

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

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Abstract

Background: It is assumed that leptin affects the circulatory system. The aim of this study was to assess the influence of chronic, dynamic and static physical effort on leptin levels and regional diastolic heart function as measured by Tissue Doppler Echocardiography in endurance athletes and healthy volunteers.

Material and Methods: A total of 120 persons participated in the study including 60 endurance athletes (professional swimmers) and 60 healthy volunteers with low physical activity. The blood concentration of leptin at rest was measured under fasting conditions in all the subjects. The leptin levels were also measured in 30 athletes and 30 volunteers immediately after dynamic and static exercises. Moreover, the echocardiographic interrogation of regional diastolic heart function was performed in 120 subjects at rest and in 60 subjects (30 athletes and 30 volunteers) shortly after dynamic and static physical effort.

Results: The relationship between leptin levels and parameters of regional left ventricular function was not confirmed. A significant effect of acute and chronic physical effort on regional diastolic heart function was exhibited among professional swimmers.

Conclusions: 1. A significant relationship between regular physical training and leptin levels was not confirmed among professional swimmers, however acute dynamic exercise had a significant impact on blood concentrations of leptin, 2. leptin does not exert an immediate and significant effect on regional left ventricular heart function among professional swimmers, 3. the period of training significantly correlates with changes in regional diastolic heart function among athletes.

Key words: physical exercise, leptin, diastolic heart function, Tissue Doppler Echocardiography, professional swimmers

Introduction

Sports medicine and cardiology have been searching for objective and easy to use tools to facilitate assessment and monitoring of circulatory system adaptation to various training models among athletes and their relationships to body mass regulation. Body mass regulation is a complicated and ambiguous phenomenon. It has been known for many years that homeostatic mechanisms exist which regulate food intake and energy consumption and that these regulatory mechanisms are hereditary (1,2). Leptin, a protein produced and secreted mostly by adipocytes, has recently been separated and described as a key player in the maintenance of body-mass homeostasis (2). It is also assumed that leptin immediately influences left ventricular heart function (2,3). It has been

recently suggested that leptin plays a significant role in the intricate cascade of cardiovascular events (4). It plays a crucial role in cardiac muscle metabolism, contributes to the geometry, mass and thickness of myocardial walls (5). Dong et al. (6) has reported that leptin-deficient ob./ob. obese mice may demonstrate impaired cardiac contractile function. Additionally, leptin level is also a strong predictor of first acute myocardial infarction (7). It is hypothesized that leptin is involved in both postinfarctous cardiac muscle injury and the pathogenesis of heart failure (8). Leptin's contribution to the physiology of regional left ventricular diastolic function as measured by Tissue Doppler Echocardiography (TDE) in endurance athletes has not been thoroughly investigated as yet. There are also contradictory published reports

regarding the nature and influence of physical effort on blood leptin levels. Moreover, there is a scarcity of data on leptin's physiology in response to different models of short lasting physical effort in professional swimmers. Hence, the aim of this study was to assess the influence of acute (dynamic and static) and regular physical effort on both serum leptin levels and regional diastolic heart function as measured by Pulsed Wave Tissue Doppler Echocardiography (PW-TDE) among professional swimmers.

Material and Methods

A total of 120 persons, including 60 endurance athletes (30 male and female swimmers aged 25.46 ± 3.86 years) and 60 healthy untrained volunteers (control group) (30 males and 30 females, aged 23.76 ± 3.24 years) entered the study. They were familiarised with the procedures prior to giving their written consent to be used in this experiment as approved by the medical ethics committee of the Medical University of Wrocław (research grant 460). The characteristics of the subjects are presented in table 1. Leptin levels were measured at rest under fasting conditions in athletes and healthy volunteers. Leptin levels were also measured immediately after dynamic (bicycle ergometry, ERG 551, Bosch Geschäftsbereich Elektronik, Germany) and static (lifting dumb-bells in a recumbent position) exercise under fasting conditions in 30 athletes and 30 persons from the control group. The measurements of serum leptin levels were performed using radioimmunological methods (LINCO Research Company, Missouri USA). Every investigated person had been asked to refrain from drinking coffee or alcohol and intensive effort for 24 hours before the blood samples were taken to measure the leptin concentration in the blood. All the participants (endurance athletes and the control group) underwent transthoracic echocardiographic interrogation using a 2.5MHz transducer with commercially available equipment (Sonos 5500 echomachine) at rest. The measurements of the dimensions of the heart cavities, left ventricular (LV) mass, LV ejection fraction were taken during conventional echocardiographic examination. The selected parameters of regional diastolic

