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Gait Analysis After Intake of Increasing Amounts of Alcohol*

E. C. Jansen[1,2], H. H. Thyssen[1], and J. Brynskov[1]

[1] Biomechanical Laboratory, Dept. of Orthopedic Surgery T_2, University of Copenhagen, Gentofte Hospital, DK-2900 Hellerup, Denmark
[2] Dept. of Anesthesia I 104, Herlev Hospital, University of Copenhagen, DK-2730 Herlev, Denmark

Summary. The ability to walk after intake of increasing amounts of alcohol was studied. Sixteen normal persons were tested on a computer-assisted treadmill. Ataxia or unsteadiness of gait was found to decrease during a blood alcohol concentration (BAC) of less than 0.4 mg/ml. Stride length was found to increase by increasing BAC.

Key words: Gait analysis, blood alcohol concentration – Ataxia, BAC – Stride lenth, BAC

Zusammenfassung. Es wurde die Fähigkeit zu laufen nach dem Konsum steigender Mengen an Alkohol getestet. Sechzehn Versuchspersonen wurden auf einem Computer-kontrollierten Laufband getestet. Ataxie oder Unsicherheiten beim Gehen nahmen bei Blutalkoholkonzentrationen (BAK) unter 0.4 mg/ml ab, während die Schrittlänge mit ansteigender Blutalkoholkonzentration zunahm.

Schlüsselwörter: Gang-Analyse, BAK – Ataxie, BAK – Schrittlänge, BAK

For ages the degree of clinical influence of alcohol on man has been estimated by observing the gait.

By the introduction of computerized gait analysis [1], a quantitative picture of the gait disturbances during influence of alcohol can be produced. Information on the alcohol-marked gait is considered of interest from the points of view of working safety, traffic safety, insurance medicine, and forensic medicine.

No previous studies of this kind are to be found in the literature.

Material and Methods

Test Persons

Nine women and seven men aged 20–29 years (average: 24 years) participated in the study. The participants had given their informed consent based on verbal and written information.

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Offprint requests to: Erik C. Jansen, MD (address see above)

The criteria for inclusion in the study were (1) no daily intake of alcohol, (2) no intake of alcohol for the last 24 h, (3) no regular intake of medicine for the last month, (4) no medicine at all for the last week, and (5) no suffering from diseases of the cardiovascular or neurologic systems, nor any diseases of the back or the lower limbs.

Gait Analysis

The gait tests were performed on an instrumented treadmill. The treadmill consists of two parallel conveyor bands providing a walking area of 200 cm in length and 60 cm in width. The ground reaction forces of the person's feet are measured by a force plate system supporting each of the conveyor bands. In this way, the vertical, transversal, and sagittal forces of each foot are measured separately. Due to the use of a treadmill, the gait distance is in principle of an unlimited length.

The ground reaction forces are measured by the strain gauges of the force plates, and the signals are transmitted to a Digital PDP 11/10 computer. The vertical forces are scanned by the computer, and the events of heel-on and toe-off are found for each of the two feet. With this information, it is simple to calculate the temporal events of gait, such as the stance phase, and the double support time. In addition, the step length and the stride length of each leg are calculated. Measurement of ataxia or unsteadiness of gait is performed by representing the force curves in each of the measured directions as mean curves "shaded" by one standard deviation (SD). The average deviation is taken as the measurement of ataxia. The ataxia has the dimension of force and is expressed as a percentage of the body weight [2].

The external work of gait can be calculated from the ground reaction forces. If the vector system of each foot is added and integrated, the velocities of the center of gravity are found. By integration over a stride, the product of the velocities and the forces of each foot is resulting in the external work. This external work is determined in the three directions for each foot. The positive work is represented by accelerative movements. The calculations are a further development of the method described by Cavagna [3].

Procedure

The series of tests started with a reference measurement for each person. In all tests the speed of gait was 4.0 km/h = 1.11 m/s. Each gait test lasted for 3.0 min. The sample for mathematical analysis was the measurements from the first to the 60th second.

