The Possibilities of Producing Reciprocal Conversion Formulae For Conformation Traits

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Abstract

Four methods of calculating conversion coefficients were examined for their reciprocal qualities between the U.S.A. PTAT for final score and Canadian ETA for final class. The Four methods together with the theoretical method were studied for their effects on coefficients and on converted values for each of 10 data sets of different lengths. Both *a* and *b* values did not differ significantly between methods or between data sets chosen. The resulting converted values, even for bulls with extreme estimated transmitting abilities, did not change appreciably over different data sets chosen but the method chosen could affect converted values by almost 3 points in Canadian final class. The most reciprocal method examined involved "converted averages" between independent calculations (by both countries) of Wilmink conversion coefficients according to Interbull guidelines. Converted values of PTAT FS = 2.00 with the preferred reciprocal method had a correlation across data sets of 0.97 with the presently recommended Wilmink method.

Introduction

The international flow of dairy cattle germplasm particularly in the Holstein breed has led to a number of technical challenges. Not least among these them is the provision of useful conversion formulae in order that dairy farmers can accurately compare the estimated transmitting abilities (ETAs) of foreign progeny-tested bulls with bulls available domestically. Conversion methods presently employed, such as those proposed by Wilmink *et al.* (1986) and Goddard (1985), use bulls with proofs in both importing and exporting countries for regression studies to estimate the slope (*b value*) and an intercept (*a value*) relationships as coefficients for the prediction (conversion) of ETAs of other bulls with an evaluation in only one country. Because the number of bulls with dual evaluations are limited, the estimated regression coefficients contain some error due to the less than perfect correlations between the dual ETAs. Correlations of less than one occur because; 1) repeatability (accuracy^2) of sire ETAs are less than one, 2) trait interpretation (measurement) may differ, or 3) daughters of imported sires may be treated differently from herdmates. To reduce bias due to selection, Interbull (1990) has recommended that conversion coefficients be calculated by the importing country using datasets made up of bulls with semen imported in the same direction. If semen is imported in both directions, as in the case of the U.S. and Canada, both countries calculate conversion coefficients based on separate data and derive separate conversion coefficients.

Dairy farmers and A.I. studs in North-America frequently use conversion formula to assess foreign semen offered for sale. However, the credibility of conversion formulae is weakened by the non-reciprocal nature of conversions. Because of errors or bias in regression estimates, conversion coefficients are rarely perfect reciprocals of each other. That is, if a bull is converted from country A to B using country B's coefficicients then back to country A, using country A's coefficients, the resulting value rarely equals the starting value. The purpose of this study is to examine simple methods of calculating reciprocal conversion equations for conformation. In addition, data sets of varying length were used to examine the methods over different data sets and over time.

Methods

A ***Joint*** data set of 252 North-American Holstein bulls, born in 1972 or later, with January 93 sire evaluations for conformation in both the U.S. and Canada were examined. All bulls met 1990 Interbull guidelines, *i.e.* ≥ 75% repeatability and daughters in ≥ 20 herds. The ***Joint*** data set was divided according to country of first evaluation using a combination of information in registration numbers and naming conventions. Approximately 57% (143) of the bulls achieved their first evaluation in Canada and their later evaluation in the U.S. and formed the ***Can>US*** data set. Bulls with semen moving in the opposite direction formed the ***US>Can*** data set. A series of subsets of the data were formed by removing the oldest bulls from the data set one year at a time. Standard Pearson product-moment correlations between ETA in each country were calculated. Subsets of all three data sets were used to determine the effect on estimated a and b values and on resulting converted values.

Four prediction methods were examined with each data subset to determine the reciprocal nature of the predictions (*i.e.* do ETAs converted from country A to country B, with coefficients predicted by country B, convert back to original values when converted by coefficients predicted by country A).

Method 1 (Standard Wilmink Approach)

Method 1 involves the standard procedure described by Wilmink *et al.* (1986) in which bulls used in the regression had semen imported in the same direction as ETAs being converted. The regression equation is as follows,

$$P_{Bj} = a + \hat{b} \cdot r_{Bj}^2 (P_{Aj} - \overline{P_{Aj}}) + e_j$$

where, P_{Bj} = ETA of bull j in country B (importing country)
P_{Aj} = ETA of bull j in country A (exporting country)
a = intercept
$\hat{b}$ = regression coefficient (Wilmink b value)
r_{Bj}^2 = repeatability (accuracy^2) of bull j in importing country.

