ACTA SCIENTIARUM POLONORUM *Acta Sci. Pol., Technol. Aliment. 10(2) 2011, 223-232*
ISSN 1644-0730 (print) ISSN 1889-9594 (online)

ARE YOUNG FEMALE ATHLETES AT RISK OF AMENORRHOEA? AN ANALYSIS OF BODY COMPOSITION AND NUTRITIONAL AND ENDOCRINE FACTORS*

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Background. Some factors which have been considered to be responsible for female athlete triad include the specific type and amount of high intensity training in young female athletes (especially when begun before puberty), reduced body weight, a lower percentage of fat tissue, and psychological stress. The aim of this study is to estimate the risk of amenorrhoea in female athletes with menstrual irregularity, on the basis of body composition results, nutritional factors, and endocrine factors.
Material and methods. Fifty-five female professional athletes with menstrual irregularities, of mean ages 17.9 ±2.1 years, with mean training histories of 5.8 ±2.6 years, and BMIs of 20.6 ±1.4 kg/m^2 participated in the study. The first group (ED) included athletes from endurance disciplines (n = 30), while the second group (WD) consisted of females from weight category disciplines (n = 25). A second classification was also employed, distinguishing between the group of athletes (IH) with luteinizing hormone to follicle-stimulating hormone ratio LH/FSH < 0.6 (n = 24) – diagnosed as hypofunction of the hypothalamus-pituitary axis – and a second group (GR) containing athletes with LH/FSH > 0.6, diagnosed as a good result (n = 31). Nutritional status was evaluated on the basis of body composition analysis using the BIA method employing a Harpenden skinfold callipers, which yielded measurements of the percentage of adipose tissue (FM), fat-free mass (FFM), and skinfold thickness (ST). Nutritional values were estimated by examining dietary records for 7 consecutive days, and using threefold recall for the last 24 h. Moreover, luteinizing hormone (LH), follicle-stimulating hormone (FSH), estradiol (E), progesterone (P), and serum leptin levels were measured.
Results. Significant differences were found between the hormone levels of for each discipline group: for LH, the ED group had 3.6 ±2.5 mlU/ml, and the WC group had 5.4 ±2.4 mlU/ml ($p < 0.05$), while for FSH, the values were ED: 5.0 ±1.8 mlU/ml, WC: 6.3 ±1.5 mlU/ml

*This project was financed by the Polish Ministry of Science and Higher Education, grant number N N312 239738.

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($p < 0.05$). Furthermore, IH athletes had significantly lower LH levels compared with GR athletes (IH: 2.8 ±0.9 mlU/ml, GR: 6.2 ±2.7 mlU/ml, $p < 0.05$). FSH, LH, LH/FSH, and leptin levels were positively correlated with energy and intake of most nutrients. These results again confirm the strong influence of anthropometric parameters (BMI: $r = 0.85$, ST: $r = 0.43$, $p < 0.05$), body composition (FM%: $r = 0.79$, FFM%: $r = –0.79$, $p < 0.05$), and age at menarche ($r = –0.39$, $p < 0.05$) on serum leptin levels in IH athletes.
Conclusion. Improperly balanced diets, low fat mass, and low leptin levels are factors which predispose to amenorrhoea. Furthermore, a gonadotropin level suggestive of hypothalamic-pituitary axis hypofunction, and positively correlated with energy intake and with leptin level, is a further factor conducive to amenorrhoea.

Key words: amenorrhoea, female athletes, sex hormones, nutrition habits, leptin

INTRODUCTION

The popularity of competitive sports, and the number of women participating in professional sports, has recently seen a substantial increase [Otis et al. 1997, Loucks et al. 2007]. Some suggested factors potentially responsible for female athlete triad include the specific type and amount of high intensity training in young female athletes (especially when begun before puberty), reduced body weight, a lower percentage of fat tissue, and psychological stress [Loucks et al. 2007, Nattiv et al. 2007].

