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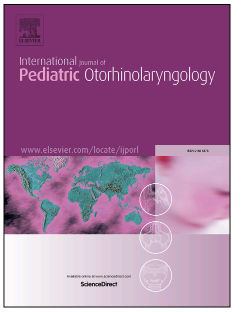

Congenital Heart Disease In Children: Orofacial Myofunctional Aspects, Eating Behavior And Facial Temperature

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CONGENITAL HEART DISEASE IN CHILDREN: OROFACIAL MYOFUNCTIONAL ASPECTS, EATING BEHAVIOR AND FACIAL TEMPERATURE

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CONGENITAL HEART DISEASE IN CHILDREN: OROFACIAL MYOFUNCTIONAL ASPECTS, EATING BEHAVIOR AND FACIAL TEMPERATURE

ABSTRACT

Objective: To characterize the eating behavior, orofacial, speech myofunctional conditions, and facial temperature of children with congenital heart disease. **Method:** This is a cross-sectional and analytical study. The sample consisted of 30 children with heart disease (cyanotic or acyanotic; mean of 5.48 ± 0.84 years old) and 28 healthy children (4.98 ± 0.64 years old). Parents were given a questionnaire to assess eating behaviors (Montreal Children's Hospital Feeding Scale). The orofacial myofunctional assessment protocol (OMES-E), the Child Language Test (ABFW), and thermography infrared of facial temperature were used. Data analysis was conducted by student's t-tests, Chi-square, logistic regression, and correlation analysis. **Results:** Eating behavior in Parents did not perceive eating behavior differences between the heart disease and control groups. However, the percentage of children with some feeding difficulty was higher in the heart disease group. There was a difference between groups regarding the appearance and posture of structures, the mobility of the mandibular and cheek, swallowing function, and the total function score. Thermographic variables did not differ between the groups, but better performance in orofacial functions correlated with the temperature of the labial commissure and lower lip points. **Conclusions:** The frequency of children with eating difficulties was higher among those with congenital heart disease, as was the increased facial temperature at the medial eyelid commissions point when submitted to interventional procedures. The orofacial myofunctional aspects showed changes in posture and position, mobility, and orofacial functions among children with heart disease as compared to the control group. There was a correlation between the temperature of the thermo-anatomical points of the labial commissure and the lower lip as well as the OMES-E function score.

Keywords: Congenital Heart Diseases, Eating Behavior, Thermography, Stomatognathic System, Speech Therapy

INTRODUCTION

Congenital heart defects are anatomical malformations of the heart and the great vessels, which occur during the embryonic period and have a clinically multifactorial etiology[1]. They can be classified as acyanotic or cyanotic.[2-4]. Cyanotic defects are more severe since unoxygenated blood enters the systemic circulation[5,6,] which reduces the hemoglobin concentration of arterial blood[1,7,8], leading to cyanosis and hemodynamic repercussion[9], with or without bluish skin, difficulty gaining weight, and oral manifestations such as stomatitis, tongue, and cyanotic gums as well as delayed tooth eruption[10]. Acyanotic defects, on the other hand, occur due to regurgitation or a left-to-right shunt, which obstructs the left or right heart chambers or congenital coronary artery anomalies[11-13]. These children usually have breastfeeding fatigue, severe sweating, pale skin, low systemic output, poor appetite, low food intake, nutrient malabsorption, coughs, nausea, vomiting, dyspnea, and cyanosis[14-18], as well as decreased gastric capacity, anoxia, altered intestinal motility, decreased absorption, increased meal times or loss of appetite[16].

These factors may negatively impact eating behavior and child development, as reported in the literature[19-21]. These difficulties may also compromise suction development, mastication, deglutition, breathing, and speech articulation due to the prolonged length of stay, which restricts eating experiences and consequently the development of oral and facial muscles [22,23]. In the case of premature babies, this situation worsens as they have a ductus arteriosus that is not yet ready to start closing when the baby is born early, and should be treated with medication or surgery [1,9]. However, for the evaluation of neuropsychomotor development of premature children, the chronological age needs to be corrected up to two years of age [1,9].A broad evaluation of the orofacial myofunctional aspects is essential, as well as complementary instrumental evaluations capable of helping inform the diagnosis. These enable the correct treatment and clinical follow-up pathways to be undertaken.

