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ORIGINAL ARTICLE

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Colour measurements of pallor mortis

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Abstract Little interest has yet been focused on the development of postmortem paleness (pallor mortis). Using an opto-electronical colour measurement device, we examined pallor mortis in 126 bodies and compared these findings to the average skin colour of 72 living Caucasian volunteers. It was shown that (a) hairy skin influences the results and any hair must be removed by shaving before colour determination, (b) among the living, there is a skin colour difference between the sexes which disappears after death, (c) postmortem paleness is caused by lack of capillary circulation after death and (d) paleness develops so rapidly after death that it has no or little use in determining time of death.

Key words Colour measurement · Skin colour, human · Pallor mortis · Time of death

Introduction

After death, with the cessation of heart action and circulation blood no longer fills the skin capillaries and sinks down to lower parts of the body where it gradually forms the cadaverous lividity or livor mortis. The intensity of lividity and its blanching upon pressure has proven to be a useful tool in determining time of death [4, 5]. On the other hand, the upper parts of a body, which are devoid of blood, develop a paleness or pallor mortis. Little interest has yet focused on this phenomenon since similar paleness of the skin may occur in the living and, therefore, belongs to the uncertain signs of death. This gave reason to determine the intensity of postmortem paleness using a modern, opto-electronic colour measurement device. The aim of this study was to quantify the paleness and to examine whether a certain degree of the gradually developing pallor could be correlated to time since death and thus serve as an additional tool in determining the time of death. Moreover, this study aimed to standardize conditions of skin colour evaluation to ensure reliable and reproducible results.

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Material and methods

The colour measurement device Micro Color (Dr. Lange, Düsseldorf, Germany) is a tri-stimulus colourimeter which has been repeatedly described in recent literature [4, 5, 9, 10] and will therefore not be presented here again. The measurement results are provided in the common CIE- (Commission Internationale d'Eclairage) L*a*b*-system. Any visible colour is represented by a set of three coordinates in this three-dimensional Euclidean space, e.g. (66.9; –3.2; 19.4) which are the coordinates of the colour of the average living Caucasian skin.

Skin colour values were obtained from 72 living, young adult Caucasian healthy volunteers (35 female, 37 male) and 126 randomly chosen corpses (32 female, 94 male) from the Aachen Institute of Forensic Medicine. Skin discolourations, bruises, visible veins, or areas of beginning decomposition in corpses were not accepted as measuring sites. All readings were repeated ten times and the mean taken as the result. The statistical evaluation is based on Student's t-test.

Skin colour determinations of volunteers were performed at the volar surfaces of the forearms while the test subjects were sitting with their arms resting on a table. The gauge was held by the volunteers themselves, having been instructed to hold but not to press it on the skin. Colour measurements of cadavers were performed on the abdomen, next to the navel which is usually the most elevated part of the body in the supine position and farthest from any livores.

Any visible hair on the dead subjects which could possibly affect the colour determination was carefully shaved before examination. To verify the effect of shaving, an additional series of 50 colour determinations was taken before and after shaving.

Results

In living subjects, a small but constant difference between females and males could be established (Table 1) where females were found to be slightly lighter (+1.9) and less red (–1.2) than males. The b*-values (yellowness), how-

Table 1 Skin colour of the living and dead, provided as L*a*b*-colour values

	All test subjects	Female subjects	Male subjects	All cadavers	Female cadavers	Male cadavers
n	72	35	37	126	32	94
L*	66.9‡	67.9†	66.0†	75.9‡	76.9	75.5
(SD)	(3.4)	(2.8)	(3.6)	(3.9)	(3.5)	(4.0)
a*	–3.2‡	–3.8†	–2.6†	–8.9‡	–9.0	–8.9
(SD)	(1.9)	(1.7)	(1.9)	(2.2)	(2.0)	(2.2)
b*	19.4	19.6	19.2	18.3	17.8	18.5
(SD)	(2.6)	(2.7)	(2.6)	(3.2)	(3.0)	(3.3)

Values between ca. +10 and ca. –10 do not induce a colour sensation in the human eye, but are associated with broken grayish or brownish hues (*n*: number of subjects examined; SD: standard deviation; † difference significant on a 99% level; ‡ difference significant on a 99.9% level)

ever, of males and females were not distinguishable with any significance. Corpses showed no similar skin colour differences by sex, suggesting that the factor causing skin colour differences between the sexes in the living is no longer active after death.

