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Predictive Equation Model to Estimate Postmortem Interval using Total Body Score

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Abstract

The decomposition process of corpse varies due to many factors. There are several studies conducted to improve the postmortem interval (PMI) by visual inspection of human remains. In this study, a total body scoring method was developed to estimate the PMI based on the decomposition and degree days (DD). One hundred and three cases were used to estimate the PMI. The autopsy reports were scored using the decomposition scoring method. The temperature data was obtained from the Thailand Meteorology Department (TMD). The PMI was estimated using the total body score (TBS), accumulated degree day (ADD) and accumulated degree hour (ADH) from the finding date back until the predicted time since death. To this end, a retroactive approach was taken in which cases from the medical examiner with a known "date last seen" and "date recovered" were compiled. A qualitative analysis was conducted examining the specific decomposition changes which occur in various contexts. Quantitatively, a linear regression analysis was employed to determine if DD or TBS explained more of the variation in decomposition. The ADH, ADD and TBS were determined to be the main components in modelling decay. These results suggest that the TBS can be optimally used to assess PMI. While the ADD and ADH were used to overestimate PMI, which indicating inconsistency of the method. In total, a set of time since death estimation formula applicable to indoor, outdoor, and aquatic contexts was produced, and region-specific standards best suited to estimating time since death in Thailand. Due to the subjectivity in all the available methods and decomposition is a highly variable process. Further research is required before an estimated PMI should be considered as evidence in court.

Keywords: Total Body Score, Postmortem Interval, Accumulated Degree Days, Accumulated Degree Hour, Estimation

Introduction

The time of death is sometimes extremely important. It is a question almost invariably asked by police officers, sometimes with a touching faith in the accuracy of the estimate. Determining the time of death is extremely difficult, and accuracy is

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impossible. Considering the variables which influence the rate of body heat loss, the best one can say about the reliability of algor mortis as a postmortem clock is that it permits a rough approximation of the time of death. PMI estimation is one of the majors in forensic pathology and forensic medicine. It is often an exclusion process of available methods which ultimately can lead to an unsatisfactory outcome due to poor reliability. This problem is most acute in the early and late PMI. When decomposition proceeds and some methods (algor, livor, and rigor mortis) are no longer applicable. Several methods, such as forensic entomology, skeletal muscle protein degradation, and the study of body decomposition by application of a morphological scoring, are expected to provide further information. However, all have certain limitations and weaknesses. Availability of a tool of methods allows a case-specific selection of the most appropriate one(s), or eventually provides improvements in the overall accuracy and precision of the PMI estimation by merging and combining methods[1].

Currently, several methods are expected to assist in the estimation of the PMI in the early, late, and advanced stages of decomposition such as forensic entomology[2], the skeletal muscle protein degradation[3], Biochemistry change and the classification of decomposition morphology by the means of a TBS[4]. However, the reliability of these methods is also affected by several sources of inaccuracy, mostly related to biotic and abiotic factors. Moreover, they are validated to varying degrees. Temperature, environment, and access for insects are well known as the most important variables influencing degradation or preservation of body tissues[2]. In case work, there is often a certain time point of interest, such as if a person died before or after a specific date. In combination with the numerous variations of the circumstances of death, this requires a tool-box of methods to select the most appropriate ones for case-specific application. Some methods have to be excluded under certain circumstances, under which other approaches work just fine. Ultimately, merging and combining several methods can improve the overall accuracy of the estimation, just as used in the compound method for early-period PMI estimation[5].

The overview of the discussed methods to estimate the PMI. There are two variants to the TBS or total decomposition score (TDS), one that has been modified by Mofatt et al[6] based on Megyesi et. al. [4], and one by Gelderman et al[7]. There are two variants to the total aquatic decomposition score, one that has been developed by Heaton et. al. [8], indicated by a subscripted 'H', and one by Van Daalen et. al. [9], indicated by a subscripted 'D'. There is one variant to charred body scale by Gruenthal et al[10]. Nowadays, the validity of the method in which TBS, ADD and ADH are used to estimate the PMI is examined. The rate of development of decomposition is temperature dependent. Each stage of development has its temperature requirement hence each stage has its own defined number of ADD or accumulated degree hours (ADH) to complete its development. Once the thermal history is obtained, it can be compared with temperatures at the death scene and PMI can be estimated [11]. The aim of this study is to estimate of the method that are based on the visual inspection of the body remains and accumulated degree, by making a comparison of currently available methods.

Materials and Methods

Research study design

In this retrospective study, the cases were selected from the human identification records which potentially could yield information on rate of postmortem change. All these cases were under the jurisdiction of the forensic medicine section, Lampang hospital, Lampang, Thailand and forensic medicine and toxicology unit, department of pathology, faculty of medicine, Prince of Songkla University, Thailand. Autopsies were performed by the forensic physician in all cases.