Among the instrumental evaluations, infrared thermography can be an important evaluation to be used in clinical speech therapy practice, since children with heart disease present altered hemodynamic[24] and cardiorespiratory symptoms[25,26]. Infrared thermography helps to evaluate temperature changes of the skin. This may represent tissue perfusion disorders due to a decrease, increase, or total stop of arterial supply, thus altering tissue perfusion[27], which can be easily applied.

In the microcirculatory dynamic analysis of the facial skin surface, healthy individuals are expected to present hyper radiant regions with higher vascularization. This mainly occurs in the orbital, frontal, labial, nasolabial, auricular, and temporal concha regions. The hypo radiant regions are the cheeks, head hair, skin hair, chin, and ear that tend to have lighter colors. No speech-language studies in congenital heart disease have been conducted that show these expected changes. For this reason, studies with standardized and validated methodologies are important. This is to obtain information on the physiological and functional aspects of the microcirculatory and autonomic system functions associated with the clinical evaluation of orofacial myofunctional aspects, since the use of facial thermography may provide relevant information to increase speech therapy performance regarding evaluation, diagnosis and therapy[28].

Therefore, the objective of this study was to characterize the eating behavior of children with congenital heart disease as reported by their parents, their orofacial and speech myofunctional condition, and facial temperature. These were compared to a group of healthy children that were from the same age group.

METHOD

This is a cross-sectional and analytical study developed in partnership with the Dante Pazzanese Institute of Heart Disease and the Orofacial Myotherapy Outpatient Clinic of the Speech Therapy Department of the UNIFESP/EPM. It was approved by the Research Ethics Committees of both Institutions/Unifesp Number 0164/2018. Children with congenital heart disease were selected from those that attended the IDPC Congenital Heart Disease Clinic. Healthy children were recruited from a municipal school in the city of São Paulo (SP), after formal written permission from both children and parents, and if they did not wish to participate in the research, refusal would not cause them any harm. Questionnaires were answered and returned in a sealed envelope and employees were instructed not to manipulate the content.

The inclusion criteria used for the congenital heart disease group were: a medical diagnosis of congenital heart disease (cyanotic or acyanotic), with patients having submitted or not to interventionist procedures (surgery and/or catheterism), had been hospitalized or attended the Outpatient Clinic of the Congenital Heart Disease of the Dante Pazzanese Institute of Heart Disease and were aged between 4 to 6 years old.

For the control group, children were required to be in good general health and have normal orofacial myofunctional characteristics as well as be between the age of 4 to 6 years old.

The exclusion criteria for both groups were: body mass index (BMI) above the 95^{th} percentile which corresponds to obesity[29], body temperature above 37.8° C[30], history of food allergies, presence of dentofacial deformities, tooth loss from caries or trauma, dental pain, orthodontic and orthopedic treatment, any syndromes, neurological or cognitive changes, absence of medical diagnosis of chronic diseases, chronic use of medications, or being under speech therapy treatment. Children who did not eat consistently were also excluded.

The children's parents that attended the IDPC Congenital Heart Disease Outpatient Clinic responded to an questionnaire. This recorded personal identification data, the patient's main complaint, the presence of heart disease, possible associated diseases, the progression of the disease, specific treatments they had received for heart disease or other conditions, dietary complaints, information on the orofacial myofunctional structures and functions of the stomatognathic system. The parents of the children in the control group received the questionnaire and responded to them at home. These were then returned to the school.

Subsequently, parents responded to the Montreal Children’s Hospital Feeding Scale[31,32]. This consists of 14 questions that focus on the oral sensorimotor domain, the child’s appetite, maternal concerns about nutrition, the child's eating behavior, caregiver strategies, and reactions by family members regarding the child's diet. The scale was cross-culturally adapted from European Portuguese to Brazilian Portuguese by Guillén (2019)[33].

The children were evaluated in the morning, taking into consideration the circadian cycle , as they may be affected by hunger and satiety and be different throughout the day.

Initially, they underwent an anthropometric and body temperature assessment. Afterward, a facial thermography examination was performed according to the guidelines from the Brazilian Association of Thermology - ABRATERM, 2017[34,] and under the conditions recommended by the American Academy of Thermology - AAT, 2019[35].

