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CHANGES OF THERMOEMISSION OF UPPER EXTREMITIES IN FEMALE HANDBALL PLAYERS – THE PRELIMINARY STUDY

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Abstract

Introduction: Thermovision is non-invasive, and non-contact method using infrared camera to register heat emitted by human skin.

Aim of study: The aim of work was an attempt to evaluate temperature changes of upper extremities in female handball players, before and after training session, and an attempt to establish a relation between these temperatures and selected morphological features and body mass components.

Methods: The subject groups consisted of 17 female handball players. During the study anthropometrical features and body mass components by bioimpedance method were measured. In each female player three series thermograms were done.

Results: The greatest decrease of Tmax and Tmean of studied parts of body appeared in female players in a series immediately after the training session.

Conslusions: The lowest temperature changes in consecutive series (not statistically significant) have been observed in left arm back. It can suggest that muscles in this body part have performed during training lower work than muscles of right extremity (arm front and arm back). There is probably a relation between mean temperature differences before and 10 min. after the training (Tmean.right.arm.front.s.1-3) of dominant upper extremity and a ratio of body mass to examined body surface on this extremity (expressed by a correlation with body mass and length of upper extremity). This relation shows energy expenditure of an organism.

***Key words**: thermoemission, thermovision, handball, female players, training*

Introduction

Thermoemission studied by thermovision is non-invasive, and non-contact method using infrared camera to register heat emitted by human skin. This method makes possible the observation of selected areas of human body. Body temperature changes in time, and also it is dependent on the body area. At the body surface it is dependent on individual features and is a function of temperature of internal organ and heat properties of tissue separating a given organ from the body surface, it means, among other things, from muscle and fat tissue contents, and also the quantity of blood flow and its temperature, skin humidity and the amount of energy produced in homeostatically regulated metabolic processes (1-4).

Thermography (thermoemission registration) found a large application in medicine, however there is a lack of complex studies on its usefulness in sport.

Physical activity causes an increase of body temperature by the heat production, first of all in muscle tissue and changes of blood flow. Temperature changes can be an index of a load of a movement system, therefore a possibility to use thermovision as a method to monitor training loads appears (5,6).

The aim of work was an attempt to evaluate temperature changes of selected body areas in female handball players, before and after the steered physical exercise (training) and an attempt to establish dependences between these temperatures and selected morphological features and body composition.

The primary assumption was to admit the close level of performance in examined female athletes.

Material and methods

In a study participated 17 female athletes, practicing a handball game in the I-league team Łącznościowiec Szczecin. Examined female athletes were 19-29 years old (M=23.0, SD=2.92) with a training experience of 5-16 years (M=9.5, SD=1.21).

For each female athlete the battery of 3 thermograms in a standing position was done:

A series 1 – before training (in a resting status), a series 2 – directly after an intensive training lasted 1.5 h (a speed-endurance training to improve accuracy of throws), and a series 3 - 10 min. after the training. Each time thermovision pictures of upper extremities (arm) on their front (front) and back (back) surfaces were registered. All thermograms were registered in digital form. The camera Therma CAM TM Sc500, Flir Inc., was used in this study. Measurements were analyzed by AGEMA company programs. The minimal (Tmin), maximal (Tmax) and mean temperature (Tmean) inside selected isotherms were registered.

Study was done in accordance to European Thermographic Society standards (4,7). The emission of skin was submitted on the level 0.98. Photographs were done in a room with humidity 60% and temperature 23°C, from a distance of 3m.

A significance of differences of analyzed temperatures was evaluated by Student t-test for dependent samples. Measurements of anthropometric features were also done in accordance to principles submitted in anthropometry (8), namely: body height (B-V), body mass, upper extremity length ($a\text{-}da_{III}$), length of arm (a-r), length of arm and forearm together (a-sty), arm circumference (a.c.), skin-fat fold at the back arm surface (a.f.). Indices of upper extremity length ($a\text{-}da_{III}$/B-V)*100%, and also Rohrer's index and BMI were calculated. Body composition was determined by bioimpedance method (Bodystat analyzer 1500, Akern Inc.): percentage of LBM, water and fat, and basal metabolic rate (basal met). Between independent variables, e.g. chronological age (ch.a.), training experience (t.e.), anthropometric features body mass components and dependent variables, e.g. analyzed temperatures of selected body areas and their changes in particular series, the Pearson's correlation was calculated.

Female athletes began and finished in turn their training, thus for each of them the equal time of training was obeyed. The training was equally carried out by a coach.

