Document Title: Validation Study of the Utility of Using Total Body Score and Accumulated Degree Days to Determine the Post-Mortem Interval of Human Remains from Three Human Decomposition Research Facilities

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FINAL SUMMARY OVERVIEW

Validation Study of the Utility of Using Total Body Score and Accumulated Degree Days to Determine the Post-Mortem Interval of Human Remains from Three Human Decomposition Research Facilities

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Purpose

Statement of the problem

Estimating the postmortem interval (PMI) for humans using gross observation of the decomposition process began as a qualitative procedure. However, in 2009 the National Academy of Science released a report titled "Strengthening Forensic Science in the United States: A Path Forward" in which the Forensic Science Committee instructed the forensic science community to improve practices in eight areas. Statement #5 instructed to "…disseminate best practices and guidelines concerning the collection and analysis of forensic evidence to help ensure quality and consistency in the use of forensic technologies and techniques to solve crimes, investigate deaths, and protect the public;". The report also stated the need for "Research to Establish Limits and Measures of Performance". Since estimating the postmortem interval for human decomposition was strictly qualitative, and the need for more measureable methods was desired, researchers began developing and using quantitative methods.

In 2005, a quantitative study was developed and published by Megyesi and colleagues (2005) and quickly became a tool for anthropologists and entomologists. The method involved the use of a total body score (TBS) that was input into an equation, resulting in an estimated accumulated degree-days (ADD) for an aid in estimation of the PMI.

$$\text{Log10}(y) = Bx2 + \text{constant} + \text{error}$$

or

$$\text{ADD}=10^{(0.002*\text{TBS}*\text{TBS}+1.81)}\pm 388.16$$

Background

Taphonomic studies were recognized as a sub-discipline approximately 50 years ago, but taphonomic studies observing human decomposition processes in medicolegal death investigations were not applied to contemporary humans until the latter part of the 20th century. Early observational studies examined the human decomposition rates in temperate (Rodriguez and Bass 1983, Bass and Meadows 1990, Bass 1997, Haglund and Sorg 1997), arid (Galloway et al. 1989, Galloway 1997), and cold climates (Komar 1998, Weitzel 2005, Bunch 2009) with focus on the effect of factors such **1)** temperature (Mann et al. 1990, Haglund and Sorg 1997, Komar 1998) **2)** insects (Payne and King 1968, Rodriguez and Bass 1983, Mann, et al. 1990, Goff 1993, Anderson and VanLaerhoven 1996, Haskell et al. 1997, VanLaerhoven and Anderson

1999, Byrd and Castner 2001, Campobasso et al. 2001, Anderson and Cervenka 2002, LeBlanc and Strongman 2002, Simpson and Strongman 2002, Bachmann and Simmons 2010), **3)** burial or surface environments (Rodriguez and Bass 1983, Rodriguez and Bass 1985, Shean et al. 1993, Spennemann and Franke 1995, Bass 1997, Rodriguez 1997, Stafford et al. 2010), **4)** scavenging activity (Haglund et al. 1988, Skinner et al. 1988, Haglund et al. 1989, Haglund 1997, Murmann et al. 2006, Reeves 2009), **5)** soil composition (Vass et al. 1992, Dent et al. 2004, Wilson et al. 2007), **6)** fire (Bass 1984, Buikstra and Swegle 1989), and **7)** submersion in water (Brooks and Brooks 1984, Pakosh and Rogers 2009). These studies laid the foundation for understanding the human decomposition process. While these types of gross observation and qualitative studies were useful for understanding decomposition, they were not statistically assessed and therefore were not measureable and fall short of meeting the Daubert standard.

Decomposition studies including quantitative data (Megyesi et al. 2005, Adlam and Simmons 2007, Bachmann and Simmons 2010, Cross and Simmons 2010, Dabbs 2010, Simmons et al. 2010a, and Simmons et al. 2010b) began in the early years of the 21st century. These studies include statistical analyses that objectively explain the accuracy of estimating time since death. A more accurate and objective assessment of the postmortem interval, using quantitative data, is more beneficial to the medicolegal community when reconstructing events surrounding one's death. It also aids in the corroboration or elimination of a suspect's alibi.

In the Megyesi et al. study, crime scene photos of deceased individuals were observed. Based on the degree of decomposition and applying the physical descriptors from the literature, the deceased was assigned a score for each region of the body (head, trunk, and limbs). The three scores were then totaled (TBS). The TBS was then correlated with accumulated degree days. Out of 68 crime scene photos 71% of the cases' dates of death were not known, but determined from entomological evidence.

The use of case photos to assess the postmortem interval is problematic in a few ways: 1) variables such as temperature and humidity affecting decomposition were unknown, 2) case photos were obtained from law enforcement agencies or the medical examiner's office so the pertinent regions necessary to assess TBS were not necessarily visible, 3) poor photo quality; and 4) since the progression of decomposition could not be observed through the photos, scores may have been inaccurately assessed. For example, some features seen in early decomposition in southeast Texas, such as desiccation of ears, nose, and fingertips continues into advanced decomposition so circumstances such as this may have confounded the correct score.

Rationale

The strength of the Megyesi et al. (2005) study was that it utilized human subjects, not human analogs, and it made a significant contribution to understanding the human decomposition process with more precision as well as providing error rates. However, the method, although now being used ubiquitously, had not been validated for its accuracy, nor validated for use in different ecozones. Validation of using the Megyesi et al. method was the basis for this study. To validate the Megyesi et al. method the following criteria was necessary:

1. To use cadavers of known date of death.
2. To be able to observe cadavers, through gross observation, on a daily basis.
3. To be able to take photos of all regions of the body that would be needed to make an accurate assessment of the TBS.
4. To record actual daily temperatures throughout the study.
5. To compare TBS scores and known ADD's from three different ecozones with the estimated ADD that was produced from the Megyesi et al. equation.

Research goals and objectives

To *statistically* validate the Megyesi et al. equation a large sample of cadavers of known dates of death were needed. To *statistically* validate the effectiveness of the equation in different ecozones multiple decomposition facilities in different ecozones was required. Three human decomposition facilities in the United States had the capability of obtaining a large sample of cadavers needed for the study and were located in different ecozones; the University of Tennessee, Texas State University, and Sam Houston State University. At known ADD intervals (e.g. 100, 300, 500, 1000 ADD) the recorded TBS was input into the equation to compare to the estimated mean ADD produced from the equation.

Inter-observer error tests were performed twice on a semi-random sample of subjects at randomly selected decomposition stages. Inter-observer validation was conducted within each facility and between facilities.

In addition, if the physical descriptors for decomposition, provided by Megyesi et al., were insufficient in describing what was observed at each decomposition facility, new descriptors and a new scoring method was to be designed and potentially implemented.

Design and Methods

Each university placed four subjects four times a year for two years; thus each university having a data set of 32 human subjects and a combined data set of 96, sufficient for statistical analysis.

Forty-eight of the subjects were placed in a shaded environment and 48 in a sun-exposed environment at each facility. All were unclothed and caged; cages made of wire mesh placed over the cadaver to protect from scavenging but to allow access by insects. Subjects were placed at the Fresh stage of decomposition and were removed from the study at skeletonization.

Each day, photos, as well as written notes, were taken of each subject's head, trunk, and limbs. Accumulated-degree days was also recorded daily. All photos were stored on external hard drives. Data for each subject was entered into an excel spreadsheet.