Each child had their hair tied back and their head covered with a disposable cap so that it did not interfere with obtaining an image. While the researcher collected information from the guardians about the child’s anamnesis and eating behaviors, each child remained seated in a chair without a headrest, maintaining a natural upright position. Care was taken to ensure that the child did not move their hands to their face so as not to palpate, press, rub, or scratch their skin. They were instructed to keep their hands on their legs while an examiner talked to the child about familiar topics that should not invoke a strong emotional reaction.

This evaluation was performed in a well-lit room with a controlled mean temperature of 22^{o} C. Images were taken after 15 minutes of the child's stay in the room. This was to allow the thermal equilibrium of the children with the temperature of the room.

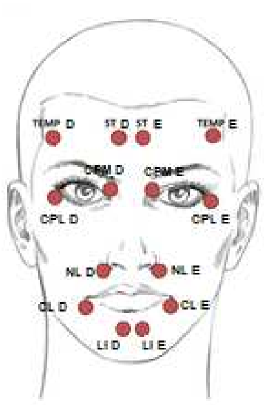

Figure 1. Identification of frontal thermo-anatomical reference points by frontal view Haddad et al., 2016. (Haddad et al., 2016)

Figure 2. Image of facial thermograph with marking of thermo-anatomical points.

The thermo-anatomical points analyzed were the temporal (TEMP), supratrochlear (ST), medial palpebral commissure (MPC), lateral palpebral commissure (LPC), right and left nasolabial (NL), right and left lip commissure (LC), and right and left lower lip (LL)[36], as shown in Figures 1 and 2.

The speech-language pathology clinical assessment was performed based on the application of the Expanded Orofacial Myofunctional Assessment Protocol (OMES-E)[37], validated for children, in which scores were given to the appearance and posture of the face, the lip, tongue, mandible, cheeks, mentalis muscle, hard palate, mobility of the lip, tongue, mandible, and cheeks as well as breathing function, deglutition, and mastication. From the sum of the scores attributed to each item contained in the protocol, the total orofacial myofunctional condition score was calculated. These ranged from 56 (worst condition or orofacial myofunctional performance) to 230 (best condition or orofacial myofunctional performance).

For speech evaluation, the Child Language Test[38] (ABFW) was used through the phonological test of naming 34 phonetically balanced figures. The test was recorded for later transcription, analysis, and classification of normal or altered speech condition as expected for the child's age.

The collected data were analyzed using the R-studio version 3.5 software for statistics. A level of 5% was considered statistically significant.

Descriptive statistics were computed for the study variables according to the group, control, and heart disease. These consisted of the mean, standard deviation, and median. The means of these groups were compared using a Student's t-test for unpaired samples. The effect size (Cohen's d) was also used to compare the means, using the following criteria: small when d = 0.2-0.3; medium when d = 0.4-0.8 and large when d> 0.08 (Cohen, 1988)[39].

To compare the eating behavior categories assessed by the Montreal Children's Hospital Feeding Scale, a Fisher's Exact Test was used to verify whether the frequencies of eating difficulties were different between the groups.

A multiple linear regression model was made to verify the effect of the acyanotic and cyanotic categories, the age and sex of the children, and other confounding variables on the mean temperatures and the delta of temperatures of the analyzed facial thermo-anatomical points.

To analyze whether speech condition was altered or not, a logistic regression model was built to assess whether the group, control or heart disease, gender, and age correlated with altered speech.

The correlations between the thermographic variables, eating behavior scores, and total scores (by category and general) of the OMES-E were calculated using a Pearson's linear correlation test.

RESULTS

The final study sample consisted of 30 participants with congenital heart disease, 18 were acyanotic, and 12 cyanotic. Four children did not undergo any intervention procedure, 15 underwent cardiac surgery, 4 underwent catheterization for diagnosis, and 7 underwent surgery and catheterism. The control group consisted of 28 healthy children aged between 4 and 6 years old. Table 1 shows the clinical characteristics of the two groups.

