A protocol proposal on calculation of the metabolic rate for surgeons in an operating room.

Nelson Rodrigues, Alberto Miguel, Senhorinha Teixeira and J. Santos Baptista
UMinho, FEUP

Abstract
Thermal comfort is a subject of great importance for the well-being and productivity of people in general, thus, a good work environment is something that should be sought whenever possible. Within this subject, the determination of the metabolic rate has great importance, although its calculation can be a laborious task. In this work, a protocol is presented to calculate the metabolic rate of a surgeon when performing his work in an operating room. The clothing, environmental conditions as well as the different tasks of the surgeon were collected through observation of three surgeries in a Portuguese hospital. These conditions were then recreated on a controlled environment of a climatic chamber and a set of tasks to reproduce the physical workload performed by the surgeon. In this controlled environment, the metabolic rate was measured using oxygen measurement and the results were compared with ISO 8996:2004 standard values. The obtained results showed a good approach to this standard.

Keywords: metabolic rate, equivalent metabolic rate calculation, operating room, surgeon.

Presentation Preference: Oral

1. INTRODUCTION
Thermal comfort is an important subject as people, when subjected to good working conditions, have increased health benefits, are more productive and less prone to errors. This, in a context of an operating room, gains even more importance. The practical principle of thermal comfort is dependent on the thermal neutrality, which is achieved when the heat produced by our body equals the heat loss to the environment. There are different methods to use on the evaluation of the thermal environment such as the Wet Bulb Globe Temperature (WBGT), Effective Temperature, Predicted Mean Vote – Predicted Percentage of Dissatisfied (PMV-PPD) and Wind Chill among others (Taleghani, Tenpierik, Kurvers, & Van Den Dobbelsteen, 2013). The existence of different methods is related to their strength of appliance. The first two methods are more appropriate to the evaluation of hot environments, on the other hand, the PMV/PPD index is better suited for the evaluation of environments near thermal neutrality and the wind chill for cold environments (Miguel, 2014). For a good precision of the evaluation methods, personal factors like clothing and metabolic rate need to be included because in the same environment, a seated person perceives the thermal environment in a different way of another one performing a heavy task.
Concerning the clothing insulation, the most common methodology relies on the use of tabled values for the insulation of individual clothing parts used in our everyday lives. The sum of the different used parts gives the total thermal insulation for the individual or control group in study. Regarding the metabolic rate, a similar approach is used to its calculation considering the tabled values referred on ISO 8996:2004. However, this methodology is not very precise since the values are statistically collected from a population that may not reproduce the case in study. The referred standard mentions a value of ±20% for the error. Fortunately, there are other methods of calculation with more precision, such as the oxygen consumption measurement. This methodology indicates a value of only ±5% for the error, which leads to an increased accuracy of the thermal comfort indices (d'Ambrosio Alfano, Palella, & Riccio, 2011). The problem with the oxygen measurement is that the costs of measurement are high and the apparatus limits the movements of the measured person, thus creating a dangerous situation for high risk activities such as a surgery. To solve this problem it is possible to use the metabolic equivalent concept. This refers to the creation of a task that reproduces what is intended to study in a controlled environment, and then proceed to the measurement of the metabolic rate. The recreation of certain tasks can have multiple setbacks, such as in the case of a surgery. The subject of thermal comfort in hospitals is not a new concept, however, it is not common for the investigation to focus on staff or in operating rooms (Khodakarami & Nasrollahi, 2012). During the development of this work, the researchers concluded that this deficit could be related to the fact that operating rooms are a hard medium to study due to their exigence and necessary bureaucracy associated to the execution of such a study. Through this work, the researchers intend to share their work on the subject of thermal comfort in operating rooms (Rodrigues et al., 2015) and, in the present case, to show the methods used to overcome the setbacks in evaluating the metabolic rate of a surgeon with a greater degree of precision.

2. MATERIALS AND METHODS

In this work a formulation to calculate the metabolic rate of a surgeon during his work activities was implemented. There are several ways to calculate the metabolic requirements for a given task. However, some of them are prohibitive to be used in certain lines of work due to its limitations, namely, restriction of movement. On the other hand, there are some easier methods to implement but lack the required precision as referred in the introduction of this study. The proposed solution, in this case, was to recreate an equivalent task that reproduced the surgeon work and determine, with greater detail, the metabolic requirements for the task.

The first and classic approach to the metabolic rate calculation used the task related metabolic rate by body segment referred in ISO 8996:2004. For the referred calculation, it was necessary to know the performed tasks and their respective time, which were collected by direct observation of three surgeries in a Portuguese hospital. To the metabolic rate derived from the tasks, it was also added the body posture as a supplement, following the instructions of the referred ISO standard.

