ASSESSMENT OF SOLAR RADIATION ABSORBED BY MAN BASED ON SIMPLE METEOROLOGICAL PARAMETERS

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INTRODUCTION

Solar radiation is a very important factor influencing human heat balance outdoors. Many different methods are in use for calculation of its value, measured in the horizontal plane, for the reference person (1). The most realistic values of absorbed solar radiation are obtained assuming an ellipsoid as an analogue model of man (2). However, in practical applications there is still a problem concerning the actual input data of solar radiation

The aim of the paper is to present a simplified method for the estimation of solar radiation absorbed by nude man. The method bases on the simple meteorological (amount and type of a cloud cover) as well as astronomical (Sun altitude) parameters.

MATERIALS and METHODS

Solar radiation data were collected during numerous climatological investigations carried out in various cloud scenarios as well as in different climatic zones and seasons. Solar altitudes (**h**) ranged from 5 to 85°. All data were gathered into three groups depending on cloud coverage. Solar radiation intensity, measured in the horizontal plane, was recalculated for the intensity of solar radiation absorbed by nude, standing man (**R'**) with the use of the following formula (2):

$$\mathbf{R'} = 0.7\ [\cot \mathbf{h}\ (0.25\text{-}0.001\ \mathbf{h}\ \mathbf{Kdir} + 0.36\ \mathbf{Kdif} + (0.49\text{-}0.005\ \mathbf{h})\ \mathbf{Kref}], \quad (W/m^2)$$

Kdir, **Kdif**, **Kref** represent intensity of solar radiation: direct, diffuse and reflected (in W/m^2).
The calculations were made using the human heat balance model MENEX (3).

RESULTS

The **R'** values, calculated with the use of above formula, were correlated with Sun altitude. The functions describing relationships between **R'** and **h** values have different runs depending on the type and amount of cloud cover (Fig. 1). Correlation coefficients vary from 0.85 to 0.94, and the regression equations have the following forms:

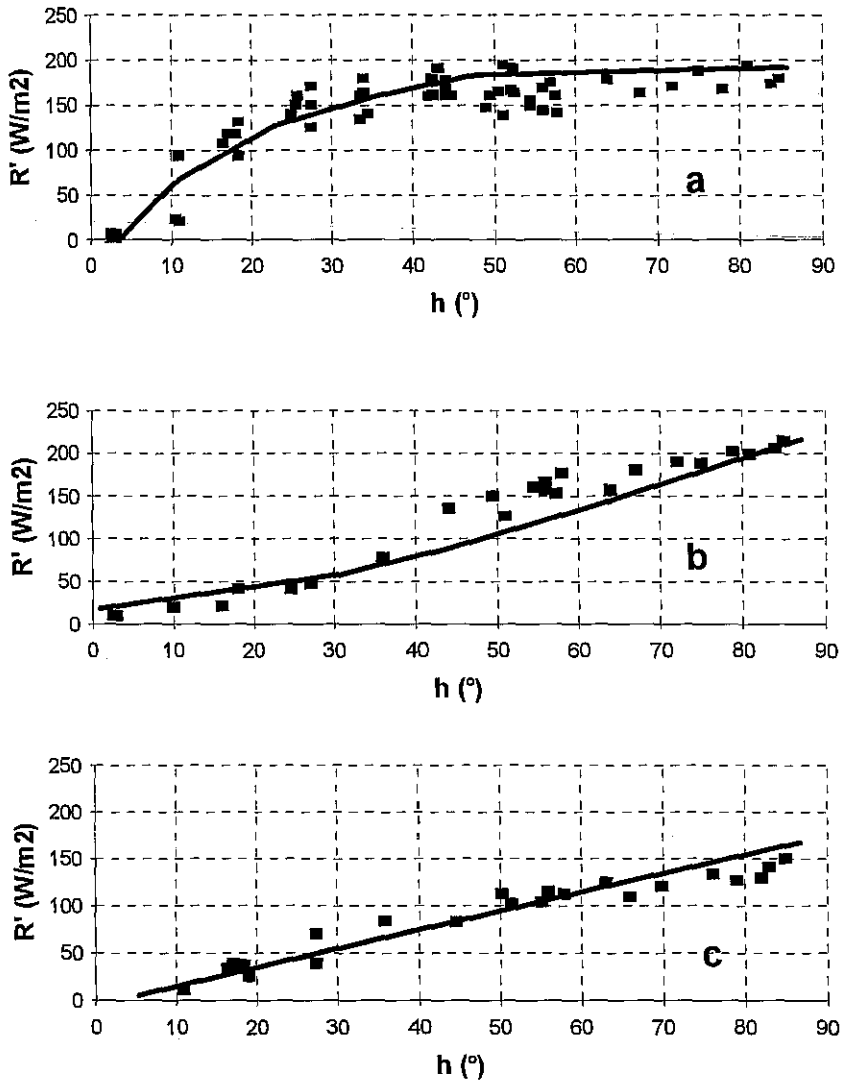

Fig. 1 Relationships between Sun altitude (**h**) and solar radiation absorbed by nude man (**R'**) in different cloud scenarios:
a - clear sky (no clouds) or Cirrus/Altocumulus (covering up to 90% of the sky) or Altostratus/Cumulus (covering up to 50% of the sky), b - Cumulus/Altostratus (covering 51-90% of the sky) or Stratocumulus/Stratus/Nimbostratus (covering up to 70% of the sky), c - others clouds scenarios

$$\mathbf{R^*} = (\ln \mathbf{h} - 1.1)/0.015,$$

- for the clear sky or Cirrus and Altocumulus clouds (covering up to 90% of the sky) as well as for Altostratus and Cumulus clouds (covering up to 50% of the sky),

$$\mathbf{R^*} = \exp(0.05\ \mathbf{h} + 2.34)$$

- for Cumulus and Altostratus clouds (covering 51-90% of the sky) as well as for Stratocumulus, Stratus and Nimbostratus clouds (covering up to 70% of the sky),

$$\mathbf{R^*} = 2.21\ \mathbf{h} - 6.8$$

- for others clouds scenarios.

R* values estimated with the use of above regression equations were compared with **R'** values calculated for an ellipsoid model of man (Fig. 2).

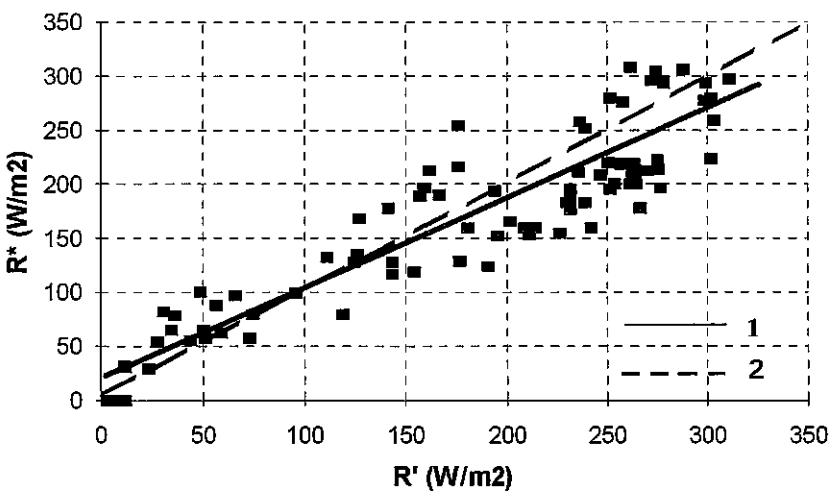

Fig. 2 Relationships between calculated (**R'**) and estimated (**R***) values of solar radiation absorbed by nude man;
1 - regression line, 2 - line of identity

Figure 2 shows the great similarity between calculated and estimated values of solar radiation absorbed by nude man. The correlation coefficient between compared values is 0.92 (for n=75, p=0.05). The slope of the regression line and the identity line are very similar. The data of solar radiation and cloud cover taken for above comparison represent various Sun altitudes (0-85°) and different climatic zones (tropical, subtropical , temperate, polar).

CONCLUSIONS

Because of high correlation coefficient between **R'** and **R*** values it seems that regression equations of **R*** can be recommended for the calculations of absorbed solar radiation. They can be applied in studies of human heat balance outdoors in various climatic zones.

The accuracy of present method as well as its ease of data collection afford possibilities for its wider use in human heat balance models in outdoor conditions. The clothing factor is needed in adaptations of this method for various models.

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