Regarding the eating behavior reported by the parents, there was no significant difference between the control and heart disease groups in terms of the total score of the scale. However, when comparing the groups regarding the frequency of children classified as without any difficulty, and with some feeding difficulty, a significant difference was observed (p <0.001; Fisher's exact test) (Table 1). According to the results, 7% of children with heart disease were allocated to the category ‘medium difficulty eating,’ followed by 3% of children in category 1, ‘mild difficulty,’ and 3% in the ‘severe difficulty eating’ category. All children in the control group were allocated to the ‘no difficulty’ eating category.

Descriptive statistics for the temperatures of the thermo-anatomical points analyzed in this study are presented in Table 2. A multiple linear regression model was built to verify if there was a significant effect of the acyanotic and cyanotic categories, as well as the confounding variables, age, and sex. No effect was observed of these on mean temperatures and the delta or difference of the temperature of the analyzed facial thermo-anatomical points (p> 0.05).

For the orofacial myofunctional evaluation, the comparison between groups by the student's t-test for unpaired samples showed a significant difference between the control and heart disease groups for the appearance and posture of the mandible, mentalis muscle and hard palate, mandible and cheek mobility, deglutition function and total OMES-E score (p <0.05) (Table 3). Considering the sum of scores by each category, it was also possible to observe differences between groups for all of the above categories, that is, the appearance and posture, mobility, and function categories (p <0.05). Mean effect sizes found for the sum of scores of ‘appearance and posture’, ‘mobility,’ and ‘function’ categories and for the total score were all above 0.6 (medium/large effect size).

Regarding speech condition, the heart disease group displayed a significant increase in the possibility of speech alterations being present as compared to the control group (*p* <0.05). Also, the statistically significant effect of age shows that the chance of speech impairment decreases as age advances (*p* <0.05), while the effect of sex was not significant (*p* > 0.05) (Table 4).

Table 5 shows the correlation matrix obtained between the total scores, and by category scores using the OMES-E protocols, the temperatures of the thermo-anatomical points, and the total score of eating behavior. Moderate positive correlations were found between the mean temperatures of the points right and left LC, and right and left LL and the best performance in the OMES-E "Functions" categories (*p* <0.01).

DISCUSSION

This study shows that the frequency of children with eating difficulties was higher among those with congenital heart disease. Additionally, the orofacial myofunctional aspects showed changes in the posture and position, mobility, and orofacial functions among children with heart disease as compared to the control group. These findings are of clinical relevance since healthy eating occurs through proper eating practices from early childhood and helps to improve the development of sucking, mastication, deglutition, breathing, and speech articulation functions[23,40]. In the case of children with congenital heart disease, eating is influenced by several factors ranging from the type of heart disease to the length of hospital stay, number and types of procedures performed[14-18] or even simply because the child is considered sick[41], which can impact on development.

The parents' perception of their child's eating behavior was assessed using the Montreal Children's Hospital Feeding Scale. We found that the total difficulty score reported by parents did not differ between the groups. However, there was a higher number of children classified with difficulty feeding among those with congenital heart disease. These complaints were related to parents' concern about food, positive or negative experiences at mealtime with the child, and the child's appetite[14,16]. The literature[18] states that children with congenital heart disease have changes related not only to their eating behavior but also to eating dysfunction. In another study[42], the parents did not denote changes regarding the appetite of children with congenital heart disease. However, these feeding difficulties can generate proprioceptive, sensitivity, muscular, mastication problems, and delays in language acquisition in these children.

When comparing groups of children with congenital heart disease and the control group regarding their mean facial temperatures and the thermal difference of the thermo-anatomical points studied, no differences were found. It was hypothesized that children with heart disease could have specific hemodynamic conditions, such as decreased or increased blood flow, obstruction, or mixed-blood flow[24], which could somehow affect their body or facial temperature. The literature[43] states that points on the forehead, collarbone, and neck are usually high-temperature points. Children under 14 years old have a similar temperature distribution, regardless of gender, which is close to an adult's temperature. There is little variation in temperatures across the child population. When comparing the thermo-anatomical points on the right and left sides of the face, we observed the presence of thermal symmetry in both the group of children with heart disease and in the control group, as described in the literature[44,45]. Some authors[46, 47] refer to the frontal region as the region which has the highest temperatures. In the presence of temperature asymmetry between the sides of the face, specific conditions can be found[48].