Results

At the tab. 1-3 there is a list of arithmetic means of Tmax and Tmean of selected surfaces of arm in female handball players. In the case of arithmetic means of Tmax and Tmean arm front and arm back the highest values were noticed always in a series 1, and the lowest in a series 2. The significance of changes of analyzed Tmax and Tmean in 3 series was evaluated by Student t-test. Results of this test are collected in tab. 1-5. In the case of Tmax and T mean changes of arm front analyzed together (right and left side) (tab. 1), and separately for right and left side (tab. 2), it was noticed that these changes were statistically significant ($p \le 0.05$) in a series 2 in relation to a series 1, and in a series 1 in relation to a series 3 (a decrease of temperatures).

Results obtained for arm back temperature changes show similar tendencies. Changes of Tmax and

Table 1. *A schedule of Tmax and Tmean of upper extremities (front and back surface) and temperature changes in consecutive series*

		Arm front		Student t-test value				Arm back		Student t-test value		
		M	SD	s.1/s.2	s.2/s.3	s.1/s.3		M	SD	s.1/s.2	s.2/s.3	s.1/s.3
s.1	Tmax	35.4	0.65	7.17*			Tmax	34.6	0.74	3.72*		
	Tmean	33.3	0.60	6.44*			Tmean	32.3	0.66	5.11*		
s.2	Tmax	34.0	0.79		1.20		Tmax	33.7	0.85		0.54	
	Tmean	31.1	0.80		1.73		Tmean	31.1	0.83		1.29	
s.3	Tmax	34.7	0.50			3.04*	Tmax	34.0	0.68			2.66*
	Tmean	32.4	0.57			4.99*	Tmean	31.9	0.69			1.46

s. - series; * a value statistically significant ($p \le 0.05$)

Table 2. *A schedule of Tmax and Tmean of upper extremities front surface (right and left side) and temperature changes in consecutive series*

		Right arm		Student t-test value				Left arm		Student t-test value		
		M	SD	s.1/s.2	s.2/s.3	s.1/s.3		M	SD	s.1/s.2	s.2/s.3	s.1/s.3
s.1	Tmax	35.2	0.68	6.82*			Tmax	33.3	0.65	5.52*		
	Tmean	33.3	0.65	6.32*			Tmean	33.2	0.56	6.21*		
s.2	Tmax	34.0	0.61		1.09		Tmax	33.9	1.01		1.24	
	Tmean	31.1	0.77		1.66		Tmean	31.1	1.57		1.80	
s.3	Tmax	34.6	0.52			2.90*	Tmax	34.7	0.61			3.09*
	Tmean	32.3	0.59			5.03*	Tmean	32.4	0.52			4.35*

s. - series; * a value statistically significant ($p \le 0.05$)

Table 3. *A schedule of Tmax and Tmean of upper extremities back surface (right and left surface) and temperature changes in consecutive series*

		Right arm		Student t-test value				Left arm		Student t-test value		
		M	SD	s.1/s.2	s.2/s.3	s.1/s.3		M	SD	s.1/s.2	s.2/s.3	s.1/s.3
s.1	Tmax	34.7	0.69	4.83*			Tmax	34.6	0.81	2.40		
	Tmean	32.3	0.65	4.96*			Tmean	32.4	0.70	4.71*		
s.2	Tmax	33.6	0.83		0.37		Tmax	33.8	0.88		0.66	
	Tmean	31.1	0.84		1.25		Tmean	31.2	0.84		1.33	
s.3	Tmax	33.8	0.65			4.33*	Tmax	34.1	0.70			1.43
	Tmean	31.3	0.71			1.76	Tmean	32.0	0.67			1.13

s. - series; * a value statistically significant ($p \le 0.05$)

Table 4. *A schedule of arithmetic means of selected morphological features and indices*

	ch.a. [yrs]	t.e. [yrs]	B-V [cm]	body mass [kg]	a-da_{III} [cm]	a-r [cm]	a-sty [cm]	a.c. [cm]	a.f. [cm]	a-da_{III}/ B-V index [%]	Rohrer's index [g/cm^3]	BMI [kg/m^2]
M	23.40	9.00	174.43	68.27	75.20	30.46	57.16	27.47	31.60	43.11	1.29	22.66
SD	2.873	3.122	3.829	4.061	2.70	1.309	3.132	1.164	62.482	1.083	0.079	1.261

Table 5. *Results of significant Pearson's correlation between temperature changes of selected areas of upper extremities in consecutive series and morphological features and body mass components*