heart function (e' - regional early mitral filling velocity, a' - regional late mitral filling velocity, dt' - regional deceleration time, $ivrt'$ - regional isovolumic relaxation time) were interrogated using PW-TDE after placing the sample volume at the medial corner of the mitral annulus in apical four chamber view (longitudinal axis of heart). The interrogation of dt' was made from the peak of e' velocity to its termination. The measurement of $ivrt'$ was performed from termination of s velocity to the onset of e' velocity. The measurements of regional LV diastolic function velocities and times from five cardiac cycles were averaged. 60 persons (30 endurance athletes and 30 healthy volunteers) were also interrogated using echocardiography shortly after dynamic and static exercise. The dynamic exercise using bicycle ergometer was started with a workload of 30 Watts and gradually increased by 30 Watts every 3 minutes and then continued until submaximal heart rate (85% of target rate; target rate = $220 - \text{age}$) was reached. At the end of each stage, the heart rate, systolic blood pressure and a 12-lead ECG were recorded by means of a cardiological monitoring system (Case 15, Marquette Electronics Inc. Milwaukee Wisconsin USA 1991) in all the studied persons throughout the exercise protocol and for 30 minutes after the exercise. The same 60 persons were submitted also to static exercise (weight – lifting in recumbent position). The static exercise was also continued until the submaximal heart rate was reached. Within 30 seconds after cessation of dynamic and static exercise the aforementioned parameters of LV diastolic function as measured by PW-TDE were evaluated according to the above-described methodology. The peak heart rate was not significantly different from the heart rate registered at the moment of post-exercise echocardiographic examination. No subjective adverse effects were observed during and after cessation of the dynamic and static exercises in both groups. Statistical analysis was performed using STATISTICA 6.0. Mean and standard deviations were calculated. Normal distribution of data was tested by the Shapiro-Wilk test. Non-parametric U-Mann-Whitney and Kruskal-Wallis tests were applied because the normal distribution of data was not confirmed. Correlations between investigated

Table 1. *The subjects characteristics (mean $\pm$ SD)*

Parameter	Endurance athletes (n = 60)	Healthy volunteers (n = 60)	p
Age [years]	25.46 ± 3.86	23.76 ± 3.24	ns
Duration of training [years]	11.76 ± 3.49	-----	-----
Height [cm]	175.96 ± 8.03	174.63 ± 6.53	ns
Body weight [kg]	81.56 ± 8.03	74.86 ± 6.53	$p < 0.05$
Body mass index [$\text{kg} \cdot \text{m}^{-2}$]	26.09 ± 3.31	24.62 ± 2.64	ns
Ejection fraction [%]	66.53 ± 4.61	67.16 ± 4.68	ns

parameters were assessed using the non-parametric Spearman coefficient. Statistical significance was set at $p < 0.05$

Results

The interrogation of LV diastolic function at rest as measured by Tissue Doppler echocardiography did not demonstrate any differences in the examined parameters between endurance athletes and control group (Tab. 2). The physical effort caused significant changes of some of the investigated parameters of regional diastolic LV function in both groups. The echocardiographic interrogation of regional LV diastolic function after static and dynamic effort confirmed the existence of significant differences in mitral annulus diastolic velocities and times between the studied

groups (athletes vs healthy volunteers). The dt' and $ivrt'$ were found shorter after dynamic effort in endurance athletes as compared with the healthy volunteers. Among the endurance athletes who participated in the study the value of e' velocity was higher than in the control group after both dynamic and static exercise. Similarly, a' velocity was lower in endurance athletes than in healthy volunteers (Tab. 3a, Tab. 3b). Positive linear correlation between duration of regular training and isovolumic relaxation time ($ivrt'$) as measured by PW-TDE at rest was exhibited ($r=0.38$; $p<0.05$) (Fig. 1). There were no significant differences in serum leptin levels at rest between endurance athletes and the control group. However, dynamic effort caused a significant decrease in serum leptin level in relation to its baseline value in both studied groups (Tab. 4). The

Table 2. The regional LV diastolic function parameters at rest in professional swimmers and healthy volunteers (mean $\pm$ SD)

