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Comparison of venous blood alcohol concentrations and breath alcohol concentrations measured with Draeger Alcotest 9510 DE Evidential

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ABSTRACT

Most comparisons of blood alcohol concentrations (BAC) and breath alcohol concentrations (BrAC) are either derived from drinking trials with rigid drinking protocols or from investigative authorities' data with considerable time differences between the determination of BAC and BrAC. In general, only comparisons of relatively low BAC–BrAC pairs are available. Therefore, the relationship between BAC and BrAC was examined even for high BAC above 2 g/kg.

The results of a large-scale drinking test under realistic conditions with 78 test persons and short time intervals between BAC and BrAC measurements are presented.

It was shown that the conversion factor Q varies greatly (between 1571:1 and 2394:1) and increases with increasing BAC. A constant conversion factor that is suitable for variable forensic purposes could not be presented.

1. Introduction

Prevention and detection of drinking and driving are major concerns of traffic policies. In 31% of all U.S. traffic deaths in 2012 (10,322 in total), drivers with blood alcohol concentrations (BAC) of 0.8 g/L or higher were involved [1]. In order to enforce traffic laws, breath alcohol analyses have been used for approximately 70 years [2] and are considered to be the most common and most widely employed procedure in the field of forensic science [3]. Investigative authorities employ breath-alcohol analysers to measure to breath alcohol concentrations (BrAC) because they can be easily applied and do not require an attending physician. However, a number of handheld breath-alcohol analysers report an estimate of BAC using an assumed blood-breath ratio of alcohol as a calibration factor that varies from country to country and falls between 2000:1 and 2400:1 [4]. Increasing the breath-alcohol analysers' acceptance is a major argument for the definition of low constant conversion factors, e.g., BAC/BrAC = 2100:1, as the breath alcohol analysis depends on drivers' cooperation [5]. Koehler et al. determined a mean BAC/BrAC ratio of 2311:1 for Draeger Alcotest 7110 Evidential [6]. Supporters of breath-alcohol instruments would prefer to abolish the taking of blood samples and expand breath-alcohol tests to criminal offense cases.

Legally valid BrAC can be obtained by approved breath-alcohol testing instruments, such as Draeger Alcotest 7110 Evidential or Draeger Alcotest 9510 DE Evidential. In other countries, examples of the available instruments are Seres Ethylometre 679T and 679ENZ or Intoxilyzer 5000 and 8000C [7]. Examinations for possible manipulations of legally valid breath-alcohol instruments have partially shown memorable results [8]; however, in summary, they are considered to be reliable and effective [3,9–11]. The correlation between BrAC and BAC is supposed to decrease with increasing distance from the statutory alcohol limit of 0.5 g/kg[1] that is most common in European countries, leading to a residual standard deviation of 0.40 g/kg at high BAC of approximately 1.70 g/kg [10].

Since 2013, Draeger Alcotest 9510 DE Evidential has been available and is approved by the Physikalisch-Technische Bundesanstalt Braunschweig up to 3 mg/L BrAC resp. 6.3 g/kg BAC (BAC/BrAC conversion factor Q = 2.1). The test's analytic procedures are identical to those of Draeger Alcotest 7110 Evidential, and only their design and handling differ.

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[1] In Europe forensically relevant blood alcohol concentrations are commonly expressed in g alcohol per kilogram blood.

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Most comparisons of BAC and BrAC are derived from drinking trials with rigid drinking protocols where participants were exposed to high alcohol-levels within short periods of time [6,12–14]. Other studies are based on routine police investigations [7,10] with significant time delays between both types of measurement. Comparisons of high BAC and corresponding BrAC are rare.

Both alcohol test methods (BAC and BrAC with Draeger Alcotest 9510 DE Evidential) were administered in a large-scale drinking test with 78 test persons under realistic conditions with short time intervals between both types of measurement. The conversion factor *Q* was retrospectively calculated for even high and very high BAC. The trial was pre-approved by the ethics committee of the University of Düsseldorf. Other results of these trials were recently published [15,16] and shall only be outlined here as is necessary for further understanding.

2. Materials and methods

2.1. Test persons

A total of 78 test persons were included in the trials (41 males, 37 females). All test persons had to present an up-to-date certificate of health. Exclusion criteria were acute illnesses, pregnancy, a history of substance abuse, disturbances of liver function and positive drug-screening of urine and blood with signs of acute drug influence. Five test persons participated on two different days, leading to a total of 83 evaluable trials. The median age was 25 years (range 18–53 years).

