinfolds were measured at individual persons gradually in a given sequence. The expert measured all anthropometric parameters that were necessary for determination of somatotypes in the selected group. The methodology Heathová-Carter (3) was used and thoroughly observed for the somatotype determination. There was measured the stature, body weight, biepicondylar parameter of humerus and femur, circumference of contracted shoulder, maximum circumference of the calf and skinfold subscapular, suprailiac, on the triceps and on the calf (1). The values were always measured on the right side of the body. The values of individual components were calculated by means of ANTROPO program.

We characterized all monitored variables by the basic descriptive statistic measures. The normality of their distribution was verified by Kolmogorov-Smirnov and Shapiro-Wilka tests. The reliability of measuring by an expert is verified through the coefficient of stability (r_{stab}). The difference in both measurements was qualified by a paired t-test.

We used Cronbach's coefficient α, coefficient of absolute reliability R*(for a single measurement) for evaluation of the consistency of expert's measuring and measuring of workers with a short experience. The values of these measurement averages were analyzed by applying the analysis of variance (ANOVA). The calculations were carried out by means of the statistic product SPSS 15.0. The significance level $\alpha=0.05$ was determined for all tests.

Results

1. The reliability of measuring by an expert

Table 1 presents the basic descriptive characteristics of the skinfolds measurement at the group being under examination (n = 32).

Table 1. *Basic descriptive statistics of the examined body*

Skinfold	$\overline{x}$ (mm)		*S*		*V*	
	1. meas.	2. meas.				
subscapular	7.3	8.1	2.7	2.5	0.37	0.31
on the triceps	12.5	13.1	5.5	5.6	0.44	0.43
suprailiac	9.6	8.8	6.8	6.0	0.70	0.68
on the calf	11.5	11.5	5.3	5.2	0.46	0.46

$\overline{x}$ - mean *S* - standard deviation *V* - coefficient of variance

The normality of distribution was disrupted at the suprailiac when there was disrupted the skewness at the first and second measurement, and at the second measurement we also registered the disturbance of sharpness (kurtosis). At the subscapular we noted the disturbance of skewness and sharpness in both measurements.

The coefficients of stability in measuring the thickness of individual skinfolds together with testing the relevance of difference measured by paired t–test (Table 2). The significance of difference in average values of both measurements showed only at the variables where the skewness and sharpness of normal distribution were strongly disrupted. The disturbance of assumed distribution normality at the monitored variables in the paired t–test could be one of the reasons of ascertained statistical significance.

Table 2. *Coefficient of stability and relevancy of paired t-test gained at the expert*

Skinfold	r_{stab}	absolute difference	t-test
subscapular	0.891	0.8	*
on the triceps	0.936	0.6	
suprailiac	0.970	0.8	*
on the calf	0.970	0	

r_{stab} – coefficient of stability * p<.05

Crucial for our examination is the appraisal of the real significance based on the changes in monitored somatotype components. At the repeated measuring no proved significant differences at both monitored components was noted (Table 3) and the reliability of measuring these components verified by test-retest method is very high.

Table 3. *Values of morphological components of both measurements by an expert*

Component	$\bar{x}$ (mm)		S		r
	1. meas.	2. meas.	1. meas.	2. meas.	
endomorphy	3.1	3.14	1.24	1.12	0.975
mesomorphy	3.94	3.89	1.15	1.07	0.975

$\bar{x}$ - mean S - standard deviation r – correlation coefficient

2. Comparison of measuring results by an expert and workers with a short experience

At the first look at Table 4 (descriptive statistic characteristics of skinflods measurement results) it is obvious that there are significant differences between the values measured by worker with various experience level.

The values of Crombach‘s coefficient α and absolute reliability coefficient (R*) are shown in Table 5. The found out values are relatively high and they are between 0.707 and 0.959. In physics the value of Crombach‘s coefficient α > 0.8 (26) is considered as an acceptable reliability.

From Crombach‘s coefficient α the reliability of the measurement average can be assessed and from absolute reliability coefficient (R*) the reliability of individual measurement can be assessed. Crombach‘s coefficient α determines the consistency from coefficients of correlation between individual measurements (it means regardless the systemic measurement error).

Table 4. *The results of measuring skinfolds*

Skinfold		Expert (mm)	Student 1 (mm)	Student 2 (mm)	Student 3 (mm)	Student 4 (mm)
Subscap.	$\bar{x}$	10.5	8.3	8.7	10.5	7.0
	s	3.8	3.3	3.3	3.5	1.8
Suprail.	$\bar{x}$	7.1	7.2	7.6	9.6	7.1
	s	3.9	3.5	3.6	4.6	3.3
Triceps	$\bar{x}$	17.1	11.6	11.5	14.8	13.6
	s	6.2	4.8	4.6	5.5	5.6
Calf	$\bar{x}$	16.0	9.8	8.7	14.7	13.2
	s	7.5	5.5	4.6	4.7	6.0

$\bar{x}$ - mean s – standard deviation

Table 5. *Values of coefficients of reliability*

Coefficients	Subscap.	Suprail.	Triceps	Σ of three folds	Calf
α	0.929	0.935	0.935	0.959	0.924
R*	0.724	0.742	0.741	0.824	0.707

α - Crombach´s α R* - coefficient of absolute reliability

By collecting the results of measurements of the same group tested by workers with various experience level, we can consider the average result as highly reliable. In case of a single worker results, we have to be cautious because $R^* < 0.8$.

We used ANOVA to determine the difference in the average values measured by individual workers. The conditions for its application were satisfied at all measurements (and their totals) except the thickness on the calf. In order to ensure the condition of distribution normality, we transformed the original variable into a new variable which was analyzed. The statistically significant difference of workers´ measurement averages was proved in all monitored cases. At a closer look at the post hoc (Duncan´s test) analysis, our results showed that the expert ´s measurement always statistically significantly varied from those of the workers with little experience. Thus, the measurements of workers with various experience level cannot be considered identical.

In the group of workers with little experience, no proved statistically significant difference in measuring the skinfolds and their total, except for the thickness of skinfold on the triceps (Table 6), were found.

Table 6. *Results of Duncan's test of mean of measuring skinfold on the triceps*

Worker	n	Group 1	Group 2
Student 2	25	11.5	
Student 1	25	11.6	
Student 4	25	13.6	13.6
Student 3	25		14.8

Discussion

It is shown the results from measurements of workers with a short experience can be considered to be identical except for casual deviations. The difference in measuring the skinfold thickness on the triceps is not considered to be objectively too significant.

There is a question whether the statistically proved difference in measuring skinfolds between an expert and a group of workers with a short experience has a real influence in light of setting the mesomorphy and endomorphy components of somatotype. For the endomorphy components determination there is used a simple sum of three skinfolds (on the triceps, subscapular, suprailiac) and this sum is then substituted in a regressive equation of a linear function (27). On the ground of this equation it is easy to prove that the *4mm* difference in sum of skinfolds means 0.5 point of endomorphy component. We found out the maximum difference of 7 mm in the results between an expert and group of workers with a short experience. Such a difference can be regarded as objectively significant because it presents approximately the value of 1 point of the endomorphy component as this component was evaluated with 0.5 point (3) accuracy.

The mesomorphy component determination is calculated by a markedly more difficult method (from the physical height, width of epicondyls of humerus and femur, circumference of contracted shoulder by thickness of skinfold on the triceps, and maximal circumference of calf reduced by thickness of skinfold on the calf). By substituting the *maximal differences* in measuring the thickness of both skinfolds into a calculation equation of mesomorphy component of a person set up of the averages of individual component measurements, the value changed only by *0.27 points*. In the light of the above, we consider the regard the reported differences in measuring the thickness of skinfolds on the triceps and on the calf objectively insignificant for the values of the mesomorphy component.