The Wilmink a value is then calculated as,

$$\hat{a} = \overline{P_B} - \hat{b} \cdot \overline{P_A}$$

Using the resulting coefficients, the U.S. trait, final score (FS), was converted to the Canadian trait equivalent, final class (FC), and vice-versa.

Method 2 (Wilmink Approach: Joint Data Set)

Method 2 employs the standard Wilmink procedure described above except a joint data set is used to estimate conversion coefficients for both directions rather than individual one-way data sets.

Method 3 (Averaged Reciprocals: One-way Data Set)

Method 3 conversion coefficients for the importing country (B) were calculated as average Method 1 coefficients estimated by each country as follows,

$$\hat{b}_B^R = 0.5\left(\hat{b}_B + \frac{1}{\hat{b}_A}\right)$$

$$\hat{a}_B^R = 0.5\left(\hat{a}_B - \frac{\hat{a}_A}{\hat{b}_A}\right)$$

where,

$\hat{b}_B^R$ = reciprocal b value for converting from A to B
$\hat{a}_B^R$ = reciprocal a value for converting from A to B
$\hat{a}_A$, $\hat{b}_A$ = Method 1 (Wilmink) coefficients calculated by country A
$\hat{a}_B$, $\hat{b}_B$ = Method 1 (Wilmink) coefficients calculated by country B

Because Method 3 is simply a compromise between the separate Method 1 estimates of each country, the results are not expected to reflect the relationship of germplasm previously imported in one direction, but rather a mutually agreed upon relationship between the two countries based on exchange of germplasm and conversion calculations in both directions.

Method 4 (Averaged Reciprocals: Joint Data Set)

Method 4 employs the procedure described in Method 3 (above) except a joint data set is used to estimate conversion coefficients for both directions rather than individual one-way data sets.

Theoretical Method (Using All Bulls With Official Evaluations)

Theoretical b values (β) were also calculated (according to Interbull recommendations, 1990) as follows;

$$\beta = \frac{\sigma_{ETAs_B}\,(\overline{r_A})}{\sigma_{ETAs_A}\,(\overline{r_B})}$$

where, σ_{ETAs} and $\overline{r}$ represent the standard deviation and average accuracy (square root of repeatability), respectively, of *all* proven sire ETAs in the latest genetic evaluation in each country. The theoretical a value (α) was calculated using bulls with dual evaluations, and was calculated as the difference between the average ETA in the importing country and the average ETA in the exporting country (converted with the theoretical b). A summary of all of the above methods can be found in Table 1.