For the inter-observer validation between facilities, a semi-random sample of digital images corresponding to 10 individuals at different stages of decomposition from the three facilities were selected. Five individuals were randomly selected from the sun group and five from the shade group. Images included all views of the head, trunk, and limbs taken of each subject. The score for each anatomical region and the TBS were evaluated by researchers from each facility independently.

Data Analysis

From pilot studies conducted at AARC prior to this research, it was observed that the relationship between TBS and ADD was not linear, therefore Spearman's rank correlation coefficient statistics were used to test the relationship between the actual and estimated mean ADD as it is designed to analyze the monotonic relationship between two variables that are not linear. In addition box plots and mean absolute deviation statistical tests were performed.

Both an ANOVA and an interclass correlation coefficient (ICC) statistic test were used to evaluate inter-observer error of assessing the total body score (TBS) on two separate sets of randomly chosen digital images.

<u>Statement of Results</u>

The two remaining subjects at the AARC facility were pulled on March 28, 2018 and analyses of all 96 subjects were conducted. Statistical results with tables and graphs of actual ADD's of 100, 300, 500, and 1000 compared to the estimated mean ADD's for the initial 28 subjects and final 96 subjects, in both sun and shade environments, are shown in the appendix. Results show that there is little correlation between the actual ADD and the estimated mean ADD at any of the four ADD's tested and becomes increasingly worse as the ADD increases. The accuracy of the TBS/ADD linear regression equation developed by Megyesi et al. (2005) for the quantitative assessment of the postmortem interval of humans should not be used as human decomposition is not a linear process.

The inter-observer error results of the study demonstrated agreement between well-trained observers based on non-serial photographs from all three facilities in this study. The trunk section had the highest inter-class correlation (.975), followed by the head (0.959), and the limbs showing the least similarity (0.940). Overall there was strong observation similarities (n=10) (p<0.001).

Scholarly Products Produced or in Process

Conference presentations

Validation of TBS/ADD Equation At 100, 300, 500, And 1000 ADD on 30 Human Subjects With Known PMI From Three Human Decomposition Facilities. Joan A. Bytheway, PhD, Nichole Miller, BS, Dawnie Steadman, PhD, Kelly Sauerwein, MA, Daniel Wescott, PhD, Chaunesey M. Clemmons, BA, Devora S. Gleiber, BA, Chloe P. McDaneld, MA, Lauren A. Meckel, MA. AAFS 69th Annual Scientific Meeting, New Orleans, Louisiana, February 2017

Training of Law Enforcement, Forensic Practitioners, Graduate Students, and Forensic and Criminal Justice High School Teachers

Short courses (i.e. two or three day to week-long) have been offered by all three institutions, educating participants on the use of the Megyesi et al. method as well as offering other solutions. Course titles and descriptions are listed in the appendix.

Peer-reviewed publications

Validation of the Total Body Score/Accumulated Degree Day Model at Three Human Decomposition Facilities Daniel J. Wescott, Dawnie Steadman, Nichole Miller, Kelly Sauerwein, M.J. Chaunesey, B. A. Clemmons, Devora S. Gleiber, Chloe P. McDaneld, Lauren A. Meckel, Joan A. Bytheway. Journal of Forensic Anthropology. DOI: http://dx.doi.org/10.5744/fa.2018.0015.

In progress

Modification of the Physical Descriptors for the Human Decomposition Process in Outdoor Death Scenes for a Subtropical, Humid Environment with Intense Solar Radiation. Joan A. Bytheway, PhD, Nichole Miller, BS. This is currently being tested at the AARC, Sam Houston State University.

Project Findings

Observation and scoring of the stages of decomposition, using the TBS method, is reliable between observers, yet the accuracy of the TBS linear regression equation is poor and the error is largely unpredictable other than it increases with postmortem time. Statistic results including tables and graphs are included in the appendix. A graph of mean absolute deviation, showing the increase in deviation as PMI progresses is also included.

The Principle Investigator and Research Assistant designed a new method of assessing the PMI with new physical descriptors that were specific to southeast Texas correlated with the use of ADD *intervals*. This method was shared with the other decomposition facilities but since some physical descriptors were not observed at the other decomposition facilities, the investigators were not comfortable including them in a new method. In addition, the interval ADD scoring system seemed confusing to some, so the method was not implemented nor disseminated. The new descriptors and new scoring sheet were revised by the principal investigator and are being tested at AARC. To date, there has been no literature on a new non-linear method for estimating the PMI quantitatively.

Even though a new quantitative method for estimating PMI was not collaboratively developed by the three investigators, the data is stored and available and new methods can be developed and tested on this data.

Implications for Criminal Justice Policy and Practice

Because of the quantifiable nature of the Megyesi et al. equation for estimating the mean ADD, it was believed that it would meet the Daubert Standard and thus became frequently used in PMI research around the world. However, this study shows that the process of decomposition is not a linear process and thus a linear equation is not sufficient.

However, the complexity of the entire human decomposition process, involving variability of individuals and internal and external variables occurring during the process has made it difficult to design a suitable and accurate equation.

Since human decomposition has been observed for many years at the University of Tennessee and for nine+ years at Texas State University and Sam Houston State University, the investigators are experts in observation of human decomposition. Until a realistic quantifiable method is developed, the more simplistic method of looking at daily temperatures correlated with gross observation of the body will still be necessary. It is still a very useful tool but without error ranges and statistical results it does not meet the Daubert standards. With the two years of collected data, there are ranges of temperatures that can be correlated with the interval of time that the body is in a certain stage of decomposition. For example, in the summer in southeast Texas a body will stay in the Fresh stage of decomposition 2-3 days. This is still very useful information for law enforcement.

The overall objective of the entire research project was gross observation of human decomposition using a quantitative mean to assess the PMI. With the use of this data, various sub-studies have been recognized and will be presented in future presentations and publications that will be useful to the scientific and medico-legal community.

Appendices

Results of ANOVA test and Interclass Correlation Coefficient for Interobserver Error

Anova: Single Factor — **Head**

SUMMARY

Groups	Count	Sum	Average	Variance
Row 1	3	26	8.66667	0.33333333

Anova: Single Factor — **Limbs**

SUMMARY

Groups	Count	Sum	Average	Variance
Row 1	3	16	5.333333	2.333333

Anova: Single Factor — **Trunk**

SUMMARY

Groups	Count	Sum	Average	Variance
Row 1	3	20	6.666667	1.333333

ANOVA results (n=5)

Head	.959
Trunk	.975
Limbs	.940

Interclass Correlation Coefficient Results (n=10)

Results of Initial sub-sample (n=28)

ADD	Spearmans' rank correlation coefficient ***r*** ***value: p value =0.005*****:** Shade	Spearmans' rank correlation coefficient ***r*** ***value: p value =0.005*****:** Sun
100	-0.7428	-0.8351
300	-0.8022	-0.9978
500	-0.6857	-0.6857
1000	-0.8158	-0.8153

