Abstract Booklet of the 14th edition of the

International Workshop on Advanced Infrared Technology and Applications, AITA 2017

and of the 8th **IWASPNDE WORKSHOP**

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UNIVERSITÉ LAVAL

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of the *Electrical and Computer Engineering* Department

X.P.V. Maldague, Editor

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X. Maldague
É. du CAO
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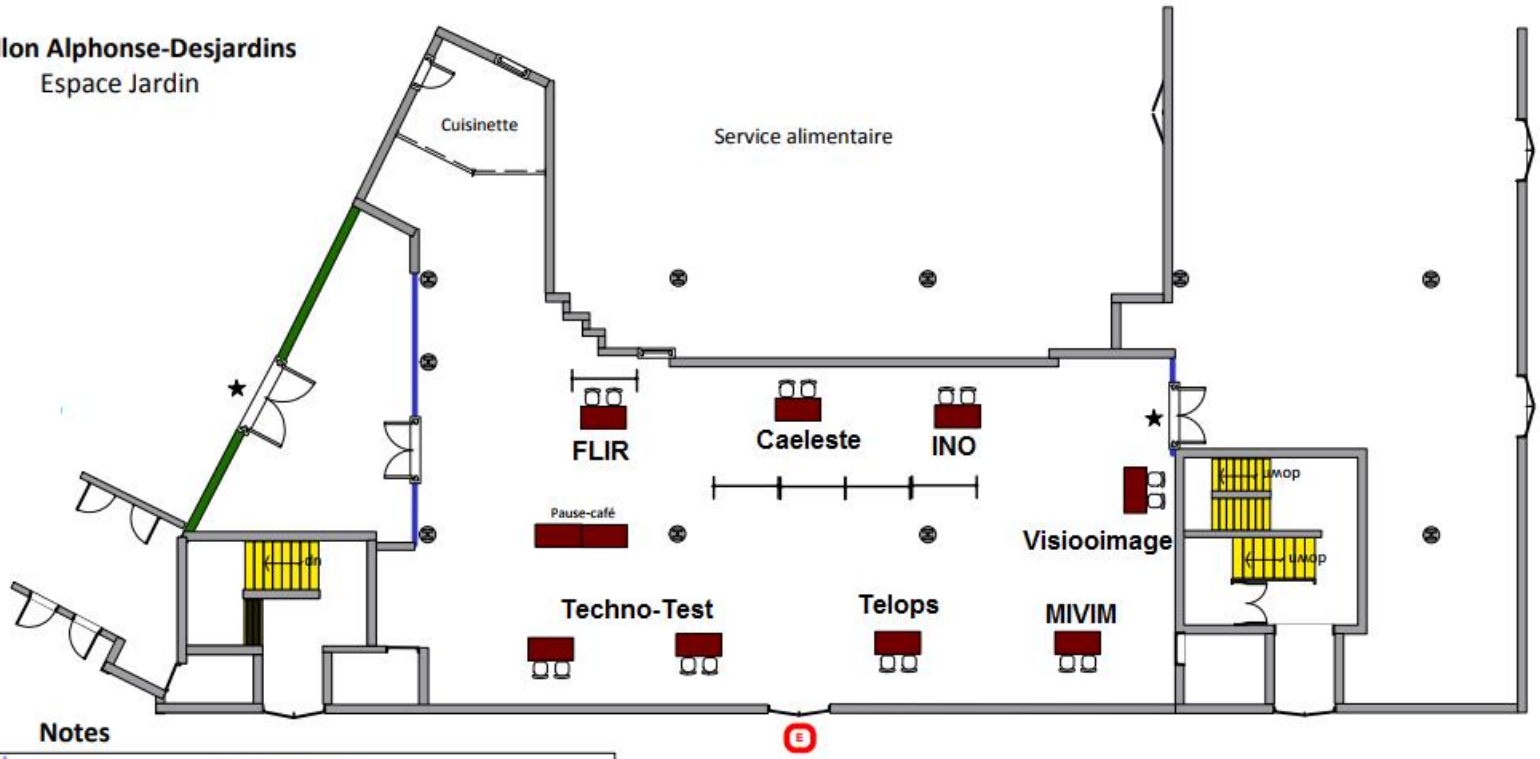

Notes

Caeleste
FLIR
InfraTec
INO
MIVIM
Techno-Test
Telops
Visiooimage

Légende

★ Entrée / Sortie — **In/Out**

Sortie d'urgence — **Emergency Exit**

Colonne — **Column**

Échelle Scale

0m 1 3 5 7 9
0pi 5 10 15 20 25 30

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Preface

It is our pleasure to welcome you here at Université Laval for the 14th edition of the International Workshop on *Advanced Infrared Technology and Applications*, AITA 2017!

