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COMPARING ROADSIDE WITH SUBSEQUENT BREATH ALCOHOL ANALYSES AND THEIR RELEVANCE TO THE ISSUE OF RETROGRADE EXTRAPOLATION

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Summary

Driving while intoxicated (DWI) legislation requires proving the critical breath alcohol concentration (BrAC) at the time of driving. With time delayed analysis, retrograde extrapolation is occasionally employed but has several uncertainties associated with it. The present study attempts to address whether subjects actually arrested for DWI are likely to have BrAC values near the time of driving differing largely from those performed at a subsequent time. Selected officers arrested $n = 161$ subjects where roadside BrAC was determined with Pre-Arrest Breath Test (PBT) devices along with subsequent duplicate evidential analyses followed by an additional PBT analysis. These two sets of duplicates, one with large time interval ($\bar{x} = 63.5$ min.) and one with a 2–3 min difference, were then compared by several statistical methods. The results showing duplicate variability did not differ when the long time interval existed ($F = 1.0$, $P > 0.05$). A small but significant decrease in BrAC with respect to time appeared for the duplicate PBT data. Retrograde extrapolation applied to the data employing an assumed 0.015 g/210 l/h yielded a small but significant overestimate of the actual roadside PBT result. Finally, evidentiary analyses performed within 2 h of driving will provide good estimates and certainly not overestimates, of the BrAC existing at the time of driving and it appears that extrapolation may be unwarranted in these cases.

Key words: Breath alcohol analysis; Retrograde extrapolation

Introduction

Many jurisdictions have 'per se' driving while intoxicated (DWI) legislation that requires proving the relevant breath alcohol concentration (BrAC) at the time of driving. For many reasons, forensic breath alcohol analysis is never performed at the time of driving, but at some later time. This gives rise to the argument that the individual may have been on the ascending portion of their breath alcohol concentration time curve, yet less than the 'per se' value, at the time of driving and subsequently tested when the BrAC had exceeded the critical level.

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This is typically known as the 'rising BrAC defense'. As a result, retrograde extrapolation is employed, given several assumptions, to provide some estimation of BrAC at the earlier time of driving. Several uncertainties are associated with this and the debate continues.

Many good studies have addressed these kinetic issues through controlled drinking experiments and generation of the concentration time curves [1–11]. Relevant parameters are then determined such as peak BrAC (or BAC), time to peak, rise after last drink, elimination rates (β), bioavailability, etc. Although these are important designs, the question remains as to whether this adequately models the actual DWI subject. The present work approaches the issue from a different perspective and appears to provide an important supplement to previous work. The present study attempts to employ repeated measurement data from actual subjects arrested for DWI and determine if breath alcohol analysis employed at a time subsequent to driving reliably estimates the BrAC at the time of driving. By comparing these time differing duplicates to evidentiary duplicates one is able to assess the variability associated with breath alcohol analysis. Only where repeated measurement differences exceed the total variability of the method can one conclude that a real or systematic change is occurring due perhaps to absorption or elimination kinetics. Although the same general approach has been previously reported [12], important differences in design and data analysis exist, keeping in mind that the design of a study is at least as important as the results [13]. As a result, further insight is gained into the assumptions associated with and even the relevance of retrograde extrapolation performed within 2 h after driving.

Methods

Selected law enforcement officers (n = 7) within the Seattle metropolitan area were trained further on the use of the PBT device (Pre-Arrest Breath Test, AlcoSensor III, Intoximeters Inc., St. Louis, MO) and the purpose of the study. During routine patrol these officers then administered roadside breath test analysis to subjects they had suspected of driving while intoxicated and recorded the time. When an arrest was made (n = 161), the individual was transported to a facility for the performance of evidential breath alcohol analyses consisting of duplicates employing the BAC Verifier DataMaster (National Patent Analytical Systems, Inc., Mansfield, OH). The evidential duplicates were typically collected within 2–3 min. of each other. Following the evidential analyses, one more single analysis was performed on the PBT device and the time recorded. All breath alcohol results were truncated to two decimal places, typical for forensic purposes. The officers were qualified operators of both the PBT and evidential breath test devices. The accuracy of evidentiary results were verified with appropriate external simulator standard results (0.090–0.110 g/210 l) while the accuracy of PBT analyses were verified from routine periodical calibration checks by means of simulators.

Only those cases were selected for analysis where the operator felt adequate end-expiratory breath samples were provided into the PBT device and all data

were clearly recorded. If inadequate samples were provided or some other problem existed and the operator noted this, these cases were not included. Other reasons for not including certain submitted data included: unacceptable simulator standard results for either the evidentiary or PBT instrumentation, incomplete or illegible data provided, any comments that would have questioned the validity of the data.