Parameter	Endurance athletes (n = 60)	Healthy volunteers (n = 60)	P
e' [cm·s ⁻¹]	15.40 $\pm$ 3.82	14.60 $\pm$ 3.53	ns
a' [cm·s ⁻¹]	11.80 $\pm$ 2.76	11.80 $\pm$ 2.58	ns
dt' [ms]	116.67 $\pm$ 29.92	105.67 $\pm$ 28.46	ns
$ivrt'$ [ms]	62.33 $\pm$ 22.27	59.67 $\pm$ 17.86	ns

Table 3a. The regional LV diastolic parameters after dynamic exercise in professional swimmers and healthy volunteers (mean $\pm$ SD)

Parameter	Endurance athletes (n = 30)	Healthy volunteers (n = 30)	P
e' [cm·s ⁻¹]	17.77 $\pm$ 3.07	15.40 $\pm$ 3.82	<0.01
a' [cm·s ⁻¹]	10.10 $\pm$ 2.35	11.79 $\pm$ 2.77	<0.01
dt' [ms]	103.83 $\pm$ 27.06	116.67 $\pm$ 29.92	<0.05
$ivrt'$ [ms]	51.83 $\pm$ 18.07	62.33 $\pm$ 22.27	<0.05

Table 3b. The regional LV diastolic parameters after static exercise in professional swimmers and healthy volunteers (mean $\pm$ SD)

Parameter	Endurance athletes (n = 30)	Healthy volunteers (n = 30)	P
e' [cm·s ⁻¹]	18.67 $\pm$ 3.16	13.83 $\pm$ 3.07	<0.001
a' [cm·s ⁻¹]	9.43 $\pm$ 2.16	11.80 $\pm$ 2.76	<0.001
dt' [ms]	109.67 $\pm$ 29.42	113.83 $\pm$ 29.58	ns
$ivrt'$ [ms]	57.50 $\pm$ 20.37	64.00 $\pm$ 17.93	ns

Table 4. Serum leptin levels (ng·ml⁻¹) at rest (I), after dynamic exercise (II) and static exercise (III) in endurance athletes and healthy volunteers (mean $\pm$ SD)

Group	Athletes	Healthy volunteers
At rest (I) vs dynamic exercise (II)	5.49 $\pm$ 4.79 (n = 60) * vs 2.91 $\pm$ 2.49 (n = 30) p < 0,05	7.33 $\pm$ 5.02 (n = 60) * vs 3.30 $\pm$ 3.02 (n = 30) p < 0,05
At rest (I) vs static exercise (III)	5.49 $\pm$ 4.79 (n = 60) vs 4.72 $\pm$ 4.21 (n = 30) ns	7.33 $\pm$ 5.02 (n = 60) vs 5.23 $\pm$ 4.05 (n = 30) ns