AITA Workshops were born in Italy were most of the Editions took place. In 2007, AITA was hosted in León, Mexico by Prof. Marija Strojnik. Hence, to mark this 10th anniversary, the Program Committee decided to organize AITA 2017 once again in North America, but this time in Quebec City, Canada.

Interestingly 2017 marks also the 150 anniversary of the Canadian Confederation with all kind of celebrations all across the country so it is a unique opportunity to host AITA right here in Canada!

AITA is a forum that brings together researchers in the field of infrared science and technology to exchange knowledge and ideas. Interestingly, the VIIIth edition of the *International Workshop on Advances Signal Processing for NonDestructive Evaluation* (IWASPNDE, Quebec Workshops) will take place as a simultaneous event.

For the 2017 edition, sessions were divided as follows: Applications, Detectors, Environment, Image processing*, Medical, NonDestructive Testing*, Techniques, Thermal properties, and we also have an invited session organized by Prof. A. Mandelis: Biothermophotonics (*: joint sessions with *VIIIth IWASPNDE*).

The following invited Keynote Lectures are others program highlights:

- «IR thermography applied to assess thermophysical properties of Thermal Barrier Coatings», Dr. Paolo Bison, CNR - ITC, Italy;
- «Cultural Heritage, an IR Perspective», Dr. Roman Maev and Dr. Dmitry Gavrilov, University of Windsor, Canada;
- «Photothermal Coherence Tomography (PCT): «Principals and Non-Invasive Biomedical, Dental and Engineering Materials NDI Applications »
Dr. Andreas Mandelis, University of Toronto, Canada.

The «Under 35 Paper Award» competition will take place during the Workshop. This Award is named after Ermanno Grinzato who passed away in 2012. Mr. Grinzato was AITA cochairman for a long time and was a very well-known scientist in the thermography community. Additional Workshop highlights are a Poster session, a Vendor Session, an Exhibit with the following Companies participating: Caeleste, FLIR, InfraTec, INO, TechnoTest, Telops, Visioo-Image.

The social program includes a Reception and a Visit, Cocktail and Banquet at «Aquarium de Québec». For this last event, we thank Telops for their generous support.

As usual, a selection of the received papers will be published in a peer-review journal: *OSA Applied Optics*.

Finally, the website: `http://aita2017.gel.ulaval.ca`
will be maintained active for future references. The website includes the Workshop Booklet with all the abstracts in .PDF format. This way to proceed was found more convenient and environmentally friendly.

As partners in the success of this week, was the help of the Program Committee, Scientific Committee, Organizing Committee, Université Laval, including my own Electrical and Computing Engineering Department and staff. The participation of our exhibitors is also appreciated. I would like also to point out the dedicated work of all our student staff and particularly of our assistant, Mr. Patrick Deschênes Labrie.

I will conclude these remarks by wishing to all a fruitful Workshop, full with great talks, great discussions, meetings of old and new faces! I would like also to thank you all for your participation which is essential to the success of AITA 2017.

Enjoy AITA 2017, enjoy beautiful Québec City, Canada!

Xavier Maldague
Chair, AITA 2017

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• Mr. Patrick Deschênes Labrie
Department of Electrical and Computer Engineering
Université Laval, Québec, Canada, G1V 0A6
Phone : ++ 1 418 656-2962
Fax : ++ 1418 656-3159
Email : Quebec@gel.ulaval.ca

NEAR INFRARED AND THERMAL IMAGING OF NORMAL AND OBESE WOMEN DURING ORAL GLUCOSE TOLERANCE TEST (OGTT)

B. Jalil[a], V. Hartwig[b] , D. Moroni[a], O. Salvetti[a], A. Benassi[a], Z. Jalil[e], L. Guiducci[b], L. Pistoia[c], T. Minutoli Tegrimi[c], A. Quinones-Galvan[c], G. Iervasi[b], A. L'Abbate[b,d]

[a]Istituto di Scienza e Tecnologie dell'Informazione "Alessandro Faedo" CNR, Pisa, Italy
[b]Istituto di Fisiologia Clinica CNR, Pisa, Italy
[c]Fondazione G. Monasterio CNR - Regione Toscana, Pisa, Italy
[d]Scuola Superiore Sant'Anna, Institute of Life Sciences, Pisa, Italy
[e]Department of Computer science, Iqra University, Islamabad, Pakistan

Originally considered as an imbalance between energy intake and expenditure, obesity is studied in this paper by comparing body temperature of abdomen, neck and hand in obese subjects to lean ones with oral glucose tolerance test during thermos neutral and cold conditions. We studied obese and normal weight females with infrared thermal imaging (IRT) and near infrared spectroscopy (NIRS). We observed that a significantly reduced temperature was much more prevalent in the obese subjects around abdominal area and relatively higher temperature on the hand of obese subjects as compared to lean ones. However, we observe the higher oxygen saturation in obese females in both hand and abdomen.

