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ORIGINAL ARTICLE

Cooling experiments using dummies covered by leaves

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Abstract One main method to estimate the time of death is the measurement of the body temperature. The cooling of a corpse depends on a number of conditions including the surroundings. In cases where the cooling conditions differ from the defined standard, a corrective factor is used to characterise the influence of clothing, air movement, the properties of the supporting base and the humidity. Nothing is known about the significance of other circumstances, for example of a tegument by leaves or wet leaves. Therefore, the cooling of dummies which were placed on a 2-cm-thick layer of wet/dry leaves and covered by a 10-cm-thick layer of leaves was investigated. Corrective factors of 1.0 for wet leaves on the ground and of 1.3 and 1.5 for drier leaves were found. If the dummies were additionally covered, corrective factors ranged between 1.8 and 2.7.

Keywords Cooling of a corpse · Tegument of leaves · Nomogram · Corrective factor

Introduction

If the time since death has to be estimated, the measurement of the rectal temperature of the corpse is a well-established but sometimes controversial method [1–4]. Different surroundings can be considered by using a corrective factor which describes the significance of clothing, covering, properties of the supporting base, air movement and water suspension [1, 2, 5].

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Sometimes, homicide victims are found lying on leaves or covered by leaves. For such a situation, there are no existing experiences on how the corrective factor has to be changed considering this situation. In homicides in particular, an estimation of the time since death can be very important for the police investigation as well as for the legal proceedings.

Therefore, we investigated the cooling of a corpse-like dummy [2, 6] which was placed on leaves and/or covered by leaves of different thicknesses.

Materials and methods

Dummies

Two different dummies were used: (A) 48×35×17 cm, mass 27.2 kg; and (B) 48×35×18.5 cm, mass 29.1 kg. The 1.5-mm-thick wrapping was made from caoutchouc and filled with a gel mixture consisting of 47.5% glycerine, water and 5% agar. Before each experiment, the dummies were warmed up for 48 h using an incubator with a constant temperature of 37°C. Because of the inaccurate function of the thermostat, the central dummy temperature varied between 35.4 and 38°C at the beginning of the measurements.

Measurements

The temperature probe was inserted into the middle of the dummy, 8.5 or 9.25 cm deep, which corresponded to half of the sagittal diameter (Fig. 1). The dummy temperature was measured every 30 min, as well as the air and the floor temperature until the dummy temperature reached the temperature of the surroundings.

Fig. 1 Dummy A with inserted temperature probe and computerised measurement

The room in which the experiments were carried out did not have any heating or windows. During the experiments, the room temperature was kept constant at an initial level between 18 to 22°C and did not vary more than 2°C during the individual experiments. The maximum difference between air and floor temperature was not higher than 0.5°C.

Covering

At first, three experiments were carried out using standard cooling conditions. In a second series, each of the three experiments was carried out with a 2-cm-thick compressed layer of leaves on the floor. In the third group, seven measurements were taken from both dummies which had been placed on the leaves (2 cm thick) and covered by a 10-cm-thick layer of leaves.

At the beginning of the measurements, the leaves were wet but became drier and drier over a period of 20 days, after which they appeared to be completely dry.

Table 1 Corrective factors determined by experiments using totally dry leaves on the floor (days 34, 37 and 43)

Dummy A	Virtual weight (kg) on leaves	Virtual weight (kg) (standardised conditions)	Corrective factor
Measurement 1	88.0	60.43	1.46
Measurement 2	93.7	60.43	1.55
Measurement 3	93.4	60.43	1.54
Dummy B			
Measurement 1	68.1	67.57	1.01
Measurement 2	86.5	67.57	1.28
Measurement 3	84.7	67.57	1.25

Table 2 Corrective factors when the dummies are covered by a nearly 10-cm-thick layer of leaves