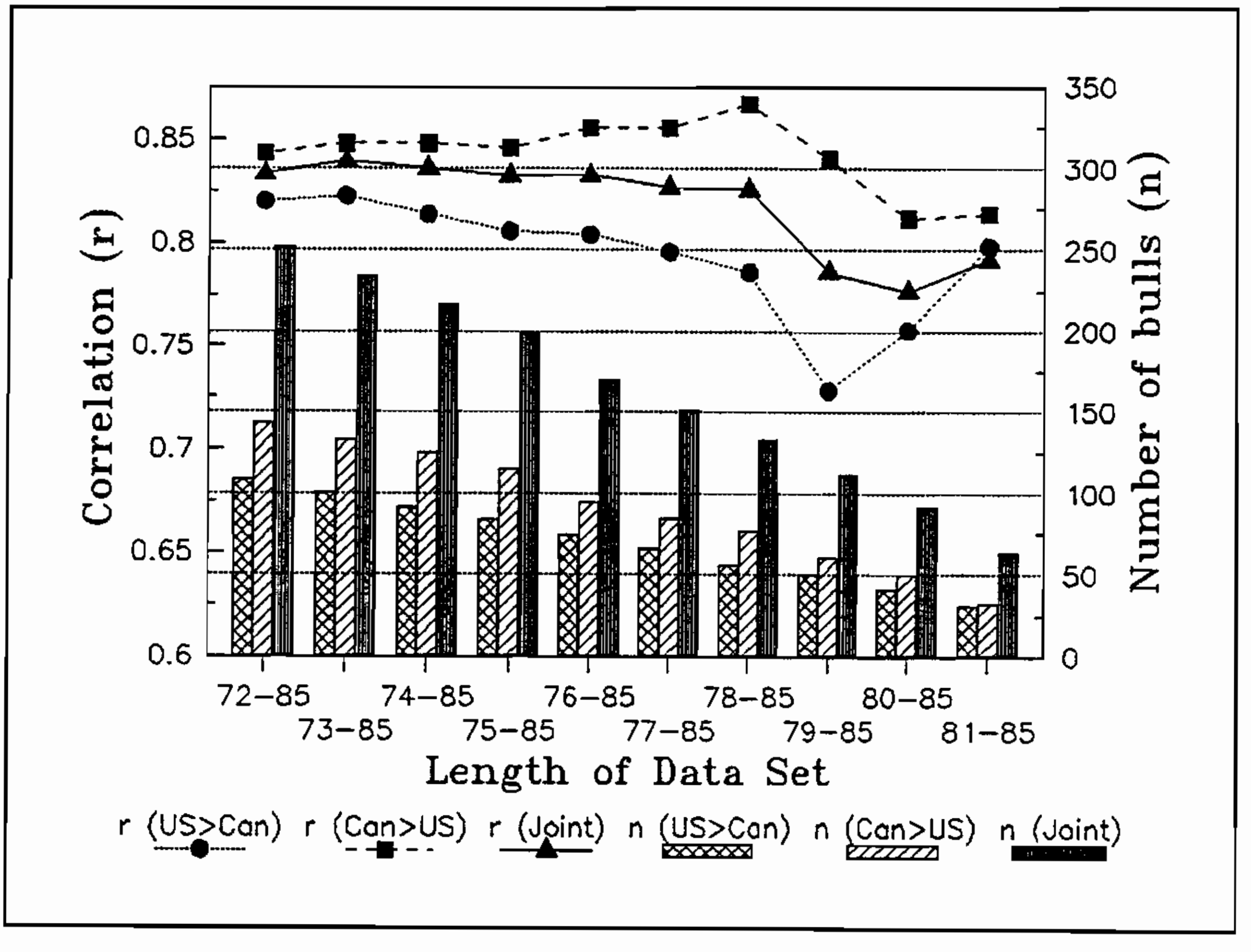
Table 1 Summary of Methods Used

	Data Set Used (Country of Initial Proof)	Dual Evaluations	Reciprocal Coefficients
Method 1	exporting only	yes	no
Method 2	joint data set	yes	no
Method 3	exporting only	yes	yes
Method 4	joint data set	yes	yes
Theoretical	b value: all evaluated bulls a value: exporting only	b value: no a value: yes	no

Results and Discussion

The number of bulls with evaluations in both countries and the correlations between ETAs for the *Joint*, *US>Can* and *Can>US* are shown in Figure 1. From Figure 1, one can see a relatively steady decline in the number bulls as the time period represented decreases. Conversely, the correlation between ETAs in each country appear to remain relatively constant until the data set chosen contains represents less than 8 years of birth. The correlations, of less than one, between the ETAs in each country probably reflect repeatabilities of less than one for ETAs, the genetic correlation between FC and FS, selection of imported bulls over time, and possible differential treatment. From the correlations shown in Figure 1, the Interbull recommendation of including the last 10 years of data appears appropriate.

Figure 1 Number of Bulls With Dual Evaluations and Correlations Between Estimated Transmitting Abilities



The estimated *b* values resulting from the four different methods are illustrated in Figure 2 along with the theoretical *b* value. As can be seen from the figure, the estimates appear to

Figure 2 The Effect of Conversion Method on Resulting *b* Values Across Data Sets.