Introduction

Obesity, now recognized as a major public health issue, is a condition associated with high body heat content. Several physiological changes that accompany the development of obesity tend to increase heat production. Obesity increasing with an alarming rate worldwide with the particular concern is the increase in health risk evidenced in younger persons and ultimately increases the risk of many serious conditions including hyper-tensions, diabetics, coronary heart disease and many more. People with a body mass index (BMI) of 30 or higher are considered obese as it describe the health condition of significantly above ideal healthy weight [1, 2]. These negative health consequences of obesity attracted many researchers to study further and explore its effects on human health. Infrared thermography (IRT) has been used in the past few decades to study diseases in which skin temperature is an indicator of inflammation or blood flow changes. The use of IRT in the measurement of human skin temperature has the advantage to be completely noninvasive. A thermal camera makes use of infrared imaging to visualize and measure the thermal energy emitted from objects in the environment. Thermal cameras are capable of discriminating temperature differences and used to assess the absolute temperature of specific points on the body, or alternatively to calculate average temperature of a specific region of the body as specified [3]. Savastano et al had studied human obesity in relation to the heat production using such cameras. They examined heat production and dissipation in obese adults as compared to normal weight adults [2]. Analysis of data indicated that obese participants demonstrated significantly lower abdominal thermal patterns than those of their normal weight counterparts. Similarly, Ludwing et al had studied maximal skin temperature at different region of interests [4]. Chudecks et al had drawn a thermal map of obese women and highlighted the body area where heat transfer is particularly impeded [5]. More recently, Gatidis et al had presented their extensive research on skin temperature using infrared thermography [6].

Assessment of oxygen saturation (StO_2) is important to study clinical condition and in monitoring several pathological changes. During the past few years, near infrared spectroscopy (NIRS) has been used to study

human adipose tissues to investigate obesity effects. NIRS is a method to non-invasively measure tissue oxygenation in vivo [7]. NIR spectroscopy has been largely used for measurement of changes in intravascular hemoglobin (Hb) and intramuscular myoglobin (Mb) for many applications *e.g.* Nirengi et al had evaluated the oxygenation in brown adipose tissues using near infrared spectroscopy in thermos neutral and cold conditions [8].
The aim of this study was to achieve a better understanding of the body temperature and oxygenation conditions on neck, hand and abdomen of normal and obese females during oral glucose tolerance tests. In the coming sections, we will first explain the methods, subjects and designed experimental protocols and then we will present our findings with discussion.

Subjects and Methods

We had performed 3-hours Oral Glucose Tolerance Test (OGTT) to find the difference of temperature and oxygenation in lean and obese subjects. The glucose tolerance test is a medical test in which glucose is given and blood samples are taken afterwards to determine how quickly it is cleared from the blood.
All the thermal images were acquired with Ti9Thermal Imagers (Fluke Corporation, Everett, WA) camera. The technique is based on the principle that the amount of energy radiated depends on the surface temperature of the object and the emissivity of the object's surface. The camera detects the infrared energy from an object and uses this information to estimate its temperature. Additionally, we acquired NIRS 2D images at the same time. The Kent imaging camera, used to take the NIRS images, is a non-invasive system for tissue oxygenation measurement based on near infrared light. The camera reports and approximates value of Hb + Mb StO_2 in superficial tissue. We have selected neck, abdomen and hand regions to study temperature and microcirculatory features in obese and lean subjects. Five healthy women (age 34.4±10.5) with low body mass index (BMI= 19.6±2.3 kg/m^2) and five overweight healthy women (age 39.8±11.0) (BMI= 27.5±1.8 kg/m^2) were studied. Table 1 shows the characteristics of all subjects. The study was authorized by the local Ethical Committee. Each subject gave written informed consent.

Experimental Design

All subjects were selected from the Metabolic Unit of Fondazione G. Monasterio CNR – Regione Toscana, Pisa, Italy. Firstly, height and weight were measured and then BMI was calculated. Moreover, NIRS and thermographic baseline images were collected (after a 15-min acclimatization period).