The above protocol provided duplicate results from both the PBT device, separated by a period of time and the evidential device, separated by 2–3 min. These sets of duplicates were then evaluated statistically in a variety of ways. First, the distribution of differences for each set of data was determined along with corresponding descriptive statistics. Differences for each instrument were also plotted against their mean to evaluate their magnitude and sign as a function of concentration. The second measurement for each instrument was then plotted and regressed against the first with the resulting linear regression parameters, confidence intervals (CI) and inferential analysis compared for each method. Next, the difference in PBT results (PBT2 – PBT1) was plotted and regressed against time between analyses in order to evaluate the difference as a function of time. Finally, the PBT2 value was extrapolated back to a hypothetical PBT1 result employing a β-value of 0.015 g/210 l/h. The actual PBT1 value was then subtracted from this hypothetical PBT1 value and the difference distribution evaluated. This was to assess the validity of performing retrograde extrapolation on the present data. All statistical analyses were performed using SPSS/PC+ (SPSS Inc., Chicago).

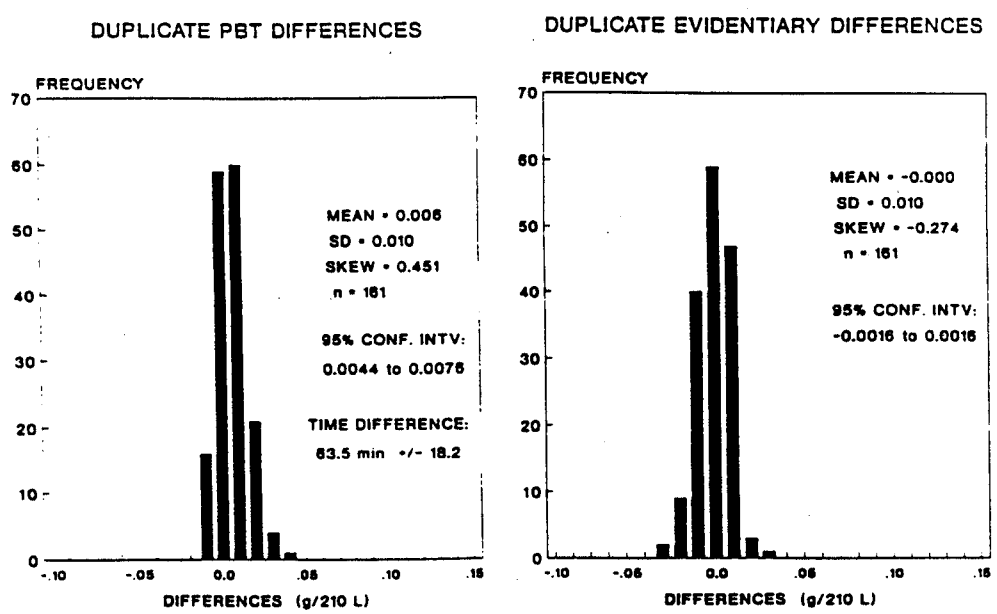

Fig. 1. Duplicate difference distributions for PBT and evidentiary values resulting from the first analysis minus the second analysis.

TABLE 1

SUMMARY OF STATISTICAL ANALYSES

Parameter	*n*	Mean	SD	95% CI for mean	Skew	Span
Evidentiary differences	161	−0.000	0.010	−0.0016—0.0016	−0.27	−0.03—0.03
PBT differences	161	0.006	0.010	0.0044—0.0076	0.45	−0.01—0.04
Time between PBT analyses	161	63.5	18.2	60.7—66.4	0.73	25—120 min
Time between evidential and PBT2 Analyses	161	11.0	6.1	10.0—11.9	1.5	2—35 min

t-TEST FOR PAIRED DATA	*t*	*P*	d_f
Evidentiary mean and PBT	2.52	0.013	160
Duplicate evidentiary results	−0.63	0.53	160
Duplicate PBT results	8.38	<0.001	160

Results

Figure 1 shows the two difference distributions resulting for each instrument. Table 1 summarizes the statistics for each of the difference distributions and shows the time difference for the duplicate PBT analyses. The time difference between the two PBT analyses was $\bar{x}$ = 63.5 min, SD = 18.2, span = 25 − 120