The results show that the various experience level of workers influences the evaluation of at least one component, thus the individual ´s classification in the corresponding category of somatotype, which is most often determined according to mutual relations of individual components (3,28,29). A faulty classification falsifies the physique of the monitored individual which not only can result in faulty conclusions when selecting the individuals for the sports event (talents selection), but also in faults when preparing and running the training process (30,31).

Conclusions

With respect to the results of repeated expert´s measurements we can regard the monitored technique of measuring the skinfolds as reliable and the differences between the repeated measurements as insignificant, because they did not appear in the final result of somatotype monitored components.

When comparing the results of expert ´s measurements and the measurements of workers with little experience, we noted a high consistency of measurement valued by Crombach´s α**.** The arithmetic average of several workers´ measurements (with a different experience in a given measurement methodology) can be considered reliable in practice. In case adding three skinfolds thickness according to the physical demands on the measurement reliability ($\alpha > 0,8$) we consider the individual measurements to be acceptably reliable. The least problematic proved to be the measurement of skinfold suprailiacal and the most problematic was the measurement of the skinfold on the calf. The absolute values of monitored skinfold measurements by experts and the measurements by workers with little experience cannot be considered to be identical.

The mesomorphy components result is not significantly influenced by the outcome differences in skinfolds thickness measurement. As a result of the endomorphy component, these differences are objectively visible (to the extent of approximately one point of the endomorphic component).

References

1. Heyward VH, Wagner DR. Applied body composition assessment. Champaign, IL: Human Kinetics, 2004.
2. Ackland TR, Elliot BC, Bloomfield J. Applied Anatomy and Biomechanics in Sport. Champaign, IL: Human Kinetics, 2008.
3. Riegerová J, Přidalová M, Ulbrichová M. Aplikace fyzické antropologie v tělesné výchově a sportu. Olomouc: Hanex, 2006.
4. Fragoso I, Fortes M, Vieira F, et al. Identifying Maturational Levels During Adolescente: A Methodological Problem. In: Reilly T, Marfell-Jones M, ed. Kinantropometry VIII. London: Routledge, 2003: 69–81.
5. Jürimäe J, Jürimäe T, Leppik A, et al. Relationship between anthropometric variables and physical activity in prepubertal girls. *J Hum Kinetics* 2001; 5: 13–21.
6. Lee AJY, Lin WH. The Influence of Gender and Somatotype on Single-Leg Upright Standing Postural Stability in Children. *J Appl Biomech* 2007; 23: 173-9.
7. Makgae P, Monyeki KD, Brits SJ, et al. Somatotype and blood pressure of rural South African children aged 6 – 13 years: Ellisras longitudinal growth and health study. *Ann Hum Biol* 2007; 34: 240-51.
8. Veldre G. Heath-Carter Somatotype Categories and their Sexual Maturation Differences in 12 – 15 – Year – old Estonian Boys and Girls. *Anthropology* 2004; 13: 269–85.
9. Gil S, Ruiz F, Irazusta J, et al. Selection of young soccer players in terms of anthropometric and physiological factors. *J Sports Med Phys Fitness* 2007; 47: 25-32.
10. Berg K, Latin. RW, Coffey C. Relationship of somatotype and physical characteristic to distance running performance in middle age runners. *J Sports Med Phys Fitness* 1998; 38: 253-7.
11. Carter JE, Ackland TR. Sexual dimorphism in the physique of World Championship divers. *J Sports Sci* 1998; 16: 317-29.
12. Chytráčková J. Možnosti individuálního hodnocení motorické výkonnosti dětí podle somatických předpokladů. In 3 rd. Antrop. Congress. Prague: UK, 1990: 105-6.
13. Pavlík J. Tělesná stavba jako faktor výkonnosti sportovce. Brno: MU PdF Brno, 1999.
14. Rienzi E. Investigation of anthropometric and work-rate profiles of elite South American international soccer players. *J Sports Med Phys Fitness* 2000; 40:162-9.
15. Carter JEL, Ackland TA, Kerr DA, et al. Somatotype and size of elite female basketball players. *J Sports Sci* 2005; 23: 1057-63.
16. Demuth A, Czerniak U, Krykala M, et al. Somatic characteristic of players from chosen national teams of field hockey. *Human Movement* 2007; 8: 27–31.
17. Querioga MR, Ferreira SA, Pereira G, et al. Somatotype and performance in futsal players. *Braz J Kineanthropometry Hum Perform* 2008; 10: 56-61.
18. Sanchez MC, Sanz D, Zabala M. Anthropometric characteristics, body composition and somatotype of elite junior tennis players. *Br J Sports Med* 2007; 41: 793-9.
19. Semple S, Neveling N, Roussouw R. Physical and performance - related profile of elite male South African distance runners. *Afr J Phys Health Educ Recreation Dance* 2003; 9: 238-49.
20. Stewart AD, Benson PJ, Michanikou EG, et al. Body image perception, satisfaction and somatotype in male and female athletes and non athletes: results using a novel morphing technique. *J Sports Sci* 2003; 21: 815–23.
21. Stoklasa H, Malgorzata S. The assessment of somatotype and bone mass density in female athletes. *J Hum Kinetics* 2003; 9: 107-12.
22. Stuelcken M, Pyne D, Sinclair P. Anthropometric characteristics of elite cricket fast bowlers. *J Sports Sci* 2007; 25: 1587-97.
23. Kutáč P, Dobešová P. Hodnocení tělesné stavby studentů 1. ročníku oboru tělesná výchova na PdF OU Ostrava. *Česká Antroplogie* 2001; 51: 116-8.
24. Riegerová J, Přidalová M, Vařeková R, et al. Hodnocení tělesné stavby studentů 1. ročníku FTK UP. In: Riegerová J., ed. Diagnostika pohybového systému. Metody vyšetření, primární prevence, prostředky pohybové terapie. Olomouc: Univerzita Palackého, 1995: 41–9.
25. Wielinski D. Somatotype and body composition of the candidates for Academy of Physical Education in Poland. In: Riegerová J., ed. Diagnostika pohybového systému. Metody vyšetření, primární prevence, prostředky pohybové terapie. Olomouc: Univerzita Palackého, 1997: 114-9.
26. Meloun M., Militky J. Kompendium statistického zpracování dat. Praha: Academia, 2002.
27. Bláha P. Antropometrie českých předškolních dětí ve věku od 3 do 7 let. Praha: Ústav sportovní medicíny, 1990.
28. Veldre G. Heath-Carter somatotype categories and their sexual maturation differences in 12–15–year old Estonian boys and girls. *Pap Anthropol* 2004; 13: 269–85.
29. Veldre G. Heath-Carter somatotypes in 12–15–year old Tartu children. *Yearbook Estonian Anthropometric Register* 2002; 251-65.
30. Chaouachi M, Chaouachi A, Chamari K et al. Effects of dominant somatotype on aerobic capacity trainability. *Br J Sports Med* 2005; 39: 954-9.
31. Legaz AA, Serrano OE, Lafuente BD. Endomorphic in athletes who make different training. *Exerc Soc J Sport Sci* 2001; 28: 362.