Initially, a test of reference or control was performed. Then a light meal was served together with one beer (12.0 ml alcohol) and 30 ml of liquor (12.0 ml alcohol). Sequential tests were performed at an interval of 1 h for the next 4–5 h. One beer and 30 ml of liquor were served after each test. The participants were free to stop for further tests at any stage of the study.

Blood samples for alcohol concentration were taken after each test through an i.v. catheter. Blood alcohol concentration (BAC) was determined by a spectographic method [4].

The correlation between log BAC and the increase in ataxia of gait were evaluated by the least squares' method.

The results were evaluated by use of the two-sided Pratt's matched pair signed rank statistic [5]. The results of the gait analysis were grouped at intervals according to the BAC. In case one of the persons had more than one measurement within the same interval, the measurement representing the lowest BAC was used in the statistical calculations of the results.

Results

Figure 1 indicates the median increase in ataxia or unsteadiness of gait with increasing BAC, while in Fig. 2 the 16 individual curves are shown. The ataxia was found to be significantly lower when the persons had a BAC of less than 0.4 mg/ml ($P < 0.05$) as compared to the persons' sober control values. The correlation between log BAC and the percentual increase in ataxia was found to be within the range of $r^2 = 0.01$–0.97. The average value was $r^2 = 0.45$.

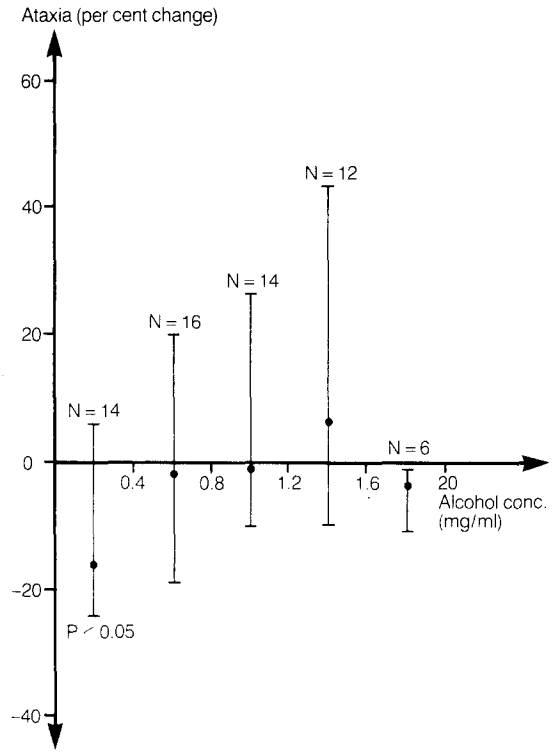

Fig. 1. The alterations in ataxia or unsteadiness of gait in 16 persons during increasing influence of alcohol. *N* indicates the number of samples within the interval of BAC. The percent change is calculated in comparison to the uninfluenced control values