The first component of female athlete triad leading to athletic amenorrhoea is low energy availability. Low energy availability can result from insufficient caloric intake or intentionally restrictive or disordered eating behaviours [Loucks and Thuma 2003]. A negative energy balance can lead to low body weight and fat mass, and may inhibit the release of hormones in the hypothalamus, pituitary gland, and ovaries [Loucks and Thuma 2003]. It is thought that a body fat level of 22% is necessary to maintain the hypothalamic-pituitary axis and the regular menstrual cycle [Frish and Mc Arthur 1974]. Besides, a deficiency in energy availability can suppress gonadotropin-releasing hormone (GnRH) at the hypothalamus, further inhibiting the release and pulsatility of luteinizing hormone (LH) and follicle-stimulating hormone (FSH) from the pituitary gland. In healthy, active women, disruption of LH pulsatility is seen when energy availability dips below a critical value of 20-25 kcal per day per kg LBM [Bonci 2010, Miles 2001]. Furthermore, Manore [2002] has taken notice of the general occurrence of athlete undernutrition, and has emphasized that intake deficiencies of B-group vitamins, iron, and zinc can unfavourably influence reproductive function in active women.

It is also known that the level of leptin, sometimes called a “satiety hormone”, is also significantly lower in female athletes with amenorrhoea than in eumenorrhoeic athletes [Miles 2001]. Leptin expression is believed to be a key metabolic mediator which may “translate” nutritional information about the body’s energy stores and amount of body fat into endocrine responses, and is responsible for creating and maintaining a functioning hypothalamic-pituitary axis [Miles 2001]. Leptin has been suggested as a link between nutritional status and the reproductive axis in women [Miles 2001].

Prolonged secondary “athletic” amenorrhoea causes very unfavourable consequences, including decreases in bone mineral density (BMD) in different areas of the skeletal system [Christo et al. 2008]. Many studies have confirmed that female athletes with amenorrhoea have significantly lower bone density, compared with eumenorrhoeic athletes [Christo et al. 2008, Rickenlund et al. 2005]. Such decreases in bone density are also irreversible. Lo et al. [2003] have reported that even after spontaneous resumption of normal menses, these athletes may never again obtain normal bone mass, and are at a greater risk of premature osteoporosis. Furthermore, prolonged disorders in the menstrual cycle have negative effects on the lipid profile, and lead to atherosclerosis and cardiovascular diseases [Rickenlund et al. 2005].

The aim of the study is to estimate the risk of amenorrhoea in young female athletes with menstrual irregularities, on the basis of body composition, nutritional factors, and endocrine factors.

MATERIAL AND METHODS

Fifty five female professional athletes with oligomenorrhoea and dysmenorrhoea from different sports clubs in Poznań, aged 17.9 ±2.1 years, participated in this study. The athletes had a minimum of 3 years' training, with an average of 5.9 ±2.7 years' training.

Each subject completed a two-part medical questionnaire. The questions in the first part concerned personal data, and data on the characteristics of the menstrual cycle: age, age at menarche, duration of menstrual cycle, duration of menstrual bleeding, non-appearance of menstruation, and painful menstruation. Questions in the second part of the questionnaire were referred to their sports activities: the age at which the girl started training, the type of sport, the sports discipline, and training load per day.

Depending on their specific sport discipline, female athletes were assigned to two groups. The first group (ED) included athletes from endurance disciplines, which emphasize a low body weight (running 2, swimming 15, triathlon 13). The second group (WC) involved disciplines employing weight categories (rowing 12, canoeing 13).

A second classification was also used to distinguish between the group (IH) with LH/FSH < 0.6 (diagnosed as hypofunction of the hypothalamus-pituitary axis), and the group (GR) with LH/FSH > 0.6 (diagnosed as a good result).

Nutritional statuses were evaluated based on anthropometrical indices (height and weight) using an anthropometer coupled with a WPT 200 OC verified medical scale (Rad Wag). BMIs (kg/m^2) were also calculated. Participants were dressed in minimal clothing during the measurements, which were rounded to the nearest 0.5 kg and 0.5 cm. Biceps, subscapular, and suprailiac skinfold measurements (ST), accurate to 0.1 mm, were performed on the right side of the body, as described by Heyward and Wagner [2003], using a Harpenden skinfold calliper. The mean of these three measurements was used as the representative value. Analysis of body fat mass (FM) and fat-free mass (FFM) was performed in the morning after an overnight fast, with the subjects lying in a supine position, using BODYSTAT 1500 and following Heyward and Wagner [2003].