To improve the analysis by limiting some variables, we decided to subdivide the group of children with heart disease according to the procedure performed: 1) surgery only, 2) catheterism only, and 3) surgery and catheterism. By analyzing the frontal view from all selected points, we found that the medial palpebral commissure (MPC) region showed the hyper radiant temperature in both the control group and the group of children with heart disease, but without significant difference. This fact may be justified by the fact that this temperature is considered the temperature closest to core temperature.

In the researched literature, we found no studies that have performed a facial thermography examination in children with heart disease. This makes comparing our findings difficult. It is noteworthy that congenital heart disease is a wide spectrum change with very variable clinical impact and may vary according to the presence or absence of heart failure, classification of heart disease, and cardiac output, among others. In our sample, we selected children older than 4 years old and found some had already had interventional procedures performed. These children’s conditions could somehow be improved by medication or surgical procedures or catheterism.

Regarding the evaluation of myofunctional structures and their functions, it was found that children with congenital heart disease showed worse orofacial myofunctional performance as compared to the control group. It is noteworthy that this is the first study that performed a standardized assessment with a validated protocol in children with congenital heart disease. When we weighted each OMES-E variable, the participants showed poorer performance regarding the appearance and posture of the mentalis, hard palate muscles, mandibular mobility, and cheeks, deglutition, and the total OMES-E score. According to some authors[49, 50] children with normal development aged between 3 and 5 years old would already have adequate scores for the appearance and posture of the myofunctional organs.

Children with congenital heart disease also presented differences in the appearance of a hard, narrow, or deep palate. This may be due to their difficulty breathing, which influences the shape of the dental arches. The maintenance of the open oral cavity results in morphological imbalance and reduces ventilatory muscle strength[25,51]. This may be because children with congenital heart disease often develop changes in respiratory mechanics[26]. The results also showed differences in mandibular mobility for children with cyanotic heart disease, which has not previously been described in the literature. It is noteworthy that the movements of the opening of the mandibular and its laterality, protrusion, and retraction are important for masticatory efficiency[52].

Regarding the cheeks' mobility, the performance and efficiency of the deglutition of solids in children with heart disease had worse scores as compared to the control group. This finding may be justified by changes in the respiratory mechanics present in this group[26], causing a decrease in ventilatory muscle strength[25] and, consequently, changes in posture, tone, and mobility of the lips, tongue, and cheeks, determining lower efficiency in stomatognathic functions[53]. This finding is fundamental for speech therapy rehabilitation to be promoted for these children. It should be started as soon as possible to minimize such changes.

We found that children with heart disease were more likely to present changes in the production of speech. According to the literature[54,55], the severity of the disease and the presence of preoperative chronic hypoxemia may justify the orofacial myofunctional alterations, as well as a deficit in the production of speech [20,56,57].

A correlation was observed between the temperature of the labial commissure and the lower lip points as well as the OMES-E function score. This was expected as the best orofacial functions result from the higher activity of the perioral muscles and higher temperatures in these regions.

Therefore, cardiorespiratory changes that may be associated with orofacial functions of children with heart disease may have an impact on eating experiences and, ultimately, child development and the establishment of healthy eating practices. This study has discussed the need for early evaluation and follow-up to ensure proper orofacial myofunctional development in children with heart disease. More studies that use facial thermography in children are needed to expand the contribution of this exam in speech therapy practice.

CONCLUSION

This study has shown that the frequency of children with feeding difficulties was higher among those with congenital heart disease. These children also displayed changes in their appearance and posture, mandibular and cheeks mobility, deglutition function, and total score of functions as compared to the control group. On the other hand, the thermographic variables did not show any difference among groups. There was a correlation between the temperature of the thermo-anatomical points of the labial commissure, the lower lip, and the OMES-E scores.