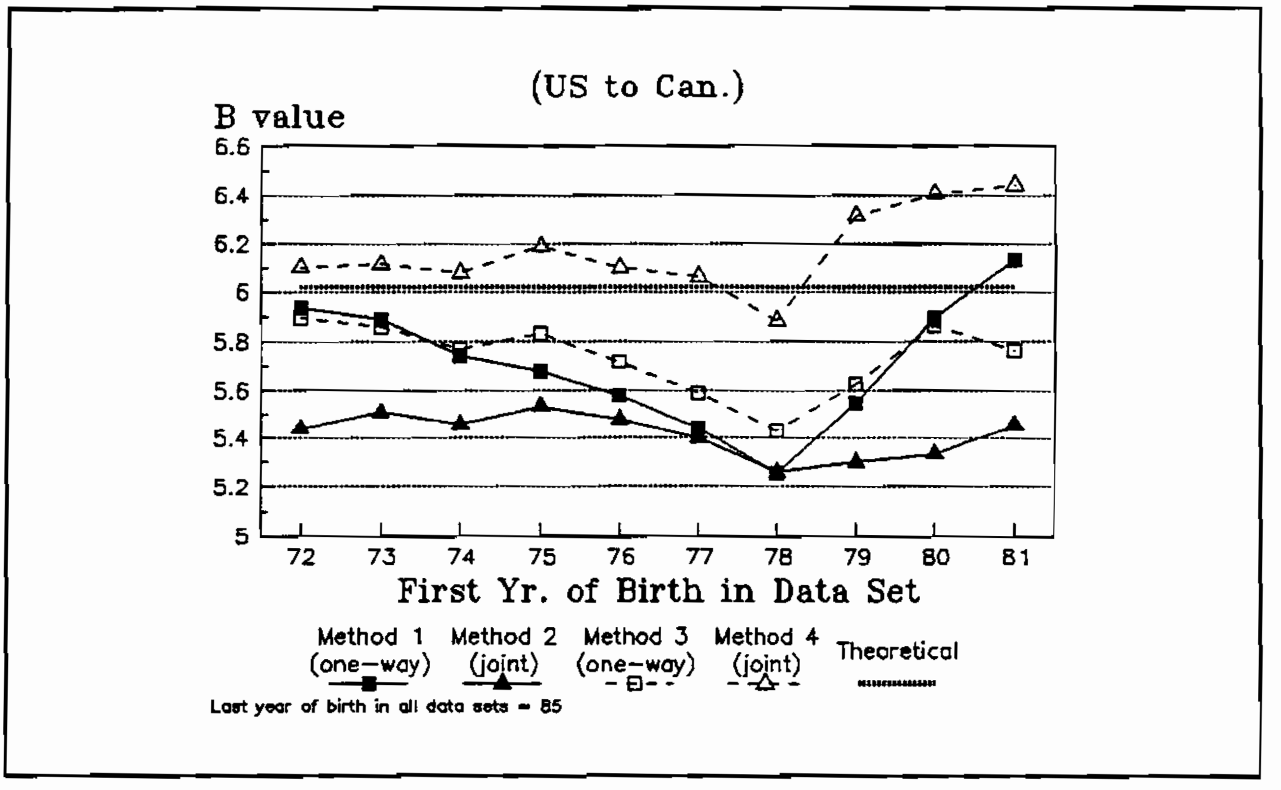
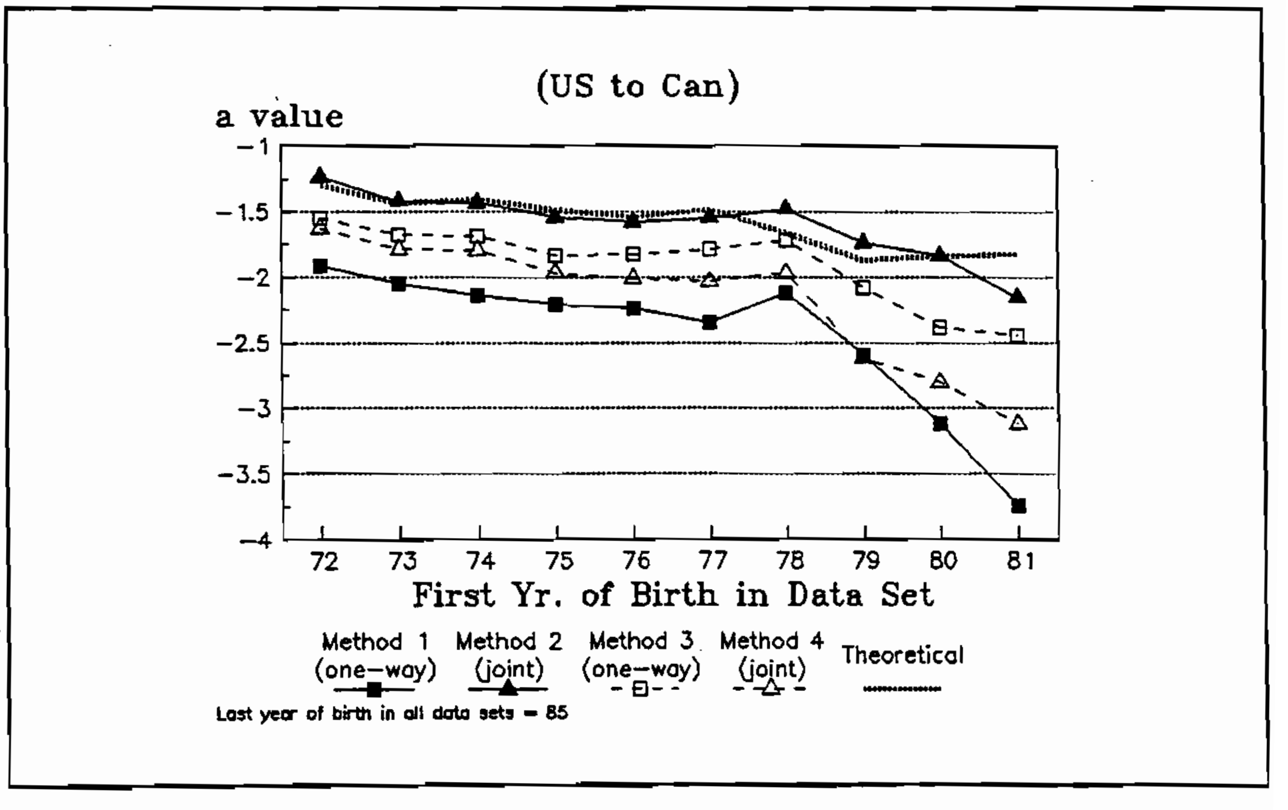