2.2. Alcohol consumption

Alcohol consumption started in the afternoon and lasted until 11 pm. The most locally popular types of alcoholic and non-alcoholic beverages were available and could be drunk according to the test persons' own discretions. The test persons were not forced to drink but were required to stop drinking when signs of alcohol intoxication (e.g., vomiting or severe imbalance) occurred.

2.2.1. Basic experimental set-up

The amount and the type of consumed alcohol were separately documented for each test person along with the period of time needed for consumption. In order to estimate the BAC while drinking, Draeger 6510 Breathalyzers were used. At each assumed BAC elevation of approximately 0.15 g/l, blood was drawn from the test persons, and the BrAC was verified by Draeger 9510 DE Evidential. BrAC were partially measured before and partially after blood-drawing.

2.3. Evaluation

The time difference between BrAC and BAC measurements was not more than 10 min (Tables 1a and 1b). The time between the end of drinking and the breath alcohol measurement varied from a few minutes to several hours; every BrAC that was unobjected by the Draeger Alcotest 9510 DE Evidential was taken into account. The blood alcohol concentrations were determined in accordance with the current German forensic guidelines [17].

3. Results

3.1. Determined maximum BAC

The maximum BAC of the test persons varied between 0.07 g/kg and 2.58 g/kg. Most test persons reached BAC between 1.00 and 2.00 g/kg (Fig. 1; *x*-axis: test persons; *y*-axis: maximum BAC in g/kg).

3.2. BrAC–BAC pairs

A total of 159 BrAC–BAC pairs could be obtained. The BAC in the evaluated BrAC–BAC cases varied between 0.11 g/kg and 2.30 g/kg. In 97 cases the BAC was measured after the BrAC, and in 62 cases before the BrAC. All BrAC–BAC pairs can be seen in Tables 1a and 1b.

3.3. Conversion factor Q in dependency from the BAC

The conversion factor *Q* varied greatly and on average rose with rising BAC. On one hand, single BrAC–BAC pairs at varying grades of alcoholisation reached *Q* of more than 2300:1; on the other hand, several *Q* determinations at low and medium BAC led to conversion factors of less than 1850:1 (Fig. 2; *x*-axis: BAC in g/kg; *y*-axis: conversion factor *Q*).

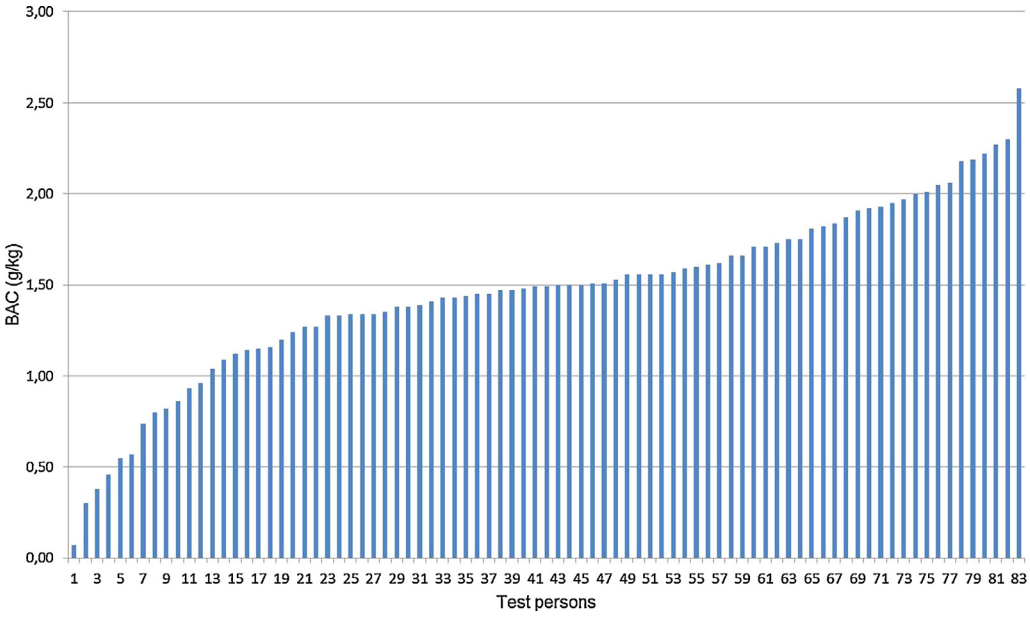

Fig. 1. Determined maximum BAC (g/kg) of each test person.