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# Evolution of the Surface Temperature of Pianists' Arm Muscles Using Infrared Thermography

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*Abstract*- **Musculoskeletal disorders are very frequent among musicians. Diagnosis is difficult due to the lack of objective tests and the multiplicity of symptoms. Treatment is also problematic and often requires that the musician stop playing. Most of these disorders are inflammatory in nature, and therefore involve temperature changes in the affected regions. Temperature measurements were recorded with an infrared camera. In this paper we present an overview of the temperature measurements made in the arms of 8 pianists during regular piano practice sessions.**

***Keywords*** **- Infrared Imaging, Thermography, Musculoskeletal Disorders (PRMD), piano playing**

## I. Introduction

According to experts, Playing Related Musculoskeletal Disorders (PRMD) affect 39% to 87% of adult musicians and 34% to 62% of students [1]. The term "overuse syndrome" is often used generically to refer to a broad range of symptoms and musculoskeletal pathologies such as tendonitis, tenosynovitis, focal dystonia, carpal tunnel syndrome. [2]. Inflammatory disorders are the most frequent and are often caused by the repetitive movements involved when playing a musical instrument. These disorders typically affect specific muscles or tendons of the arm, wrist, neck or back [2,3,4]. Diagnosis is often difficult for many PRMD because there are few objective tests and symptoms may vary greatly, although pain is almost always present [2]. Treatment is also problematic since it often requires that musicians stop playing temporarily, and sometimes indefinitely [2,3].

Being able to understand how these disorders appear and how they develop into debilitating conditions is important for treatment and perhaps even more for prevention through adapted corrective techniques. One possible cause of the appearance of PRMD is either an improper playing technique or the pedagogic approach used; this is because these two factors often do not take into consideration the physical characteristics of the musician [2,3]. Thus, it seems appropriate to first study younger pianists, who are still developing their playing technique, to see whether early signs of PRMD can be identified. Another possible cause of PRMD is the lack of or insufficient warm-up. The benefits of warm-up have long been known in sports and most athletes warm up before exercising, although the literature on the effects of various warm-up methods on performance is surprisingly scarce [5]. Warm-up is far less common among professional musicians even though intensive playing of a musical instrument puts significant stress on the muscles involved, which can be compared to the physical stress experienced by an athlete. Therefore, we believe it is important to study the effects of a warm-up on the performance of musicians.

The inflammatory nature of PRMD and the effects of warm-up imply temperature changes in muscles and musculoskeletal tissues. These temperature changes can be detected at the surface of the skin and recorded by infrared thermography [6,7]. In this study, we collected information on the temperature change of several areas of the arm during a piano practice session and present some of the preliminary results.

## II. Methodology

### *A. Data acquisition*

Several hundred infrared images of the hands, arms, neck and face were acquired for 8 volunteer pianists during a regular piano practice session, following the approval by the Ethics Committee of the University of Ottawa. The subjects were:

1) 5 young pianists (4 females, 1 male), aged between 6 and 18 years, with 2 to 15 years of piano playing experience; the subjects practiced an average of 30 minutes to 2 hours daily.
2) 2 graduate music students (1 male, 1 female), with over 15 years of experience and at least 2 hours of daily practice.
3) 1 piano teacher with extensive experience.

The pianists were asked to come 15 minutes prior to their regular practice time wearing a sleeveless shirt to allow their body temperature to reach equilibrium with the ambient temperature of the room, which was kept constant at around 23 degrees Celsius. A first series of images of hands, arms, neck and face were taken, after which subjects started playing the piano. Standard views were used for each region of interest. Every 15 to 20 minutes, another series of images was taken until the end of the practice, which could last from 30 minutes to 2 hours. The duration of the practice was the same as the regular practice time of each subject and they played according to their level.

At the end of the practice, subjects were asked to wait 15 more minutes without playing, after which a last series of images was taken. Each series of images during the practice session took approximately 5 minutes. For each body region,

we recorded a series of 10 images on average to reduce the risk of erroneous measurements. Images were recorded using a Thermacam SC500 from FLIR Systems Inc. Each image was 320 X 240 pixels and the thermal sensitivity was 0.1 degree Celsius. The images were subsequently transferred to a PC for analysis.

*B. Data processing*

Injuries in pianists are commonly located in the wrist and finger extensors and lumbricals, the interossei of the right hand, the pronator teres, and in several of the flexor muscles of the forearm. We therefore focused our efforts on the surface temperature variations corresponding to the muscles and tendons of the arm and more specifically on the following regions: biceps, triceps, flexor and extensor muscles of the forearm, elbow-joint area and deltoid.

