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Effect of Yoga and Swimming on Body Temperature of Pregnant Women

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SUMMARY

Introduction: Physical activity for pregnant women should be controlled and adapted in order to minimize the risk of loss of balance and fetal trauma (Davies, Wolfe, Mottola, y MacKinnon, 2003). Non-invasive technologies are required for understanding better the effects of physical activity on pregnant women. Infrared thermography allows, remotely, securely and without any contact, to measure and display accurate temperatures on the human skin.
Methods: We studied the effect of two different organized physical activities on the skin temperature (Tsk) of 28 volunteer 31-weeks-pregnant women (Yoga: n=14; Swimming: n=14). Two sets of six thermograms (Anterior and Posterior of the Upper and Lower limbs, and Left and Right Lateral Upper body) were registered by a T335 FLIR infrared camera: the first after 10 minutes of acclimatization to the room conditions and before the physical activity, and the second within the ten minutes after finishing the physical activity.
Results: Because of the significant difference in general Tsk of the women in the first assessment ($t(26) = 9.21$; $p < 0.05$) probably due to increased use of creams ($\chi 2(1) = 9.33$; $p < 0.05$), lower room temperatures ($t(26) = 4.00$; $p < 0.05$) and humidity ($t(26) = 7.49$; $p < 0.05$) in the yoga group, only the increment of Tsk between pre- and post-activity measurements were considered for the analysis of the data. Our results indicate (see Table 8) that general Tsk were significantly reduced after swim-ming ($t(13) = 11,60$; $p < 0.05$) and non-significantly increased after the yoga practice ($t(13) = -1,19$; $p = 0.25$). This tendency was similar in all the body areas in the Swim group and more heterogeneous after the yoga practice with non significant differences in the limbs and significant differences in the trunk areas (including breast and belly).
Conclusions: The results point out a significant reduction of Tsk of expectant mothers after aquatic activity even in the breast and belly areas, probably due to inadequate water temperature although the values of Tsk does not appear to be hazardous to the fetus. Practicing yoga during pregnancy slightly increases the Tsk in the whole body maybe because of the characteristics of the activity.

1. INTRODUCTION

Nowadays, physical and sport practice has become a daily occurrence, which defines each society. International institutions recommend the promotion of Physical Activity (33) as one of the best ways to prevent some of the most frequent health problems of the population (32). Therefore, in countries where women are treated equally by society, exercise has become part of everyday life of many women, even during pregnancy, the women's stage in which occur the most important physiological and psycho-logical adaptations. Everyday there is a greater number of women who wish (14) to continue training during their pregnancy.

1.1 Pregnancy and Physical Activity

The prescription of exercise in pregnant women has varied depending on available scientific information (1, 19, 29). The large number of anatomical, biological and psycholog-ical changes that occur in women during pregnancy (17, 35) and the individual differences on these changes (30), make difficult to reach a consensus on the volume, intensity, and kind of exercise to be prescribed for pregnant woman.
However, several studies (12, 18, 22, 26, 28) indicate that moderate exercise dur-ing a healthy pregnancy

can have physical and psychological benefits in pregnant women and offer little risk to the fetus.
Effects of physical activity in pregnant women have been studied through their influence on different organs and systems of the pregnant woman taking into account different parameters:
1) heart rate is significantly higher in pregnant women who are physically active; however, blood pressure helds similar parameters in pregnant and non-pregnant women (37);
2) ventilation change for physiological, mechanical and chemical reasons (13, 34, 36);
3) metabolism yield to different results (18);
4) temperature has been a major concern of physical exercise during pregnancy because hyperthermia produced by an excessive exercise may cause problems in the fetus development (16, 18).

A recent study (15) concluded that temperature of pregnant women did not increase significantly during or after exercise (36.5 vs. 36.7 °C). The methods used for assessing temperature were electronic thermometers located in the selected area and inside the ear canal. None of the pregnant women approached their body temperature to dangerous levels while practicing low-impact exercise. We can conclude that low intensity aerobic exercise at about 70% of maximum heart rate seems to be safe for the fetus in terms of risk by maternal hyperthermia.
Other works (5) have investigated the effects of exercise on the oxygen and substrate delivery to the interphase, which can exceed 50% during exercise; however, regular bouts of sustained exercise may improve oxygen and substrate delivery at rest. Additionally, Clapp stated that the type of maternal carbohydrate intake and food intake frequency can also influence the substrate availability of the fetus through their effects on maternal blood glucose and insulin levels, concluding that exercise in early and mid pregnancy stimulates placental growth while the relative amount of exercise in late pregnancy determines its effect on late fetal growth. On the other hand, low-glycemic diets decrease growth rate and size at birth while high-glycemic food sources increase it.

