A MODIFIED EQUATION FOR THE CALCULATION OF SOLAR HEAT LOAD IN MAN

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INTRODUCTION

Absorption of solar radiation is an important source of heat load in man. It may be defined by the general equation:

$$R = (\beta_1 \cdot Q_{direct} + \beta_2 \cdot Q_{diffuse} + \beta_3 \cdot Q_{reflected}) \cdot \alpha \cdot Cl$$

where: R is the absorbed radiation, Q is the intensity of various components of solar radiation (measurements at the horizontal plane are most popular in meteorology), $\cdot \beta_1$, β_2 and β_3 are weighting coefficients for the components, a is the coefficient of skin and clothing reflectance and Cl is a clothing factor.

Most of existing methods estimate β-coefficients taking into account a vertical cylinder as an analog model of the human body. However, only one equation (1) is based on actual experimental measurements of the radiation heat balance of a cylinder.

The correlation between R-values and mean skin temperature is rather small for methods using a cylinder model (0.51-0.69). It also seems that with some methods. predicted R-values are unrealistic high in comparison with radiation absorbed by a cylinder **(2).**

This paper reports results of measurements of solar radiation absorption with an alternative analog model of the human body - an ellipsoid.

METHODS

Absorbance of solar radiation by the ellipsoid temperature sensor (Brüel & Kjaer, MM 0023) was studied in a climatic chamber using a iodide solar lamp (Thorn, CSI OQ 1000).
Measurements were performed in two air temperatures: 0 and **20** °C. Examined solar angle (h) ranged from 5 to 50°. Changes of diffuse and reflected solar radiation intensity were simulated by changes of floor, wall and ceiling colours.

RESULTS

Solar radiation absorbance, especially direct and reflected radiation, strongly depended on **sun** altitude. Its minimum value was observed with a solar angle of 5" (40-50 W/m^2) and its maximum value with a **sun** elevation **of 20°** (100-110 W/m^2).

The weighting coefficients for the various components of solar radiation were calculated as follows:

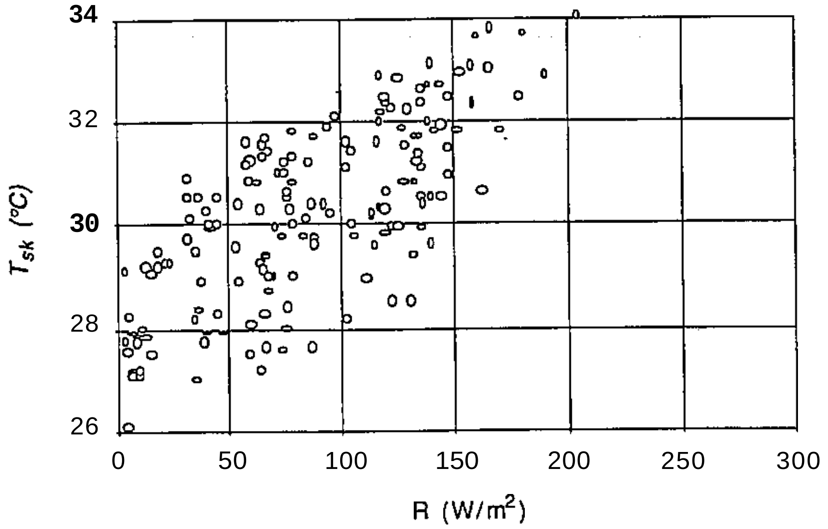
β_1 = cot h (0.25 - 0.001 h),
β_2 **= 0.36**
β_3 **= (0.49 -** 0.005 h).

The accuracy of coefficients was tested during control measurements conducted in a climatic chamber as well as outdoors. Correlation between measured and calculated amounts of absorbed solar radiation by an ellipsoid sensor was 0.93.

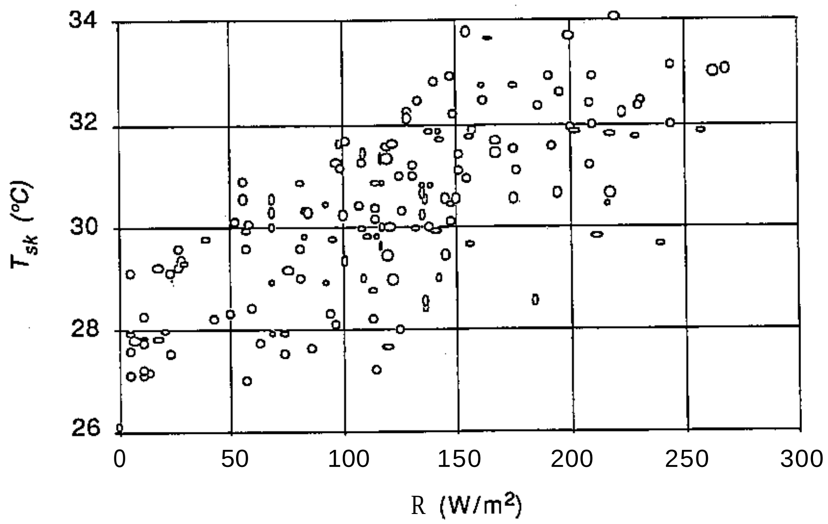
DISCUSSION

Skin temperature strongly depends on intensity of solar beams (3). Accordingly, calculated absorbed solar radiation (excluding a clothing factor) for an ellipsoid and for a cylinder model of the human body was compared with mean the **skin** temperature (T_{sk}) observed on subjects outdoors **(4).**

The two figures below show that T_{sk} correlates better with R calculated on the basis **of** the ellipsoid model than on the cylindrical model. Correlation coefficients are 0.74 and 0.68, respectively.



Correlation between mean skin temperature (T_{sk}) and absorbed solar radiation (R) calculated for the ellipsoid model, r=0.74.



Correlation between mean skin temperature (T_{sk}) and absorbed solar radiation (R) calculated for the cylinder model by Krys and Brown (1990), r=0.68.

CONCLUSIONS

Obtained results suggest that the physiological responses to solar radiation, defined by the mean skin temperature, may be better simulated by an ellipsoid human body model than by a cylindrical one.

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