Clyde C. Snow, [1] *Ph.D.*

Equations for Estimating Age at Death from the Pubic Symphysis: A Modification of the McKern-Stewart Method

REFERENCE: Snow, C. C., **"Equations for Estimating Age at Death from the Pubic Symphysis: A Modification of the McKern-Steward Method,"** *Journal of Forensic Sciences*, JFSCA, Vol. 28, No. 4, Oct. 1983, pp. 864-870.

ABSTRACT: Morphological changes of the pubic symphysis provide an important means of estimating age at death in the adult skeleton. Today, the most widely used method of symphysial aging is the three-component system devised by McKern and Stewert for males and modified by Gilbert and McKern for females. Examination of the published data for both sexes reveals that the relationship of *total symphysial score* with predicted age and observed standard deviations can be expressed by a set of simple linear and polynominial equations. This approach is more statistically efficient since it uses the total data base rather then independently treated data subsets in predicting age from total symphysial score. It has the added advantage of providing a simple method of predicting symphysial age on small computers or programmable calculators.

KEYWORDS: physical anthropology, musculoskeletal system, human identification

The quantitative assessment of morphological change in the pubic symphysis is widely used to estimate age at death in skeletal remains. Presently, the method developed by McKern and Stewart [*1*] is commonly applied to obtain age estimates for males. This method was modified by Gilbert and McKern for estimating age from female pubes [*2*].

In both methods, the individual scores of the three morphological components (dorsal demiface, ventral rampart, and symphysial rim) are summed to obtain the symphysial score. This score, ranging in value from 0 to 15, is then used to derive age from the appropriate tables supplied by the above authors (Tables 1 and 2). These tables provide the mean, standard deviation, and observed range of age for each increment of the score.

The tables are most frequently used by physical anthropologists to derive age estimates from individual skeletons. In the forensic science area, one seldom has recourse to them more than a few times a month and, for such occasional use, they are entirely sufficient. There are instances, however, such as mass disasters or multiple homicide cases, when many bodies or skeletons must be processed for identification within a short period of time. In such situations, it would be advantageous to have the information required for symphysial aging reduced to a form adaptable for computer programming. It would also save time and labor in more leisurely projects such as when symphysial age must be determined in a large collection of prehistoric burials.

Received for publication 14 Feb. 1983; accepted for publication 22 March 1983.

[1] Forensic anthropology consultant, Cook County Medical Examiner's Office, Chicago, IL and Oklahoma State Medical Examiner's Office, Oklahoma City, OK.

TABLE 1—*Age predicted from total symphysial score in males according to McKern and Stewart* [1].

Total Score	*n*	Age Range	Mean Age	Standard Deviation
0	7	-17	17.29	0.49
1-2	76	17-20	19.04	0.79
3	43	18-21	19.79	0.85
4-5	51	18-23	20.84	1.13
6-7	26	20-24	22.42	0.99
8-9	36	22-28	24.14	1.93
10	19	23-28	26.05	1.87
11-12-13	56	23-39	29.18	3.33
14	31	29+	35.84	3.89
15	4	36+	41.00	6.22
Total	349	...	...	...

TABLE 2—*Age predicted from total symphysial score in females according to Gilbert and McKern* [2].

Total Score	*n*	Age Range	Mean Age	Standard Deviation
0	2	14-18	16.00	2.82
1	12	13-24	19.80	2.62
2	13	16-25	20.15	2.19
3	4	18-25	21.50	3.10
4-5	7	22-29	26.00	2.61
6	8	25-36	29.62	4.43
7-8	14	23-39	32.00	4.55
9	5	22-40	33.00	7.75
10-11	11	30-47	36.90	4.94
12	12	32-52	39.00	6.09
13	8	44-54	47.75	3.59
14-15	7	52-59	55.71	3.24
Total	103	...	...	...

The purpose of this paper is to present a set of equations for predicting age from symphysial score. These equations are, in essence, condensations of the McKern-Stewart and Gilbert-McKern tabular data.

Method

The equations for males are derived from the table presented by McKern and Stewart [*1*, p. 85] in their 1957 study of the pubic symphysial age changes in 349 U.S. Korean War dead. Those for females are based upon Gilbert and McKern's table summarizing their findings on symphysial age changes in an autopsy series of 103 American females ranging in age from 14 to 59 years [*2*, p. 34]. As the standard deviations given by Gilbert and McKern in their original study were miscalculated, the corrected values presented by Stewart [*3*, p. 168] are used here. In both studies, the authors found that some numerically consecutive symphysial scores gave nearly identical age estimates and, therefore, they grouped such sets into single categories. Thus, in males, scores of 1 and 2, 4 and 5, 6 and 7, 8 and 9, and 11, 12, and 13 were combined. By this process, the total number of male age categories was reduced to ten (Table 1). Similar combinations in the female data resulted in a final set of twelve age categories (Table 2).