A template was devised, based on anatomical drawings showing the location of superficial and deep anatomical structures for each view (anterior, dorsal, lateral) [8]. Fig. 1 shows two of the templates used. The template was then matched to the current image using easily detectable landmarks such as the depression between the wrist and the hand, or between the brachium and the forearm at the elbow. This ensured that the regions selected were consistent across the series of images. Given a specific region, we computed the average temperature for each image. The resulting temperature was further averaged among the images from one series (typically between 5 to 10 images). The standard deviation within one series was also computed to detect and discard outlier measurements.

## III. Results

Fig. 2, 3 and 4 show typical temperature variations of the skin areas corresponding to deltoid, biceps (both lateral view and anterior view), triceps, elbow joint, extensor and flexor of the right arm for three subjects. Each data point represents the average temperature over a series of images. The first point in time occurs after the equilibration period and the last point in time occurs after the relaxation period at the end of the session.

Fig. 5 and 6 compare the temperature variations for the extensor and flexor muscles of the right arm for all subjects.

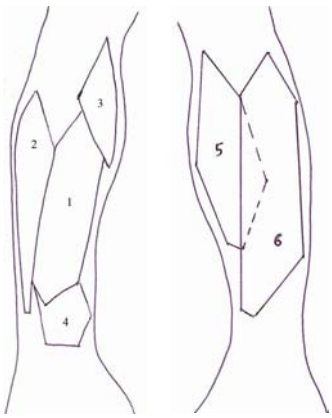


Fig. 1. Examples of two templates used for finding the temperature of extensor (1,3,4 and 5) and flexor (6 and2) muscles of the forearm.

## IV. Discussion

The evolution of the surface temperature of the muscles of the arm varies significantly between subjects and different trends can be seen in the graphs. The evolution of temperatures differs significantly going from a slow general decrease of the temperature over the practice (Fig. 4) to a very abrupt decrease in the middle of the practice (Fig. 2). Here the technique used when playing or the number of years of experience could explain some of the differences in responses. For example, the variation of temperature for the extensor and flexor muscles of subject 1 and 8, both experienced pianists with established playing technique, is almost opposite in the middle of the practice, when typically the pieces played are the most challenging. On the other hand, the response for extensor and flexor muscles of subject

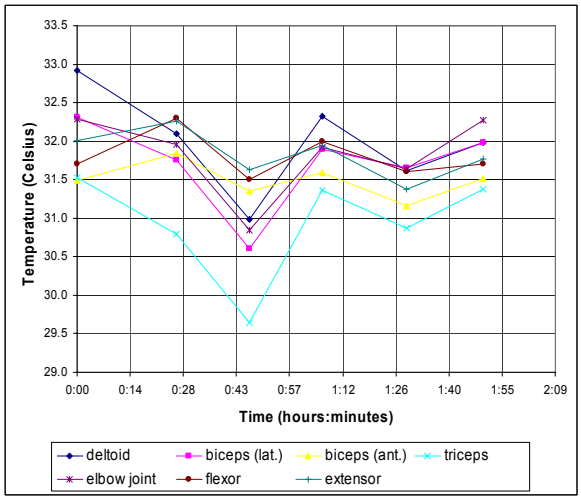


Fig. 2. Surface temperature of muscles of the arm during a piano practice for subject 3.

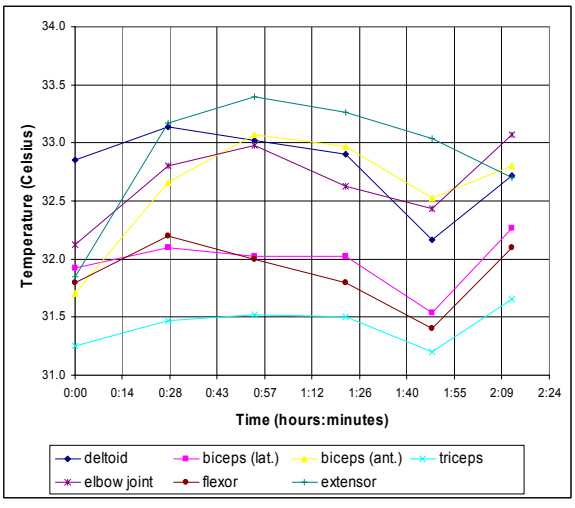


Fig. 3. Variation of the surface temperature of muscles during a piano practice for subject 1.

3, less experienced, is almost identical, which may suggest a lesser range of motion of the wrist. The ability of infrared thermography to differentiate between the different playing techniques is an interesting perspective, which will require further investigation.