1.2 Thermography health and pregnancy

In the field of medicine, infrared thermography is considered as a diagnostic tool for pathologies as breast cancer (11), deep vein thrombosis (7), lateral epicondylitis (3), stress fractures (10), rheumatic diseases (6, 8, 23), reflex sympathetic dystrophy (4), dermatological diseases (31), fever detection (9, 21) or Diabetes (25).

There are some significant changes during pregnancy related to physical activity as increased maternal and fetal body temperature that may pose a hypothetical risk of exercise during pregnancy (19). Several physiological mechanisms maintain thermal balance during exercise of moderate intensity, one of them is the increased blood flow to the skin level in acral areas and reduced on the trunk and proximal extremities (2).
In this paper, we will attempt to use infrared thermography to study the effects of physical activity on body temperature of pregnant women.

2. METHODS

2.1 Sample

The study sample consisted of 28 physically active pregnant women divided into two groups: half of them were engaged in low intensity yoga (n = 14) and the other half (n=14) practiced an aquatic activity (Swim) specifically designed for pregnant women.

2.2 Equipment

Thermograms were recorded with a T335 FLIR® in-frared camera (FLIR® Systems, Sweden). Maximal and averaged Tsk were extracted from each consid-ered Region Of Interest (ROI) with the software ThermaCAM Reporter 6 provided by the camera manufacturers. The environmental conditions were controlled by a BAR-908-HG® portable weather sta-tion (Oregon Scientific, USA).

2.3 Data collection

Before the training session, subjects remained in the data collection room at least for 10 minutes dressing only underwear for adapting to the room conditions before collecting the first thermogram series. During the acclimatizing time, subject fulfilled a questionnaire about incidence factors on thermography and personal data for required in the study and signed the informed consent to participate in the study. Subjects proceed directly to the data collection room drying the skin without rubbing for second thermograms se-ries within the 10 minutes after the activity.
The study protocol was approved by the Ethics Committee of the Technical University of Madrid following the principles outlined by the World Medical Assembly Declaration of Helsinki.
Six thermograms were registered before and after the workout in both activities (fig. 1): Dorsal (20 ROI), Ventral (19 ROI) and Left- and Right-Lateral

(2 x 12 ROI) in Upper Body, and Dorsal (16 ROI) and Ventral (12 ROI) Lower Body. Yoga data were registered in May by 11:00 AM in one of the rooms of a Yoga Center while water activities data were collected in July by 9:45 AM in a changing room attached to the swimming pool.

2.4 Analysis of the data

For data analysis, initial region of interest (ROI) where grouped into "areas" and, later, the areas into "zones" for better management and subsequent interpretation of the data. The grouping criteria are summarized in Table 1.

Table 1. Criteria for areas and zones establishment.

ZONE	Areas Included	# of ROI
LOWER LIMB	Right and Left Thigh	6
	Right and Left Leg	5
	Right and Left Knee	2
	Right and Left Ankle	1
UPPER LIMB	Right and Left Forearm	4
	Right and Left Arm	2
	Right and Left Elbow	2
	Right and Left Wrist	2
TRUNK	Right and Left Trapezium	2
	Right and Left Rips	1
	Neck	2
	Right and Left Shoulder	2
	Dorsal	5
	Lumbar	3
BELLY	Abdomen	5
BREAST	Right and Left Breast	2

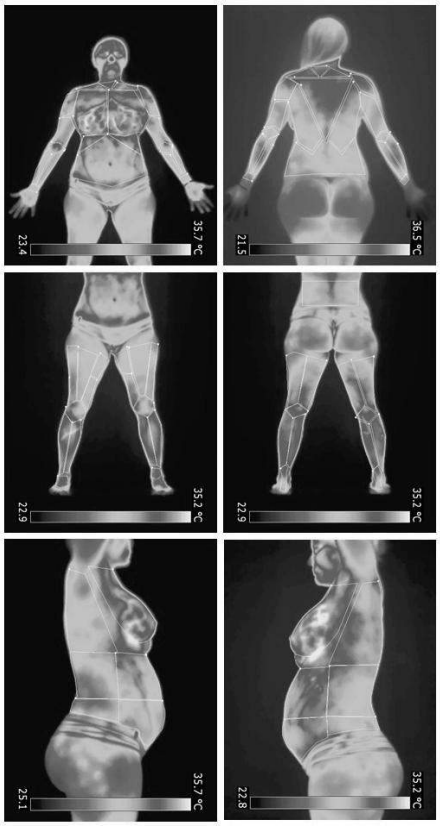

Fig. 1 - Location of the ROI in each thermogram.