Dummy A	Virtual weight (kg) on leaves	Virtual weight (kg) (standardised conditions)	Corrective factor
Measurement 1	142.3	60.43	2.35
Measurement 2	140.9	60.43	2.33
Measurement 3	136.7	60.43	2.26
Measurement 4	146.2	60.43	2.41
Measurement 5	154.0	60.43	2.54
Measurement 6	164.5	60.43	2.72
Measurement 7	147.0	60.43	2.43
Dummy B			
Measurement 1	120.0	67.57	1.77
Measurement 2	154.6	67.57	2.28
Measurement 3	136.7	67.57	2.02
Measurement 4	159.2	67.57	2.35
Measurement 5	165.5	67.57	2.45
Measurement 6	177.2	67.57	2.62
Measurement 7	155.8	67.57	2.30

Virtual “body” weight

Each dummy cooled under defined circumstances like a corpse of a specified body weight, depending on the dummy’s dimension [2]. The cooling coefficient (B) was calculated (during the linear phase of the curve) by linear regression from the logarithms (ln) of the difference of dummy temperature and temperature of the ambient (Y) and the time of cooling (X). From the coefficient B, the body weight (M) can be calculated as follows: $M=(-1.285/B-0.0284)^{1.6}$.

As shown in experiments using corpses, the calculated weight corresponds to the real body weight within the range of the standard deviation (6.1 kg) [7]. Finally, the corrective factor of the body weight can be calculated as the quotient from the virtual weight under specific conditions and the virtual weight determined under standardised conditions.

Results

The virtual body weight of dummy A was calculated to be 60.4 kg (standardised conditions) and 67.6 kg for dummy B.

Table 3 Recommended corrective factors with regard to leaves

Leaves	Wet through	More or less dry
Compressed 2 cm below the body	1.0	1.3–1.5[a]
10-cm thick covering the body	Not investigated	1.8–2.7[a]

[a] The minimum and maximum of the range should be used to calculate the extremes of the time of death

Dummies on leaves

For dummies lying on wet leaves (day 4 of the experiment), the corrective factor was calculated to be 1.01. On days 9 and 17 (drier leaves), corrective factors of 1.28 and 1.25 were determined. Experiments using totally dry leaves on the floor (days 34, 37 and 43) gave corrective factors of 1.46, 1.55, and 1.54, respectively (Table 1).

Dummies on leaves, covered by leaves

When the dummies were covered by a nearly 10-cm-thick layer of leaves, it led to corrective factors between 1.77 and 2.72 (Table 2).

Discussions

As expected, a layer of leaves, either as base or as base and cover, can act as isolation causing a reduced cooling of a corpse, or as shown in our experiments with a dummy. The corrective factor of about 1.5 for dummies lying on a 2-cm-thick layer of dry leaves seems to be high compared to corrective factors found for Styropor or thick padding as a base (≤1.3) [2]. This discrepancy can be explained by the fact that the corpses in the former experiments were placed on a smooth and rigid surface. Therefore, the contact area of the body and this base is relatively small, whilst in our experiments using leaves, the material is flexible and adapts itself to the body surface. In consequence, the contact area between the “back” and the base is bigger than in the former experiments and an additional contact of the side regions of the body (dummy) because of the compression of the layer of leaves by the body weight, and therefore enlarging the isolated surface.

The corrective factor for a dummy covered by a 10-cm-thick layer of dry leaves was comparable to that determined for very thick clothes or thick blankets (2.0–2.7) [1–8].

The great variability of the isolating effect of apparently identical layers of leaves can be explained by different amounts of enclosed air. The corrective factor of 1.77 which was determined in one experiment on day 23 could have been due to the low humidity of the leaves which influenced the result.

The increase of the corrective factor from 1.0 in the case of wet leaves to 1.3 in nearly dry leaves and to 1.5 in dry leaves demonstrates the influence of wetness and humidity with regard to the isolating properties of the leaves, even though the estimation of these parameters is subjective.

As far as the results from experimental studies using dummies can be transferred to the cooling of corpses [1, 2, 8], it can be concluded that the corrective factors evaluated in this study can be used to estimate the time of death in forensic cases. Our results show that the isolating effect of leaves as a base as well as a cover for corpses can be estimated by a wide range of corrective factors only. Therefore, individual differences have to be considered in each single case, and the time of death can only be roughly determined (Table 3).

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