Metabolic rate evaluation of an orthopedic surgeon through oximetry

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ABSTRACT
Thermal comfort is an important factor in a professional's environment, having a role on his health and productivity. The PMV/PPD index allows to combine environmental and personal factors into a known thermal sensation scale. For a correct application of the method, it is necessary to accurately assess its variables. Due to the metabolic rate complexity allied to the need of studying the case of health professionals, this work assesses the metabolic rate of a surgeon using a precise measurement method such as oximetry. Although the results are similar to other studies in the field, the creation of equivalent tasks has proven to be complex.

KEYWORDS: PMV/PPD, Thermal Comfort, Equivalent Task, Climatic Chamber, Surgeon

1. INTRODUCTION

The human body is a system that interacts with its environment. For a proper functioning, this interaction needs to be balanced in different biological aspects, including the thermal balance. When the body is faced with an external factor, an effort for adaptation is demanded, which results in discomfort. This sensation decreases human performance and may cause health issues such as stress (Miguel, 2014; Parsons, 2014). To protect people from its thermal environmental it is crucial to understand the phenomena that contribute to the thermal comfort. Nowadays it is defined as "that condition of mind which expresses satisfaction with the thermal environment" (ASHRAE Standard 55:2004; ISO 7730:2005). However, this definition is very subjective, taking into account variables such as the mood of a person. To overcome this limitation, thermal comfort indexes, namely the PMV/PPD, were created, which approximate the thermal comfort to the concept of thermal neutrality (Fanger, 1970). This index correlates four environmental and two personal variables and constitutes a measure for the thermal sensation from -3 (cold) to +3 (hot) with 0 being the thermal neutrality. The result's precision is associated with the quality of assessment regarding the necessary variables (d'Ambrosio Alfano, Palella, & Riccio, 2011). From these, the metabolic rate presents the biggest ambiguity and complexity with an accuracy of ±20% when using an approximation with tabled values. However, when assessing through oximetry, the precision rises to ±5% (ISO 7730:2005). Though, this method has certain restrictions as the encumbrance resultant from the measuring equipment, besides the associated cost. For this reason, and in cases where the activity is sensitive, such as in an operating room, makes this method better suited for use in a controlled environment alongside the equivalent tasks.
Facing this problematic, the objective of this work was defined as the determination of the surgeon's metabolic rate, without jeopardizing his work.

2. MATERIALS AND METHODS

To accomplish the defined objective, the metabolic rate was measured using a series of equivalent tasks on a controlled environment.

The first step towards the objective, consisted in the assessment of the surgeon's tasks, during the execution of his work, trough observation. In this regard, the tasks were registered following the evaluation of level 2 (Method A) described in ISO 8996:2004, alongside with the time allocated for each task.
The environment control for the equivalent tasks execution was achieved using the climatic chamber FITOCLIMA® 25000 EC 20, from the Faculty of Engineering of University of Porto. In the tasks' definition, the experimental project was subjected to three main restrictions: the execution time, the available budget and the tasks type that could be implemented in the climatic chamber.
Due to time limitations and to reduce the subjects' period of occupation in a closed room, each experiment was reduced from 1 hour to 35 min per person. To keep consistency, the time proportion of each equivalent task was kept constant. The tasks type, intensity and time are represented on Table 1.

Table 1 – Type and intensity of the activities developed during the performed test.

Work intensity	Time (min)	Time (%)
Both hands and arms, light	20	57
Both hands, light	8	23
One hand, light	2	6
Both arms, medium	3	8
Both hands, hard	2	6

Taking into consideration the limitations referred before, the first two tasks were performed recurring to a puzzle. The first task consisted in sorting the pieces of 4 different puzzles. Regarding the third task, the game Operation® was chosen as an equivalent task. The fourth task consisted in using an electric screwdriver to screw and unscrew a set of 6 bolts on a wooden beam. For the last task, a hand exercise spring was used, were the subjects had to squeeze.
The referred tasks were developed in the climatic chamber with the temperature set to 21°C and the relative humidity to 55%. The sample of these tests consisted of 8 nurses. All of them were volunteers from the hospital where the data regarding the environment, clothing and tasks were obtained. Before the beginning of the test, the subjects dressed the typical clothing of a

surgeon and were equipped with the oximeter. The device used in the metabolic rate measurement was the COSMED® k4b^2. During the development of the tests, the subjects were followed by the researchers, who would verify the time used in each task, as well as, if they were performed accordingly. The full description of the used methodology was described in Rodrigues, Miguel, Teixeira, & Santos Baptista (2016).