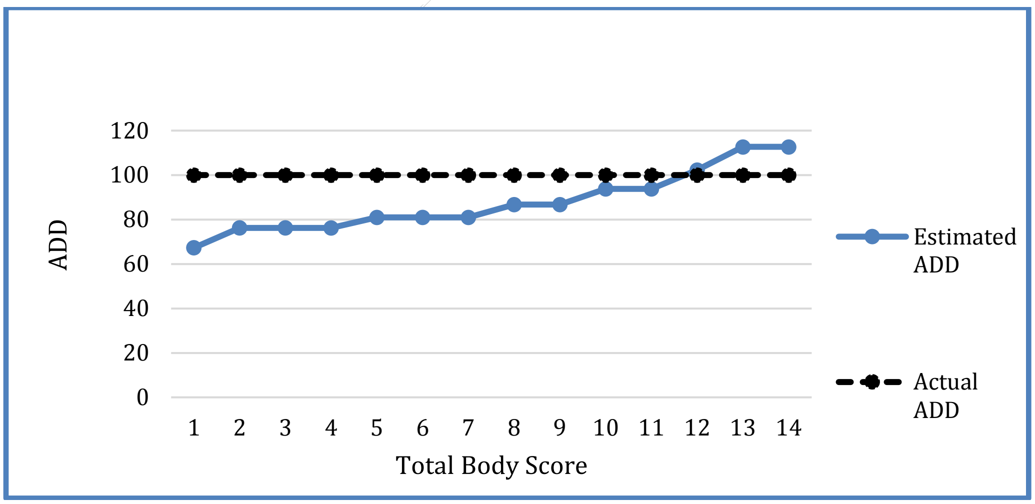


Figure 1. The graph of Actual ADD of 100 for each **shade** subject and the estimated equation mean ADD for each subject. Most estimated mean ADD, regardless of time of season, fall below the actual 100 ADD.

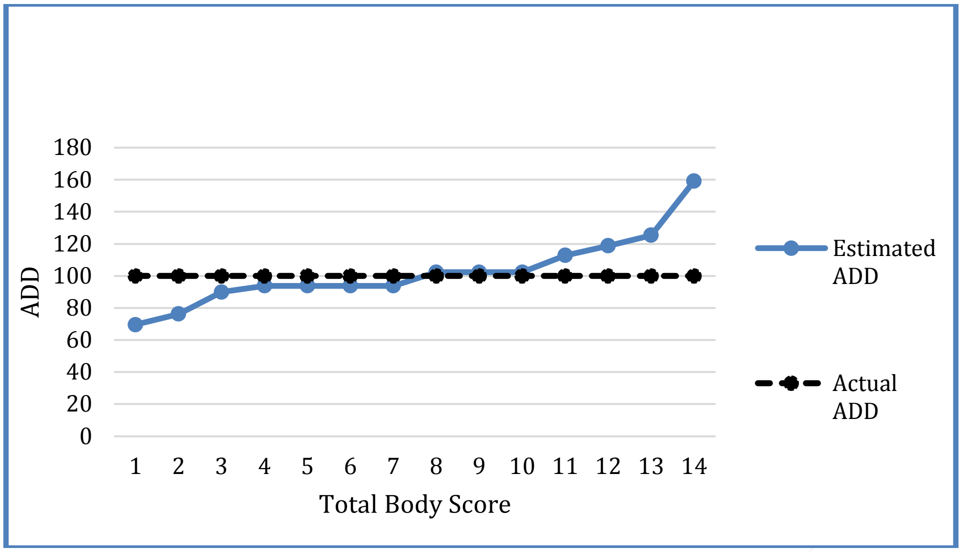


Figure 2. The graph of actual ADD of 100 and the estimated mean ADD for each **sun** subject. Although a stronger relationship exists with sun subjects than shade subjects, six of the estimated mean ADD for sun subjects are well above or below the actual ADD.

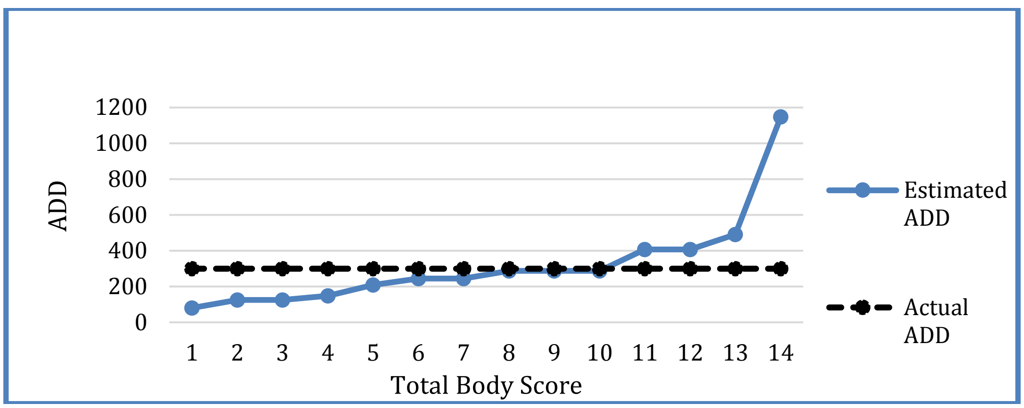


Figure 3. The graph of actual ADD of 300 and the estimated mean ADD for each **shade** subject.

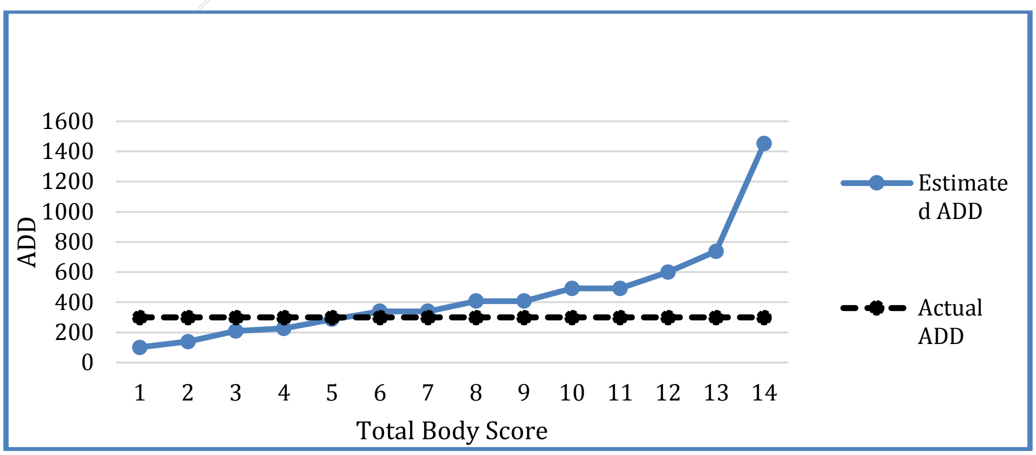


Figure 4. The graph of actual ADD of 300 and the estimated mean ADD for each **sun** subject.

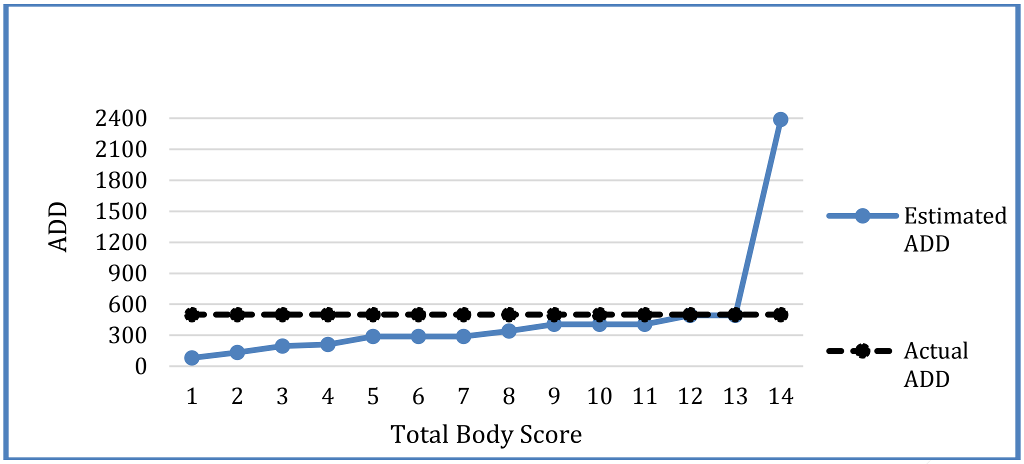


Figure 5. The graph of actual ADD of 500 and the estimated mean ADD for each **shade** subject.