Dietary records for 7 consecutive days were obtained under the supervision of dieticians. All meals (including their recipes and item masses) and non-meal foods, beverages, and fluids were recorded in diary form. Threefold recall for the last 24 hours was carried out to verify the data from the dietary records. The nutritional value of the daily diets was analysed for energy, and nutrient levels were established by the *Dietetyk* software package, which is based on the Polish food composition tables [Kunachowicz et al. 2005].

Serum levels of luteinizing hormone (LH), follicle-stimulating hormone (FSH), estradiol (E), and progesterone (P) were determined by time-resolved fluorescence immunoassay, using commercial kits [Al-Harithy et al. 2006]. On the basis of the LH and FSH data, the presence of hypothalamus-pituitary insufficiency was estimated [Weimann 2002]. For this purpose, the LH results were divided by the FSH results, with ratios less than 0.6 signifying hypothalamus-pituitary insufficiency [Weimann 2002]. Leptin serum levels were measured by an immunoradiometric assay by RIA for leptin, using commercial kits [Leal-Cerro et al. 1998]. All hormones levels were determined in duplicate. Blood samples were taken in the morning (6.00-9.00), before the first meal. The subjects were instructed to abstain from caffeine and alcohol for 24 hours before the blood sampling, and to refrain from performing strenuous exercise on the day of sampling. None of the girls in the study used oral contraceptives or any medication which might alter the levels of the evaluated parameters.

The girls and their parents were informed in advance of all aspects of the study, and gave their written consent in each case. The study was approved by the Poznań Medical Ethics Committee (no. 334/09).

Comparisons between groups were carried out using a one-way ANOVA. In addition Spearman correlation coefficients were calculated, in order to examine the relationship between sex hormones and other parameters. Statistical analyses were performed using STATISTICA 8.0 (StatSoft, 2008). A *P* value of less than 0.05 was considered significant.

RESULTS

Significant differences between groups were observed only in the duration of the training period and in fat-free mass. Moreover, in the IH group, lower fat mass was observed as compared to the GR group (Table 1), although this was statistically non-significant.

Table 1. Athlete characteristics

	All (n = 55)	Discipline groups		Diagnosis groups	
		ED (n = 30)	WC (n = 25)	IH (n = 24)	GR (n = 31)
Age, years	17.9 ±2.1	18.3 ±2.0	17.5 ±2.2	17.8 ±2.0	18.1 ±2.2
BMI, kg/m^2	20.6 ±1.4	20.8 ±1.3	20.5 ±1.5	20.9 ±1.0	20.4 ±1.7
ST, mm	9.3 ±2.2	9.7 ±2.1	8.9 ±2.2	9.8 ±2.0	9.0 ±2.3
FM, %	19.1 ±3.9	19.2 ±3.4	19.0 ±4.5	18.8 ±4.2	19.3 ±3.7
FM, kg	11.4 ±2.5	11.2 ±2.2	11.6 ±2.8	11.4 ±2.6	11.3 ±2.5
FFM, %	80.9 ±3.9	80.8 ±3.4	81.0 ±4.5	81.4 ±4.2	80.7 ±3.7
FFM, kg	48.2 ±4.7	47.1 ±3.7^a	49.5 ±5.5^b	49.6 ±5.7^b	47.2 ±3.5^a
Intensity of training, h/day	3.9 ±1.2	3.9 ±1.1	3.9 ±1.3	4.0 ±1.3	3.8 ±1.1
Duration of training, years	5.8 ±2.6	6.5 ±3.0^b	5.1 ±2.2^a	6.3 ±2.6^b	5.3 ±2.8^a

a, b – different letter superscripts indicate significant differences ($p < 0.05$).

The nutritional patterns of the groups are presented in Table 2. Athletes' daily diets were not properly balanced for energy or for most nutrients, but no significant differences were observed between the groups.