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	Congenital Heart Disease group		Control group
	Cyanotic	Acyanotic	
N	12	18	28
Age			
mean (SD)	5.49 (1.03)	5.48 (0.68)	4.98 (0.64)
Median	5.9	5.85	5
Gender			
Girls	5	9	10
Boys	7	9	18
BMI (kg/m^2)			
mean (SD)	16 (4.0)	15.6 (2.21)	15.27 (1.89)
Surgery (n)	9	13	-
Catheterism (n)	5	5	-
Eating behavior *(total score)*			
mean (SD)	39.0 (18.3)	39.5 (15.5)	34.0 (10.3)
Median	36.5	37.5	34.0
Eating behavior (%)			
Without difficulty	83.3	88.9	100
Light difficulty	0	5.6	0
Medium difficulty	16.7	0	0
Severe difficulty	0	5.6	0

Table 2. Mean values (SD) and comparison between control group and heart disease groups for thermographic variables

ROIs (°C)	Heart Disease Group	Control Group	*p*-value*
	Mean (SD)	*Mean (SD)*	
TEMP R	35.17 (0.81)	35.10 (0.79)	0.739
TEMP L	35.02 (0.86)	35.01 (0.79)	0.965
tD	0.14 (0.38)	0.09 (0.28)	0.538
ST R	34.97 (0.84)	34.80 (0.81)	0.427
ST L	34.95 (0.81)	34.78 (0.82)	0.416
tD ST	0.02 (0.18)	0.02 (0.20)	0.977
LPC R	34.48 (0.92)	34.43 (0.86)	0.839
LPC L	34.49 (0.81)	34.66 (0.80)	0.430
tD LPC	-0.02 (0.48)	-0.16 (0.45)	0.269
MPC R	35.88 (0.91)	35.88 (0.63)	0.994
MPC L	35.84 (0.85)	35.79 (0.64)	0.814
tD MPC	0.04 (0.35)	0.08 (0.25)	0.577
NL R	34.39 (1.22)	34.79 (0.89)	0.154
NL L	34.39 (0.97)	34.66 (1.06)	0.314
tD NL	-0.02 (0.67)	0.13 (0.66)	0.387
LC R	34.41 (1.26)	34.41 (1.03)	0.998
LC L	34.14 (1.09)	34.36 (1.06)	0.437
tD LC	0.28 (0.76)	0.05 (0.54)	0.198
LL R	34.18 (1.14)	34.09 (1.17)	0.765
LL L	34.01 (1.11)	33.81 (1.27)	0.512
tD LL	0.16 (0.40)	0.28 (0.45)	0.291

TEMP: temporal; ST: supratrochlear; LPC: lateral palpebral commissure; MPC: medial palpebral commissure; NL: nasolabial; LC: labial commissure; LL: lower lip; R: right; L: left; tD: the thermic difference between the face's right and left sides.

* probability in the Student's t-test

Table 3. Mean values (SD) and comparison between control and heart disease groups for OMES-E protocol variables and categories

	Heart Disease group Mean (SD)	Control group Mean (SD)	*p-value**	Cohen's d effect size
Appearance/Posture				
Face	11.67 (0.54)	11.57 (0.62)	0.542	
Cheeks	7.60 (0.71)	7.71 (0.59)	0.517	
Mandible	10.83 (1.07)	11.68 (0.60)	**0.001**	
Lips	11.63 (0.55)	11.89 (0.41)	0.050	
Mentalis Muscle	3.63 (0.48)	3.93 (0.37)	**0.013**	
Hard Palate	6.80 (1.58)	7.57 (0.78)	**0.024**	
Tongue	7.47 (1.02)	7.50 (1.09)	0.906	
sum – appearance/posture	59.63 (4.35)	61.86 (1.90)	**0.016**	0.66
Mobility				
Lips	19.13 (3.84)	19.82 (4.02)	0.515	
Tongue	33.87 (2.68)	34.25 (2.72)	0.597	
Mandible	24.40 (6.94)	29.36 (2.07)	**0.001**	
Cheeks	19.03 (4.87)	22.54 (5.04)	**0.011**	
sum – mobility	96.43 (11.90)	105.96 (9.42)	**0.002**	0.89
Functions				
Respiration	3.80 (0.60)	3.96 (0.19)	0.169	
Deglutation	25.37 (2.52)	27.14 (1.25)	**0.002**	
Mastication	17.97 (2.99)	19.54 (2.81)	0.057	
sum-functions	47.13 (4.06)	50.64 (3.23)	**0.001**	0.96
Total score OMES-E	203.20 (14.08)	218.46 (9.66)	**0.000**	1.26

* probability in Student's t-test

Table 4. Adjustment of the logistic regression model considering intercept, age and presence of heart disease for speech change