Figure 3 The Effect of Conversion Method on Resulting *a* Values Across Data Sets



follow a similar pattern, *i.e.* the lowest estimate for each method occurred when using bulls born between 1978 and 1985. None of the methods were significantly different ($p < .05$) from each other or from the theoretical method. The method that most closely follows the current Wilmink method (method 1) is method 3, probably because a one-way data set is used as in Method 1, only the resulting coefficients are "averaged" with the converted values calculated by the exporting country. Because Methods 2 and 4 use a joint data set, bulls with initial evaluations in the *importing* country are also included and thereby a bias may be introduced into the regression estimates. The estimate of the slope using Method 2 are the most different from the theoretical estimate, whereas, the Method 4 estimates are the most similar. Because Method 4 involves averaging two one-way estimates (as in Method 3), any biases, introduced by using bulls in which the flow of germplasm is opposite to the conversion, may cancel each other.

The estimated a values from the four different methods are illustrated in Figure 3 together with the theoretical value. As with the b values, all estimates of a appear to follow a similar pattern, however, individual estimates are not significantly different ($p < .05$) between methods. Estimates of a appear to remain steady until less than 8 years of bulls are included in the data, at which estimates decrease. All estimates of a do not differ significantly ($p < .05$) from the theoretical value.

Estimates of a indicate differences in the base populations in each country and tend to vary over time. However, their use, together with estimates of b to attain converted values result in only minor fluctuations of the converted values. The converted values of even extreme PTAT Final Score values do not vary appreciably as shown in Figure 4. Method 1 shows the greatest variation at 2.25 points for FC (0.45 s.d.) and Method 2 varies the least at 0.92 points FC (0.18 s.d.). Method 4 tended to follow the theoretical estimates most closely. The value of converted evaluations of extreme sires (PTAT FS = 3.00) could differ between methods by almost 3 points for Canadian FC.