Table 2. Daily intake of energy and nutrients

	All (n = 55)	Discipline groups		Diagnosis groups	
		ED (n = 30)	WC (n = 25)	IH (n = 24)	GR (n = 31)
Energy, kcal/d	2 503 ±569	2 384 ±537	2 654 ±580	2 480 ±554	2 486 ±591
Energy, kcal per day per kg FFM	52.3 ±12.6	51.7 ±12.2	53.0 ±13.3	51.3 ±13.2	53.1 ±12.2
Protein, g	85 ±19	81 ±15	92 ±22	82 ±18	88 ±21
Fat, g	98 ±26	98 ±27	99 ±22	92 ±20	99 ±30
Carbohydrate, g	319 ±79	303 ±69	339 ±88	320 ±82	318 ±79
Vitamin A, µg	1 318 ±157	1 507 ±205	1 092 ±655	1 530 ±222	1 154 ±793
Vitamin D, µg	2.5 ±1.5	2.4 ±1.3	2.5 ±1.8	2.5 ±1.5	2.4 ±1.5
Vitamin B_{12}, mg	4.6 ±4.7	5.5 ±1.6	3.6 ±1.3	5.7 ±6.8	4.0 ±1.7
Folic acid, µg	212 ±63	198 ±47	229 ±77	206 ±58	216 ±69
Calcium, mg	887 ±282	899 ±261	875 ±290	829 ±234	931 ±311
Magnesium, mg	327 ±86	323 ±58	336 ±105	311 ±86	339 ±86
Iron, mg	12.2 ±3.0	12.1 ±2.6	12.3 ±3.4	12.0 ±3.4	12.3 ±2.6
Zinc, mg	11.5 ±3.2	10.8 ±2.0	12.3 ±4.2	11.2 ±2.9	11.7 ±3.5

In case of hormones, the discipline groups showed significant differences in their levels of LH and FSH. Additionally, the IH athletes had significantly lower LH levels than the GR athletes.

A trend toward lower leptin levels in the IH group, as compared with the GR group, was also observed, although it was not statistically significant (Table 3).

Table 3. Endocrine factor characteristics

	All (n = 55)	Discipline groups		Diagnosis groups	
		ED (n = 30)	WC (n = 25)	IH (n = 24)	GR (n = 31)
Age at menarche, years	13.1 ±1.1	12.9 ±1.1	13.3 ±1.1	12.9 ±1.2	13.2 ±1.0
LH/FSH	0.8 ±0.4	0.8 ±0.8	0.9 ±0.3	0.5 ±0.1[a]	1.1 ±0.3[b]
LH, mlU/ml	4.5 ±2.6	3.6 ±2.5[a]	5.4 ±2.4[b]	2.8 ±0.9[a]	6.2 ±2.7[b]
FSH, mlU/ml	5.6 ±1.8	5.0 ±1.8[a]	6.3 ±1.5[b]	5.4 ±1.3	5.7 ±2.1
Estradiol, pg/ml	33.8 ±16.4	35.4 ±18.7	31.7 ±12.9	32.1 ±12.3	35.2 ±19.0
Progesterone, ng/ml	0.8 ±1.7	1.4 ±2.7	0.4 ±0.5	0.6 ±0.9	1.0 ±2.1
Leptin, ng/ml	4.5 ±2.6	4.7 ±0.6	4.4 ±2.6	3.9 ±2.0	4.9 ±2.9

a, b – different letter superscripts indicate significant differences ($p < 0.05$).

Among the IH athletes, sex hormone levels were significantly correlated with many parameters: FSH levels were found to be positively correlated with the mean skinfold measurement, energy per kg of FFM, and intakes of protein, foliate, magnesium, iron and zinc. Positive correlations were observed between the level of LH and the intake of energy and most other nutrients (protein, fat, carbohydrate, vitamin D, magnesium, iron, and zinc). A significant relationship was also found between the LH/FSH ratio and intakes of energy, protein, carbohydrate, and vitamin D.