3. RESULTS

The experiment allowed to obtain the metabolic rate for each subject along the execution time. Since the collected data presented a high sampling for the metabolic rate and a high variability, the data were simplified using the averaged value regarding intervals of 30 seconds. During the calculation of the averaged values, it was also verified the existence of outliers. However, the data without the outliers presented a uniformity that hid some details. Because of that, it was chosen to keep the outliers since they were already attenuated by averaged values (see Figure 1). The vertical lines represent the transition time from one task to the next one. Although the test ended at 35 minutes, Figure 1 presents data until 3 minutes after.

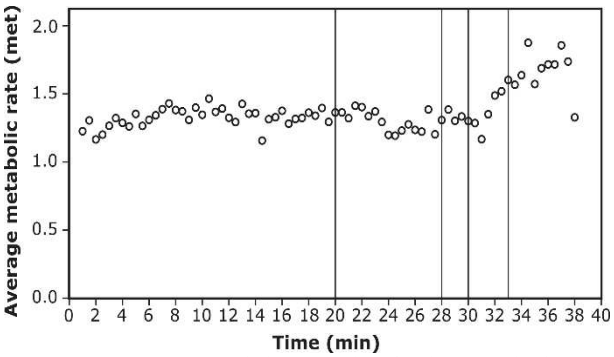

Figure 1 – Average metabolic rate values for the 8 tested subjects, along the duration of the test.

Regarding the first three tasks, the Kruskal-Wallis test for non-parametric data with an alpha of 5% showed no statistical difference between the results. However, for the last two tasks, representing a medium and a high metabolic rate, there is a tendency to an increasing metabolic rate. The resulted data also showed that the metabolic rate was kept for some time after the ending of the test. The overall average for the metabolic rate was 1.37 met, with a standard error of 0.01. On the other side, the metabolic rate calculated using the ISO 8996:2004 resulted in a value of 2.29 met.

4. DISCUSSION

Regarding the first observation, concerning the metabolic rate between the first three tasks, a possible explanation for the absence of differentiation resides in the definition of the equivalent tasks. It is possible that the proposed tasks did not produce perceptible differences in the metabolic rate, resulting in tasks that although different in its execution, they presented the same metabolic load. For a better understanding of the performed tasks and their proximity to the surgeon work, it is advised, if possible, the inclusion of surgeons on the test sample. While performing these tasks, one of the subjects referred that the workload was typical of a light surgery, for example, to the wrist. On the fourth task, representing a medium workload, it is already visible an increment of the metabolic rate. This result demonstrated that the proposed task was enough to produce a differentiation from the light ones. On the last task, the metabolic rate kept raising and presented its highest value. This was a good result since it was pretended to represent the workload with the highest intensity. During the execution of this task, the subjects referred to have felt a hotter thermal sensation. Some of the subjects even reported that it was enough to make them perspire. The persistence of the metabolic rate after the ending of the tests performed is an indicator that the human body presents a degree of inertia. This result questions the reduction of time held, since the metabolic rate could keep increasing during a one-hour surgery.

When comparing the metabolic rate obtained by oximetry with the value obtained from the metabolic tables, it is verified that the measured value is smaller. According to other studies published, the metabolic rate of a surgeon can vary from 1.38 met for light surgeries to 2.1 met for some heavier surgeries (Sudoł-Szopińska & Tarnowski, 2007; Van Gaever, Jacobs, Diltoer, Peeters, & Vanlanduit, 2014). These studies are another indicator that the tasks executed during the tests are representative of a light surgery. However, both obtained values are plausible to represent a surgery, depending of its nature. Here again, the inclusion of a surgeon would facilitate the classification of the surgery type, as well as to define the equivalent tasks.

5. CONCLUSIONS

After the completion of the present work, it was possible to determine the metabolic rate of the subjects. It was verified that only the tasks proposed for medium and high metabolic rate produced a differentiation to the light workloads. The obtained results pointed to a metabolic rate representative of a light surgery as, for example, the case of a wrist surgery. Although the determined metabolic rate (1.37 met) is coherent with the workload from light surgeries, obtained from other studies, this value does not reproduce the case where the observation of the workload was made on harder surgeries. This result pointed that there is a substantial difference from what it is perceived from observation of a task, to the real execution. To improve this work in future iterations, it is advised to better evaluate the equivalent tasks with the inclusion of surgeons on the study and to increase the overall duration of the test. This last modification will give the human body time to adapt to the workload.

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