The first step in calculating the equations presented here was to plot the age means given in the original tables against symphysial score (Fig. 1). When two or more scores had been combined in the original tables, their median value was plotted against the age mean.

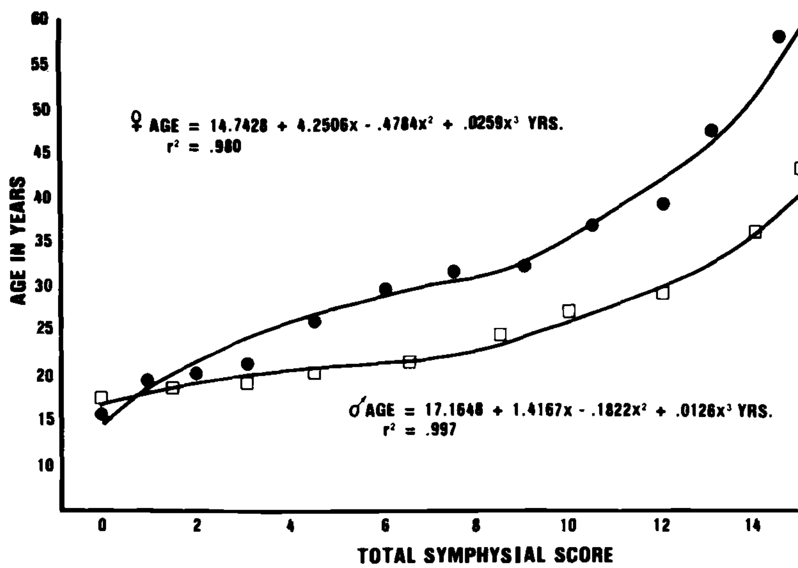

FIG. 1—*Mean ages of males* [1] *and females* [2] *plotted against total symphysial score (open squares = male and closed circles = females).*

Inspection of Fig. 1 shows a strong curvilinear relationship between symphysial score and age in both sexes. The best-fitting curves expressing these relationships are weighted third-order polynomial regressions. These equations are:

Males

$$\text{Age (years)} = 17.1648 + 1.4167X - 0.1822X^2 + 0.0126X^3$$

$$r^2 = 0.997$$

Females

$$\text{Age (years)} = 14.7428 + 4.2506X - 0.4784X^2 + 0.0259X^3$$

$$r^2 = 0.980$$

in which X is the symphysial score and r^2 is the coefficient of determination.

A second set of equations were then calculated to express the variability of the age estimates derived from the above formulas. First, the standard deviations of each age mean of the original tables were plotted against symphysial score. In males, the relationship is curvilinear and is best fit by a third-order polynomial weighted for subsample size (Fig. 2). The equation is:

$$\text{Male S.D. (years)} = 0.6591 + 0.0705X - 0.0023X^2 + 0.0011X^3$$

$$r^2 = 0.960$$

Compared to those of the males, the female standard deviations are both larger and less strongly correlated with symphysial score (Fig. 3). Their larger values are probably a reflection of the influence of parity on the variability of female pubic morphology. Their weaker

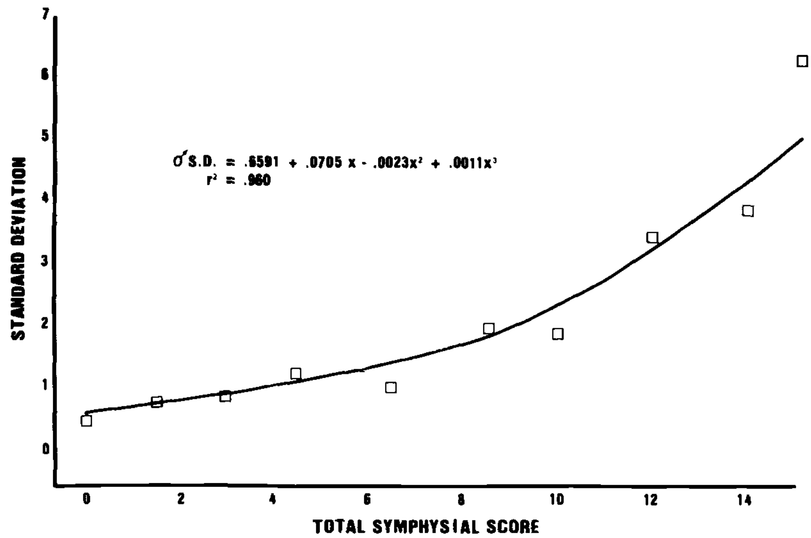

FIG. 2—*Standard deviations of male age means* [1] *plotted against total symphysial score.*