		Sex	Age (years)	BMI (Kg/m^2)
Lean	*Subject 1*	*F*	27	20,4
	Subject 2	*F*	33	19,0
	Subject 3	*F*	22	17,9
	Subject 4	*F*	44	18,0
	Subject 5	*F*	46	19,8
Obese	*Subject 6*	*F*	50	30,1
	Subject 7	*F*	48	24,9
	Subject 8	*F*	43	33,4
	Subject 9	*F*	23	27,2
	Subject 10	*F*	35	25,0

Table 1. Participant characteristics.

A 3-h oral glucose tolerance test (OGTT) with the ingestion of 75 g of oral glucose was performed. NIRS and IRT images were taken every hour during 180 minutes. At the end of OGTT, a cold stimulation was performed by immersing the subject's left hand in ice-water for one minute. Finally, NIRS and IRT images were acquired immediately after the cold stimulus.

Results

Figure 1 (a) and (b) show respectively the thermal and StO_2 images of hand. Similarly, Figure 2 (a) and (b) represent abdomen temperature and StO_2 respectively and Figure 3 (a) and (b) show thermal and StO_2 images of the neck area.
Figures 4, 5 and 6 show the temperature averaged on five lean subjects and on five

overweight subjects for hand, neck and abdomen area during the entire experimental paradigm (3-h OGTT test and post ice stimulation). Figure 7, 8 and 9 show the mean StO_2 for both groups in hand, neck and abdomen respectively.

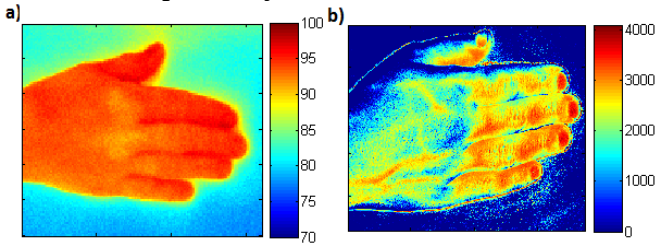

Fig1. a) Thermogram of hand. b) NIRS image of hand.

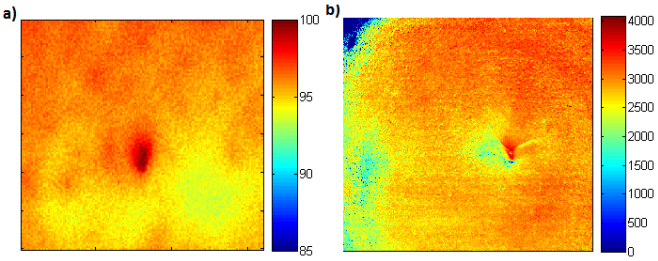

Fig2. a) Thermogram of abdomen. b) NIRS image of abdomen.

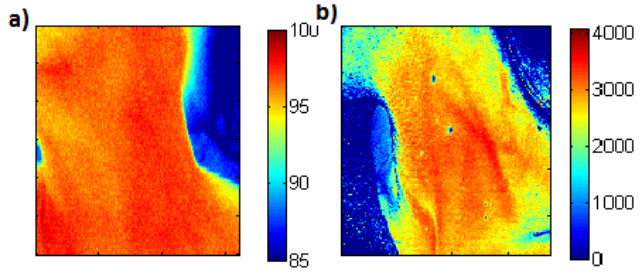

Fig3. a) Thermogram of neck. b) NIRS image of neck.

Discussion

The major finding of the present study is that we detected, both in lean and overweight subjects, a consistent, and highly localized, increase in local temperature of hand, neck and abdomen area induced by a glucose ingestion. We also observed that obese participants had lower abdominal skin temperature and higher in hand as compared to the lean subjects. This result, relative only to the baseline condition, is the same that is reported in [4]. It is even more interesting to note that the hand temperature in lean subjects continues to increase during the OGTT test while in the obese subjects the hand temperature remains more or less constant. Interestingly, abdomen temperature in obese subject changes more during the first 2 hours of OGTT protocol respect to the temperature of the same area in lean subjects.

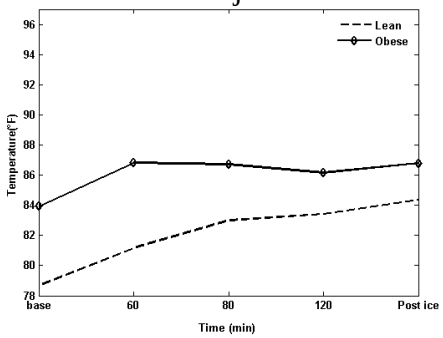

Fig 4. Mean hand temperatures in all subjects measured by infrared thermography.