Received: February 25, 2008
Accepted: May 23, 2008
Published: June 03, 2008

Address for correspondence:
Petr Kutáč
Varenská 40a
Ostrava 1, 70200
Czech Republik
e-mail: petr.kutac@osu.cz

Vojtech Gajda: vojtech.gajda@osu.cz

Medicina Sportiva
Med Sport 12 (2): 41-45, 2008
DOI: 10.2478/v10036-008-0008-8

CHANGES IN RELATIVE AND ABSOLUTE FORCE MEASURED DURING POWERLIFTING AFTER A 4-WEEK TRAINING USING THE WEIGHTLIFTING METHOD AND STICK ISOMETRIC (MIXED) METHOD*

Marek Kruszewski[A,B,C,D,E,F], Artur Kruszewski[C,D,E], Bartłomiej Kruszewski[B,C,D]

Department of Combat Sport and Weightlifting, Academy of Physical Education, Warsaw, Poland

Abstract

Introduction: The effectiveness of applied methods is, first of all, determined by the potential of muscular strength increase, reflected by sports results, obtained during powerlifting exercises. The results depend to a large extent on the volume and intensity of training load. When training loads are identical, the evaluation of method effectiveness is based on the improvement of sports results. In case of different training load components however, we should consider them in method effectiveness evaluation as they may significantly affect the increase in muscular power. Some authors claim that the greater the training volume the better results are obtained. Others claim that excessive training volume is only a burden for the participants. Training intensity is also an important factor affecting its usefulness and it should be considered in evaluation of its effectiveness.

Aim of the study: The aim of this paper is an attempt to evaluate the effect of training using the weightlifting method and the stick isometric method on sports results during the following test exercises: deadlift, squat with a barbell on the shoulders and bench press.

Methods: The studies were conducted in two groups of young men who trained using the weightlifting method (n=31) and the stick isometric method (n=28). No participant had done any strength sports before.

Results: After a 4-week training using both methods, a significant increase in the obtained values was observed during the test exercises. The ANOVA variance analysis revealed that there were no significant differences in the obtained values, although during the mesocycle**, the "weightlifting" group worked much less compared to the "stick isometric group".

Conclusions: The obtained results were probably influenced by the power value obtained in a training unit (thrice as high during weightlifting trainings compared to the group using the "stick isometric" method).

***Key words:** absolute strength, relative strength, powerlifting, weightlifting method, stick isometric method*

Introduction

Sports trainers use different methods of muscle strength development. Depending on the participants' needs and the specifics of a given discipline, they select the most useful one (1-10). The effectiveness of applied methods is, first of all, determined by the potential of muscular strength increase, reflected by sports results, obtained during powerlifting exercises (2,11-16) The results depend to a large extent on the volume and intensity of training load. When training loads are identical, the evaluation of method effectiveness is based on the improvement of sports results. In case of different training load components however, we should consider them in method effectiveness evaluation as they may significantly affect the increase in muscular power. Some authors claim that the greater the training volume the better results are obtained (2,6,8,10). Others claim that excessive training volume is only a burden for the participants. Training intensity is also an important factor affecting its usefulness and it should be considered in evaluation of its effectiveness (5,15,17-20). Evaluation of the weightlifting method and the stick isometric methods, depending on the load is questionable in case strength training and requires further studies (6,11,21-23). Therefore it seems justifiable to carry out an experimental study, examining the effect of a 4-week training, using the above mentioned methods, on the changes in absolute (possible to be developed by a contestant during selected movements) and relative strength (the quotient of absolute muscular power and the contestant's body mass) of young men who had never done any strength sports.

*stick isometrics - also training of "mixed method", which is also called "the method of insertions, stops or isometrical halts". Its point is to use during the work with dynamic character (in concentric and eccentric movements) some insertions of isometrical character.

** mesocycle - is a practical term used universally in Polish, Russian, German and generally - European theory of sport, and also in planning force training. It means an average training cycle and in dependence of a training period, as well as a kind of discipline, it can last from 3 to 8 weeks, in which time some periodical tasks in build process are realized. In force sports are used 4 -weeks' mesocycles, and mostly - their classic form so-called "bps" - the mesocycles of direct entry preparation, which help to select the right weights in a 4- weeks period before main contests. Lasting for several months- the periods of makrocycle - preparatory, main and transitory, consist of mesocycles which are built of mikrocycles (usually a week), and these ones contain precise units which are planned exactly in a way of training weights and physical exercises.

Material and Methods

2 groups of young males participated in the study. One group (n= 31) was trained using the weightlifting method, while the other one was trained using the stick isometric method (n=28). The examined groups did not differ significantly in body height, age and body mass (tab.1). None of the participants had done any strength sports before.

Table 1. *Characteristics of the examined groups*

Group	Age (years)	Body mass (kg)	Body height (cm)
Stick isometric	22 ± 2.6	79.69 ± 10.80	181.79 ± 5.90
Weightlifting	22 ± 0.9	74.19 ± 5.96	179.25 ± 3.86

Experiment

The "weightlifting" group trained thrice a week, while the group using the stick isometric method, underwent training 5 times a week. Prior to the study, the participants signed declarations that they would not use any adjuvant drugs during the experiment. Their diet was made uniform and contained at least 2 grams of protein per 1 kg of body mass during a 24 hour period. Prior to the training, both groups were tested while performing the following tasks: "deadlift", squat, and bench press. The exercises selected for the study were easy to perform and did not require any complex technical skills. Therefore, a potential effect of the applied techniques on the improvement of sports results was excluded, and it was assumed that the resulting changes were due to the applied training methods – the weightlifting and mixed (stick isometric) method. After 4 weeks, the second test was conducted, including measurements of the same parameters as those used during the first study.

The scheme of the weightlifting group training

Monday – 1 bench pressing. 2. squats 3. Clean lift 4. Trunk bending in a supine backward position. *Wednesday* – 1. Pressing in a standing position. 2. Leg press on an adjustable incline bench. 3. Bending on a Roman Chair or snatch lift . 4. Hip lifts when leaning on forearms.

Thursday – 1. Pressing in a seated position. 2. Squats with a barbell placed on the thorax.

3. Bends with a barbell when standing on flexed knees. 4. Stretching abdominal muscles tight (knees pulled up to the chin during a balanced sitting on the edge of the chair).

Load dosing - obtaining a maximal weight (MW) according to the weightlifting method (1,12, 21) (from 40 % with 2 – 3 repetitions x 2 series with a 10% progression) + 80 % with 3 repetitions during exercises 1, 2, 3 + 100 per cent with one repetition x 3 series during exercises 1, 2, 3.

$$\frac{CM}{1}\ x3; \qquad \frac{80\%CM}{3}\ x3$$

where in the numerator % of the maximal weight; in the denominator – the number of repetitions, the number of series next to the fraction, during exercises No 4 – all series (3) "for refusal". All trainings were preceded by a warm up with no external load.

Variants of the stick isometric training

Each training session included 3exercises: Lifting and holding a barbell in the middle of bench pressing + slow lowering; reaching a semi - squat and holding the bar (the angle between the thigh and the shank, approximately 120°) + return to the baseline position, lifting and holding the bar in the middle of deadlift (the bar held on the knee level) + slow lowering.

Two training options were performed: the first one – on Monday and Tuesday, the second one – on Wednesday, Thursday and Friday.

Option I. After the warm up, the participants reached their maximal power potential, according to the weightlifting method guidelines. Next, they performed 3 series of repetitions with maximal weight during each of the above mentioned tasks. The repetition with an isometric stopping lasted 8 seconds, while the interval between each repetition also lasted 8 s., and after each series – 60 s.