	Tmean.right.arm.front.s.1-3	Tmax.right.arm.back.s.2-3	Tmax.left.arm.front.s.2-3
body mass [kg]	.5496 p=.034*	-.1114 p=.693	.5064 p=.054
a-sty [cm]	.3041 p=.270	-.5549 p=.032*	-.1225 p=.664
a.c. [cm]	.2548 p=.359	-.2098 p=.453	.5566 p=.031*
a.f. [mm]	.5032 p=.056	-.0899 p=.750	.6667 p=.007*
a-da_{III} [cm]	.5356 p=.040*	-.1587 p=.572	.2437 p=.381
basal met [kcal/24ha/70kg body mass]	.5029 p=.056	-.2658 p=.338	.6629 p=.007*

*a value statistically significant ($p \le 0.05$)

Tmean of arm back, analyzed together (right and left side) (tab. 1), and also only right arm back (tab. 3) are statistically significant ($p \le 0.05$) in a series 1 in relation to a series 2. A decrease of Tmax of analyzed areas is also statistically significant in a series 1 in relation to a series 3. The lowest changes of Tmax and Tmean (not statistically significant) have been obtained in the area of the left arm back (tab. 3). Probably it is a result of a lower engagement in exercise of muscle groups of this area. It is also due to add that unquestionable majority of female athletes have been right-handed and at this extremity the greatest temperature changes have been observed.

At the tab. 4 arithmetic mean values of selected morphological features and indices are introduced.

At the tab. 5 there are results of Pearson's correlation between independent variables: ch.a., t.e., anthropometric features and body mass components and dependent variables: temperatures of selected body areas (upper extremities) and their changes in series. Statistically significant dependences ($p \le 0.05$) have been in: Tmean.right.arm.front.s.1-3 (a difference of mean temperatures of right arm front in a series 1 in relation to a series 3) and they have correlated significantly with a-da_{III} and a-r. However, Tmax.right.arm.back.s.2-3 (a difference of maximal temperatures of right arm back in a series 2 in relation to a series 3) has correlated significantly with a-sty, and Tmax.left.arm.back.s 2-3 (a difference of maximal temperatures of left arm back in a series 2 in relation to a series 3) has correlated with a.c., a.f. and basal met.

Discussion

Analyzed temperature changes in selected body areas (upper extremities) are connected with an effect of a steered physical exercise – training. Probably they are dependent on an organism's adaptation processes to training loads. It is involved among others with an adaptation of muscle system through enlargement of muscle mass, better blood supply, associated with increasing of a number of an open, active capillaries, an increase of a glycogen contents and phosphagen, more efficient turnover of high energetic intermediates, and also on facilitation of elimination processes (8).

Performing of physical exercise during a training unit is connected with great energy expenditure, and the same with an enhancement of body temperature. An organism in a defense against of hyperthermy actuates defensive mechanisms of sweat secretion. Hence, a decrease of temperatures registered in female athletes in a series 2 (directly after the training) has been a result of sweat evaporation. This way of heat lost is very effective (during an exercise 80% of heat is returned to environment through evaporation) (9). In this paper the main problem is a registration of an excess of radiated heat from permanently exposed body parts, in our case upper extremities. However, study connected with an evaluation of a level of an aerobic performance in female athletes both towards $\dot{V}O_2$max and anaerobic threshold (ventilatory threshold) are scheduled as a consecutive study stage.

After each physical work the adequate recovery is necessary. All organism functions should return to a resting status. It is an active process and requires an energy supply. In a series 3, thus 10 min. from the end of exercise, an insignificant temperature increase in female athletes in relation to a series 2 has been noticed. It is connected with a beginning of a recovery to homeostasis.

Hunold (10) suggested that anatomical and, morphological parameters can influence on temperature breakdown and their changes in selected isotherms. They considered also that temperature breakdown in selected isotherms (specific „thermal map") in a resting status is an individual feature and it is repeatable in the same conditions.

Conclusions

1. The lowest temperature changes in consecutive series (not statistically significant) have been observed in left arm back. It can suggest that muscles in this body part have performed during training lower work than muscles of right extremity (arm front and arm back).
2. There is probably a relation between mean temperature differences before and 10 min. after the training (Tmean.right.arm.front.s.1-3) of dominant upper extremity and a ratio of body mass to examined body surface on this extremity (expressed by a correlation with body mass and length of upper extremity). This relation shows energy expenditure of an organism.

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A – Study Design
B – Data Collection
C – Statistical Analysis
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E – Manuscript Preparation
F – Literature Search
G – Funds Collection