* leptin levels at rest: athletes vs healthy volunteers; $p > 0.05$

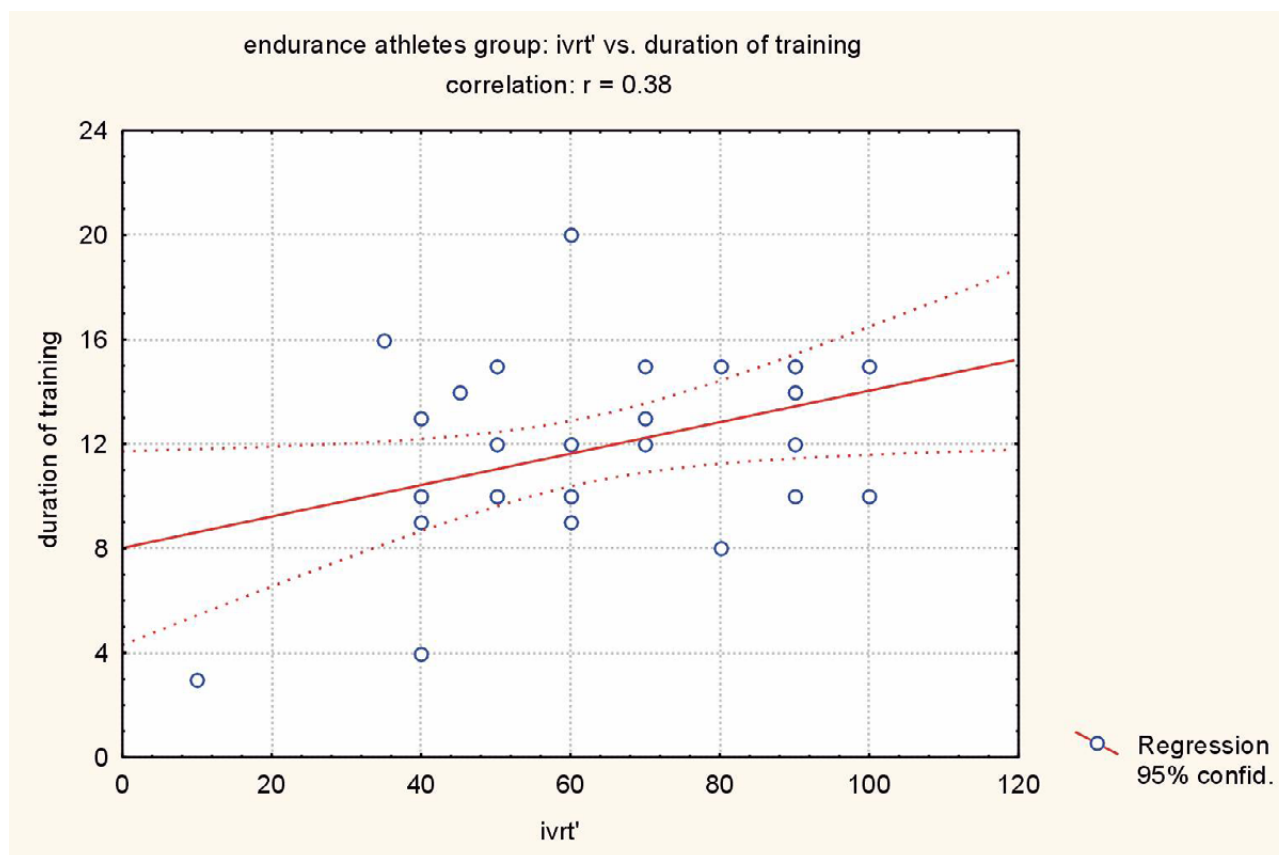


Fig.1. Positive linear correlation between regular training period (years) and isovolumic relaxation time (ivrt') at rest in professional swimmers ($r=0.38$; $p<0.05$)

static effort did not have a significant effect on leptin concentration in blood in these groups. There was no significant relationship between the training experience and serum leptin level at rest, following static and dynamic exercise in endurance athletes. There was no significant correlation between serum leptin level at rest and after exercise (static and dynamic effort) and body mass index (BMI), height and weight both in endurance athletes and the controls. No significant relationship between serum leptin levels and the investigated parameters of regional LV function at rest and on acute physical exercise (dynamic and static effort) were found, either.

Discussion

Clinical and experimental studies conducted to date have confirmed the significant contribution of hormonal system to the body mass regulation and functioning of cardiovascular system (9). Numerous reports on the influence of physical exercise on the dynamics of leptin production by adipocytes and its relation to physiology of cardiovascular system both in endurance athletes and normal activity persons can be found in the literature (3, 8, 9, 10). Moreover, leptin is recognized by some authors as a strong marker of training stress (11). At the same time, it has also been demonstrated that some changes in regional diastolic LV heart function as measured with use of Tissue Doppler Echocardiography (TDE) reliably reflect the effect

of various training protocols on myocardial function among athletes (12). This is commonly known that the assessment of left ventricular diastolic function with Conventional Doppler imaging is depended on many factors, which in fact are not immediately related to the heart filling conditions and heart function (13). Thus TDE is considered a new promising tool in this respect (12, 14, 15). Experimental studies conducted on animals have confirmed the important role of leptin in the regulation of heart function. Christoffersen et al. (16) have indicated a considerable accumulation of lipid molecules in cardiomyocytes and their role in the impairment of LV global diastolic heart function in mice with the ob.-leptin encoding gene mutation. The obtained results of the study did not demonstrate any significant differences in serum leptin levels and Doppler Tissue parameters of regional diastolic heart function at rest between professional swimmers and the control group. On the other hand, the significant decrease in serum leptin levels in response to the acute dynamic exercise was observed both in athletes and the control group. Furthermore, Leal-Cerro et al. (17) have shown a significant decrease in serum leptin concentration on acute physical effort in endurance athletes. Although, the static effort did not significantly influence serum leptin levels in either of the investigated groups. Moreover, some of the investigators do not confirm any remarkable influence of acute exercise on leptin levels irrespective of the training status of the