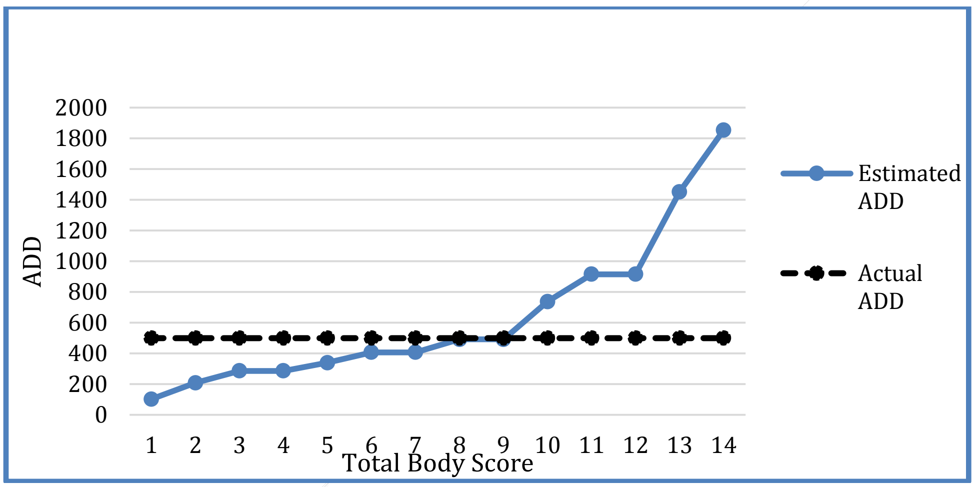


Figure 6. The graph of actual ADD of 500 and the estimated mean ADD for each sun subject.

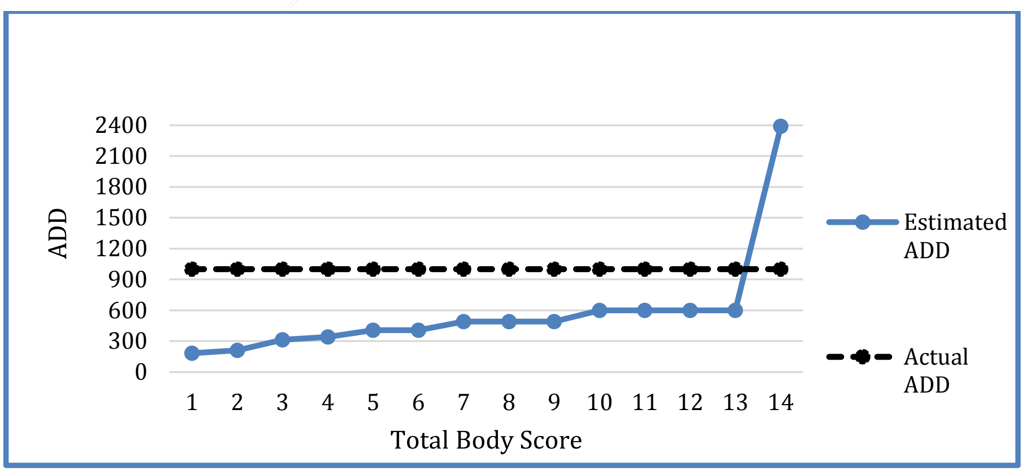


Figure 7. The graph of actual ADD of 1000 and the estimated mean ADD for each shade subject.

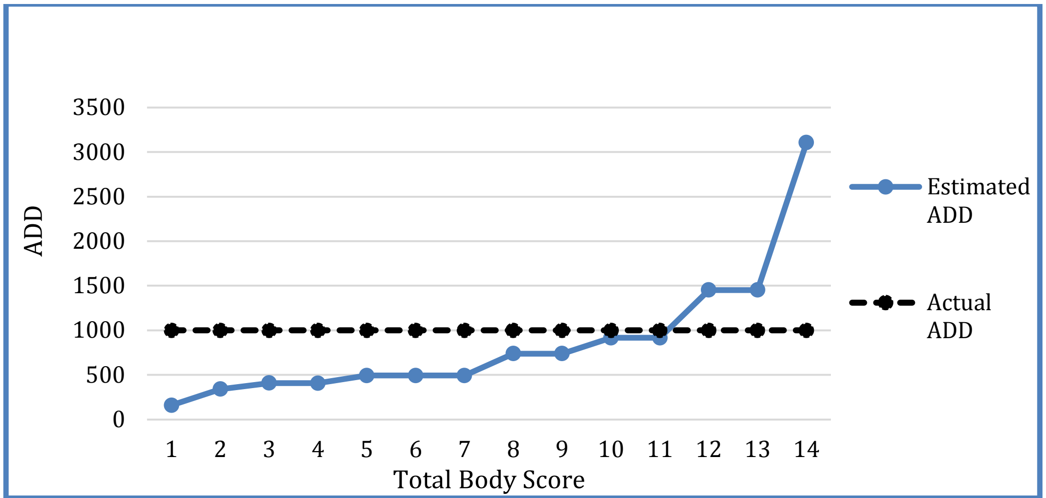


Figure 8. The graph of actual ADD of 1000 and the estimated mean ADD for each sun subject.

