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# Thermal symmetry – Is it a good indicator?

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**Abstract**

The diagnostic of pathological states using thermal images rely in quantitative simple indicators such as thermal symmetry values. It is aim of this research to investigate whether the thermal symmetry definition is enough to discriminate between healthy and pathological states and overlook other statistical methods in that task. Four images of ankles (1 healthy and 3 pathological) were used as data, 2 ROI were analysed. This research proves that the use of thermal symmetry is a poor indicator, boxplot charts and asymmetry coefficients add useful information that must be considered but are insufficient. Further research is required to overcome this.

## 1. Introduction

Infrared thermal imaging is an objective indirect measurement of an object surface. It can be analysed quantitatively or qualitatively. Normally thermal images are analysed by spot value, region of interest (ROI) or cross-section, it allows single image analysis or related images sequence analysis. In a single image, the most common analysis when two parts of object in the scene share the same underneath structure and have been taken at same distance and similar angle, is to draw two ROIs and compare the measurements.

In medical and veterinary research, since most of the human or other animal body regions are similar on structure across the main longitudinal axis, the measure of ROIs difference is often called by “thermal symmetry” or “thermal asymmetry” [1]. Vardasca et al. [2] in 2012 defined the term thermal symmetry of the limbs as “the ‘degree of similarity’ between two Areas of Interest (AOI), mirrored across the human body’s longitudinal main axes which are identical in shape, identical in size and as near identical in position as possible. The degree of similarity is measured in terms of mean and standard deviation of the respective temperatures in the AOIs”. This reference measure study [2] concluded that thermal symmetry in healthy subjects being measured in terms of absolute difference between left and right sides of body extremities had a maximum value of 0.5±0.3ºC, allowing this value to be used as threshold for most clinical practitioners. Many studies were conducted and referenced this indicator, however they relied only in the absolute difference of the mean temperatures of the ROIs.

It is aim of this research to investigate whether the thermal symmetry definition is enough to discriminate between healthy and pathological states as suggested by Vardasca et al. in 2012 and overlook other mathematical/statistical indicators that might be useful to take in attention.

## 2. Methodology

For testing the proposed aim, four images of both ankles were selected from a database, being one healthy and the remaining ones clinically confirmed pathological at different stages of an ankle sprain pathology (grade I, Grade II and Grade III). To each image a rectangular ROI (with a size of 43x31) was drawn using the FLIR tools software Descriptive statistics were determined per ROI, histogram and boxplot graphs were created per image accommodating the two ROI and the asymmetrical coefficients of Pearson and Bowley were calculated [3, 4]. All measures and visual charts were interpreted with the objective of discriminating the two ROIs. All analysis were made in the MS Excel spreadsheet software.

## 3. Results

The thermal images of the ankles encompassing a healthy sample and a grade I, grade II and grade III ankle sprain are displayed in fig. 1, the descriptive statistics are shown in table 1, the histograms are presented at fig. 2 and the boxplot charts at fig. 3 and the asymmetrical coefficients in the table 2.