Furthermore, the results again confirmed the strong influence of anthropometric parameters and body composition on serum leptin levels. Additionally, serum leptin levels were found to be negatively correlated with age at menarche in IH athletes, and positively correlated in both IH and GR athletes with the intake levels of energy and of all nutrients, including microelements and vitamins (Table 4).

Table 4. Relationship between selected hormones, body composition, and nutritional values in female athletes with hypothalamus-pituitary axis hypofunction

	FSH	LH	E2	P	LH/FSH	Leptin
BMI, kg/m^2	0.18	0.06	0.25	0.27	–0.10	0.85
FM, %	0.08	0.30	0.18	–0.27	0.30	0.79
FM, kg	0.10	0.29	0.33	–0.30	0.27	0.04
FFM, %	–0.08	–0.30	–0.18	0.27	–0.30	–0.79
FFM, kg	0.011	–0.10	0.22	0.05	–0.21	0.17
ST, mm	0.41	0.36	0.26	–0.32	0.08	0.43
Training period, years	–0.02	–0.29	–0.28	0.23	–0.31	0.09
Age of menarche, years	–0.19	–0.26	–0.09	0.17	–0.17	–0.39
Intensity of training, h per day	0.24	0.05	–0.01	–0.16	–0.12	0.52
Energy, kcal	0.30	0.59	0.07	–0.02	0.45	0.60
Energy, kcal per day/kg FFM	0.39	0.35	0.07	–0.17	0.1	0.04
Protein, g	0.46	0.70	0.04	–0.17	0.44	0.59
Fat, g	0.26	0.46	0.21	0.08	0.34	0.58
Carbohydrate, g	0.26	0.59	0.01	–0.04	0.47	0.56
Vitamin A, µg	0.16	–0.03	–0.36	–0.10	–0.20	–0.17
Vitamin D, µg	0.36	0.69	0.15	–0.08	0.52	0.42
Vitamin B_{12}, mg	0.18	0.05	–0.30	–0.10	–0.12	–0.13
Foliate, µg	0.57	0.33	–0.35	–0.13	–0.17	0.61
Calcium, mg	0.11	0.28	0.33	–0.31	0.26	0.07
Magnesium, mg	0.57	0.62	–0.22	–0.19	0.20	0.49
Iron, mg	0.54	0.57	–0.26	–0.11	0.17	0.59
Zinc, µg	0.59	0.75	–0.01	–0.14	0.35	0.53

DISCUSSION

Athletic amenorrhoea was first recognized in the late 1970s, and was thought to be due to the effect of intensive endurance exercise and poor dietary intake, leading to inadequate nutritional status due to hypofunction of the hypothalamus-pituitary axis [Feicht et al. 1978]. Several studies suggest that prolonged secondary amenorrhoea leads to osteoporosis in premenopausal age [Noakes and Van Gend 1988].

In this study, factors conducive to amenorrhoea in athletes with menstrual irregularity were examined. Our findings support previous results from the literature, that the diets of female athletes with menstrual disorders were not properly balanced in respect of energy and of several nutrients which have an effect on the regulation of the menstrual cycle – namely zinc, folic acid, and magnesium. The values of calcium and vitamin D intake – essential nutrients in the prevention of osteoporosis – were also similar to the results of some other authors [Heaney et al. 2010]. Moreover, the energy values of the athletes' diets were lower than the recommended norm, but the energy densities of the daily diets were higher than 30 kcal/kg FFM/24 h.

Secondly, all athletes participating in this study had a level of body fat lower than 19%. According to Thong et al. [2000] and Nicholas et al. [2007], this is a serious condition which may contribute to amenorrhoea. Other authors have also observed lower fat mass in athletes with menstrual disorders [Thong et al. 2000], and have suggested that high body fat can protect against the development of amenorrhoea. Also, female athletes whose gonadotrophin levels point to hypothalamic-pituitary insufficiency have lower body fat than other athletes, although this difference was not statistically significant. Stokić et al. [2005] examined the body composition of ballet dancers, and determined that inadequate body fat mass was the main cause of amenorrhoea in this group of women.