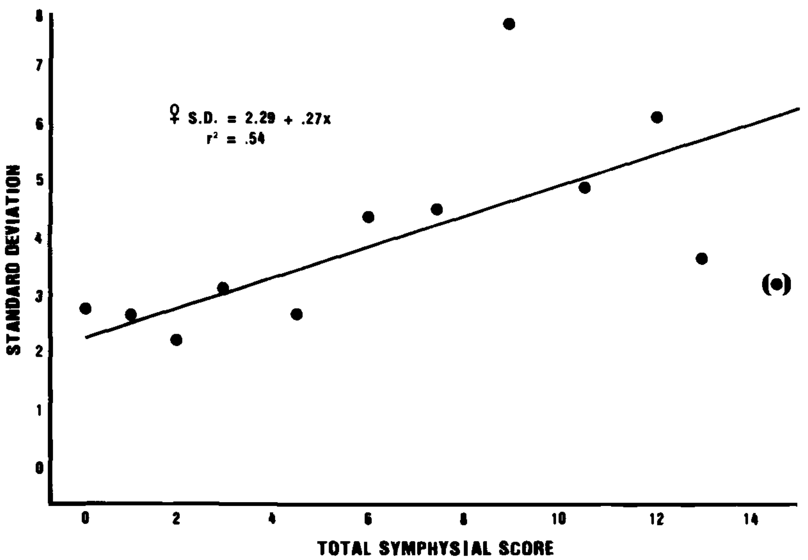

FIG. 3—*Standard deviations of female age means* [2] *plotted against total symphysial score.*

correlation with symphysial score is most likely a function of the rather small subsample sizes of the Gilbert-McKern series. For these data, the best fit is provided by a simple linear regression weighted for subsample size. In calculating this equation, the very small standard deviation of 3.24 years for the 14-15 symphysial score category was ignored since it is obviously a statistical artifact resulting from the truncation of the data by excluding individuals older than 59 years from the original series [2, p. 34]. The final equation is:

$$\text{Female S.D. (years)} = 2.29 + 0.27X$$

$$r^2 = 0.54$$

Results

The predicted age means, standard deviations, and the ±2 S.D. ranges for symphysial scores between 0 and 15 calculated from the above equations are given in Table 3 for males and Table 4 for females. Examination of these data show that, in most instances, the ±2 S.D. ranges exceed the observed ranges given in the original data tables. Table 5 compares the ages predicted from the formulas with those of the original data. The agreement between the values is generally quite close and in only two instances do they differ by more than two standard errors of the mean.

Discussion

Judging from the findings presented above, the reduction of the McKern-Stewart and Gilbert-McKern data to the equations presented here does not significantly reduce the accuracy of the age estimates derived from symphysial score. In theory at least, it should enhance their predictive power since the equations are derived from the data as a whole whereas, in the original studies, the age categories were treated independently.

As confidence limits derived from the standard deviation are more reliable than those based on the observed range, these equations cast new light on Suchey's test of the method of pubic aging in which she solicited the age estimates of 11 female pubes by 23 experienced forensic anthropologists. In analyzing her data, she used the observed ranges given by Gilbert and McKern as her criterion for judging the accuracy of the age estimates. Of the 253 age estimates provided by her respondents, only 129 (51.0%) fell within the observed range limits. However, a review of her data shows that 170 (67.2%) of the estimates are included within the 2 S.D. limits calculated from the equations (Table 6). This finding suggests that the standard deviation more realistically reflects the morphological variability of the female pubic symphysis than the narrower limits imposed by the observed range.

Summary

An analysis of the data that forms the basis of the McKern-Stewart method for estimating age from symphysial score in both sexes shows that it can be reduced to a series of four

TABLE 3—*Male ages and standard deviations predicted from symphysial scores by regression equations.*

Symphysial Score	Estimated Age	Standard Deviation	±2 S.D. Range
0	17.16	0.66	15.85-18.48
1	18.41	0.73	16.96-19.87
2	19.37	0.80	17.77-20.97
3	20.12	0.88	18.36-21.87
4	20.72	0.97	18.77-22.67
5	21.27	1.09	19.09-23.45
6	21.83	1.24	19.35-24.30
7	22.48	1.42	19.64-25.31
8	23.29	1.64	20.01-26.57
9	24.34	1.91	20.52-28.16
10	25.71	2.23	21.24-30.18
11	27.47	2.62	22.23-32.71
12	29.70	3.07	23.55-35.85
13	32.47	3.60	25.27-39.68
14	35.86	4.21	27.43-44.29
15	39.95	4.91	30.12-49.77