Using this method, it was possible to obtain a value for the metabolic rate. However, this is an approximation of the real metabolic rate with an accuracy of ± 20% (ISO 8996:2004). The oxygen measurement is, however, a more accurate method with an expected accuracy of ± 5% (ISO 8996:2004). To verify the certainty of our data, it was created a protocol to calculate the metabolic rate with the oxygen measurement. This way, a controlled environment was created where a group of people, one at a time, were placed performing a set of controlled tasks regarding the observations of the surgeons' activities. The controlled environment was achieved using a climatic chamber Fitoclima 25000 EC20 at 21 °C and 50% of relative humidity. This chamber with internal dimensions of 2.400 x 3.600 x 3.200 (H x W x D) had a temperature range of -20 °C to +50 °C, an uniformity of ±1 °C and a measurement precision of ±0,5 °C. Regarding the relative humidity its range was from 30 to 98%, an uniformity of ±2% and a precision of ±1%.

Due to the costs of maintaining a controlled environment in a climatic chamber and due to time restrictions of people and resources, the total time of the experiment was reduced from 1 hour (the duration of the surgeries) to 35 min. In Table 1, it is specified the time for each task.

Table 1 – List of the equivalent tasks and its respective duration.

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

There were limitations regarding the budget and type of activities that could be performed on the climatic chamber. The research team is aware that this is a restriction to the accuracy of the proposed protocol, however, inside a low budget and taking into account activities that didn't jeopardize the ventilation system of the climatic chamber, the five different tasks presented in Table 1, were handled in the following way:

Regarding the first two work activities, it was chosen a set of activities related to the work intensity on the table, namely a set of puzzles (**Erro! A origem da referência não foi encontrada.**). This task was further divided into two parts. The first part consisted on the sorting of pieces belonging to four puzzles that were huddled together. The difference between them besides its size was a geometric form on the back of the pieces. This task required a search performed with both harms and hands to move, locate and grab the pieces. This game therefore provided a work approximation to the necessary work intensity and required attention from the performer as it is necessary in the case of a surgery. The task performed with one hand by the surgeons was a precise and light one. The equivalent task for the physical workload was executed recurring to another game, in this case named operation. In this game people had to perform a precise yet light manual work. As an alternative, it was thought to use other methods to reproduce this task as well, like the cutting of fake skin. However, the light manual work didn't consist only in cutting but also on other tasks like sewing and wound treatment which implied different movements than a cut.

For the final task, regarding the work with both arms and both hands (hard), a set of manual tasks was chosen. This was necessary to reproduce the hard physical workload in a surgery, orthopaedic in this case. In orthopaedic surgery, there are brief moments of high physical workload and also the use of tools such as electric saws, electric drills and hammer. Considering the available time and the restrictions on waste production that could damage the ventilation system, it was only performed a task using an electric drill/screwing machine. The equivalent task consisted in screwing a set of screws on a wood beam and unscrewing them for three minutes of the experiment using an electric drill. This task required precision and control on the electric screw machine as the trigger had variable velocity related to the applied pressure. Also, the application of pressure was necessary for the screws to enter the wood beam, increasing the necessary metabolic rate to the task execution. When performing the tests, people referred that they felt an increased metabolic rate at this part. The final task for representation of the highest metabolic activities consisted on squeezing a hand exercise spring, represented on Figure 2, for two minutes. With this task, some people referred that they felt a brief sensation of perspiration despite its reduced duration.

With this protocol, and comparing the results of the oxygen measurement with the more common approach regarding the metabolic table use, it was achieved a very similar metabolic value, 1.33 Met for the former and 1.27 Met for the latter.

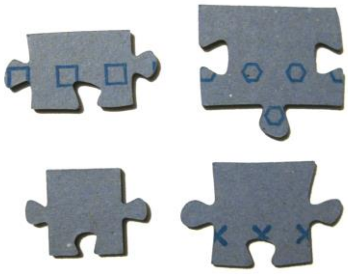

Figure 1 – Representation of one of the used games the games used in the setup of the experiment.

Figure 2 – Representation of the hand exercise spring used on the experiment setup.

3. CONCLUSIONS

Through this work, it was possible to set up a procedure to determine the metabolic rate of a surgery and surpassing the problem of using the oxygen measurement equipment during a real surgery, recurring to the metabolic equivalent approach. It was also possible to conclude that the chosen equivalent tasks reproduced the metabolic rate represented in the ISO 8996:2004 standard which allowed us to conclude that for our case, the tabled values didn't deviate much from the actual metabolic rate value. However, it is important to notice, that these equivalent tasks, despite resulting in a metabolic rate value approximated to the ISO tables which granted them a validation, may not reproduce the surgery tasks with the necessary certainty. For a greater precision, further studies, where the tasks are more similar to the surgery should be executed.

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