Thirdly, it has been supposed that menstrual disorders in athletes caused by low levels of body fat may be related to defects of endocrinal function and lower serum leptin level. The results of several studies with professional female athletes with low body and low fat mass have shown that low serum leptin level can lead to dysfunction in the menstrual cycle [Miles 2001]. Indeed, Miles [2001] has pointed to significantly lower serum leptin level in athletes with amenorrhoea, as compared to eumenorrhoeic athletes [Miles 2001]. These findings are supported by the present study, in that serum leptin levels in athletes were significantly lower than the physiological range. Additionally, non--significant differences were observed in athletes with different values of gonadotrophin LH/FSH ratio: specifically, the athletes whose gonadtrophin ratios indicated hypothalamic-pituitary axis hypofunction had lower serum leptin levels.

Furthermore, this study also focused on the relationship between the level of leptin and sex hormones, body composition, training period, and nutritional habits in the athletes with hypothalamic-pituitary axis hypofunction. The results support the previous findings in the literature that there is a strong relationship between the level of leptin, on one hand, and body composition and nutritional habits, on the other. The relationship between sex hormones, body composition, energy, and nutrition intake shows that the energy and nutrition value of daily diets has a significant effect on endocrinal factors. The hypothesis of Matkovic et al. [1997], Maïmoun et al. [2010], and Weimann et al. [2002], emphasizing significant association between menarche and disorders of the menstrual cycle on the one hand with low leptin levels in older age on the other, has also been confirmed. These authors have also shown that delayed menarche can be a significant factor in osteoporosis at the premenopausal stage [Matkovic 1997], and they further emphasize the risk of consequent menstrual disorders in female athletes with inadequate gonadotrophin ratios, as their age of menarche is clearly delayed.

It should be pointed out that LH/FSH ratios lower than 0.6, and FSH values lower than 0.3 mlU/ml, can be diagnosed as hypothalamic-pituitary hypofunction: the endurance athletes had FSH results near to this value. It has been frequently shown in other studies that aesthetic and endurance sports constituted the greatest risks to reproductive function among female athletes [Sherman and Thompson 2006]. That study also showed that gonadotrophin levels were significantly lower in endurance athletes.

CONCLUSION

It seems that endurance discipline athletes are at a serious risk of amenorrhoea, on account of the positive correlation found to obtain between gonadotropin levels (which can be used to diagnose hypofunction of the hypothalamic-pituitary axis) and energy intake, as well as leptin level.

Further research conducted on a larger group of female athletes seems, however, to be necessary.

REFERENCES

Al-Harithy R.N., Al-Doghaither H., Abualnaja K., 2006. Correlation of leptin and sex hormones with endocrine changes in healthy Saudi women of different body weights. Ann. Saud. Med. 26, 2, 110-115.

Bonci L., 2010. Sports nutrition for young athletes. Pediatr. Ann. 39 (5), 300-306.

Christo K., Prabhakaran R., Lamparello B., Cord J., Miller K.K., Goldstein M.A., Gupta N., Herzog D.B., Klibanski A., Misra M., 2008. Bone metabolism in adolescent athletes with amenorrhea, athletes with eumenorrhea, and control subjects. Pediatrics 121 (6), 1127-1136.

Feicht C.B., Johnson T.S., Martin B.J., Sparkes K.E., Wagner W.W. Jr., 1978. Secondary amenorrhoea in athletes. Lancet 2, 1145-1146.

Frish R.E., Mc Arthur J.W., 1974. Menstrual cycles: fatness as a determinacy of minimum weight and height necessary for their maintenance or onset. Science 185, 849-860.

Heaney S., O'Connor H., Gifford J., Naughton G., 2010. Comparison of strategies for assessing nutritional adequacy in elite female athletes' dietary intake. Int. J. Sport. Nutr. Exerc. Metab. 20 (3), 245-256.

Heyward V.H., Wagner D.L., 2003. Applied Body Composition Assessment. Human Kinetics Champaign, IL.

Kunachowicz H., Nadolna I., Przygoda B., Ivanow K., 2005. Tables of nutritional value of foodstuffs and dishes. Inst. Żywn. Żyw. Warszawa.