TABLE 4—*Female ages and standard deviations predicted from symphysial scores by regression equations.*

Symphysial Score	Estimated Age	Standard Deviation	±2 S.D. Range
0	14.74	2.29	10.16-19.32
1	18.54	2.56	13.42-23.66
2	21.54	2.83	15.88-27.20
3	23.89	3.10	17.69-30.09
4	25.75	3.37	19.01-32.49
5	27.27	3.64	19.99-34.55
6	28.62	3.91	20.80-36.44
7	29.94	4.18	21.58-38.30
8	31.39	4.45	22.49-40.29
9	33.13	4.72	23.69-42.57
10	35.31	4.99	25.33-45.29
11	38.09	5.26	27.57-48.61
12	41.62	5.53	30.56-52.68
13	46.05	5.80	34.45-57.65
14	51.55	6.07	39.41-63.69
15	58.27	6.34	45.59-70.95

TABLE 5—*Comparison of ages predicted from symphysial scores by equations and age means of symphysial score classes observed in the McKern-Stewart (male) and Gilbert-McKern (female) series.*

Symphysial Score	Males				Females				Symphysial Score
	Pred	Obs[a]		n[a]	Pred	Obs[b]		n[b]	
0	17.2	17.3	0.1	7	14.7	16.0	1.3	2	0
1–2	18.9	19.0	0.1	76	18.5	19.8	1.4	12	1
					21.5	20.1	−1.4[c]	13	2
3	20.1	19.8	−0.3[c]	43	23.9	21.5	−2.4	4	3
4–5	21.0	20.8	−0.2	51	26.5	26.0	−0.5	7	4–5
6–7	22.1	22.4	0.3	26	28.6	29.6	1.0	8	6
					30.7	32.0	1.3	14	7–8
8–9	23.8	24.1	0.3	36	33.2	33.0	−0.2	5	9
10	25.7	26.0	0.3	19	36.8	36.9	0.1	11	10–11
11–13	29.8	29.2	−0.6	56	41.7	39.0	−2.7	12	12
					46.3	47.8	1.5	8	13
14	35.7	35.8	0.1	31	55.0	55.7	0.7	7	14–15
15	39.8	41.0	1.2	4					

[a] From McKern and Stewart [*1*].
[b] From Gilbert and McKern [*2*].
[c] 2 S.E. $\bar{x}$ of observed mean.

regression equations. Two of the equations are third-order polynomial regressions of age on symphysial score in males and females. The second pair calculates the standard deviation of the age estimate from symphysial score.

These equations have two advantages over the tables presented by McKern and Stewart and by Gilbert and McKern for estimating age from symphysial score in males and females, respectively. First, in deriving the equations, the data sets are treated as a whole rather than as a series of independent subsamples. This should result in more accurate age estimates. The second advantage is that, since these equations can be readily programed on a small

TABLE 6—*Age estimates from Suchey's test[a] falling within limits of observed ranges and ±2 S.D. ranges.*

Age of Test Specimen	No. Specimen Within Observed Range	No. Specimen Within ±2 S.D.	Difference
19	18	20	3
23	10	14	4
27	21	22	1
29	15	21	6
31	19	21	2
32	12	12	0
42	9	16	7
45	11	14	4
47	13	20	7
51	1	4	3
60	0	6	6
Total	129	170	41
% of total test estimates	51.0	67.2	16.2

[a]Suchey [*4*, p. 469, Table 3].

computer or programmable calculator, they offer a more rapid method of determining age from symphysial score.

References

[*1*] McKern, T. W. and Stewart, T. D., "Skeletal Age Changes in Young American Males," Technical Report EP-45, U.S. Army Quartermaster Research and Development Center, Environmental Protection Research Division, Natick, MA, 1957.

[*2*] Gilbert, B. M. and McKern, T. W., "A Method for Aging the Female *Os pubis*," *American Journal of Physical Anthropology*, Vol. 38, 1973, pp. 31-38.

[*3*] Stewart, T. D., *Essentials of Forensic Anthropology*, Charles C Thomas, Springfield, IL, 1978.

[*4*] Suchey, J. M., "Problems in the Aging of Females using the *Os pubis*," *American Journal of Physical Anthropology*, Vol. 51, 1979, pp. 467-470.

Address requests for reprints or additional information to
Clyde Collins Snow
2230 Blue Creek Parkway
Norman, OK 73071