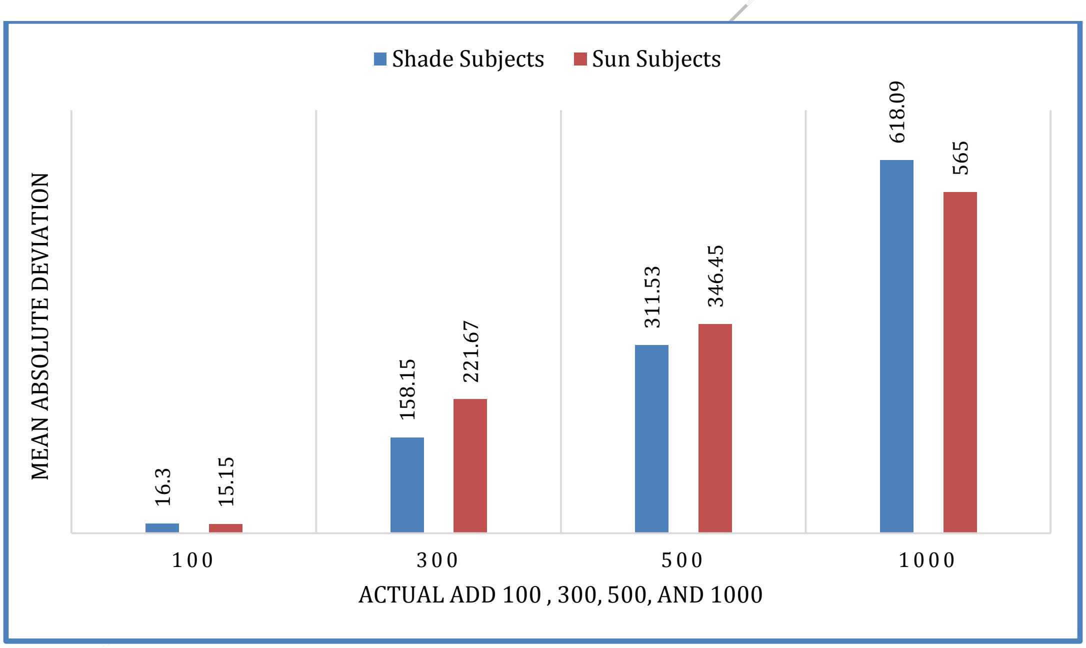
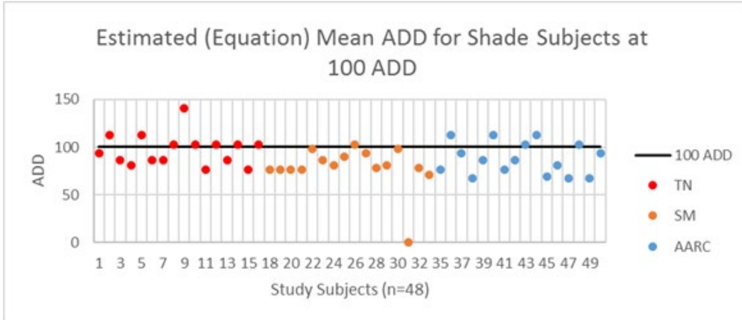
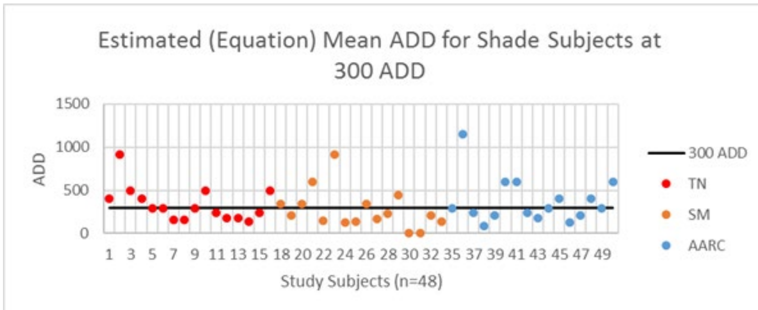
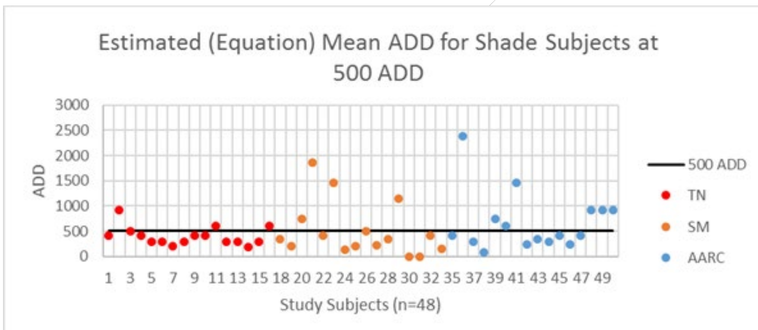


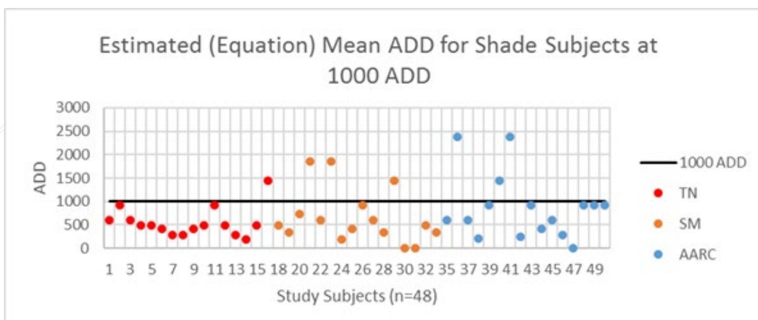
Figure 9. The graph of mean absolute deviation for sun and shade subjects for each actual ADD category.

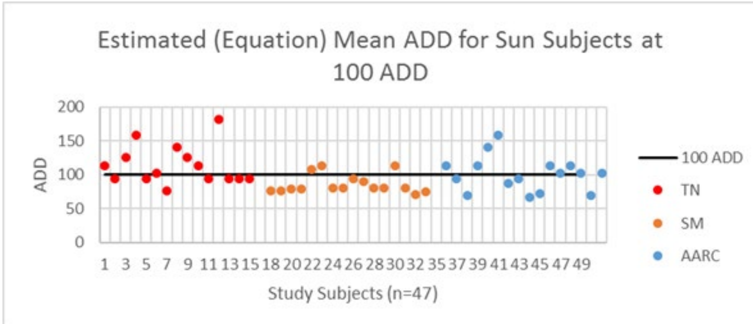
Final Results of the complete data set (n=96). Values at zero in the graphs indicate that the subject was removed from the study due to scavenging.

