# 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 $W/m^2$) 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:

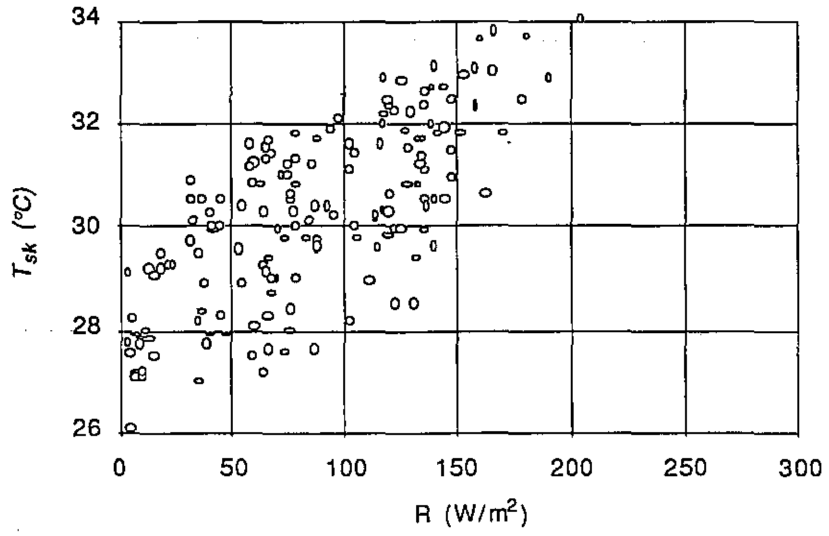
$\beta_1$ = cot h (0.25 - 0.001 h),
$\beta_2$ = 0.36
$\beta_3$ = (0.49 - 0.005 h).

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.

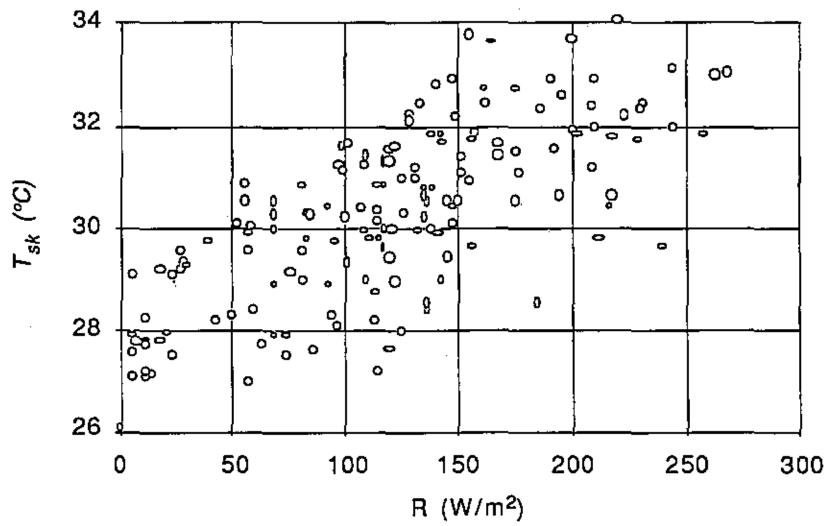
## DISCUSSION

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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