ESTIMATION OF METABOLIC RATE FROM CARDIAC FREQUENCY FOR FIELD STUDIES: CORRECTING FOR *"THERMAL PULSES"*

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With increasing mechanization of production usually metabolic rate will not constitute a limiting factor by itself, but is needed to assess thermal strain especially in hot working conditions. The oxygen consumption can be measured directly (e.g. by a respiratory gas clock); the measurement cannot be made continuously throughout a complete shift and usually is restricted to time intervals below 20 minutes. Several authors have linked metabolism to cardiac frequency because cardiac frequency can be measured during complete shifts. However, the metabolism estimated from cardiac frequencies in the field usually was higher than the directly measured metabolism; this overestimation is caused by the different influences of static work components, stress, dehydration etc. on cardiac frequencies in the field. In case of hard physical work or climatic load cardiac frequency may increase considerably with elevated body temperature. Vogt *et al.* proposed a methodology to assess the fraction of cardiac frequency that is caused by elevated body temperature (*"thermal pulses"*): as the time constant of the cardiovascular system is much shorter than the time constant for heat loss of the body, they proposed to use the cardiac frequency in the fourth minute after the begin of a resting break to estimate the cardiac frequency that is caused by the elevated body temperature itself. If there is a sufficient number of breaks during a shift, the cardiac frequency may be corrected for the thermal pulses by linear interpolation between these breaks but this correction is not adequate for the time in between, especially if high work load is present between these breaks. For a study concerning the strain of miners at hot working places we developed a procedure improving Vogt's method by using continuous measurements of body temperature: by plotting the values of cardiac frequency over the values of body temperature for each shift we got diagrams showing the lowest cardiac frequency occurring for each value of body temperature: by smoothing this characteristic we get a gauge function to correct the cardiac frequencies for thermal pulses throughout the shift for all levels of body temperature. This correction was applied for a field study of physiological strain of coal miners at hot working places (38 miners in a total of 112 shifts). As a result, the cardiac frequencies at the working site that increased for 36 min^{-1} above the resting values (mean values for all shifts) showed a fraction of thermal pulses amounting to 12 min^{-1}. For the complete shifts (descent - ascent) the increase of cardiac frequencies above resting values was 30 min^{-1}, 9.4 min^{-1} of which could be classified as thermal pulses. - Correspondingly, the increase of metabolic rates due to the work (mean ± std.dev.) reduced from (305 ± 108) W to (223 ± 77) W during the time at the working site, when estimated from a set of simultaneous measurements of oxygen consumption and cardiac frequency in underground work. This methodology allows to evaluate the fraction of cardiac frequency that is caused by the increase of body temperature throughout complete shifts, if body temperature is measured continuously and if enough breaks have been made during a shift. In mechanized coal mining, the last condition usually is fulfilled due to the sequence of operations.

Vogt, J.J., Foehr R., Kirsch J., Golle F., Meyer-Schwertz M.-T., 1970. Estimation des charges de travail et des charges de chaleur en situation réelle de travail: principes et applications d'une nouvelle méthodologie. Le Travail Humaine 33, 125-140.

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