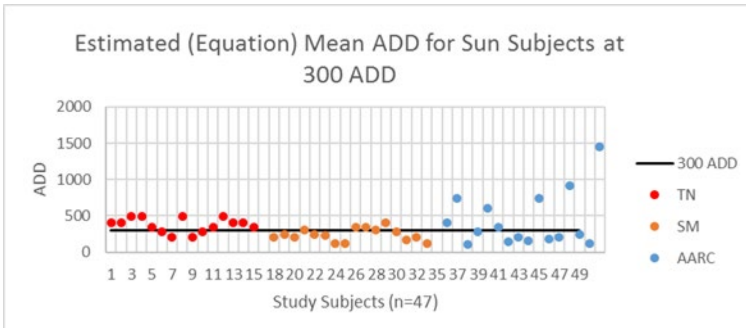


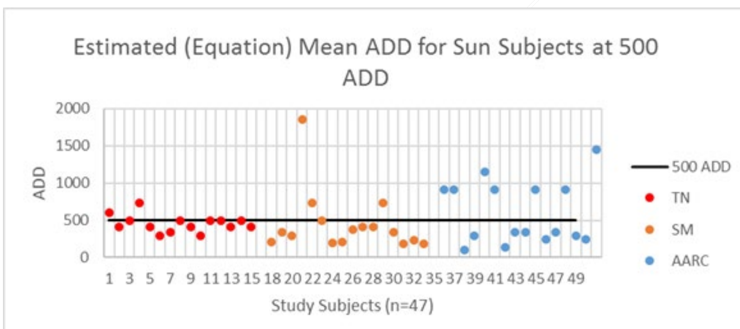


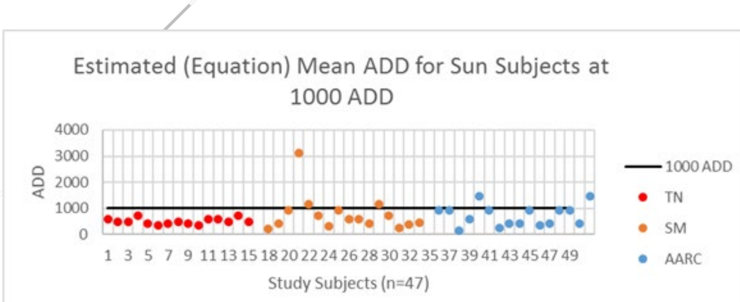






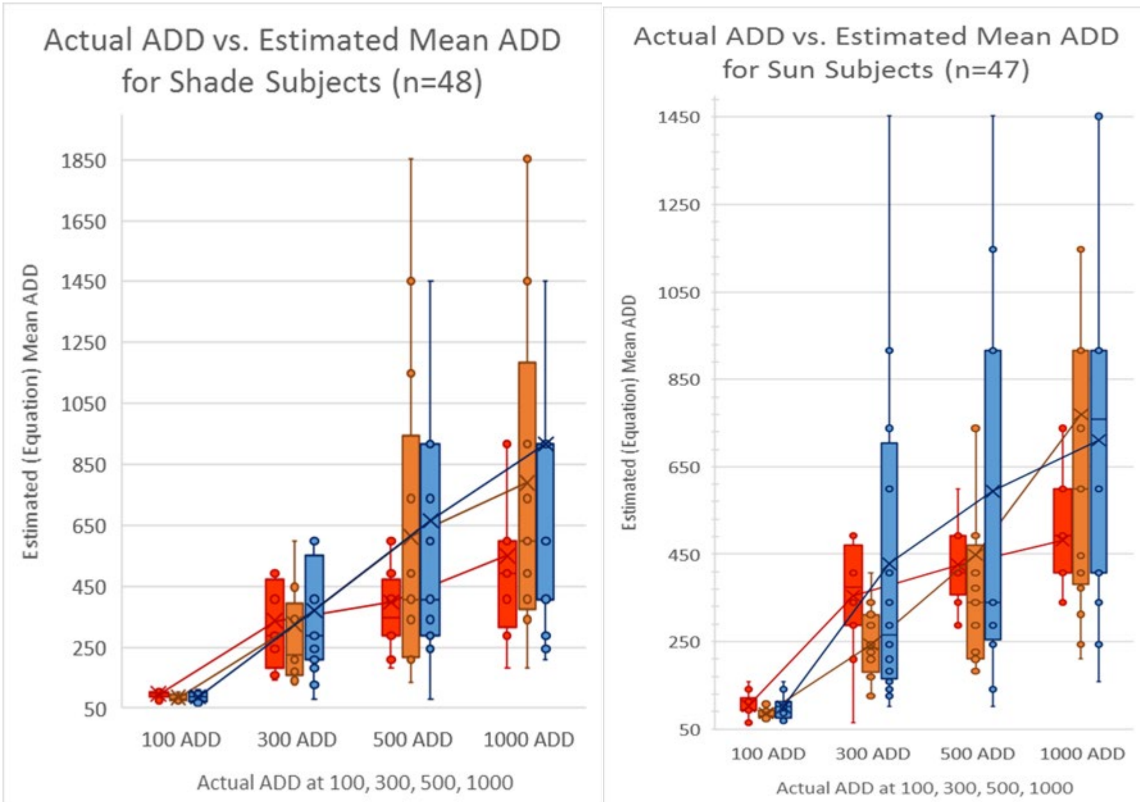




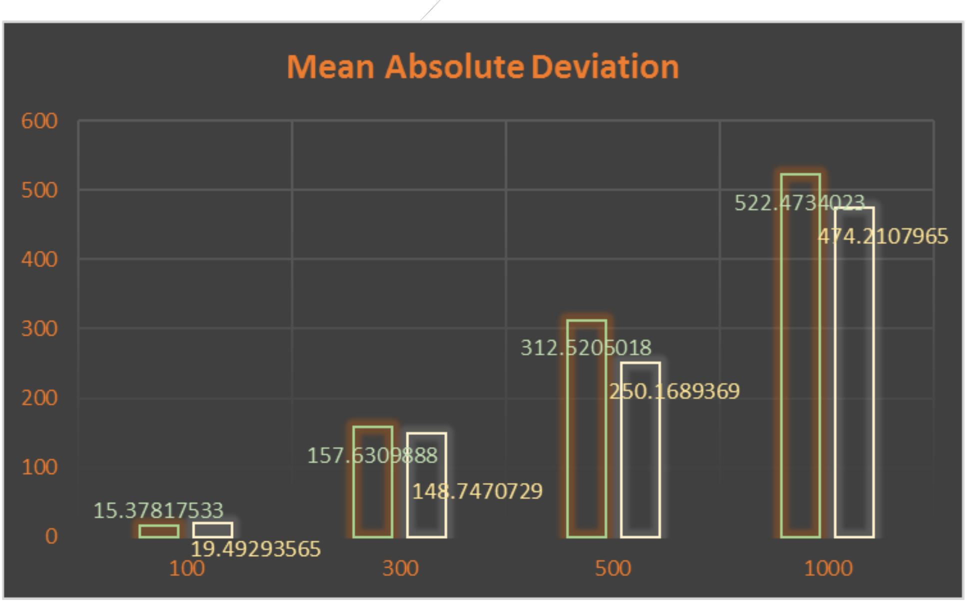


ADD	SUN 14	SUN 48	SHADE 14	SHADE 48
100ADD	-0.8351	0.654283	-0.7428	0.6181319
300ADD	-0.9978	0.21775	-0.8022	0.1372549
500ADD	-0.6857	0.264706	-0.6857	0.0485036
1000ADD	-0.8153	0.244118	-0.8158	-0.065934

Spearman's rank Correlation Coefficient r values for both sample sets (n=28), (n=96).



Box plots and whiskers of the deviation from the actual ADD and the estimated mean ADD.



Mean Absolute Deviation shows the increase in deviation as the postmortem interval increases for both sun and shade subjects (n=96).

The revised physical descriptors tailored for the southeast region of Texas.