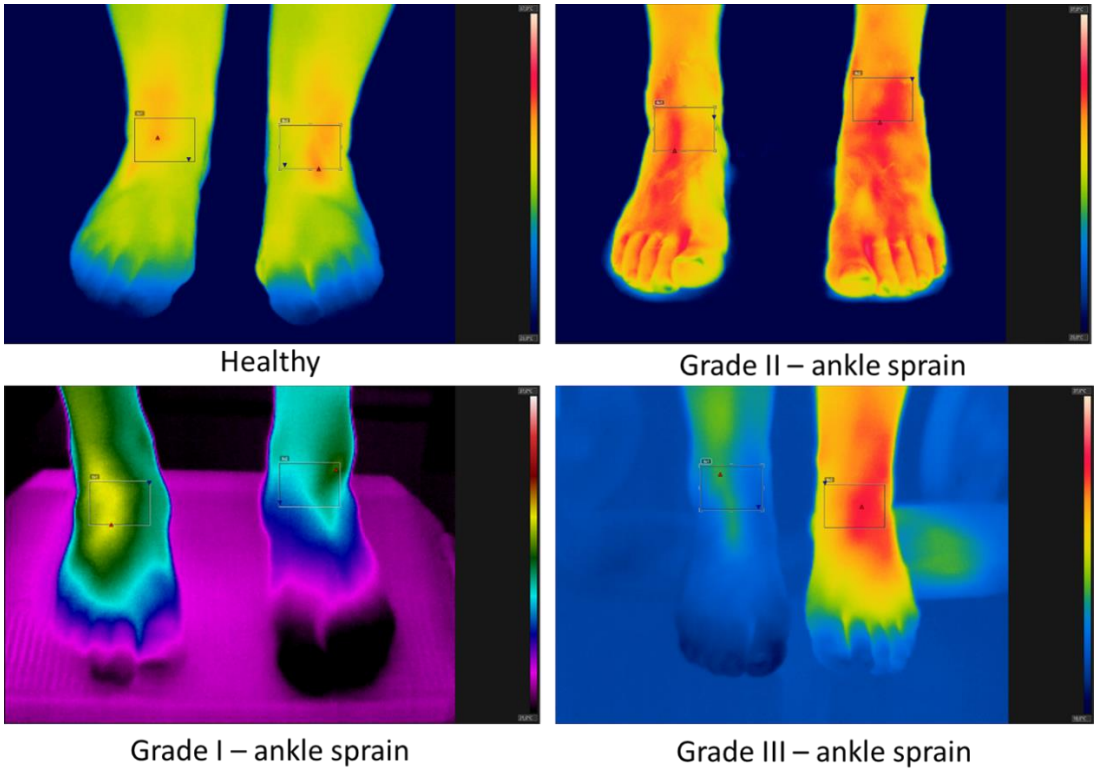


***Fig. 1.*** *The thermal images used in this study with the Regions of interest.*

***Table 1.*** *The descriptive statistics of the sample.*

| Measures | Heathy | | | Grade I | | | Grade II | | | Grade III | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Right | Left | Diff. | Right | Left | Diff. | Right | Left | Diff. | Right | Left | Diff. |
| Mean | 31,1 | 31,3 | 0,2 | 30,1 | 27,5 | 2,6 | 32,5 | 33,1 | 0,6 | 24 | 31,7 | 7,7 |
| Mode | 31,3 | 32 | 0,7 | 31 | 27,1 | 3,9 | 32,3 | 32,8 | 0,5 | 25,2 | 32,7 | 7,5 |
| Median | 31,2 | 31,4 | 0,2 | 30,4 | 27,4 | 3 | 32,4 | 33 | 0,6 | 24 | 32 | 8 |
| Minimum | 30 | 29,8 | 0,2 | 28,2 | 25,6 | 2,6 | 30,4 | 31,7 | 1,3 | 22,1 | 29,2 | 7,1 |
| Maximum | 32,2 | 32,7 | 0,5 | 31,2 | 29,4 | 1,8 | 33,9 | 34,3 | 0,4 | 25,6 | 33 | 7,4 |
| Std. Dev. | 0,5 | 0,8 | 0,3 | 0,9 | 0,9 | 0 | 0,7 | 0,5 | 0,2 | 1 | 1 | 0 |
| Skewness | -0,2 | -0,2 | 0 | -0,5 | 0,2 | 0,7 | -0,1 | 0,2 | 0,3 | -0,1 | -0,7 | 0,6 |
| Kurtosis | -0,9 | -1,3 | 0,4 | -1,1 | -0,7 | 0,4 | -0,2 | -0,9 | 0,7 | -1,3 | -0,7 | 0,6 |