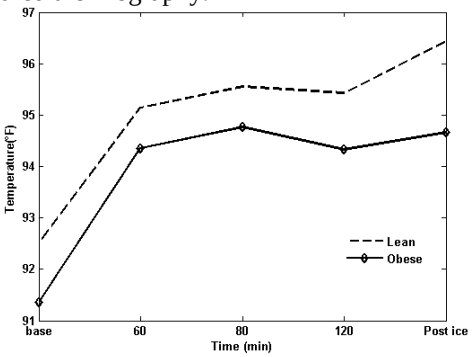

Fig 5. Mean neck temperatures in all subjects measured by infrared thermography.

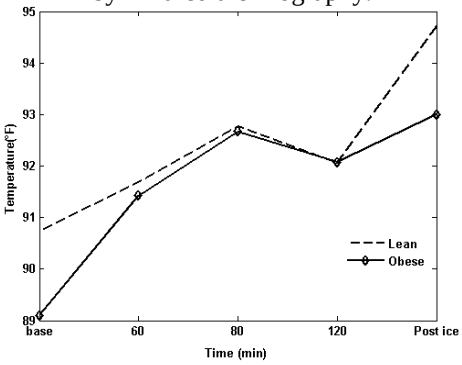

Fig 6. Mean abdominal temperatures in all subjects measured by infrared thermography.

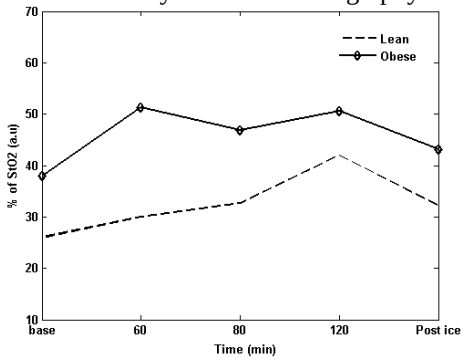

Fig 7. Mean hand StO_2 in all subjects measured by near infrared camera.

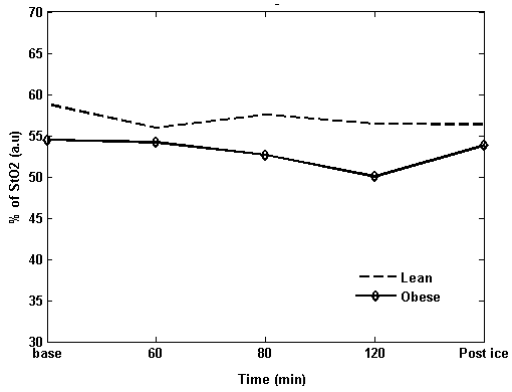

Fig 8. Mean neck StO_2 in all subjects measured by near infrared camera.

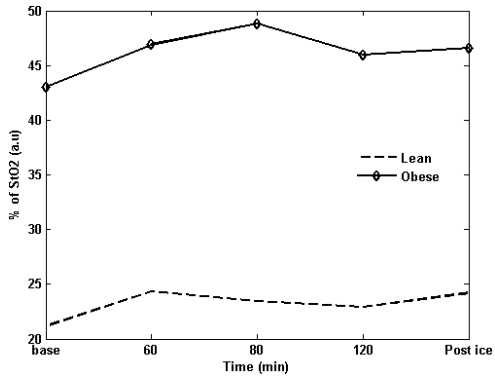

Fig 9. Mean abdominal StO_2 in all subjects measured by near infrared camera.

Temperature of the neck area have similar trends during the entire experimental paradigm for the both two groups.

We had also evaluated the differences in the oxygenation saturation of both lean and obese subjects in order to obtain information about the tissue perfusion. StO2 has significant differences between lean and obese group only for hand and abdomen area but not for the neck. This difference is more pronounced in the abdomen area: oxygen saturation is higher in the abdomen area of obese subjects during the entire experimental paradigm. This could indicate a different distribution of vessel in superficial tissue of the abdomen. Otherwise this could be due to a very different depth of subcutaneous fat.

Conclusion

In this paper, we have applied non-invasive multimodal imaging techniques to monitor thermogenesis conditions in lean and obese females with different body max index. We observed relatively lower abdominal skin temperature and relatively higher temperature in hand in obese females as compared to the lean ones measured in both thermos neutral and cold conditions. As body core temperature represents a marker of energy expenditure, results from this study suggest that reduction of body core temperature plays a crucial role in favoring weight gain in obese subjects. At the same time, we observed higher oxygenation level in obese females. The difference is much higher in abdominal area as compared to the hand in obese females. In conclusion, IRT and NIRS methods are non-invasive, inexpensive and simple methods to investigate fatty tissues in human body. It is important to validate these finding further on large data set in different physical conditions and with obesity related diseases.

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