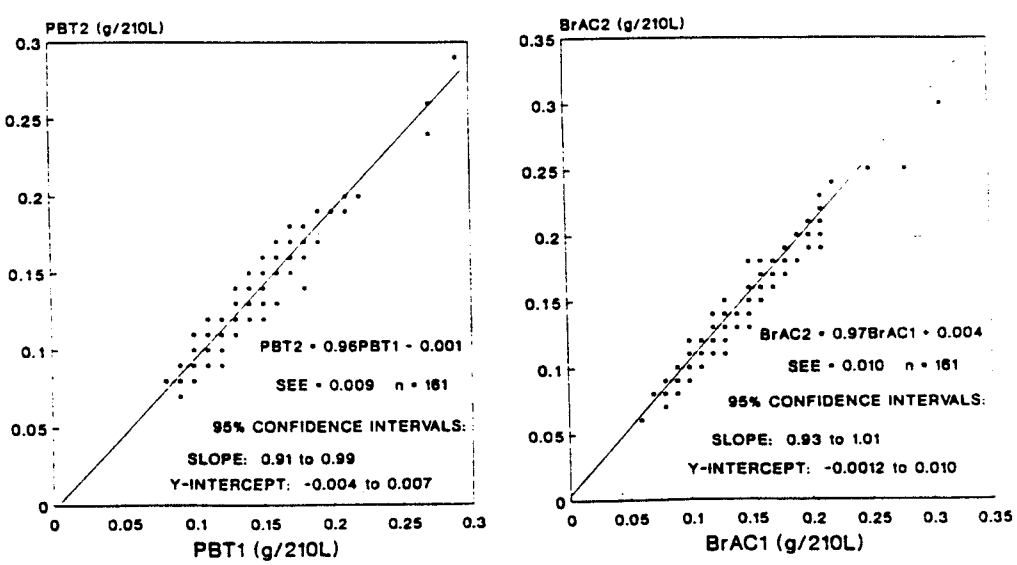

Fig. 2. Regression of the second analysis against the first for both the PBT and evidentiary duplicates.

min. The time difference between roadside PBT and evidentiary analyses were $\bar{x}$ = 52.5 min, SD = 17.8 min. and span = 18–114 min. These data were collected in a largely metropolitan area and would not reflect more rural environments. The evidential BrAC results spanned from 0.06–0.31 g/210 l while the PBT1 values spanned from 0.08–0.29 g/210 l. The two distributions in Fig. 1 were tested for equal variance by the usual F-test and resulted in F = 1.0, d_f = 160,160, $P > 0.05$. Finally, Table 1 also shows the results of t-tests for paired data comparing each of the two instrument duplicates in addition to a comparison of the evidentiary mean with the subsequent PBT2 result. It may be seen that non-significant differences occurred ($P > 0.05$) only with the evidentiary duplicates. The significant differences between the evidentiary results and PBT2 (P = 0.013) can be explained either by calibration differences between the instruments or by less than equivalent end-expiratory breath samples being provided into the two devices. The significant differences between the two PBT results ($P < 0.001$) probably reflects the time interval involved and resulting alcohol metabolism since the duplicate evidentiary results showed non-significant differences ($P > 0.05$).

The plot of each instrument's differences against their mean along with ± 2 SD intervals showed no significant trends as a function of concentration. This method is useful in assessing duplicate difference trends throughout the concentration range [14].

Figure 2 shows the regression plot for each set of duplicates along with resulting regression parameter estimates and 95% CI. It is seen that the 95% CI for the slope includes 1.0 only for the evidentiary data. The 95% CI for each intercept, on the other hand, does include zero. The time interval between the PBT analyses does not appear to influence the regression parameters when compared to the duplicate evidentiary analyses. When the two slopes were compared, no significant difference was noted (t = −0.88, $P > 0.05$). Likewise, the

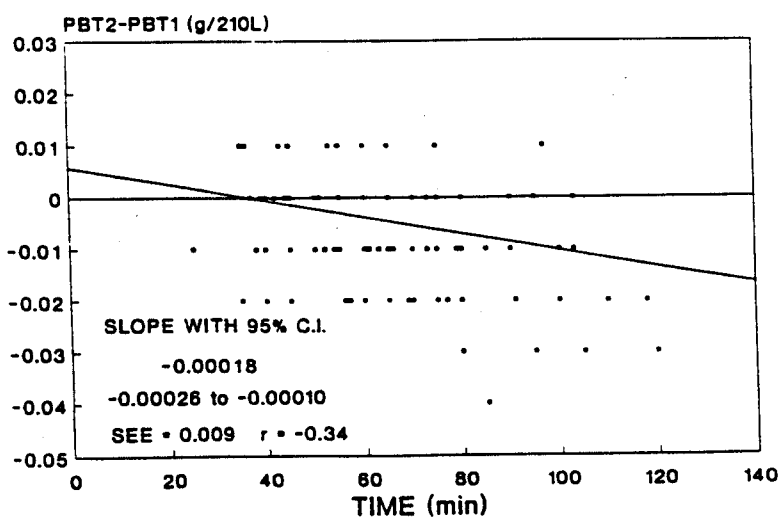

Fig. 3. Change in BrAC as a function of time employing the PBT duplicates.