Leal-Cerro A., Garcia-Luna P.P., Astorga R., Parejo J., Peino R., Dieguez C., Casanueva F.F., 1998. Serum leptin levels in male marathon athletes before and after the marathon run. J. Clin. Endocrinol. Metab. 3 (7), 2376-1379.

Lo B.P., Hebert C., McClean A., 2003. The female athlete triad: No pain, no gain? Clin. Pediatr. 42, 573.

Loucks A.B., Manore M.M., Sanborn C.F., Sundgot-Borgen J., Warren M.P., 2007. The female athlete triad: position stand. Med. Sci. Sports Exerc. 39, 1867-1881.

Loucks A.B., Thuma J.R., 2003. Luteinizing hormone pulsatility is disrupted at a threshold of energy availability in regularly menstruating women. J. Clin. Endocrinol. Metab. 88 (1), 297--311.
Manore M.M., 2002. Dietary recommendation and athletic menstrual dysfunction. Sports Med. 32 (14), 887-901.
Matkovic V., Ilich J.Z., Skugor M., Badenhop N.E., Goel P., Clairmont A., Klisovic D., Nahhas R.W., Landoll J.D., 1997. Leptin is inversely related to age at menarche in human females. J. Clin. Endocrinol. Metab. 82, 10, 3239-3245.
Maïmoun L., Coste O., Galtier F., Mura T., Mariano-Goulart D., Paris F., Sultan C., 2010. Bone mineral density acquisition in peripubertal female rhythmic gymnasts is directly associated with plasma IGF1/IGF-binding protein 3 ratio. Eur. J. Endocrinol. 163 (1), 157-164.
Miles M., 2001. Leptin: A link between energy imbalance and exercise-induced amenorrhea in female athletes. Nutrition Bytes 7 (2).
Nattiv A., Loucks A.B., Manore M.M., Sanborn C.F., Sundgot-Borgen J., Warren M.P., 2007. American college of sports medicine position stand. The female athlete triad. Med. Sci. Sports Exerc. 39 (10), 1867-1882.
Nicholas J.N., Rauch M.J., Barrack M.T., Barkai H.S., Nichols J.F., 2007. Disordered eating and menstrual irregularity in high school athletes in lean-build and nonlean-build sports. Int. J. Sport. Nutr. Exerc. Metabol. 17, 364-377.
Noakes T.D., Van Gend M., 1988. Menstrual dysfunction in female athletes. A review for clinicians. S. Afr. Med. J. 73, 350-355.
Otis C.L., Drinkwater B., Johnson M., Loucks A.B., Wilmore J., 1997. ACSM position stand: The female athlete triad. Am. Coll. Sport Medic. 29, 1-9.
Stokić E., Srdić B., Barak O., 2005. Body mass index, body fat mass and the occurrence of amenorrhea in ballet dancers. Gynecol. Endocrinol. 20 (4), 195-199.
Rickenlund A., Eriksson M.J., Schenck-Gustafsson K., Hirschberg A.L., 2005. Amenorrhea in Female athletes is associated with endothelial dysfunction and unfavorable lipid profile. J. Clin. End. Metabol. 90 (3), 1354-1359.
Sherman R.T., Thompson R.A., 2006. Practical use of the International Olympic Committee Medical Commission Position Stand on the female athlete triad: a case example. Int. J. Eat. Disord. 39, 193-201.
Thong F.S.L., McLean C., Graham T.E., 2000. Plasma leptin in female athletes: relationship with body fat, reproductive, nutritional, and endocrine factors. J. Appl. Physiol. 88 (6), 2037-2044.
Weimann E., 2002. Gender-related differences in elite gymnasts: the female athlete triad. J. Appl. Physiol. 92 (5), 2146-2152.