The data are given as the means ± Standard Deviations (SD). Only mean Tsk values are exposed in order to reduce the number and size of tables.
The normality of the data distribution for each dependent variable was tested with the Kolmogorov-Smirnov method. Student t-tests for independent samples were run to compare quantitative Tsk data between Yoga and Swim groups, Student t-test for paired samples for comparing pre- and post-exercise results, and Chi-square test (χ^2) were applied for dichotomic variables (Yes-No). The statistical significance was set at $\alpha = 0.05$ in the software SPSS 15.0.

3. RESULTS

As can be seen in Tables 2 and 3, it was registered an increased use of creams ($\chi2(1) = 9.33$; $p < 0.05$) , lower drugs consume ($\chi2(1) = 7.04$; $p < 0.05$), lower room temperatures ($t(26) = 4.00$; $p < 0.05$) and lower humidity ($t(26) = 7.49$; $p < 0.05$) in the yoga group; however, the weeks of gestation of both samples were similar.
Averaged Tsk values for each considered area before and after the physical activity are listed in Table 4. Significant differences by physical activity (all of them $p<0.05$) were recorded in most of the areas except for the breast and the abdominal areas with lower Tsk before exercise in the Yoga group.

Table 2 - Atmospheric conditions and weeks of gestation for activity (** $p < 0.05$; ns = non-significant differences).

	Temperature (**)		Humidity (**)		Week (ns)	
	Mean	SD	Mean	SD	Mean	SD
Swim	36.3%	1.1	27.4 ºC	0.7	33.5	1.6
Yoga	27.2 %	4.4	25.1 ºC	2.1	29.5	7.5

It is worth noting that, after the physical activity practice, significant differences were found on breast ($t(26) = -7.21$; $p < 0.05$), abdominal ($t(26) = -5.96$; $p < 0.05$), and belly ($t(26) = -5.88$; $p < 0.05$) with lower Tsk in the Swim group, as also happen with the rest of the areas except wrists, thighs, legs and knees (all of them $p < 0.05$).
Finally, our results indicate (see Table 7) that General Tsk were significantly reduced after swimming ($\Delta TskS = -3.30 \pm 0.43$ ºC; $t(13) = 11,60$; $p < 0.05$) and non-significantly increased after the yoga practice ($\Delta TskY = 0.21 \pm 0.55$ ºC; $t(13) = -1,19$; $p = 0.25$). This tendency was similar for all the body areas in the Swim group and more heterogeneous after the yoga practice with non-

significant differences in the limbs and sig-nificant differences in the trunk areas (including breast and belly).

Table 3 - Influence factors for activity (** p < 0.05; ns = non-significant differences).

		SWIM	YOGA
Creams **	NO	12	4
	YES	2	10
Therapy (ns)	NO	14	13
	YES	0	1
Coffee (ns)	NO	12	11
	YES	2	3
Alcohol (ns)	NO	12	14
	YES	2	0
Tobaco (ns)	NO	14	14
	YES	0	0
UVA Rays (ns)	NO	14	14
	YES	0	0
Drugs **	NO	3	10
	YES	11	4
Shower (ns)	NO	9	5
	YES	5	9

Table 4 - Tsk values (ºC) on the considered area previous to perform the activity (** p < 0.05; ns = non-significant differences). Left = L; Right = R.