	Intercept	Age	Heart Disease
Speech	**Effect (LL-UL)**	**Effect (LL-UL)**	**Effect (LL-UL)**
	13.86 (0.19-1033.5)	0.4 (0.17-0.97)*	4.97 (1.16-21.34)*

Logistic regression model; *p<0.05; LL: lower limit; UL: upper limit

Table 5. Correlation matrix (r) obtained between OMES-E category scores, eating behavior total score and thermo-anatomic point temperatures

	Appearance-Posture OMES-E	Mobility OMES-E	Functions OMES-E	Total Score OMES-E
Eating behavior total score	0.11	-0.09	0.08	-0.02
Temp R	0.12	-0.13	0.23	-0.01
Temp L	0.13	-0.10	0.22	0.01
tD TEMP	0.01	-0.06	-0.05	-0.06
ST R	0.12	-0.12	0.17	-0.02
ST L	0.12	-0.18	0.19	-0.06
tD ST	-0.10	0.25	-0.03	0.17
MPC R	0.15	-0.15	0.14	-0.04
MPC L	0.11	-0.18	0.14	-0.08
tD MPC	-0.34	-0.12	-0.18	-0.23
LPC R	0.20	-0.10	0.22	0.03
LPC L	0.17	-0.09	0.25	0.04
tD LPC	-0.04	0.10	-0.18	0.02
NL R	0.16	-0.08	0.16	0.02
NL L	0.24	-0.28	0.14	-0.13
tD NL	-0.17	0.11	0.11	0.08
LC R	0.22	-0.19	**0.33***	-0.01
LC L	0.36	-0.23	**0.40***	0.01
tD LC	-0.11	-0.09	-0.03	-0.11
LL R	0.22	-0.25	**0.30***	-0.07
LL L	0.23	-0.23	**0.30***	-0.05
tD LL	0.04	0.01	0.03	0.03

TEMP: temporal; ST: supratrochlear; LPC: lateral palpebral commissure; MPC: medial palpebral commissure; NL: nasolabial; LC: labial commissure; LL: lower lip; R: right; L: left; tD: the thermic difference between the face's right and left sides.
r, Pearson's correlation coeficient; **p*<0.01

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ST L	0.12	-0.18	0.19	-0.06
tD ST	-0.10	0.25	-0.03	0.17
MPC R	0.15	-0.15	0.14	-0.04
MPC L	0.11	-0.18	0.14	-0.08
tD MPC	-0.34	-0.12	-0.18	-0.23
LPC R	0.20	-0.10	0.22	0.03
LPC L	0.17	-0.09	0.25	0.04
tD LPC	-0.04	0.10	-0.18	0.02
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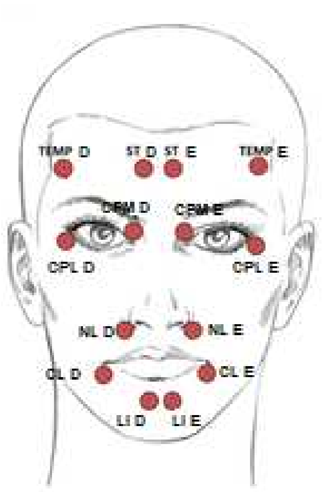

Figure 1. Identification of frontal thermo-anatomical reference points by frontal view Haddad et al., 2016.

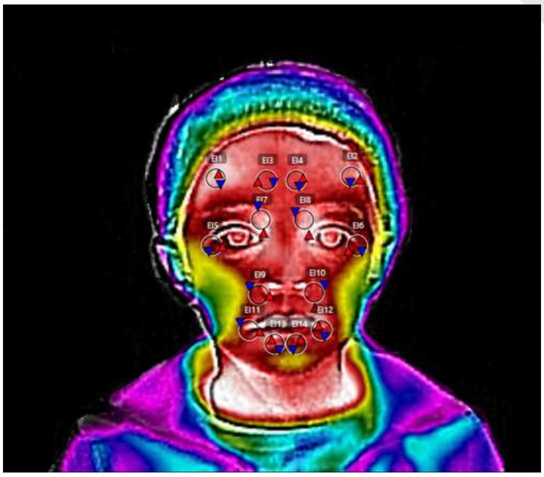

Figure 2. Image of facial thermograph with marking of thermo-anatomical points.