In order to test the effect of converting U.S. final score equal to PTAT = 3.00 to Canadian final class then back to U.S. final score is shown in Figure 5. One can see that Method 2 estimates were the least reciprocal followed then by Method 1. Theoretical estimates are also not perfectly reciprocal, probably because different data sets are used to calculate the a and b values. Theoretical b values are calculated using all evaluated bulls whereas a values are calculated separately using bulls with evaluations in both countries. Both Methods 3 and 4 appear to be very close reciprocals of each other, although Method 4 does overestimate the double-converted value slightly for smaller and younger data sets.

As a measure of the appropriateness of the various methods, Methods 2, 3 and 4 along with theoretical estimates were used to convert a typical imported bull (PTAT = 2.00 for FS) to Canadian values for all data sets. The converted values were compared with corresponding values from the currently accepted Wilmink method (Method 1). The relationship between US values converted by Method 1 and the other methods is shown in Figure 6. Not

Figure 4 The Effect of Conversion Method on Converted Values of PTAT Final Score = 3.00

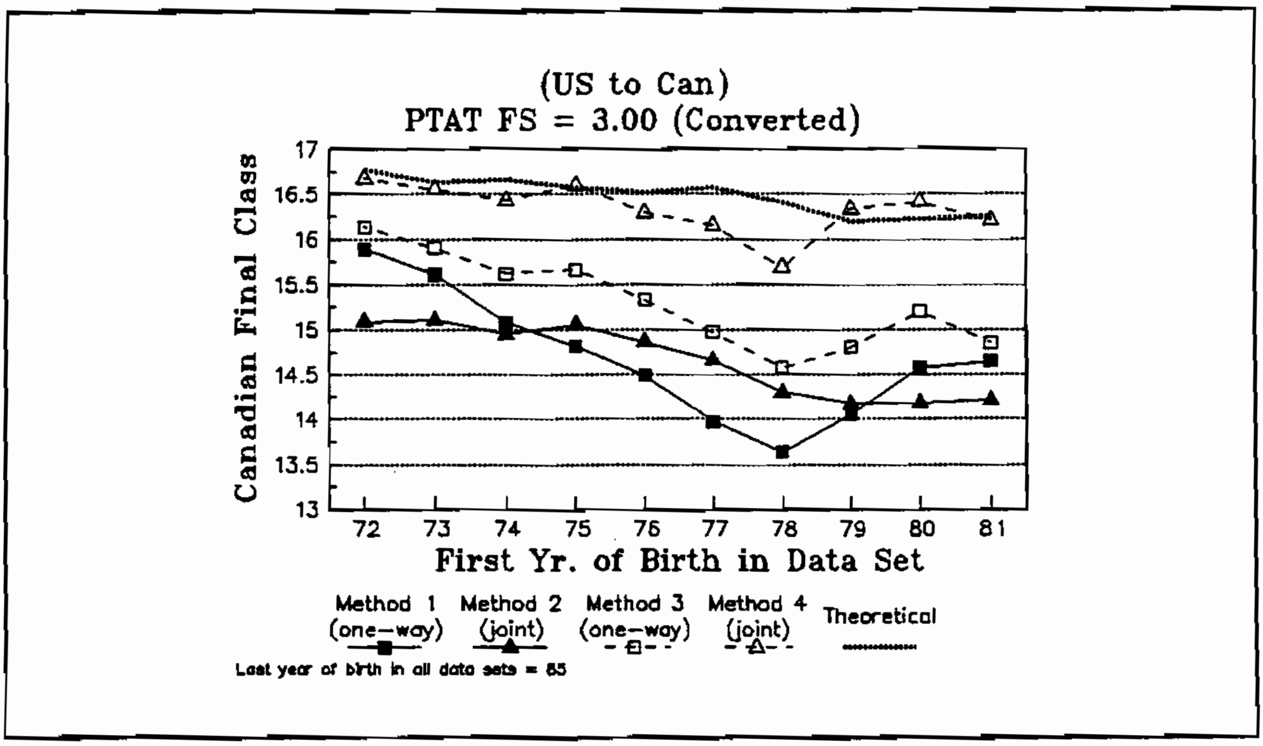


Figure 5 Values of PTAT 3.00 (FS) When Converted to Can. FC Then Re-converted to U.S. FS