two Y-intercepts were not significantly different ($t = -0.82$, $P > 0.05$). These are useful inferential methods in comparing independent linear regression results [15].

Figure 3 shows the PBT differences plotted and regressed against time. The differences were computed from PBT2 – PBT1 in order to reveal a decline in BrAC with time if it exists. The regression coefficient (slope) was −0.00018 with a 95% CI of −0.00026 to −0.00010. The CI not including zero shows a small but significant decrease in BrAC with time. However, a great deal of variability exists with standard error of the estimate (SEE) = 0.009 g/210 l.

Finally, Fig. 4 shows the distribution of differences between the actual PBT1 analysis and the hypothetical value ($PBT1_{EXT}$) resulting from extrapolating the PBT2 value back in time. In addition, Fig. 4 shows the differences as a function of time. The difference ($PBT1_{EXT}$ – PBT1) produced small but significant positive results $\bar{x}$ = 0.005 g/210 l with 95% CI including 0.0036 to 0.0064 g/210 l) revealing that extrapolation typically overestimated the actual results. Retrograde extrapolation produced a systematic bias in this case. Just the opposite resulted in a recent study where extrapolated values tended to underestimate true values using β = 0.015 g/100 ml/h [16]. The longer elimination periods used in that study [16] probably explains the differences. When plotted as a function of time, no significant trend resulted (Fig. 4). However, it is observed that for the longest times in the scatterplot the bias was zero. Retrograde estimation did not generally improve with time until one approached the 2-h limit.

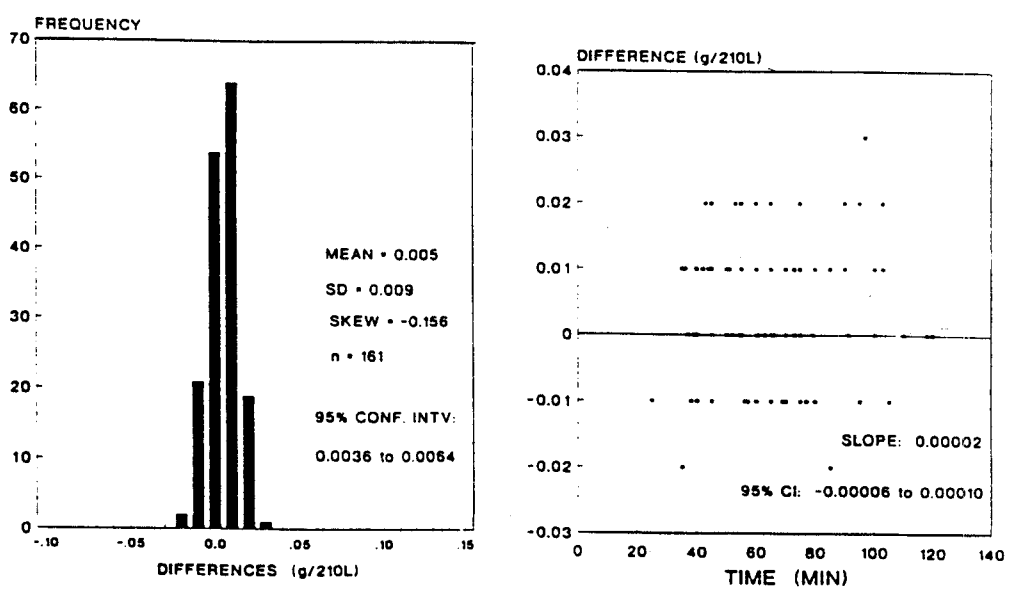

Fig. 4. Distribution of differences between extrapolated ($PBT1_{EXT}$) and actual (PBT1) results together with their differences as a function of time.

Discussion

Retrograde extrapolation is employed in jurisdictions and mandated by some, that express the 'per se' offense contemporaneous with the time of driving. Several studies have attempted to address the many uncertainties associated with retrograde extrapolation including: peak BrAC (BAC), times to peak, elimination rates (β), drinking patterns, type of drink, etc. Typically, these have been controlled clinical studies of 'one variable at a time' design where individuals are administered known doses of alcohol and their BrAC (BAC) time curves are determined. The advantage of the present study is that actual field data of arrested subjects from the relevant population are evaluated where there is presumably a host of drinking patterns, β values, peak values, etc. as well as large between-subject variability.