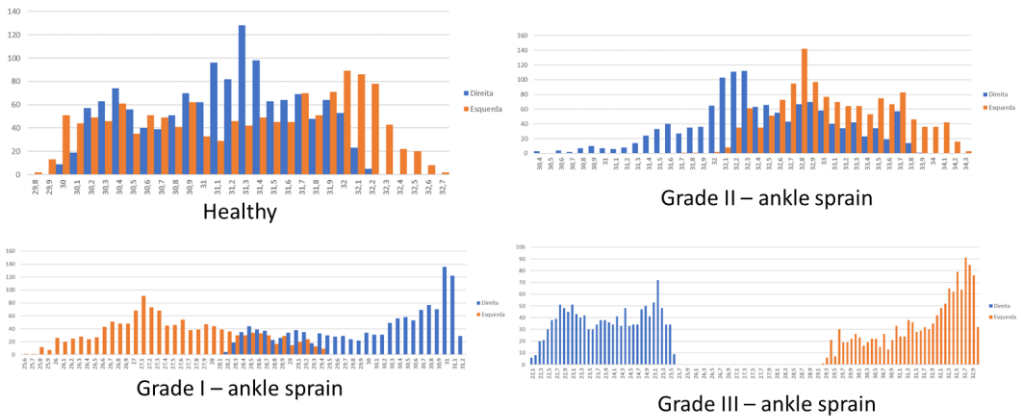


***Fig. 2.*** *The histograms of the different images with the ROIs.*

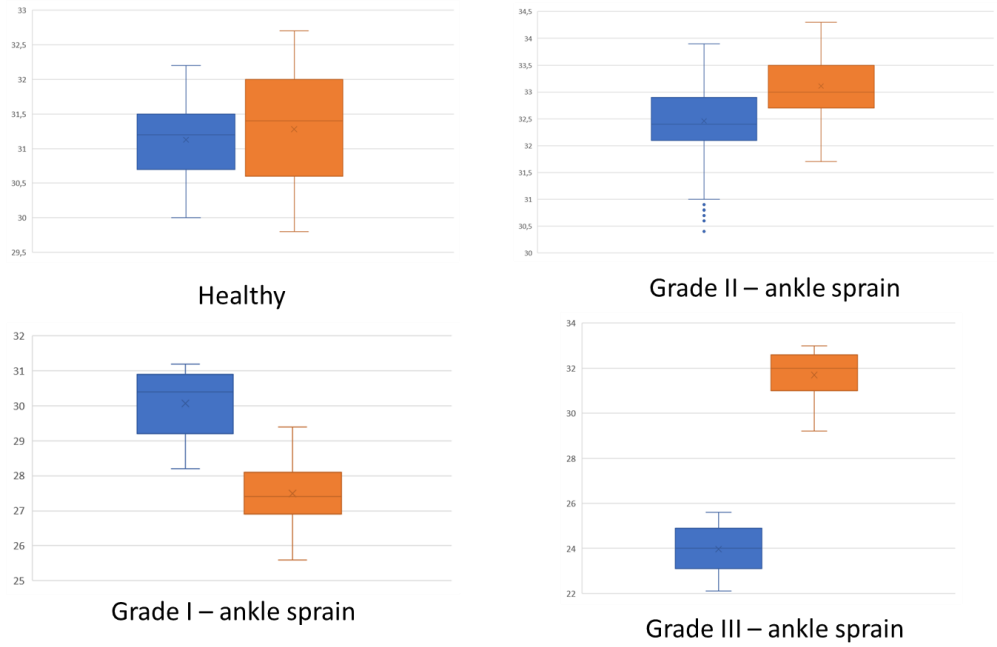


***Fig. 3.*** *The boxplot charts of the different images with the ROIs.*

***Table 2.*** *The asymmetry coefficients of the sample.*

| Measures | Heathy | | | Grade I | | | Grade II | | | Grade III | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Right | Left | Diff. | Right | Left | Diff. | Right | Left | Diff. | Right | Left | Diff. |
| Pearson 1 | -0,4 | -0,9 | 0,5 | -1 | 0,4 | 1,4 | 0,3 | 0,6 | 0,3 | -1,2 | -1 | 0,2 |
| Pearson 2 | -0,6 | -0,4 | 0,2 | -1 | 0,3 | 1,3 | 0,4 | 0,6 | 0,2 | 0 | -0,9 | 0,9 |
| Bowley | -0,2 | -0,1 | 0,1 | -0,4 | 0,2 | 0,6 | 0,25 | 0,25 | 0 | 0 | -0,25 | 0,25 |

## 4. Discussion and conclusion

It can be observed that relying only in the thermal symmetry as defined by Vardasca et al. in 2012 [2] the grade II ankle sprain falls into the healthy classification demonstrating the failure of that discrimination method that just attends to mean temperature and standard deviation differences between ROIs (table 1). Using only the histogram charts (fig. 2) the same confusion between the healthy sample image and the grade II exists. The use of boxplot charts (fig. 3) helps to discriminate between these two confusing elements of the sample and have its visualization confirmed by the asymmetry coefficients presented at table 2. Although none of this statistical method alone can act as discriminator by itself.

This research proves that the use of the previously definition of thermal symmetry is a poor indicator of a pathological state and has overlooked different statistical methods to strengthen its discrimination, boxplot charts and asymmetry coefficients add useful information that must be considered but are insufficient. Further research is required and the use of Principal Component Analysis should be investigated.

## REFERENCES

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