CZY MŁODE SPORTSMENKI SĄ ZAGROŻONE WYSTĄPIENIEM AMENORRHOEA? ANALIZA SPOSOBU ŻYWIENIA, STANU ODŻYWIENIA ORAZ CZYNNIKÓW ENDOKRYNOLOGICZNYCH

Wstęp. Intensywny wysiłek fizyczny podejmowany przez młode sportsmenki, szczególnie przed wejściem w okres dojrzewania, niski odsetek tkanki tłuszczowej, redukcja masy ciała oraz stres towarzyszący rywalizacji sportowej są uważane za czynniki predysponujące do wystąpienia zespołu triady sportsmenek. Celem badań była ocena ryzyka wystąpienia amenorrhoea na podstawie stanu odżywienia, sposobu żywienia oraz czynników endokrynologicznych u zawodniczek cierpiących na zaburzenia miesiączkowania.
Materiał i metody. Do badań włączono 55 sportsmenek – w wieku 17,9 ±2,1, średnim stażu treningowym 5,8 ±2,6 roku oraz BMI 20,6 ±1,4 kg/m^2 – cierpiących na zaburzenia miesiączkowania. Zawodniczki podzielono na grupy w zależności od charakteru uprawia-

nej dyscypliny [dyscypliny wytrzymałościowe ED (n = 30), dyscypliny wymagające podziału według kategorii wagowych WC (n = 25)]. Drugi podział uwzględniał wynik badania hormonów gonadotropowych (LH/FSH < 0,6 – niewydolność przysadki mózgowej, IH (n = 24), LH/FSH > 0,6, GR (n = 31)]. Stan odżywienia oceniono na podstawie analizy składu ciała metodą BIA (odsetek tkanki tłuszczowej (FM) oraz beztłuszczowej masy ciała (FFM)) oraz pomiaru grubości fałdów skórno-tłuszczowych (ST) z wykorzystaniem cyrkla Harpendena. Ocenę sposobu żywienia przeprowadzono na podstawie metody bieżącego notowania z siedmiu dni oraz metodą trzykrotnego wywiadu z ostatnich 24 godzin. Co więcej, określono również poziom hormonów płciowych (hormon luteinizujący (LH), folikulotropowy (FSH), estrogeny (E), progesteron (P)) oraz leptyny we krwi.
Wyniki. W zależności od uprawianej dyscypliny sportowej, istotne statystycznie różnice zaobserwowano w poziomie LH (ED: 3,6 ±2,5 mlU/ml, WC: 5,4 ±2,4 mlU/ml, p < 0,05) oraz FSH (ED: 5,0 ±1,8 mlU/ml, WC: 6,3 ±1,5 mlU/ml, p < 0,05). Zawodniczki IH charakteryzował znamiennie niższy poziom LH w porównaniu z grupą GR (IH: 2,8 ±0,9 mlU/ml, GR: 6,2 ±2,7 mlU/ml, p < 0,05). Co więcej u zawodniczek IH odnotowano istnienie dodatniej korelacji pomiędzy spożyciem energii i większości składników odżywczych. Otrzymane wyniki po raz kolejny potwierdziły istnienie zależności pomiędzy parametrami antropometrycznymi (BMI: r = 0,85, ST: r = 0,43, p < 0,05), składem ciała (FM%: r = 0,79, FFM%: r = –0,79, p < 0,05) i wiekiem menarche (r = –0,39, p < 0,05) a poziomem leptyny we krwi zawodniczek IH.
Wnioski. Nieodpowiednio zbilansowana dzienna racja pokarmowa, niski odsetek tkanki tłuszczowej oraz poziomu leptyny w surowicy krwi to czynniki predysponujące do zaniku miesiączkowania. Co więcej, kolejnym czynnikiem sprzyjającym wystąpieniu amenorrhoea są wyniki gonadotropin wskazujące na występowanie niewydolności przysadki, pozytywnie korelujące z spożyciem energii oraz poziomem hormonu sytości.

Słowa kluczowe: amenorrhoea, sportsmenki, hormony płciowe, sposób żywienia, leptyna

Received – Przyjęto: 11.10.2010

Accepted for print – Zaakceptowano do druku: 18.12.2010

For citation – Do cytowania: Łagowska K., Jeszka J., 2011. Are young female athletes at risk of amenorrhoea? An analysis of body composition and nutritional and endocrine factors. Acta Sci. Pol., Technol. Aliment. 10(2), 223-232.