

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),  $\beta_1$ ,  $\beta_2$  and  $\beta_3$  are weighting coefficients for the components,  $\alpha$  is the coefficient of skin and clothing reflectance and  $Cl$  is a clothing factor.

Most of existing methods estimate  $\beta$ -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<sup>2</sup>) and its maximum value with a sun elevation of 20° (100-110 W/m<sup>2</sup>).

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

$$\beta_1 = \cot h (0.25 - 0.001 h),$$

$$\beta_2 = 0.36$$

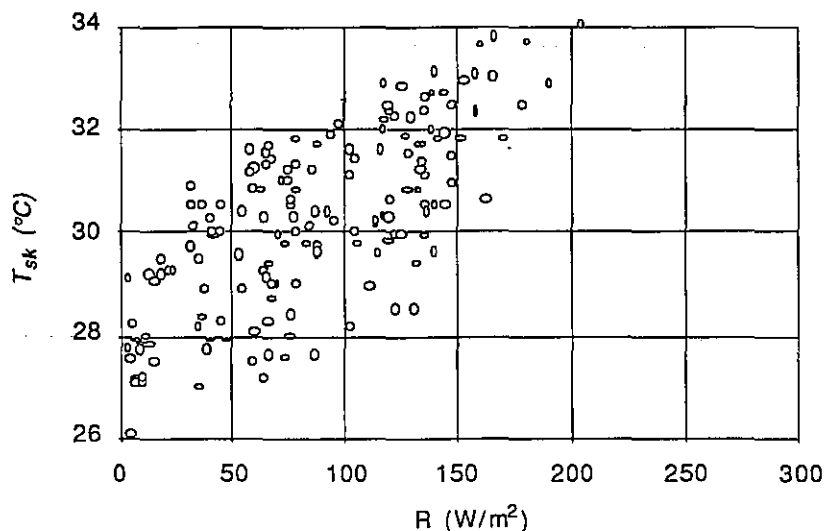
$$\beta_3 = (0.49 - 0.005 h).$$

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.

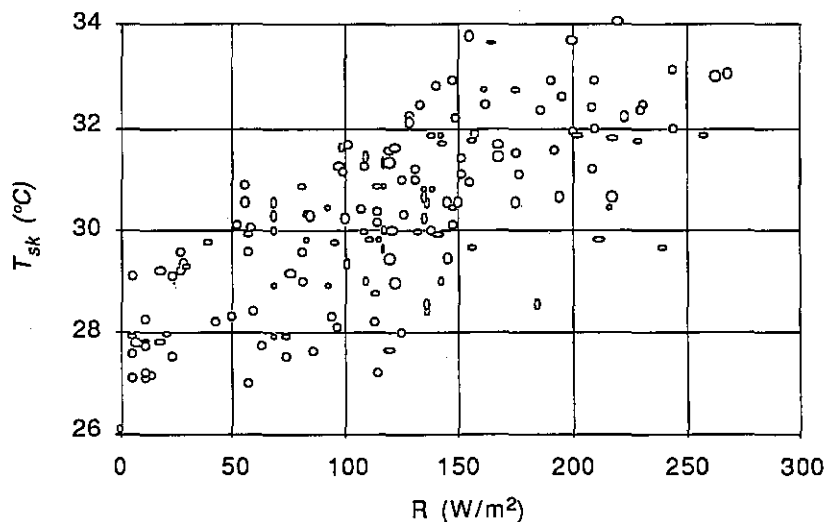
**DISCUSSION**

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.

## REFERENCES

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