Option II. After the initial warm up, the participants performed 3 series including 4 repetitions with 80% MW. The repetition with isometric stopping lasted 15s, the interval between each repetition – 60s, and the interval between each series – 180s. The value of useful work, calculated as alteration of potential bar energy while performing different exercises, constituted measurement base. The lifting height corresponded to the participant's height, according to Saksonow's method (18), modified by Kruszewski (5). The exercise volume is the ratio of the weight mass (kg) and lifting height (m). The weightlifting height is different for each training task and depends on the athlete's body height (tab. 2).

Table 2. *Weightlifting height (in % values of body height) during exercises*

KIND OF EXERCISE	LIFTING HEIGHT (%)
1. deadlift	48.4 % (of body height)
2. squat	36.9 % (of body height)
3. bench pressing (narrow grip)	26.8 % (of body height)
4. pressing while standing	30.3 % (of body height)
5. Bowing with weight on the shoulders	36.0 % (of body height)

Evaluation of maximal power potential was made using the weightlifting method. The participants' potential was examined during three exercises: squat with a bar on the shoulders, bench pressing and deadlift. The method modified for the study can be expressed by the following formula:

$$\frac{40\text{–}45\%CM}{2\text{–}3}x2\text{–}3;\quad \frac{50\text{–}55\%CM}{2\text{–}3}x2\text{–}3;\quad \frac{60\text{–}65\%CM}{2\text{–}3}x2\text{–}3;$$

$$\frac{70\text{–}75\%CM}{2\text{–}3}x2\text{–}3;\quad \frac{80\%CM}{1\text{–}3}x1\text{–}2;\quad \frac{90\%CM}{1\text{–}2}x1\text{–}2;\quad \frac{100\%CM}{1}\ x1$$

where: in the numerator – the load value in % of maximal weight (MW), in the denominator – the number of repetitions within the series, next to the dash – the number of series.

ANOVA variance analysis was used for repeated measurements; standard deviations (SDs) were calculated and significance level (SL) was accepted as 0.05. The significance of differences in mean values of the examined variables between the groups were determined using the Newman - Keulus test as well as the significance of changes in each repetition (the differences in the mean values for both groups during measurements 1 and 2). The significance of result improvement was also verified depending on the examined group (the interaction between the group and repetition). The study was conducted twice. For the final analysis, the mean values from 2 measurements were used.

Results

The study results were preceded by the analysis of work performed by both groups in one training unit during a week and month and of power developed during the training (fig.1,2,3,4)

Analysis of the data concerning work performed during one training session did not reveal any significant differences between the "weightlifting" group (22.65 kJ) and "stick isometric" group (21.22 kJ).

Weekly proportions of the performed work changed significantly. The mean value of work performed within

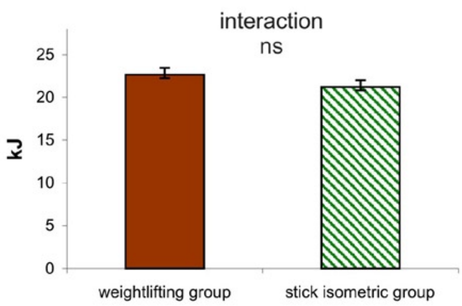


Fig. 1. *Mean value of exercise performed by the participants using the stick isometric method and weightlifting method during one training session*

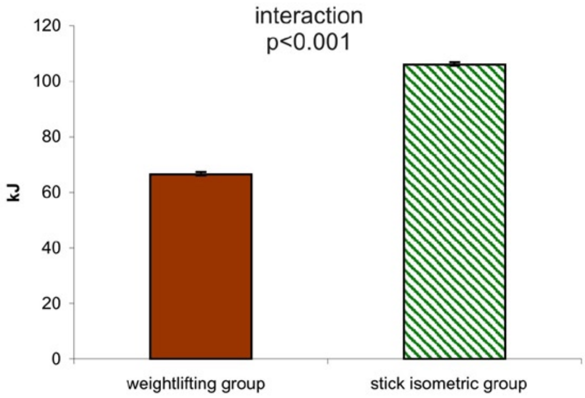


Fig 2. *The mean value of work performed by groups using the isometric method and the weightlifting method within a week*

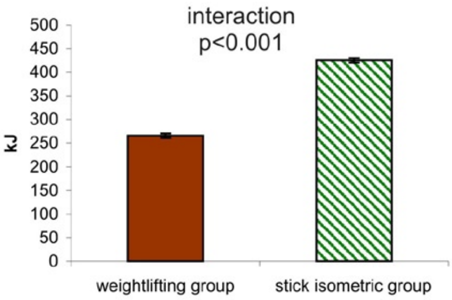


Fig. 3. *The mean monthly value of work for the weightlifting and stick isometric group*

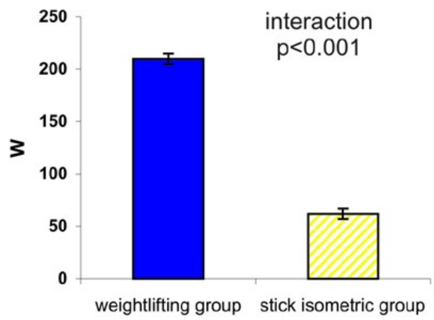


Fig. 4. *The mean value of power obtained during stick isometric and weightlifting training*

a week by a participant using the stick isometric method was 106.11 kJ, so it was significantly higher than the mean value of work performed by a weightlifting participant (66.50 kJ). This marked difference was due to the number of weekly training sessions. The "stick isometric group" underwent 5 trainings weekly, while the "weightlifting" group was trained only thrice a week.

The mean value of work performed during a mesocycle by a participant using the stick isometric method (425.53 kJ) was significantly higher compared with the mean work performed by weightlifters (266.02 kJ). This is due to the above mentioned number of training sessions.

The mean value of power obtained during one training session by a participant using the weightlifting method was 209.81 W, so it was significantly higher as compared to the participant using the stick isometric method (61.97 W). This difference probably results

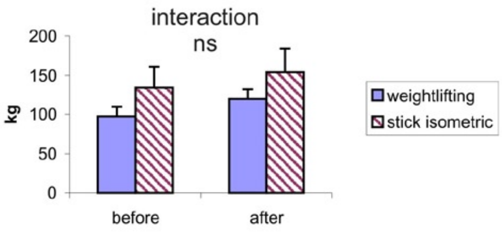


Fig. 5. *Changes in results during the „deadlift"*

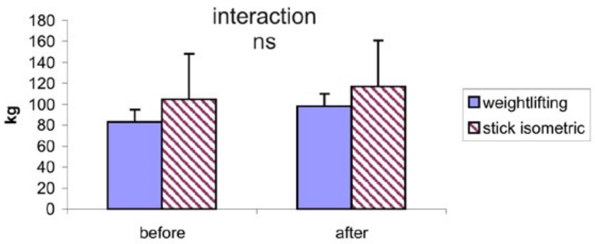


Fig 6. *Changes in results during squats*

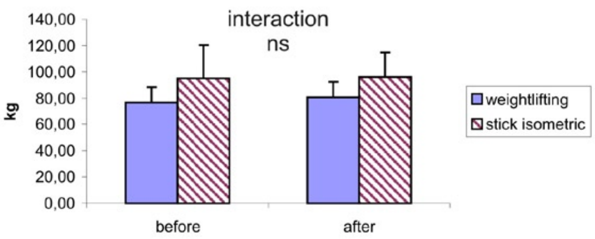


Fig. 7.*Changes in results during bench pressing*

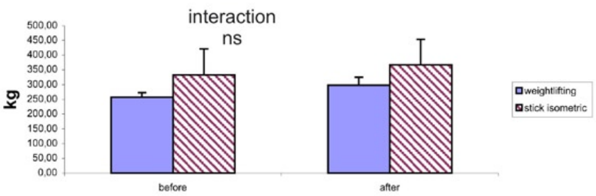


Fig. 8. *Changes in the results during powerlifting*

from markedly longer period of isometric tension, occurring when using the stick isometric method. Such a great difference might suggest obtaining better results by the group using the stick isometric method (13).