The variation of temperature of specific muscles may also vary significantly among subjects as seen in Fig. 4, although a more general trend seems to emerge for other groups of muscles, for example in Fig. 4. Sudden drops or increases in temperature at the beginning of the practice session could be attributed to a lack of warm-up.

The small number of subjects as well as the wide range of factors that can influence the temperature of the muscles used while playing the piano is a possible explanation for the great difference of responses among the subjects. For example, the length of practice, the difficulty level of the music played, as well as the order in which the pieces are played, are some of the parameters to take into account in order to understand the variation in muscle temperatures.

## V. Conclusion and Future Work

This paper presented some interesting early results on the variations of temperature of the muscles of pianists during a practice session. It shows that there are temperature variations in most muscles for all participants. However, the nature of these variations is not consistent among all participants. This may be attributed to age, years of experience, difficulty level of the music, etc. Although the large variability in the results makes it difficult to draw general conclusions on the thermal behavior of the muscles involved when playing the piano, it raised several questions that will be addressed in future work. In particular, a controlled study of warm-up procedures and their effects will be performed to help understand some of the sudden changes of temperature seen in this first study.

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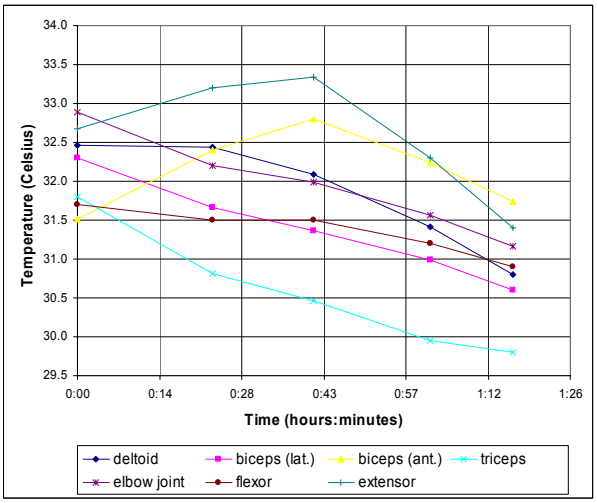


Fig. 4. Variation of the surface temperature of muscles of the arm during a piano practice for subject 8.

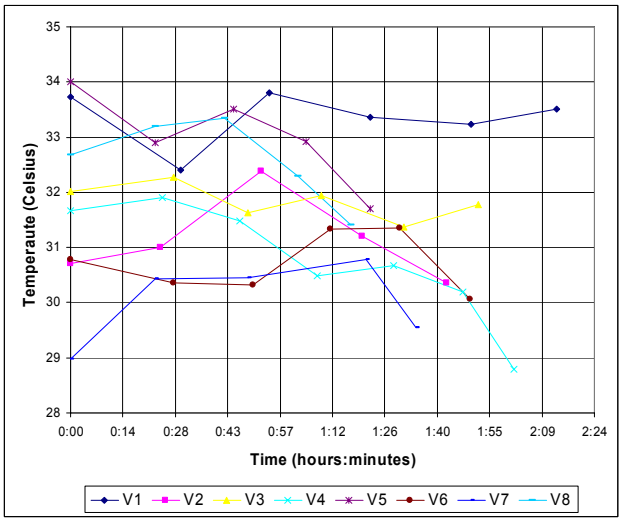


Fig. 5. Variation of the surface temperature of the right extensor muscles of the arm during a piano practice for all subjects.

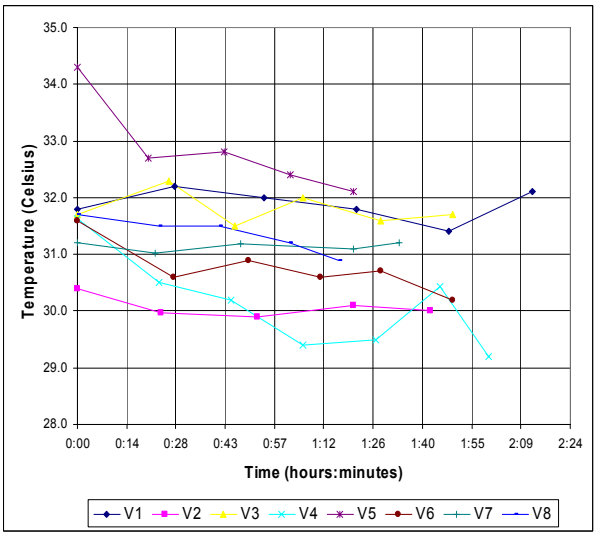


Fig. 6. Variation of the surface temperature of the right flexor muscles of the arm during a piano practice for all subjects.

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