One important result of the present study is that duplicate test variability is shown not to be significantly influenced by time between analyses. The variability of the distributions seen in Fig. 1 did not differ significantly ($P > 0.05$) even though the duplicate PBT results averaged over 1 h apart. This has implications for jurisdictions performing duplicate evidentiary analyses 15–30 min apart. Duplicate variability should not be importantly affected with these time intervals. Time is also shown not to influence variability from the results of the regression analysis. The slope along with SEE of the PBT regression analysis seen in Fig. 2 should be largely different from that of the evidentiary duplicates if time were an important influencing factor. The slope and Y-intercepts of the two regressions, however, are seen not to differ from each other significantly ($P > 0.05$). The SEE values are likewise very similar. A further implication is that immediate transportation for breath alcohol analysis may not be as critical as previously thought.

Variability, however, is not the total picture. There can be similar variability and yet a systematic difference between duplicates where time is the primary predictor variable. A small but systematic difference between the duplicate PBT results as a function of time is seen from several of the statistical results. The mean difference and 95% CI ($\bar{x}$ = 0.006 g/210 l, 0.0044 to 0.0076) shows the later analysis to be significantly less than the first. The plot of differences (PBT2 – PBT1) against time also shows a small but significant decreasing trend in BrAC as a function of time. Finally, the t-test for paired data showed significant differences between the first and second PBT result. Each of these results suggests that the BrAC of pooled data shows a small but important decreasing trend with respect to time. This further suggests that individuals do not appear to be on the ascending portion of their concentration time curves while driving and is shown further by the small magnitude of negative values (–0.01 g/210 l) seen in Fig. 1. This has important forensic implications.

Although the duplicate differences were shown not to be importantly influenced by concentration for either method, other work has shown that measurement variability is an important function of concentration [17,18]. The fact that total method variability (analytical + biological) increases with concentration must be considered when analyzing and interpreting data at various concentrations.

It seems that the important question is, can we measure a change in BrAC over time in light of the inherent method variability? A good estimate of total method variability (analytical + biological) is seen in the duplicate evidential results of Fig. 1. The largest source of that total variability is undoubtedly the biological component and relates to the nature of breath sampling [19,20]. It is important, therefore, that one thoroughly understand the biology involved in measurement before interpreting the data analysis. In order to conclude a systematic change over time the difference needs to exceed some critical value typically approaching 0.025 g/210 l in breath alcohol measurement [20]. In the case of blood alcohol analysis, where sampling variability is far less than in breath analysis, the critical difference necessary to conclude a real difference would be less. In this case, real differences may be measurable in shorter time intervals. Breath alcohol, however, is the far more prevalent specimen and these sampling influences on variability need to be understood when attempting to extrapolate and interpret data.

Finally, the results do not appear to warrant retrograde extrapolation for time intervals up to 2 h after a driving incident. Changes due to either absorption or elimination kinetics do not appear to be large enough to exceed the inherent measurement variability. The results seem to suggest that individuals are either still on their concentration plateau or just beginning to descend with respect to time and is particularly emphasized by the results of extrapolating the PBT2 value back to a hypothetical PBT1 value (Fig. 4). Similar results were observed by Neuteboom and Jones [3] in a very useful study where they found only 2% appeared to be on the ascending portion from duplicate analyses. This further emphasizes the fact that when retrograde extrapolation is performed, a range of values should be reported with the lower limit being the results of actual evidentiary analyses. The results of evidentiary breath alcohol analyses administered within 2 h of driving appear to be very good approximations and certainly not overestimations, of the BrAC at the time of driving for medico-legal purposes.

Conclusions

Applying actual field data from subjects arrested for DWI to address the relevance of retrograde extrapolation seems an important supplement to the already large body of controlled study pharmacokinetic literature. The many statistical methods applied to the data appear to indicate that for up to 2 h the change in BrAC is not sufficient to exceed the sampling variability associated with breath alcohol analysis. A small but systematic decrease in BrAC with time was detected but in the context of large variability. There was certainly no evidence that individuals were on the ascending portion of their concentration time curves at the time of driving. As a result, forensic breath alcohol analysis employing duplicates along with other appropriate quality control procedures appears to provide very good estimations of BrAC values when conducted within 2 h of driving.

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