FRESH	Head		Trunk		Limbs
IF	**Skin color of ___ is individually normal** □forehead □ right side of head □ neck □left side of head □ chin □ cheeks □ nose	IF	**Skin color of ___ is individually normal** □Thoracic region □Abdomen region □Right side of body □Left side of body	IF	**Skin color of ___ is individually normal** **Right:** □upper arm □lower arm □upper leg □lower leg **Left**: □ Upper arm □ Lower arm □ Upper leg □ lower leg
IF	**Skin elasticity of ___ is individually normal** □ anterior face □ right side of head □left side of head □ neck	IF	**Skin elasticity of ___ is individually normal** □Thoracic region □Abdomen region □Right side of body □ Left side of body	IF	**Skin elasticity of ___ is individually normal** **Right**: □ upper arm □ lower arm □ upper leg □ lower leg **Left**: □ Upper arm □ Lower arm □ Upper leg □ lower leg
MF	**Marbling minimally present on :** □ forehead □right side of head □ neck □left side of head □chin □ nose	MF	**Marbling present minimally to moderately on :** □Thoracic region □Abdomen region □Right side of body □Left side of body	MF	**Marbling present minimally to moderately on :** **Right:** □ upper arm □ lower arm □ upper leg □ lower leg **Left**: □ Upper arm □ Lower arm □ Upper leg □ lower leg
MF	**Skin color change :** □ forehead (gray,tan,green) □right side of head (gray,tan,green) □neck (gray,tan,green) □left side of head (gray,tan,green) □chin (gray,tan,green) □nose(gray,tan,green)	MF	**Skin color change :** □Thoracic region (gray,tan,green) □Abdomen region (gray,tan,green) □Right side of body(gray,tan,green) □Left side of body (gray,tan,green)	MF	**Skin color change (ARM)** **Right arm:** □ upper arm (gray,tan,green) □ lower arm (gray,tan,green) **Left arm**: □ Upper arm (gray,tan,green) □ Lower arm (gray,tan,green)
MF= min LF= mod	**Seeping of fluid from:** □ Eyes(min,mod) □ Nose (min, mod) □ Mouth (min, mod) □ Ears (min,mod)	LF	**Skin slippage - minimally present:** □Thoracic region □Abdomen region □ Right side of body □ Left side of body	LF	**Skin color change (LEG)** **Right leg:** □ upper leg (gray,tan,green) □ lower leg (gray,tan,green) **Left leg**: □ Upper leg (gray,tan,green) □ lower leg (gray,tan,green)
LF	**Skin Slippage - minimally present:** □ forehead □ right side of head □ neck □left side of head □ chin □ nose			LF	**Skin slippage - minimally present:** **Right**: □ upper arm □ lower arm □ upper leg □ lower leg **Left**: □ Upper arm □ Lower arm □ Upper leg □ lower leg
EARLY	**Head**		**Trunk**		**Limbs**
IE	**Marbling moderately to maximally present on :** □ forehead □ right side of head □ neck □left side of head □ chin □ nose	IE	**Marbling maximally present:** □Thoracic region □Abdomen region □Right side of body □Left side of body	IE	**Skin slippage moderatetly to maximally present:** **Right:** □ upper arm □ lower arm □ upper leg □ lower leg **Left:** □ Upper arm □ Lower arm □ Upper leg □ lower leg
IE=mod ME=max	**Skin slippage:** □ forehead (mod, max) □ right side of head (mod, max) □ neck (mod, max) □left side of head (mod, max) □ chin (mod, max) □ nose (mod,max)	IE=mod ME=max	**Skin slippage:** □Thoracic region (mod, max) □Abdomen region (mod, max) □Right side of body (mod, max) □Left side of body (mod, max)	IE	**Marbling maximally present:** **Right:** □ upper arm □ lower arm □ upper leg □ lower leg **Left:** □ Upper arm □ Lower arm □ Upper leg □ lower leg

ME	**Seeping of fluid moderately to maximally from (presence not enough to form CDI) :** □ Eyes □Nose □ Mouth □ Ears	ME	**Skin color change:** □Thoracic region (brown, purple, orange, dark blue/green) □Abdomen region (brown, purple, orange, dark blue/green) □Right side of body (brown, purple, orange, dark blue/green) □ Left side of body (brown, purple, orange, dark blue/green)	IE	**Skin color change:** **Right**: □ upper arm(brown, purple, orange, dark blue/green) □ lower arm(brown, purple, orange, dark blue/green) □ upper leg(brown, purple, orange, dark blue/green) □lower leg(brown, purple, orange, dark blue/green) **Left:** □ Upper arm(brown, purple, orange, dark blue/green) □ Lower arm(brown, purple, orange, dark blue/green) □ Upper leg(brown, purple, orange, dark blue/green) □ lower leg(brown, purple, orange, dark blue/green)
ME	**Incipient desiccation of :** □ Cheeks □Forehead □Chin □ Neck □Eyes □Ears □Nose □ Lips	IE	**Incipient desiccation of :** □Thoracic region □Abdomen region	IE=min ME=mod LE=max(tissue crinkle required)	**Incipient desiccation of Fingertips and Toes/Heels:** **Fingertips**: □right hand (min, mod, max) □left hand (min, mod, max) **Toes/heels**: □ left foot (min, mod, max) □ right foot (min, mod, max)
ME	**Skin color change :** □forehead(brown, purple, orange, dark blue/green) □right side of head(brown, purple, orange, dark blue/green) □neck(brown, purple, orange, dark blue/green) □left side of head(brown, purple, orange, dark blue/green) □ chin(brown, purple, orange, dark blue/green) □nose(brown, purple, orange, dark blue/green)	ME	□ **Incipient bloat** of trunk	ME	**Incipient bloat of (appearance of arms/legs retaining water) :** **Right:** □upper arm □ lower arm □ upper leg □ lower leg **Left:** □Upper arm □ Lower arm □ Upper leg □ lower leg
ME	**Incipient bloat of:** □ Face/cheeks □ Lips □ Neck	ME	**Full bloat:** □ **Full extension of abdomen**	LE	**Full bloat (skin tightly stretched):** □ Arms abduct from body □ plie position of legs
LE	**Full bloat of:** □ Face/cheeks □ Lips □ Neck			IE=min ME=mod LE=max	**Incipient to full desiccation of:** **Right:** □ upper arm (min,mod,max) □ lower arm(min,mod,max) □ upper leg(min,mod,max) □ lower leg(min,mod,max) **Left**: □ Upper arm(min,mod,max) □ Lower arm(min,mod,max) □ Upper leg(min,mod,max) □ lower leg(min,mod,max)
LE	□ **Hair of head sloughing off**				

ADVANCED	Head		Trunk		Limbs
IA	**Leaching of fluid from ____ producing CDI:** □Eyes □ Nose □ Mouth □ Ears	IA	**Leaching of fluid from ___ producing CDI:** □Right side of body □ Left side of body □ genital area	IA	**Leaching of fluid from ___ producing CDI:** □ Right arm □ Left arm □ Right leg □ Left leg
IA	**Incipient collapse of:** □cheeks, □neck	IA	**Incipient collapse of:** □ thoracic region □ abdominal region	IA	**Incipient collapse (swelling is disappearing) of:** **Right**: □ upper arm □ lower arm □ upper leg □ lower leg **Left**: □ Upper arm □ Lower arm □ Upper leg □ lower leg
IA	**Color change :** □ forehead (black, dark brown) □ right side of head (black, dark brown) □ neck (black, dark brown) □left side of head (black, dark brown) □ chin (black, dark brown) □ nose (black, dark brown)	IA	**Incipient collapse of:** □ groin area (males: penis erection and scrotum begins to deflate, females muscle tissue presence decreases)	IA	**Color change:** **Right**: □ upper arm(black, dark brown) □ lower arm(black, dark brown) □ upper leg(black, dark brown) □ lower leg(black, dark brown) **Left**: □ Upper arm(black, dark brown) □ Lower arm(black, dark brown) □ Upper leg(black, dark brown) □ lower leg(black, dark brown)
MA	**Full collapse of:** □cheeks/face with crinkling of skin	IA	**Color change to :** □Thoracic region(black or dark brown) □Abdomen region(black or dark brown)	MA	**Full collapse of ____ with incipient crinkling of skin** □right arm □left arm □right leg □left leg
MA	□**Full collapse of neck**	MA	**Full collapse with incipient crinkling of skin of:** □thoracic region □ abdominal region □ groin area	LA	**As soft tissues degrade, outline of bones under _____tissue becomes apparent (tissue "hugging bone"):** **Right:** □ upper arm □ lower arm □ upper leg □ lower leg **Left**: □ Upper arm □ Lower arm □ Upper leg □ lower leg
MA	□**Widening of eye opening and drying of skin tissue**	MA	□**Widening of groin area opening and drying of skin tissue**	MA= min-mod LA= max	**Crinkling of tissue on ____ (minimal 1-5mm w fold, moderate 5-10mm w fold , maximum 10+mm):** **Right:** □ upper arm(min,mod,max) □ lower arm(min,mod,max) □ upper leg(min,mod,max) □ lower leg(min,mod,max) **Left**: □ Upper arm(min,mod,max) □ Lower arm(min,mod,max) □ Upper leg(min,mod,max) □ lower leg(min,mod,max)
MA	□**Widening of mouth opening and drying of skin tissue**	LA	**As soft tissues degrade, outline of bones under _______tissue becomes apparent (tissue "hugging bone"):** □thoracic region □abdominal region □groin area	LA	**Bone exposure to left humerus:** □ 10% □ 20% □ 30% □ 40%