After a 4-week training session, comparison was made of the changes in absolute and relative strength during powerlifting exercises. Another comparison of absolute and relative strength was made following the weightlifting and stick isometric training mesocycle during the "deadlift" (fig. 5).

The increase in mean values of the "deadlift" results was significant for both groups (repetition effect $p<0.001$). In the weightlifting group, the mean value was 22.08 kg, while in the stick isometric group it was 20 kg. The increase in values per kg of body mass was also significant – 0.3 and 0.6 kg respectively. No marked differences were observed between the groups.

The changes in absolute and relative strength during squats with a bar on the shoulders were also compared.

The changes in mean values of the results obtained during squats with a bar on the shoulders were also significant for both groups (repetition effect $p<0.001$). In the weightlifting group the mean value was 14.79 kg, while in the stick isometric group it was 12.33 kg (Fig.6). The increase in body mass was also significant for both groups – 0.19 and 0.16 kg respectively. No significant differences were observed between groups. The changes in absolute and relative strength during bench pressing were insignificant (Fig.7).

The changes in results during bench pressing in a supine position were insignificant for both groups (repetition effect $p<0.01$). The mean value for groups using the "weightlifting" and "stick isometric" method were 3.96 kg and 1.17 kg respectively. The increase in body mass was also insignificant for both groups – 0.06 kg and 0.07 kg respectively. No significant differences between groups were observed.

After a 4-week training session, comparison was made of changes in absolute and relative strength during powerlifting for both groups (Fig. 8).

The mean improvement of the results during powerlifting was significant for the weightlifting and isometric group – 40.84 kg and 33.5 kg respectively. The increase in body weight was also significant – with the values of 0.55 kg and 0.48 kg respectively. No significant differences between groups were observed.

Discussion

The increase in the result values during powerlifting were significant for both groups, thus using both training methods favourably affected their development. It should be stressed however, that the weightlifting group worked less during the mesocycle compared to the stick isometric group. This seemed to confirm the hypothesis that high level of muscular strength might have been obtained using optimal loads instead of maximal training loads (4,5,7). Training effectiveness probably had an impact, mainly on its intensity and therefore, despite a significant difference in work performed by both groups, the increase in values of the sport results was similar (5,8,9,11,16). As the training was carried out using a weightlifting method, it proved more effective. It seemed that better results might be obtained using the mixed (stick isometric) method in case of high performance weightlifting participants (1,4,9,11,13). Therefore, the effectiveness of both training methods still needs to be examined.

In both groups, significant increase in absolute and relative strength was noted during the "deadlift", squat with a bar on the shoulders and powerlifting. Insignificant effect of both training forms on bench pressing might have been due to several factors. The load applied using both methods was close to maximal, so the number of possible repetitions was limited. The response to such stimuli was increase in strength of large muscle parts, e.g. during squats or "deadlift" (12,15,19,23-25). During bench pressing, muscular effort was stimulated by more repetitions during a longer period (1,5,19,21,24,26) and therefore, the results did not improve significantly. In conclusion, using both methods resulted in a significant increase in absolute and relative strength, and thus, significant improvement of powerlifting results.

The increase in absolute and relative strength in the weightlifting group despite markedly lower effort, might have been due to high training intensity.

References

1. Baechle TR, Groves BR. Weight Training Instruction (Steps to Success). Champaign, IL: Human Kinetics, 1994.
2. Dziedzic A. Trening ciężarowca. Warszawa: Sport i Turystyka, 1969.
3. Gazowic O, Hamar D, Schickhofer P. Effect of weight training with different velocity in concentric phase on strength and power. Conference Book of International Conf. on Weightlifting and Strength Training. Hakkinen K. ed. Lahti, Finland, 1998: 305-6.
4. Kruszewski M. C`era una volta la cortina di ferro. L`allenamento bulgaro applicato al sollevamento pesi. *BIG Fieri di Essere Bodybuilder* 2004; 2: 86-9.
5. Kruszewski M. Podnoszenie ciężarów i kulturystyka. Warszawa: COS, 2005.
6. Miedwiediew AS, Marczenko WW. K woprosu programirowanija trienirowocznych nagruzok u tiażiełoatlietow. Moskwa: Tiażiełaja Atletika, 1984: 20-4.
7. Moritani T. Time course of adaptations during strength and power training. In: Komi PV. ed. Strength and power in sport. Oxford: Blackwell Scientific Publications, 1992: 266-78.
8. Roman RA. Trienirowka tiażiełoatlieta w dwojeborije. Moskwa: Fizkultura i Sport, 1974.
9. Schmidtbleicher D. Strength training in high performance athletes. Proc. 2nd International Conference on Weightlifting and Strength Training. Lee CP. ed. Ipoh, Malaysia, 2000: 10-21.
10. Schröeder W, Harre D, Bauersfeld M, et al. Fundamentals and methods of strength training – In Principles of Sports Training. Berlin: Sportverlag, 1982: 108-24.
11. Baechle TR. ed. Essentials of strength training and conditioning. Champaign, IL: Human Kinetics, 1994.
12. Baker D, Billeter R, Hoppeler H. Muscular basis of strength. In: Komi PV. ed. Strength and power in sport. Oxford: Blackwell Scientific Publications, 1992: 39-63.
13. Eberhardt A, Kruszewski M, Szczypiorski P. The effect of muscle force mixed (stick isometric) training on the kinetic activity of peripheral blood granulocytes. Wychowanie Fizyczne i Sport – Proceedings of the 3rd International Scientific Congress on Modern Olympic Sport, Supplement, Wydawnictwo Naukowe PWN, 1999; 1: 324-5.
14. Kruszewski M, Eljasz J, Wit B, et al. Motor potential changes in effect of isometric strength training supplemented by HMB. 3rd International Conference on Strength Training – Strength training in sport and in rehabilitation. Abstract Book, November 13-17, Semmelweis University Budapest, Hungary 2002.
15. Kruszewski M, Wit B, Buśko K, et al. Effect of powerlifting training supplemented by creatin on sport results and body components. Proc. 2nd International Conference on Weightlifting and Strength Training, Lee CP. ed. Ipoh, Malaysia 2000: 103-4.
16. Zatsiorsky VM. Science and practice of strength training. Champaign: Human Kinetics, 1995.
17. Noble I, McCraw IW. Comparative effects of isometric and isotonic training programs on relative load, endurance and work capacity. *Research Quart* 1973; 44: 96-108.
18. Saksonow NN, Zariczewa KA, Aleksiejewa II. et al. Energieticzeskije traty tiażiełoatlietow na trienirowkie. Moskwa: Tiażiełaja atlietika, 1973: 21-8.
19. Tesch PA. Strength training and muscle hypertrophy. Conference Book of International Conference on Weightlifting and Strength Training. Hakkinen K. ed. Lahti, Finland, 1998: 17-22.
20. Wilson GJ. Strength and power in sport. In: Bloomfield et al. eds. Applied anatomy and biomechanics in sport. Melbourne: Blackwell, 1994: 110-208.
21. Baroga L. Necessary physical and psychological features of high performance in weightlifting. Conference Book of International Conference on Weightlifting and Strength Training. Hakkinen K. ed. Lahti, Finland, 1998: 95-100.
22. Hakkinen K. Neuromuscular adaptation to strength training in middle-age and elderly men and women. Conference Book of International Conference on Weightlifting and Strength Training. Hakkinen K. ed. Lahti, Finland, 1998: 37-42.
23. Robergs RA, Roberts S. Exercise Physiology. Exercise. Performance and Clinical Applications, Mosby–Year Book, Inc 1997.
24. Bompa TO. Cechy biomotoryczne i metodyka ich rozwoju. Warszawa: Resortowe Centrum Metodyczno-Szkoleniowe Kultury Fizycznej i Sportu, 1987.
25. Rowell LB, Shepherd JT. Handbook of physiology, Section 12: Exercise: regulation and integration of multiple systems. New York-Oxford 1996.
26. Kruszewski M, Kępa G, Merda W. Trening kulturystyczny w okresie przygotowawczym. Warszawa: AWF, 1997.