The differences between skin colours of the living and the dead (Table 1) were highest on the L*- (+9.0) and on the a*-axes (–5.7) whereas the b*-values differed only by –1.1. Thus, the postmortem pallor could be clearly demonstrated and was found to be restricted to the L*- and a*-values of the skin colour.

To elucidate the chronological development of postmortem paleness, a small subgroup ($n = 5$) of cadavers was selected in which colour measurement had taken place shortly after death range (2.7–6.6 h, mean 4.2 h). This was compared to a similar group ($n = 6$) but with later measurement times range (10.3–35.0 h, mean 23.4 h). No statistically significant difference between any comparable values of these groups was detected (Table 2), or between these groups and the average values for all cadavers.

The average skin colour before and after shaving at identical sites showed a marked change of only the L*-values (+7.3; Table 2) whereas a*- and b*-values were not substantially changed by shaving.

Table 2 Influence of time since death and effect of shaving on skin colour measurement results

	Ca. 4 h after death	Ca. 24 h after death	Before shaving	After shaving
n	5	6	50	50
L*	76.7	73.8	67.0‡	74.3‡
(SD)	(5.0)	(5.3)	(6.8)	(5.7)
a*	–10.3	–7.8	–7.8	–8.5
(SD)	(3.6)	(3.1)	(2.8)	(2.9)
b*	17.4	18.9	19.9	19.3
(SD)	(4.2)	(4.8)	(4.5)	(4.7)

‡ Difference significant on a 99.9% level

Discussion

The necessity of shaving any hair from skin prior to colour determination has not yet been reported in the literature but could be demonstrated here. Results from unshaven skin proved to be, independent of hair colour, generally darker (L*-value) but not different from shaven skin in colour (a*- and b*-axes). This is because the illuminating light is scattered, repeatedly reflected and partially absorbed by the hair, thus allowing a smaller amount of light to fall back into the measuring device, inducing a decrease of L*.

The colour differentiation by sex in the living subjects and the postmortem pallor of the dead subjects were both restricted to L*- and a*-values, with b* unchanged. This may be explained as follows:

a) The a*-values (redness) are nearly completely determined by the amount of blood circulation at the skin and the colour saturation of the blood
b) the b*-values (yellowness) are predominantly determined by tanning intensity and skin pigmentation which does not disappear after death
c) the L*-values of skin colour depend on combined circulation and pigmentation intensity

Thus, the sex difference can be understood assuming the common fact that females generally have a lower erythrocyte count and a lower hemoglobin content in blood than males. This leads to a slightly lighter and less reddish colour in female skin. In the dead, such colour differentiation is not observed as there is no longer capillary circulation of skin which could cause any colour difference. In addition, this lack of blood circulation at the skin is demonstrated to cause postmortem pallor.

These findings are supported, in part, by Vasilevskii et al. [11] who stated that sex differences based on different blood compositions are found in fair-skinned people whereas in darker-skinned populations these appear to be caused by a different degree of tanning – in cultures where the everyday life of males and females is so different that tanning differences may develop. Our results (no sex difference of b*-values) show that such behavioural differences do not exist in our culture. Thus, it is understandable that several, but not all [6], anthropologists and ethnologists have detected skin colour differentiation by sex as well.

Several investigations of skin colour of the living [1, 2, 8, 9] found similar L*- and b*-values as reported here, but a*-values, however, differed. This deviation is not as serious as it appears because skin redness depends on blood circulation and may change substantially within seconds due to such factors as body position, environmental temperature, psychological influences and many other variables. Trujillo et al. [9] stated that skin circulation "is determined by a number of factors which we were unable to control". Thus, a deviation of a*-values in different studies may easily be explained by variations in the location, i.e. room temperature, body position etc.

Apart from the works from Lins [7] and Blazek [3], no additional publications of colour data from both living and dead subjects were found. Converted into L*a*-values, Lins reported an increase of +3.8 in L* and a decrease of –6.4 in a* after death and Blazek +1.1 in L* and –2.2 in a* after death, both similar to our findings (L*: +9.0; a*: –5.7).

Based on this it appears that postmortem paleness – different to cadaverous lividity – develops so rapidly that colour change only occurs within the first few hours after death, therefore calling into question the utility of colour measurement of pallor mortis in determination of the time of death.

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