MA	□ **Teeth more fully exposed**	MA= min-mod LA= max	**Crinkling of tissue on ____ (minimal 1-5mm w fold, moderate 5-10mm w fold , maximum 10+mm)** □thoracic region(min,mod,max) □abdominal region(min,mod,max) □groin area(min,mod,max)	LA	**Bone exposure to right humerus:** □ 10% □ 20% □ 30% □ 40%
MA	**Further desiccation of ___ and widening of tissue with possible small sections of bone exposure to:** □eyes □ears □nose □lips	LA	**Bone exposure to left side of ribs:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to left radius and ulna:** □ 10% □ 20% □ 30% □ 40%
MA= mod LA= max	**Crinkling of tissue on ____ (minimal 1-5mm w fold, moderate 5-10mm w fold , maximum 10+mm)** □cheeks (mod,max) □chin (mod,max) □forehead (mod,max) □neck (mod,max)	LA	**Bone exposure to right side of ribs:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to right radius and ulna:** □ 10% □ 20% □ 30% □ 40%
LA	**As soft tissues degrade, outline of bones under _______tissue becomes apparent (tissue "hugging bone"):** □cheeks □chin □forehead □neck	LA	**Bone exposure to anterior portion of ribs:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to left carpals:** □ 10% □ 20% □ 30% □ 40%
LA	**Bone exposure to anterior region of skull:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to right clavicle:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to right carpals:** □ 10% □ 20% □ 30% □ 40%
LA	**Bone exposure to posterior region of skull:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to left clavicle:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to left metacarpals:** □ 10% □ 20% □ 30% □ 40%
LA	**Bone exposure to right side of skull:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to right os coxa:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to right metacarpals:** □ 10% □ 20% □ 30% □ 40%
LA	**Bone exposure to left side of skull:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to left os coxa:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to left hand phalanges:** □ 10% □ 20% □ 30% □ 40%
LA	**Bone exposure to right side of mandible:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure of thoracic and lumbar vertebrae:** □ 10% □ 20% □ 30% □ 40%	LA	**Bone exposure to right hand phalanges:** □ 10% □ 20% □ 30% □ 40%
LA	**Bone exposure to left side of mandible:** □ 10% □ 20% □ 30% □ 40%			LA	**Bone exposure to right femur:** □ 10% □ 20% □ 30% □ 40%
LA	**Bone exposure to anterior mandible:** □ 10% □ 20% □ 30% □ 40%			LA	**Bone exposure to left femur:** □ 10% □ 20% □ 30% □ 40%
LA	**Bone exposure to right side of neck:** □ 10% □ 20% □ 30% □ 40%			LA	**Bone exposure to right tibia and fibula:** □ 10% □ 20% □ 30% □ 40%

LA	**Bone exposure to left side of neck:** □ 10% □ 20% □ 30% □ 40%			LA	**Bone exposure to left tibia and fibula:** □ 10% □ 20% □ 30% □ 40%
LA	**Bone exposure to anterior neck:** □ 10% □ 20% □ 30% □ 40%			LA	**Bone exposure to right tarsals:** □ 10% □ 20% □ 30% □ 40%
				LA	**Bone exposure to left tarsals:** □ 10% □ 20% □ 30% □ 40%
				LA	**Bone exposure to right metatarsals:** □ 10% □ 20% □ 30% □ 40%
				LA	**Bone exposure to left metatarsals:** □ 10% □ 20% □ 30% □ 40%
				LA	**Bone exposure to right foot phalanges:** □ 10% □ 20% □ 30% □ 40%
				LA	**Bone exposure to left foot phalanges:** □ 10% □ 20% □ 30% □ 40%
SKELETONIZED	**Head**		**Trunk**		**Limbs**
S	□ **Desiccated sheet of tissue covering bones but not attached to bones (i.e. edges may be curled & could be peeled off easily thus considered skeletonized)**	S	□ **Desiccated sheet of tissue covering bones but not attached to bones (i.e. edges may be curled & could be peeled off easily thus considered skeletonized)**	S	□ **Desiccated sheet of tissue covering bones but not attached to bones (i.e. edges may be curled & could be peeled off easily thus considered skeletonized)**
S	**Bones of ___ exposed 50%:** **Right Side:** □ skull □mandible □ cervicals **Left Side**: □ skull □mandible □ cervicals **Anterior:** □ skull □mandible □ cervicals **Posterior**: □ skull □ cervicals	S	**Bones of ___ exposed 50%:** **Ribs:** □right side □left side □anterior portion **Clavicles**: □right bone □left bone **Os coxa**: □ right side □left side □ **groin/pubic area** □ **Thoracic & Lumbar vertebrae**	S	**Bones of ______ exposed 50%:** **Right:** □ upper arm □ lower arm □ upper leg □ lower leg **Left:** □ Upper arm □ Lower arm □ Upper leg □ lower leg

The revised scoring sheet to be used in conjunction with the new physical descriptors. This method is currently being tested at AARC, Sam Houston State University.

TBS-ADD

Date:________________ AARC _________________ **Cage Type:** Sun Shade

Weather Conditions

Sunny **Partly Cloudy** **Cloudy** **Raining**

- HEAD -

Comments:

Fresh	**Early**	**Advanced**	**Skeletonization**
IF	IE	IA	S
MF	ME	MA	
LF	LE	LA	

Stage Selection:

IF	IF/MF	MF	MF/LF	LF	LF/IE
IE	IE/ME	ME	ME/LE	LE	LE/IA
IA	IA/MA	MA	MA/LA	LA	LA/S
S					

1 unit difference= Transitional Stage; >1 unit difference= Non-transitional Stage

- TRUNK -

Comments:

Fresh	**Early**	**Advanced**	**Skeletonization**
IF	IE	IA	S
MF	ME	MA	
LF	LE	LA	

Stage Selection:

IF	IF/MF	MF	MF/LF	LF	LF/IE
IE	IE/ME	ME	ME/LE	LE	LE/IA
IA	IA/MA	MA	MA/LA	LA	LA/S
S					

1 unit difference= Transitional Stage; >1 unit difference= Non-transitional Stage

- LIMBS -

Comments:

Fresh	**Early**	**Advanced**	**Skeletonization**
IF	IE	IA	S
MF	ME	MA	
LF	LE	LA	

Stage Selection:

IF	IF/MF	MF	MF/LF	LF	LF/IE
IE	IE/ME	ME	ME/LE	LE	LE/IA
IA	IA/MA	MA	MA/LA	LA	LA/S
S					

1 unit difference= Transitional Stage; >1 unit difference= Non-transitional Stage

An example of the course agenda for the Human Decomposition short course offered at AARC, July 2018.

June 18-19, 2018 a course, titled **Forensic Taphonomy in Texas** was conducted at the FACTS facility by Dr. Wescott. This course introduced law enforcement officers, medicolegal professionals, and graduate students to the TBS/ADD method.

May 29-June 1, 2018, a course entitled **Field Methods** was conducted at the ARF for students and professionals. The TBS/ADD method and suggested additions created from this study were among the materials taught.

June 18-22, 2018, a course at the ARF for DuPage College (IL) was given in which TBS/ADD and our suggested additions were taught.

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