Received: February 28, 2008
Accepted: June 16, 2008
Published: June 20, 2008

Address for correspondence:
Marek Kruszewski
03-525 Warszawa
ul. Św. Wincentego 40 m. 41
e-mail: marek.kruszewski@awf.edu.pl

Artur Kruszewski: arturk-69@tlen.pl
Bartłomiej Kruszewski: bakrusz@wp.pl

Medicina Sportiva
Med Sport 12 (2): 46-48, 2008
DOI: 10.2478/v10036-008-0009-7

ABNORMAL P WAVE MORPHOLOGY IN THE ELECTROCARDIOGRAM OF A HURDLE RUNNER WITH A HISTORY OF PRESYNCOPE – A CASE REPORT

Małgorzata Poręba[1(A,B,D,E,F,G)], Robert Skalik[2(A,B,D,E,F,G)], Rafał Poręba[3(A,D)], Paweł Gać[1,3(E)], Witold Pilecki[1(E)], Ludmiła Borodulin-Nadzieja[2(E)], Małgorzata Sobieszczańska[1(E)], Ryszard Andrzejak [3(E)]

[1]Department of Pathophysiology, Medical University of Wrocław, Poland
[2]Department of Physiology, Medical University of Wrocław, Poland
[3]Department of Internal Medicine, Occupational Diseases and Arterial Hypertension, Medical University of Wrocław, Poland

Abstract

Heart rhythm disturbances and their significance for health and fitness status of endurance athletes are still under investigation. In the clinical setting, it is often difficult to clearly establish the prognostic value of abnormalities found in electrocardiographic records in athletes. Hence, a case of a 29-year-old hurdle runner after an incident of pre-syncope with changes in ECG tracings typical for an athlete concomitant with non-specific P wave morphology abnormalities is presented. It is still an unresolved issue if the P morphology resembling “P mitrale” and “P pulmonale” may predict the occurrence of supraventricular arrhythmias in athletes while preliminary echocardiography and other laboratory tests results are within the normal limits. After the detailed medical investigation we concluded that the symptoms manifested by our patient could have been due to overtraining. However, the precise mechanism of the pre-syncope remains unknown and the athlete is still under our follow-up.

Key words: *ECG, 24Holter monitoring, hurdle runner, athlete, P wave*

Case report

We present a case of a 29 year old male athlete (professional hurdle runner) with 7 year training experience who was admitted to the hospital with a history of recent incident of pre-syncope. A pre-syncope event had occurred at home with no prodromal symptoms, was not associated with physical activity and lasted very short according to patient’s report. On physical examination the patient was afebrile with heart rate of 60 beats/min, a respiratory rate of 14 breaths/min, arterial blood pressure of 120/65mmHg. No significant abnormalities including neurological dysfunctions were noted. Laboratory tests including blood levels of creatinine kinase (CK) and its isoenzyme CK MB, troponin, TSH, glucose and electrolytes were within the normal limits. The athlete was not on any permanent medication. The athlete’s electrocardiogram (ECG) demonstrated: right axis deviation (+ 100 degrees, sinus rhythm with a heart rate of 76 beats per minute, a PQ interval of 160ms, a QT interval of 348 ms (corrected QT interval was 376 ms), a “narrow” QRS complex of 96ms. A notched P wave with an increase in its amplitude up to 2,5-3 mm was found in the limb leads II, III and aVF. The duration of a P wave was 120ms resembling “P mitrale” and “P pulmonale”. High amplitude R waves were present in limb lead II, III and aVF (25-30mm) with negative T waves. In 24 hour ECG Holter monitoring and in the 12-lead resting ECG record concave ST segment elevations up to 4-5 mm were found. In 24h Holter ECG monitoring minimal, maximal and mean heart rates were, respectively: 35, 114 and 74 beats/min. 24 hour Holter monitoring was performed twice within a short period of time after the syncopic incident. Nevertheless, no significant or life threatening incidents of arrhythmia were found. Echocardiogram was normal. At present, the athlete is under regular cardiological check-up. No further incidents of presyncope or even dizziness were observed in the athlete in the follow-up.

Discussion

Physiological adaptation of the heart to intense physical training may produce both electrocardiographic (ECG) and echocardiographic changes that are usually not observed in untrained persons (1). The documented incidents of sudden cardiac death among young athletes urge the precise assessment of arrhythmias in athletes with a history of syncope (2,3). Life threatening arrhythmias may produce only mild symptoms or be manifested as a syncope or even cardiac arrest (1-3). The investigated hurdle runner did not present any recurrent symptoms before admission to hospital. Arrhythmias seen in athletes include sinus bradycardia, sinus pauses and supraventricular

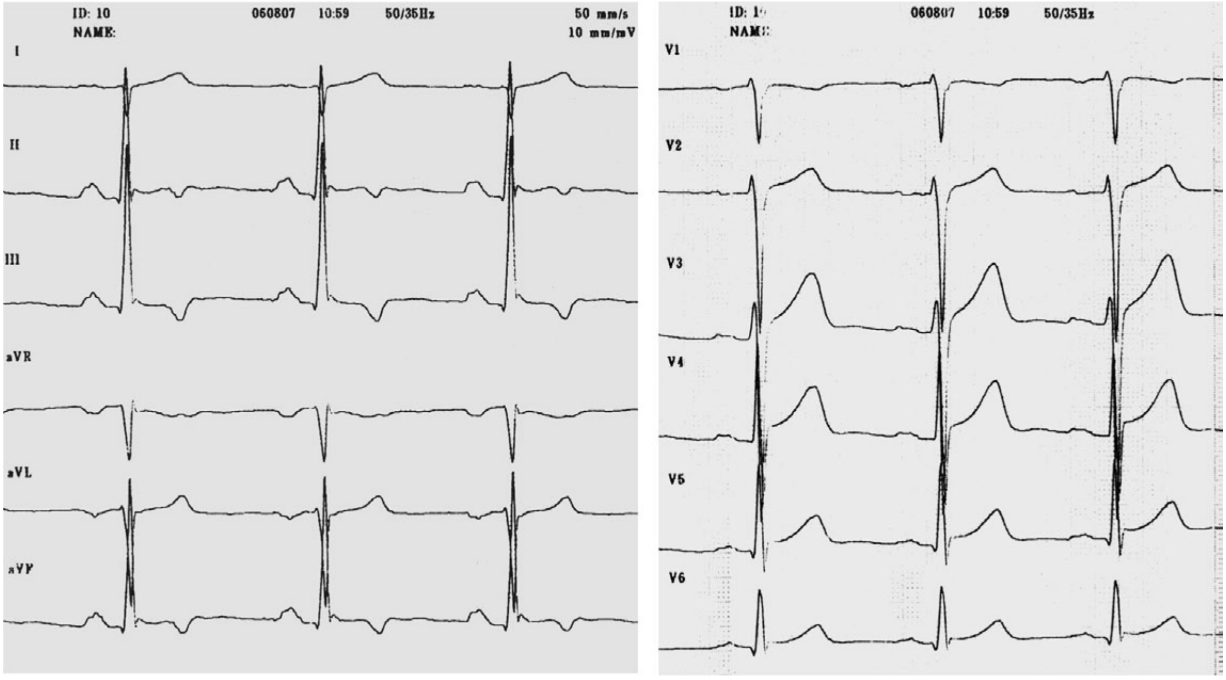


Fig. 1. *12-lead electrocardiogram of 29 year old male athlete (professional hurdle runner). The pathological P wave is observed in limb leads*