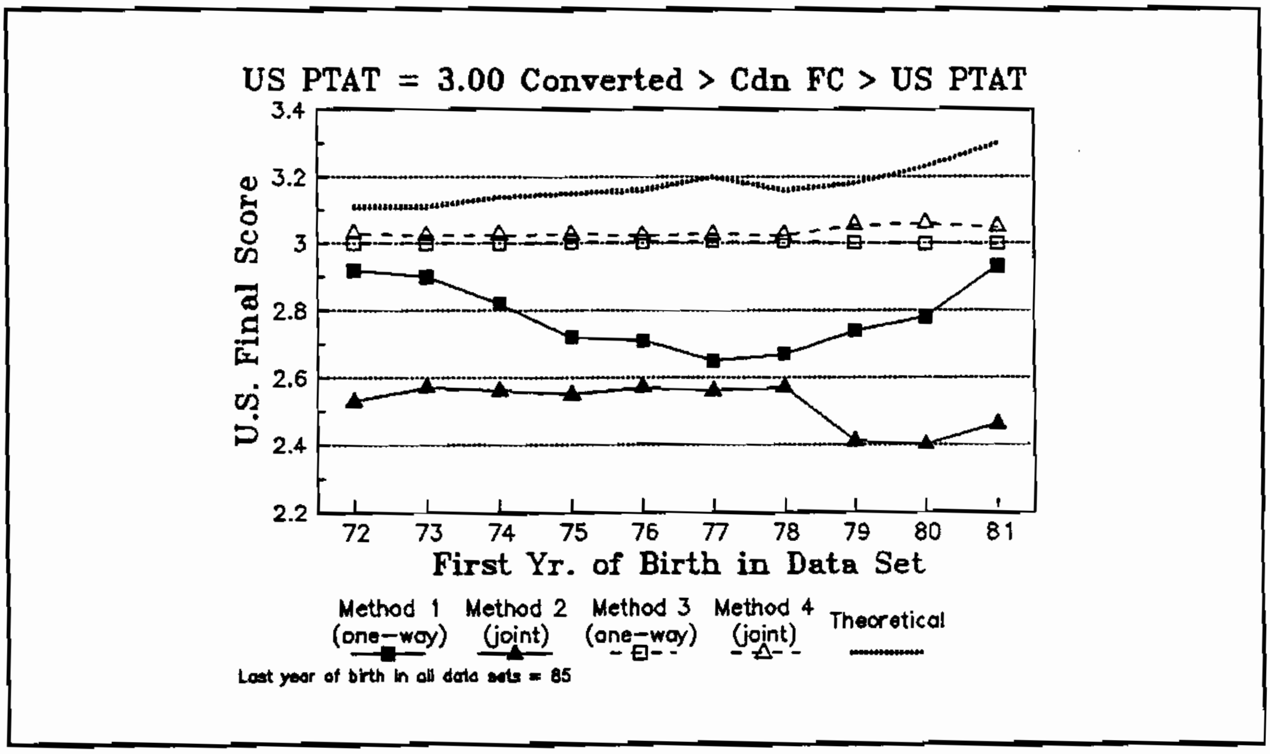
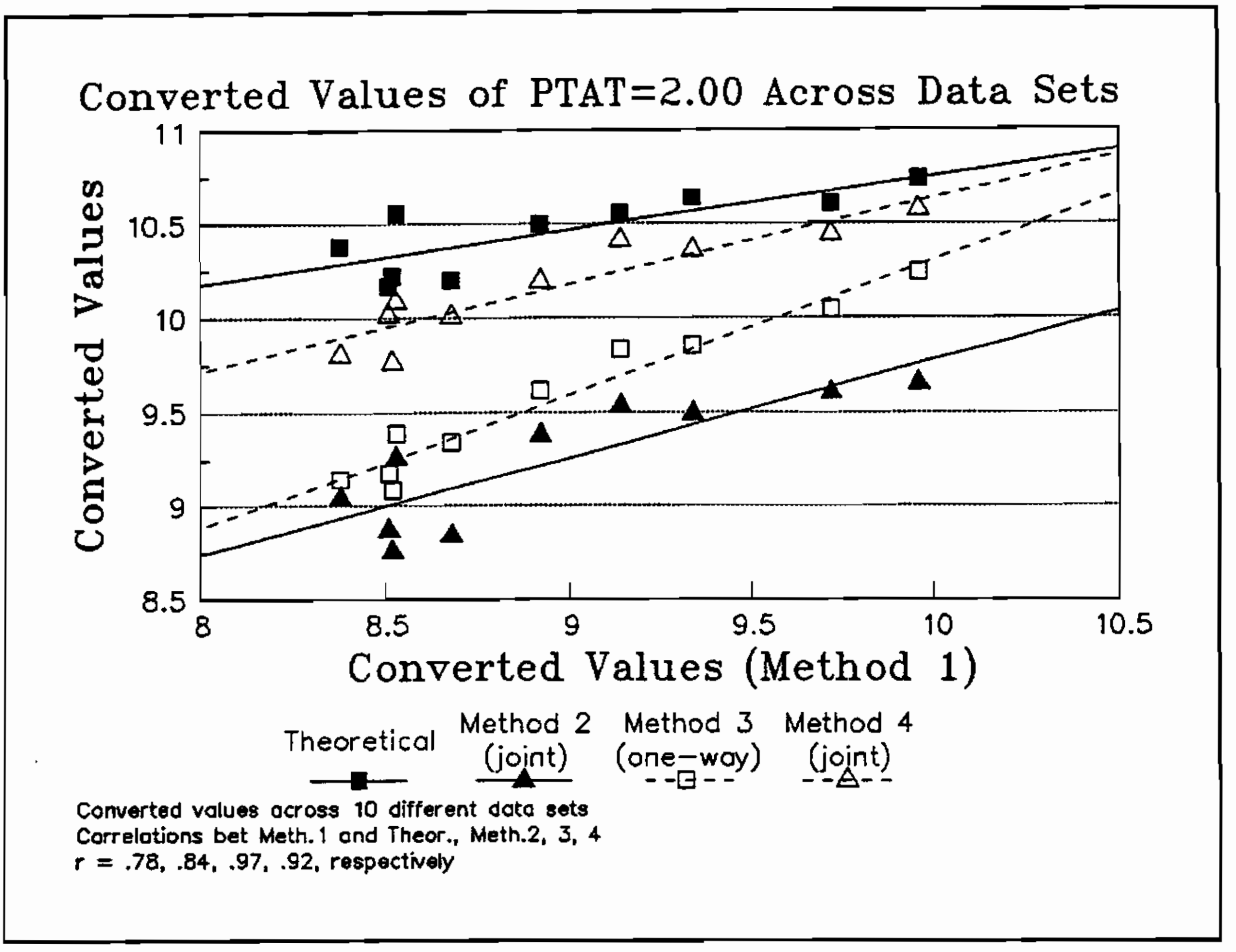


Figure 6 Correlation Between Converted Values of PTAT=2.00 Using Method 1 and Other Methods.



surprisingly, the best correlation (0.97) was achieved with Method 3. Methods 4, 2 and theoretical had correlations of 0.92, 0.84 and 0.78, respectively. A similar ranking of methods was found with regard to correlations when PTAT = 3.00 was used, only the correlations were slightly lower.

Conclusions

Of the methods examined, Method 3 is recommended as the preferred method to establish reciprocal conversion coefficients, based on the very strong reciprocal nature of Method 3 and the high correlation (0.97) with the presently recommended Wilmink method. Method 4 also has good reciprocal qualities but has a lower correlation with Method 1. Although theoretical estimates were not perfectly reciprocals, a similar "averaging" of the theoretical *a* values would lead to reciprocal conversion equations.
Theoretical estimates do not account for genotype by environment interaction or differences

in trait interpretation but they are also not affected by possible biases (*e.g.* differential treatment) in the data set.

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