	Swim		Yoga		
	Mean	SD	Mean	SD	Dif.
R. Thigh	30.03	0.75	27.07	1.14	**
L. Thigh	30.07	0.65	26.98	0.72	**
R. Leg	29.92	0.67	26.80	1.30	**
L. Leg	30.06	0.77	26.49	1.33	**
R. Knee	30.48	1.52	26.83	1.28	**
L. Knee	30.92	1.06	27.86	1.22	**
R. Ankle	30.94	0.93	25.19	2.07	**
L. Ankle	30.88	0.98	26.60	1.30	**
Lumbar	31.38	0.96	29.21	1.07	**
R. Forearm	33.61	0.72	31.38	1.51	**
L. Forearm	33.16	0.75	31.22	1.39	**
R. Arm	32.44	0.95	30.55	1.20	**
L. Arm	31.95	1.13	30.44	0.82	**
Ant. Trunk	32.75	1.00	31.33	0.90	**
Post. Trunk	32.32	1.19	31.37	1.11	**
R. Elbow	32.65	0.86	30.63	0.80	**
L. Elbow	32.38	1.02	30.41	0.79	**
Abdominal	34.82	0.73	34.50	1.54	ns
R. Wrist	33.43	0.61	29.55	1.79	**
L. Wrist	33.19	0.81	28.98	2.18	**
Breast	33.22	0.74	32.67	0.68	ns
Belly	32.41	1.22	30.97	0.98	**
General	31.96	0.77	29.46	0.66	**

Tables 5 and 6 provide data about the Tsk of the main zones considered, showing results congruent with those of their corresponding areas. We can point out that General Tsk recorded before practicing the activity (TskSWIM = 31.96 ± 0.77 ºC vs. TskYOGA = 29.46 ± 0.66 ºC) were significantly higher for the Swim group ($t(26) = 9.21$; $p < 0.05$) and after exercise (TskSWIM = 28.65 ± 1.31 ºC vs. TskYOGA = 29.67 ± 0.53 ºC) they became significantly lower in the Swim group ($t(26) = -2.70$; $p < 0.05$).

Table 5 - Tsk values (ºC) on the considered zones previous to perform the activity (** p < 0.05; ns = non-significant differences).

	Swim		Yoga		
	Mean	SD	Mean	SD	Dif.
Lower Limb	30.41	0.81	26.73	0.99	**
Trunk	32.66	0.95	31.41	0.85	**
Upper Limb	32.85	0.81	30.39	1.02	**
Breast	33.22	0.74	32.67	0.68	ns
Belly	32.41	1.22	30.97	0.98	**
General	31.96	0.77	29.46	0.66	**

Table 6. Tsk values (ºC) on the considered area previous to perform the activity (** p < 0.05; ns = non-significant differences).

	Swim		Yoga		
	Mean	SD	Mean	SD	Dif.
Lower Limb	27.09	1.40	26.51	0.51	ns
Trunk	29.45	1.35	31.86	0.73	**
Upper Limb	29.40	1.57	30.77	0.96	**
Breast	30.52	1.17	33.19	0.74	**
Belly	29.25	1.29	31.73	0.91	**
General	28.65	1.31	29.67	0.53	**

Table 7. Increment of Tsk (ΔTsk = Tsk Post-Pre exercise in ºC) on the considered zones (** p < 0.05; ns = non-significant differences).

	Swim		Yoga	
	Mean	SD	Mean	SD
Lower Limb	- 3.32 **	1.28	- 0.21 ns	0.90
Trunk	- 3.21 **	0.94	0.45 **	0.60
Upper Limb	- 3.45 **	1.44	0.38 ns	1.11
Breast	- 2.70 **	0.92	0.52 **	0.44
Belly	- 3.15 **	1.11	0.77 **	0.54
General	- 3.31 **	1.07	0.21 ns	0.66

4. DISCUSSION

It has been previously studied the effect of low-impact exercise on pregnant women (15). Aerobic exercises at 70% of maximum heart rate increased the temperature of the mother, but ap-pear to be safe in terms of risk of maternal hyperthermia. In the study by Larson, the measurement from pregnant women temperature was conducted by an ear thermometer, but works done with different

methods of measuring body temperature obtained similar results.(24)

Our thermographic data show that pregnant women Tsk is not greatly increased after exercise; moreover, with swimming even decreased, probably due to the aquatic environment in which the activity is conducted at an approximate temperature of 27.5 ºC and with physical characteristics (i.e. head conductivity) that facilitates the corporal heat loss while the subject is immersed into the water.

Data from this study should be considered with caution because the environmental conditions of tem-perature and humidity during data collection are not the optimal to be used as reference values, especially the data from the Swim group, that were recorded in summer with an average room temperature of 27.4 °C. According to Ring & Ammer (24) the optimal temperature of room for a thermography should be between 18 and 22 °C. We are sure that those temperature conditions have influenced in the recorded Tsk for the Swim group.