examined persons (18). Probably the contradictory results of the aforementioned investigations were caused by a non-uniformity of the examined groups, differences in training status and gender-related factors relating to leptin's response to acute physical stress. As to the echocardiography, the significant changes in regional diastolic LV function in response to the dynamic and static exercise were also noted. The significantly stronger amelioration of regional diastolic velocities and times in response to acute exercise in athletes when compared with the control group was probably an effect of good adaptation of left ventricular filling to the changing loading conditions during intensive effort (13). The response of PW-TDE diastolic velocities to the acute physical stress suggests a more effective relaxation activity in the longitudinal axis of the heart in endurance athletes (15). The evident changes in the post-exercise hemodynamics of swimmers' heart as measured with echocardiography in view of the lack of significant discrepancies in the examined Doppler Tissue parameters between investigated groups under resting conditions (swimmers versus healthy volunteers) demonstrate that some of the adaptational changes in "athlete's heart" physiology can be only revealed after exposing the heart to various training conditions (dynamic or static). Unfortunately, our results did not confirm the significant relationship between leptin levels and the examined doppler parameters of regional LV diastolic heart function in either of the investigated groups. Plasma leptin is presumably not sensitive to an increase in training volume in athletes, therefore according to some investigators this hormone may not be useful for monitoring the effect of training stress on the circulatory system in athletes (19). Surprisingly, there was no significant association between the duration of intensive and regular training, body mass index (BMI) and leptin levels in athletes. In addition, the leptin levels did not correlate with the body mass index among healthy volunteers, either. Gippini et al. (3) obtained similar results in athletes as well as untrained volunteers. According to Gippini et al. (3) the elevated BMI in athletes does not influence serum leptin level. Insufficient energy supply rather than inadequate volume of adipose tissue induces disorders of leptin's physiology after acute physical stress (10). Hence, the sufficient energy supply contributes significantly to the regulation of leptin secretion and a deficiency of it may disturb the physiology of this hormone in athletes. Under these circumstances this may confound the search for leptin-myocardium relations. It is likely that there are different mechanisms, which regulate leptin secretion and are activated depending on the type and intensity of physical effort both in athletes and persons with a sedentary lifestyle. The

lack of significant changes of serum leptin levels in persons undergoing static exercise versus obvious decrease in leptin concentration on dynamic effort confirms the above hypothesis. In accordance with some authors static exercise does not interact with leptin production regardless of changes in BMI (3). However, it may have an impact on regional LV function as confirmed by our investigation. Hence, it can be assumed that leptin's physiology may be immediately unrelated to heart muscle function in athletes in spite of concomitant changes both in its serum concentration and regional diastolic TDE parameters during acute exercise (20). The obvious influence of training period on regional isovolumic relaxation time (ivrt') as confirmed by TDE, but without its significant link to leptin levels, supports this. Furthermore, it may be presumed that the obvious adaptational changes in regional diastolic heart function in response both to acute exercise and chronic training observed in our study may not in some special circumstances (training mode, diet, mental stress- hypothalamus-limbic system interaction) correspond with leptin metabolism in athletes. The changes found in the examined TDE parameters during acute exercise predominantly result from the adjustment of circulatory hemodynamics to the preset exercise protocol. The hormonal system's response to physical effort is rather a consequence of acute deficiency of energy induced by exercise than a remarkable manifestation of swimmers' training status. It is probable that leptin secretion in response to acute and chronic effort is a complicated issue and strictly related to neuroendocrine and musculoskeletal system, other humoral factors, adipose tissue content, training status, type and intensity of physical exercises, which supposedly bias the assessment of leptin's real effect on LV function (2, 21). On the other hand, we cannot exclude that acute exercise-induced fluctuations in energy homeostasis, here manifested by changing leptin levels, may somehow affect the heart's local metabolism and thus modulate regional diastolic heart function in athletes irrespective of the dynamics of leptin's metabolism.

Conclusions

The significant relationship between regular long lasting physical training and leptin levels was not confirmed among professional swimmers 2. leptin does not exert an immediate and significant effect on regional left ventricular diastolic heart function in professional swimmers, 3. the duration of training and different exercise protocols caused significant changes in regional diastolic heart function among professional swimmers in comparison to healthy volunteers, which makes TDE a potential tool for assessing the training status in athletes.

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A – Study Design

B – Data Collection

C – Statistical Analysis

D – Data Interpretation

E – Manuscript Preparation

F – Literature Search

G – Funds Collection