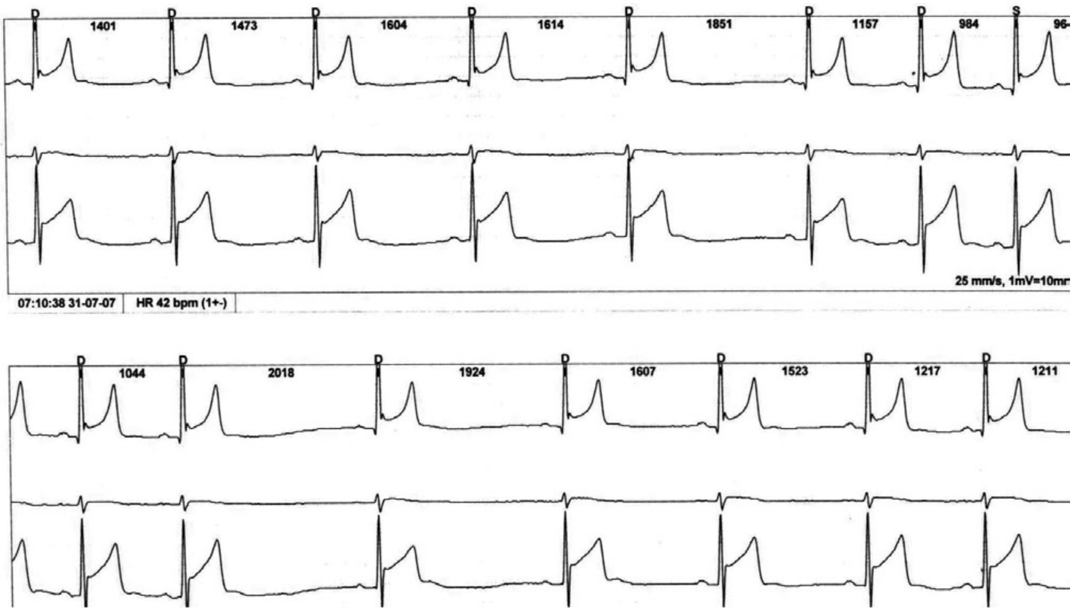


Fig. 2. *A strip from 24 hour Holter monitoring of 29 year old male athlete (professional hurdle runner). Significant concave ST elevations are present. Holter leads CM5, CM1, IS.*

ectopic beats (2,3). Conduction abnormalities such as prolonged P-Q interval, first degree AV heart block, Wenckebach type I AV heart block are also found (2,3). Other commonly seen ECG abnormalities include right axis deviation, increased right and left ventricular voltage, ST segment elevations, biphasic and inverted T waves (2,3). Previous investigations reported that atrial arrhythmias, particularly atrial fibrillation (AF), may be the heart's response to regular physical training in athletes, overtraining-induced inflammatory processes or even steroid abuse-induced hypertension, coronary artery disease or hypertrophic cardiomyopathy (4-6). Prolonged P wave duration and increased P wave dispersion (PWD), which is the difference between the shortest and the longest P wave, has been reported to be a risk factor for atrial fibrillation (7). However, Karakaya et al. did not demonstrate any significant differences in P wave duration or P wave dispersion between athletes and sedentary controls (8). Although the data are equivocal, we hypothesize that abnormal P wave morphology in the hurdle runner's ECG record could potentially be a strong substrate for incidents of supraventricular arrhythmia as a cause of presyncope. Various changes found in the ECG records of the hurdle runner formerly referred to as typical for "athlete's heart" may not explain the symptoms presented by the patient. However, sometimes it is difficult to decide whether alterations found in ECG are true pathology or typical change for athletes in case clinical symptoms are present. Regarding the presence of normal echocardiogram in the athlete , the abnormalities of the P wave could also be a phenomenon related to intensive training. However, electrocardiographic changes may forerun the ongoing structural anomaly of the athlete's heart not yet detected by echocardiography (9). For these reasons, 24h Holter monitoring was performed twice and the athlete was qualified for regular medical check-up.

Graf et al. investigated mechanisms of unexplained syncope in patients of an outpatient clinic and in majority of subjects non-invasive examinations were decisive (10). The age and number of significant prodromes were predictive factors of arrhythmic syncope (10). The authors called the diagnostic approach to patients with syncope a difficult and challenging clinical problem as syncope remains unexplained in 13-54 % of patients. Nevertheless, the most prevalent cause of syncope is vasovagal response - 23% in a group of unexplained syncope, cardio-inhibitory carotid sinus syndrome – 18 %, hypotensive (8%) and tachyarrhytmic (7%) incident. Psychogenic causes can account for less than 6 % of all syncope cases, however the authors found it in 17 % of patients with unexplained syncope (11). Moreover, Graf et al. showed that prolonged P-wave duration identifies a subgroup of patients more likely to suffer from cardiovascular disorders and arrhythmic syncope including tachy- and bradyarrhythmias (10). Hadssaguerre et al. have recently showed that in patients resuscitated after idiopathic ventricular fibrillation the prevalence of electrocardiographic early repolarization defined as an elevation of the QRS-ST junction of at least 0.1 mV from the baseline in the inferior or lateral lead manifested as QRS slurring or notching was statistically significant (12). Although the authors did not consider a group of athletes in their investigations, this suggestion prompted us to keep the patient under regular follow-up, because the similar electrocardiographic pattern as aforedescribed was present in the electrocardiogram of our patient.

Conclusions

To conclude, symptoms manifested by our patient could have been due to overtraining. However, the precise pathomechanism of the pre-syncope remains unknown and it may also belong to the group of cases of unknown origin.