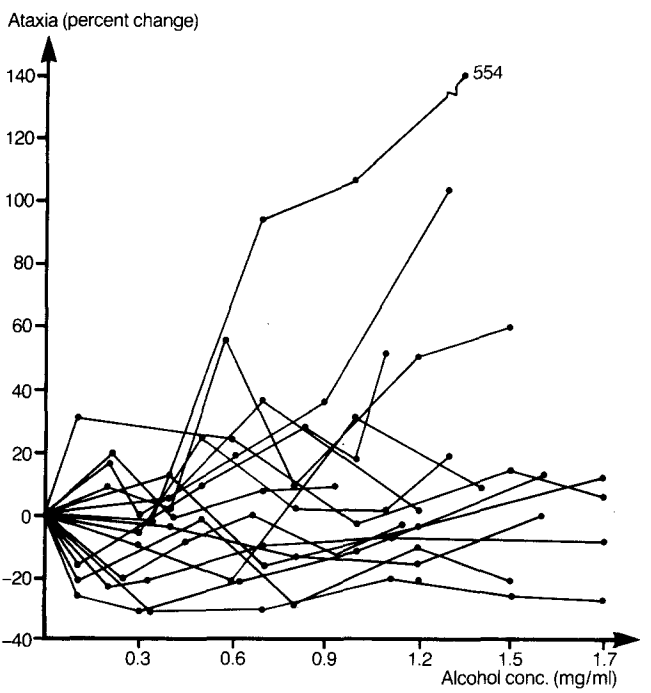

Fig. 2. The development of ataxia in 16 individual persons during increasing influence of alcohol. The percent change is calculated in comparison to the uninfluenced control values

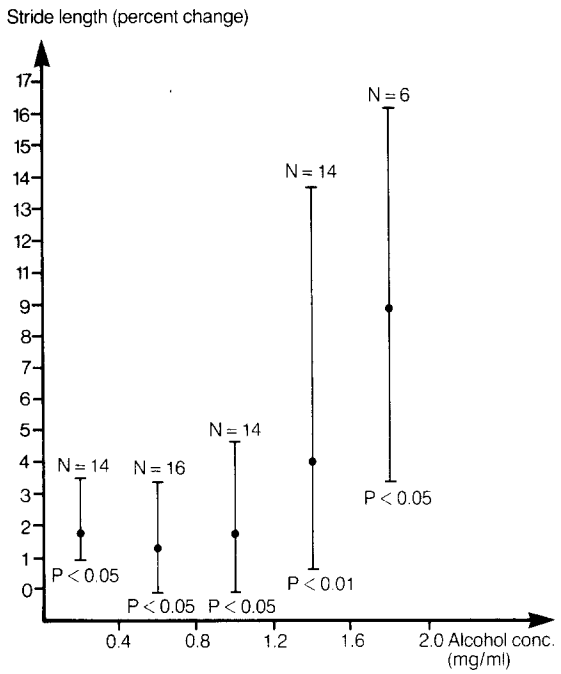

Fig. 3. The alteration of stride length in 16 persons during increasing influence of alcohol. The percent change is calculated in comparison to the uninfluenced control values

The analysis of the temporal factors showed that the stride length increased by increasing BAC as shown in Fig. 3. The stride length was the only factor of this type which altered during increased influence of alcohol. The other temporal factors (double support time and stance phase) did not alter, nor did the external work of gait. All persons were able to perform the gait tests, but two persons did not want to participate in the last 5-h test.

Discussion

As one may expect, a wide scatter was found on the results concerning the ataxia of gait, as gait is a complex psychomotor function. The ataxia was found to be significantly decreased at a BAC of less than 0.4 mg/ml. The same trend of a more stable psychomotor function was also found in a study on the influence of alcohol on the standing position [6]. Surprisingly enough, an increased ataxia at increasing influence of alcohol was not found. The finding of increased stride length at increasing influence of alcohol is a trend not previously reported in the literature. A possible explanation for this phenomenon may be that the persons have an impaired control of their knee function, and therefore tend to keep their knees more stretched during gait than normally. A more heavy intoxication, than applied in this study, may exaggerate this finding into the well-known tumbling gait of a drunken person.

It is also of interest that the other calculated factors of gait were undisturbed by the influence of alcohol.

The wide scatter of the results, and the lack of correlation between ataxia and BAC, give an objective illustration of the action taken by the Danish legislation which does not require gait tests any more as part of the investigation of persons being accused of driving under influence of alcohol. The findings should be evaluated in the light that the persons most likely tried to walk as normal as possible during the 3 min of gait test, and thereby have put a maximal voluntary effort into this performance test.

It is concluded that alcohol induces an increased stride length with an increasing influence of alcohol, and the gait is slightly more uniform at a low influence of alcohol. Otherwise, there are no significant alterations as compared to the normal gait.

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