In this sense, humidity is also an important factor that may have influenced our results, since the collection of data on the Swim group was carried out in a locker room attached to the pool, where the moisture content (36.3%) was significantly greater than in the Yoga center (27.2%).

Other factors could have influenced the recorded Tsk and they were recorded in the initial questionnaire. It has been found evidence of the influence of the creams on the infrared emission of the skin (27). In the case of pregnant of the Yoga group, the application of creams was significantly higher (71.4% of pregnant women) compared with 14.5% of those who practiced aquatic activities. This may be one of the reasons why Tsk from Yoga group, both pre-and post-exercise, were so low. We also found significantly higher drug consumption in the Swim group (78.6%) compared with the Yoga group (only 28.6%). We ignore the type of drugs consumed and whether they could have a thermogenic effect or could have induced an increased peripheral blood flow, but this factor could be contributing, together with the higher humidity and room temperature, to differences on initial Tsk values of pregnant women from both groups.

The results point out a significant reduction of Tsk of expectant mothers practicing aquatic activities even in the breast and belly areas, probably due to inadequate water temperature and the low-intensity characteristics of the activity performed, although the values of Tsk does not appear to be hazardous to the fetus. More studies about the influence of water temperature and the amount and intensity of the aquatic activities on the recovery of the normal temperature processes after aquatic exercise should be conducted not only with pregnant women but also with normal swimmers.

Practicing yoga during pregnancy slightly increased the Tsk in the whole body probably due to the characteristics of the activity (low intensity and controlled movements, many of them in sitting or lying positions).

Due to the lack of optimal conditions during the collection of the data, and in order to reduce the impact of the influence factors (i.e. creams usage and drugs consumption) we decided to use ΔTsk (Tsk before exercise – Tsk after exercise) instead of direct Tsk data for discussing the influence of the practice physical activity on the Tsk of the pregnant women.

In Swim group, the belly Tsk and other body zones significantly decreases with respect to the before exercise values, with maximal descents of -3.45 ºC on the upper limbs and minimal on the breast (ΔTsk = -2.70 ºC) and belly (ΔTsk = -3.15 ºC). One must bear in mind that the activities of this group are done into a swimming pool and they should be considered the above mentioned characteristics of the water for heat conduction. Also should be noted that chest and belly are covered by the swimsuit. Additionally, the lower Tsk descent may be the result of the mechanisms of temperature compensation ex-pressed by (18) as a way to maintain the temperature of the fetus.

In Yoga, the area with a higher Tsk increase after exercise is the belly (ΔTsk = 0.77 °C) followed by the breast (ΔTsk = 0.52 °C), both of them statistically significant values. In general, Tsk after practicing Yoga tends to non-significantly increase on 0.21 °C. Legs are the single body zone with a non-significant lower Tsk after exercise (ΔTsk = -0.21 ºC). We think that this Tsk descent could be due to the sitting position hold during Yoga practice, which get in contact the legs with the floor, reduces the activity of the legs, and slightly and temporary blocks the blood flow on this area.

In general, we can see that the significant reduc-tion of the Tsk after swimming was -3.31 ºC and after yoga the Tsk increased non-significantly by 0.21 ºC (Table 7). If we compare the general and belly Tsk after swimming (28.65 ºC and 29.25 ºC respectively) with the Tsk of those areas in the Yoga group before exercise (29.46 ºC and 30.97 ºC respectively), they are quite similar. That could support the idea that the significant descent of Tsk after practicing aquatic activity is not so dangerous; however, practicing the activity in a slightly warmer swimming pool could promote a lower loss of Tsk on those areas. On the other hand, we should also consider that in summer time the descent of Tsk generated by the aquatic activity could refresh the mother

helping her to withstand better the effects of heat during the summer.

5. CONCLUSIONS

From our work we can conclude that thermography can be applied for its simplicity and safety of assesing the Tsk of the pregnant population practicing physical activity, but in order to obtain optimal results the environmental variables and certain factors that may influence the Tsk record must be controlled.

The Tsk of the belly was significantly reduced af-ter practicing the aquatic activity in -3.31 ºC and was non-significantly increased after practicing yoga in 0.21 ºC. Even though the descent of Tsk after swimming is quite drastic, not appear to be dangerous for the well-being of the fetus; however, it is suggested to perform aquatic activities in water warmer than normal in order to minimize the heat loss at the end of the activity.

Practicing yoga during pregnancy slightly increases the Tsk in the whole body probably due to the characteristics of the activity.

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