References

1. Skalik R, Janocha A, Borodulin-Nadzieja L et al. The effect of different exercise protocols on leptin levels and regional left ventricular diastolic heart function among professional swimmers - a comparison with untrained subjects: a Doppler tissue imaging study. *Med Sport* 2006; 10: 24-9.
2. Ferst JA, Chaitman BR. The electrocardiogram and the athlete. *Med Sport 1*984; 1: 390-403.
3. Braksator W, Mamcarz A, Dłużniewski M. Kardiologia Sportowa: Via Medica, Gdańsk 2007.
4. Hoogsteen J, Schep G, Van Hemel NM et al. Paroxysmal atrial fibrillation in male endurance athletes. A 9-year follow up. *Europace* 2004; 6: 222-8.
5. Swanson DR. Atrial fibrillation in athletes: implicit literature-based connections suggest that overtraining and subsequent inflammation may be a contributory mechanism. *Med Hypotheses* 2006; 66: 1085-92.
6. Sullivan ML, Martinez CM, Gallagher EJ. Atrial fibrillation and anabolic steroids. *J Emerg* Med 1999; 17: 851-7.
7. Aytemir K, Ozer N, Atalar E et al. P wave dispersion on 12-lead electrocardiography in patients with paroxysmal atrial fibrillation. *Pacing Clin Electrophysiol* 2000; 23: 1109-12.
8. Karakaya O, Saglam M, Barutcu I. Comparison of the predictors for atrial rhythm disturbances between trained athletes and control subjects. *Tohoku J Exp Med* 2005; 207: 165-70.
9. Gregor P, Widimský P, Cervenka V et al. Electrocardiographic changes can precede the development of myocardial hypertrophy in the setting of hypertrophic cardiomyopathy. *Int J Cardiol* 1989; 23: 335-41.
10. Graf D, Schlaepfer J, Gollut E et al. Predictive models of syncope causes in an outpatient clinic. *Int J Cardiol* 2008; 123: 249-56.
11. Farwell D, Sulke A. Does the use of a syncope diagnostic protocol improve the investigation and management of syncope? *Heart* 2004; 90: 52–8.
12. Haïssaguerre M, Derval N, Sacher et al. Sudden cardiac arrest associated with early repolarization. *N Engl J Med* 2008; 358: 2063-5.

Received: April 17, 2008
Accepted: June 16, 2008
Published: June 20, 2008

Address for correspondence:
Małgorzata Poręba
Department of Pathophysiology
Medical University of Wrocław
Marcinkowskiego 1, 50-368, Wrocław,Poland
Fax: +48 71 784 00 61
e-mail: sogood@poczta.onet.pl

Robert Skalik rskalik@fizjo.am.wroc.pl
Rafał Poręba rporeba@ak.am.wroc.pl
Paweł Gać pawelgac@interia.pl
Witold Pilecki witpil@patfiz.am.wroc.pl
Ludmiła Borodulin-Nadzieja borodulin@fizjo.am.wroc.pl
Małgorzata Sobieszczańska malsobie@poczta.onet.pl
Ryszard Andrzejak ryszard@chzaw.am.wroc.pl

Medicina Sportiva
Med Sport 12 (2): 49-50, 2008
DOI: 10.2478/v10036-008-0010-1

ON THE PROBLEM OF DETECTING LOW BURDEN ATRIAL FIBRILLATION IN HEALTHY ATHLETES

COMMENTS ON: „ABNORMAL P WAVE MORPHOLOGY IN ELECTROCARDIOGRAM IN A HURDLE RUNNER WITH A HISTORY OF PRESYNCOPE -A CASE REPORT"

Don R. Swanson

This case report address the problem of supraventricular arrhythmias in athletes, and offer the intriguing and novel hypothesis that „abnormal P wave morphology in the hurdle runner's ECG record could potentially be a strong substrate for incidents of supraventricular arrhythmia as a cause of presyncope" (1). In a 12-lead resting ECG and two 24h Holter monitor sessions, no significant incidents of arrhythmia were found.

The plausibility and importance of the above hypothesis is enhanced by a recently reported 10-year prospective study, the aim of which was to evaluate P-wave duration and morphologic characteristics as potential risk markers for the long-term development of atrial fibrillation (AF) in a general population of apparently healthy older adults (age 55-74). The joint occurrence of a notched or deflected P-wave and long P-wave duration (>=120ms) was found to be an important risk indicator for subsequent development of AF (2). This finding, in the light of the above case report (1), suggests that it would be timely and valuable to conduct a similar study in athletes with lone AF.

There is an apparently high prevalence of AF in athletes (3,4). Because most athletes in general have excellent cardiovasacular health, and are much younger than the typical AF patient, such a prevalence is not easily explained. Overtraining and subsequent inflammation may be a contributory mechanism (4). Moreover, intensive exercise often induces acute esophageal reflux, and the usual treatment of esophageal acidic exposure with proton pump inhibitors in patients with AF as well as reflux was found, in a few studies, to diminish AF burden (5). The value of any case report of AF in athletes would be enhanced by including appropriate laboratory tests for inflammatory markers and assessment of possible esophageal reflux.

Lone paroxysmal AF (lone PAF), so often found in athletes, may be considered a pure form of AF in contrast to the far more frequent and strongly age-related prevalence of AF with multiple heart disease comorbidities. The pure form may offer a promising research target for determining the origins of AF. It is plausible to assume that the initial onset of lone PAF may typically be asymptomatic and with very low frequency and duration of episodes - i.e. low AF burden (percent of time in AF). Both AF burden and symptoms tend to increase progressively, with possibly many patients remaining asymptomatic.

Studies of elderly AF patients have reported an incidence of asymptomatic AF from 10% to 40%. However, in one small sample of patients with PAF, asymptomatic episodes were 12 times more common than symptomatic AF (6). The rate of asymptomatic PAF cases in an otherwise healthy population of athletes apparently has not been determined, but the above clinically-based AF data suggest that the percentage of asymptomatic cases may be high.

The 48h Holter monitoring in the above case report (1) may not have been adequate to assure detection of brief (<12h) infrequent (<1/week) AF episodes. In any event it is inherently difficult to detect low burden AF, and of course the absence of symptoms would add further to the difficulty.

Continued progress in automating P-wave analysis and AF diagnosis for small Holter and event monitors suitable for use while running or during other sport workouts may contribute to surmounting the difficulty of low-burden detection by making longer monitoring periods practical (7). If P-wave morphology can be truly predictive, as reported in (2), it may be possible to circumvent long monitoring periods. However it will always be difficult to distinguish new onset from a progressive increase in existing low-burden AF.

Apart from any clinical implications of very low AF burden in otherwise healthy athletes, sports medicine researchers should not overlook what may be a unique opportunity to study the origins of such AF 'in statu nascendi' so to speak.

References

1. Poręba M, Skalik R, Poręba R, et al. Abnormal P wave morphology in electrocardiogram in a hurdle runner with a history of presyncope - a case report. *Med Sport* 2008; 12(2): 46-8.
2. De Bacquer D, Willekens J, De Backer, G. Long-term prognostic value of p-wave characteristics for the development of atrial fibrillation in subjects aged 55 to 74 years at baseline. *Am J Cardiol* 2007; 100: 850-54.
3. Tagger JS, Lip GYH. Risk predictors for atrial fibrillation (Editorial). *Europace* 2008; 10: 6-8.
4. Swanson DR. Atrial fibrillation in athletes: Implicit literature-based connections suggest that overtraining and subsequent inflammation may be a contributory mechanism. *Med Hypotheses* 2006; 66:1085-92.
5. Swanson DR. Running, esophageal acid reflux, and atrial fibrillation: A chain of events linked by evidence from separate medical literatures. *Med Hypotheses* 2008; (in press). Available online at doi:10.1016/j.mehy.2008.02.017
6. Rho RW, Page RL. Asymptomatic atrial fibrillation [Review]. *Prog Cardiovasc Dis* 2005; 48(2): 79-87.
7. Grassia T. Device of the month. New event monitor accurately assesses atrial fibrillation. *Cardiol Today* 2007; August. http://www.cardiologytoday.com

Received: June 03, 2008
Accepted: June 04, 2008
Published: June 20, 2008

Address for correspondence:
Don R. Swanson
The University of Chicago
Division of the Humanities
Chicago, USA
fax: 773 702 8267
e-mail: swanson@uchicago.edu

Author's contribution	B – Data Collection	D – Data Interpretation	F – Literature Search
A – Study Design	C – Statistical Analysis	E – Manuscript Preparation	G – Funds Collection