Total body scoring

The decomposition scoring method was developed by Meewuttisom and Poriswanish's data[12] was used as a basis. The scoring method separates the human body into three regions (Head, body and limbs), because these body parts decompose in a different rate[7]. Each body characterization was assigned six stadia with corresponding scores, with a lowest score of one (Fresh or no visible changes). Every stage contains specific decomposition

phenomena but these were assigned a separate score, because they can occur at the same time or one by one[13,14]. The TDS represents the sum of the skin color of facial decomposition score (FDS, 8 scores), the body decomposition score (BDS, 8 scores), and the limbs decomposition score (LDS, 8 scores), swelling (5 scores), blistering and peeling characteristics (5 scores), hair loss (2 scores), bone exposed (10 scores) and insect activity (2 scores) score [12]. The stages of decomposition were derived from an extensive literature study as shown in Table 1.

$$TBS = aH + aT + aL + b + c + d + e + f = 48$$

Table 1: Categories and developed decomposition scoring method

Score	Description
Skin color - Head, Trunk & Limp (a)	
1	None
2	Pink
3	Marbling
4	Green
5	Green/Black
6	Black and moist
7	Beyond black 1 (grey and moist)
8	Beyond black 2 (light brown and dry)
Swelling (b)	
1	None
2	Begin bloat
3	Full bloat
4	Partial deflate
5	Fully deflate
Blistering and peeling characteristics (c)	
1	None
2	Minimal bleb
3	More bleb, minimal slippage (<50%)
4	Most slippage (50-75%)
5	Nearly all slippage (>75-100%)
Hair loss (d)	
1	No
2	Hair loss
Bone exposed (e)	
1	No
2	Facial bone 25%
3	Facial bone 50%
4	Facial bone 75%
5	Facial bone 100%
6	Extremity - subcutaneous exposed
7	Extremity - muscle and tendon exposed
8	Extremity - ligament and tenure structure preserved
9	Extremity - bone exposed
10	Bare bone
Insect activity (f)	
1	No
2	Yes

Results and Discussion

The 103 autopsy case reports were conducted from the Lampang hospital and department of pathology, faculty of medicine, Prince of Songkla University, Thailand. These cases were autopsied through forensic medicine unit and human identification laboratory records for information on the duration of the PMI, the circumstances of recovery, condition of the body, and the results of the investigation into the cause and manner of death. The lowest and highest of TBS values were 8 and 37, respectively. Using the linear regression model, a predictive equation was developed that can be used to calculated PMI for unknown case (Table 2).

Table 2: The linear regression model

Variable	Formula	Coefficient of determination (R^2)
PMI_{TBS}	y = 0.1925x + 7.0923	0.9796
PMI_{ADD}	y = 0.3321x + 4.385	0.9997
PMI_{ADH}	y = 5.854x + 36.69	0.9984

The coefficient of determination of TBS, ADD, and ADH were 0.9796, 0.9997, and 0.9984, respectively. This means that 97, 99, and 99% of the variability in decomposition as reflected by PMI is accounted for by TBS, ADD, and ADH, respectively. The results showed that the most of PMI_{TBS} values were in the

PMI_{REPORT} range by forensic physician. While, both of PMI_{ADD} and PMI_{ADH} values were higher than the PMI_{REPORT} range. Therefore, ADD and ADH methods are unreliable because they cannot provide accurate PMI in individuals and localities. This reason may be affected from temperature in different season and localities.

Table 3: Categories of TBS and comparison of PMI

TBS	PMI_{TBS} (Hour)	PMI_{REPORT} (Hour)	Remark
8	4.72	0.5-12	Land: Indoor remains (88)
9	9.91	6-16	Land: Indoor remains (1), Outdoor remains (1)
10	15.10	8-24	Land: Indoor remains (3)
14	35.88	24-48	Land: Indoor remains (1)
19	61.86	48-72	Drowning or Submerged or Aquatic (1)
24	87.83	72-96	Drowning or Submerged or Aquatic (1)
26	98.22	48-72	Land: Indoor remains (1)
28	108.61	24-96	Land: Indoor remains (2)
33	134.59	48-168	Land: Indoor remains (3)
37	155.36	72-120	Land: Indoor remains (1)

Amount of land indoor, land outdoor and aquatic remains were 100, 1, and 2, respectively. The four cases of land indoor remains PMI_{TBS} values were higher than PMI_{REPORT}, possibly due to the fact that in summer it accelerated the rate of decay (Table 3).

Conclusion

These results suggest that the TBS can be optimally used to assess PMI. While, the method consistently overestimates ADD and ADH, and therefore is not a reliable method for determining an accurate PMI in an individual and localities. The limitation of appropriate temperature applications must also be given consideration when applying this research to cases where a body has decomposed in a temperature-controlled environment. The current study was the lack of complete information on the scene, which led to impossibility to measure all the additional factors affecting the postmortem changes of the body. Extensive data on scene peculiarities, such as airflow level, humidity, and also the more detailed information on the bedding of the corpse, sun exposure, could possibly let us to define their affection level on the PMI evaluation, with further comprehensive modifications to currently used methods. Therefore, the decomposition should be models as being dependent on the accumulated temperature rather than just the elapsed time since death. A fundamental portion of this research methodology is based on the concept of accumulated degree days, which utilize average ambient temperatures. However, in indoor environments with controlled temperatures the ambient temperature remains stable throughout the day, perhaps with only minor variations due to external factors such as airflow from a fan or sunlight shining in through a window. Likely, a more stable temperature environment would lead to better results with less variation as it is a more controlled variable, but the extent to which this would affect the equations produced has not been explored. Finally, it has clearly been established through many other previous published studies that decomposition is a temperature dependent process. Thus, it follows that research of this nature needs to be conducted with respect to various geographic regions. Likewise, other countries would need to conduct studies to determine the differences in PMI due to the variations in their climate. Studies utilizing similar methods have been conducted on a short-term basis in other geographic regions with varying success, but for optimal use and application to a forensic death investigation. These studies would need to be conducted with many more replicate trials and should take seasonal variation into account when establishing the methodology for predicting time since death.

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Conflict of interest: None

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