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M. Nieschalk · C. Ortmann · A. West · F. Schmäl
W. Stoll · G. Fechner

Effects of alcohol on body-sway patterns in human subjects

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Abstract The vestibulospinal aspects of vestibular function are commonly neglected in the evaluation of alcohol-induced intoxication. Thus, in the present study the effect of an acute intoxication with a low or moderate quantity of alcohol was examined with respect to the equilibrium in 30 healthy subjects. The blood alcohol concentration (BAC) was measured 30 min after the ingestion of the last alcohol, ranging between 0.22 and l.59‰. Stability of stance was quantified by static platform posturography in Romberg-test conditions with eyes open and eyes closed. Among other parameters, the average body sway path (SP) and area of body sway (SA) were assessed. Posturography revealed a significant increase in body sway. There was a positive correlation between SA (or SP) and BAC both with eyes open and eyes closed. Multiple group comparisons revealed that the large-alcohol-dose group (BAC ≥ 1.0‰) could be clearly differentiated from test cases with BAC lower than 0.8‰. Sway area was the most sensitive parameter for detecting increased body sway after alcohol ingestion. The area increase, present not only with eyes closed but with eyes open, revealed an inadequate compensation of the ethanol-induced ataxia by visual stabilization. The Romberg's quotient, which denotes eyes closed relative to eyes open, remained constant. The increase in sway path with eyes closed showed an omnidirectional sway. A comparison of the sway pattern of subjects after acute ethanol ingestion with the data of patients with permanent cerebellar lesions suggested that the acute effect of alcohol resembles that of a lesion of the spinocerebellum. This finding contrasts with earlier studies, which postulated an acute effect of ethanol resembling that in patients with an atrophy of the anterior lobe of the cerebellum due to chronic alcohol abuse. In seven cases of the lower dose group (BAC ≤ 0.8‰), a reduction in body sway after alcohol ingestion was observed. This finding may be consistent with a dose-related biphasic action of alcohol, which – besides its well-known depressant effects with high doses – also shows stimulatory action with small doses.

Key words Postural control · Posturography · Vestibulospinal examination · Blood alcohol

M. Nieschalk (✉) · F. Schmäl · W. Stoll
Klinik und Poliklinik für Hals-, Nasen- und Ohrenheilkunde,
Westfälische Wilhelms-Universität Münster,
Kardinal-von-Galen-Ring 10, D-48129 Münster, Germany
Fax: +49-251-8356812

C. Ortmann · A. West · G. Fechner
Institut für Rechtsmedizin,
Westfälische Wilhelms-Universität Münster,
von-Esmarch-Strasse 62, D-48149 Münster, Germany

Introduction

Many investigators have reported the effects of alcohol on the oculomotor system (Barnes 1984; Barnes et al. 1985; Umeda and Sakata 1978; Wilkinson et al. 1974) and on the vestibular system through positional alcohol nystagmus (Aschan et al. 1956; Brandt 1991; Money and Myles 1974). However, there are few reports concerning the acute effects of ethanol on the vestibular function, which controls postural stability. This is even more surprising given the fact that postural imbalance after alcohol ingestion is a well-known phenomenon.

By using a static platform, it was the aim of the present study to give advice for the computerized posturopgraphic measurement of intense alcoholic toxic effects on body sway.

Prior studies of alcohol have used elements of dynamic posturography (Diener et al. 1983; Goebel et al. 1995; Tianwu et al. 1995; Woolacott 1983). These reports are helpful in order to demonstrate the sensitivity of the aformentioned method, yet they leave unanswered some important questions – particularly the nature of the effects of low and moderate doses. Physiological, behavioral, and biochemical evidence demonstrated a dose-related biphasic effect of ethanol (Pohorecky 1977). Besides its well-known depressant effects with high-doses, alcohol also shows stimulatory action with small doses. It was one intent of the present study to evaluate the existence of a

biphasic action of ethanol on the equilibrium. Furthermore, in subjects with chronic alcohol intoxication, postural instability has been found to correlate with an atrophy of the anterior lobe of the cerebellum (Dichgans and Diener 1985; Diener and Dichgans 1990). Thus, some investigators have already suggested the possibility of anterior lobe lesion in connection with acute alcohol intoxication (Ledin et al. 1983; Ledin and Ödkvist 1991). The present study was carried out to examine whether alcohol has a specific affinity to one or several of the structures involved in postural stabilization.

Materials and methods

Subjects

Thirty healthy subjects with no history of dizziness or metabolic, neurologic, or otologic disturbances (17 males, 13 females, aged 22–35 years, mean age 27 years), were tested. The mean weight was 75 kg. Drinking habits were similar within the group, all of the subjects reported that they drank alcohol only occasionally with a degree of alcohol consumption self-described as light to moderate. None had any apparent medical or balance problem or visual abnormality and all denied the current use of cigarettes or any drug. None of the subjects had received any kind of medication 24 h before the test.

All subjects were volunteers and gave informed consent prior to inclusion in the study, which was in accordance with the ethic standards laid down in the Declaration of Helsinki.

Methods of analysis and description of the sway-parameters involved

Subjects were placed with bare feet, parallel 4 cm apart, on a force measuring platform and instructed to maintain a relaxed posture and to stand as steady as possible with their arms folded in front of the chest. The displacement of the projection of a standing subject's center of foot pressure (CFP) was recorded continuously in antero-posterior (AP) and lateral (LAT) directions by means of four strain-gauges at each corner of the platform (Fried and Arnold 1987) (Fig. 1). The test results (statokinesigrams) were converted from analogue to a digital form and analysed by means of a computer program (Canvass 3.5.3 for Macintosh) within a time interval of 20 s (Diener et al. 1983).

The quantitative parameters of the present study were considered in terms of areas and lengths of sway. The sway area (SA) was measured according to the confidence-ellipse method and expressed as cm^2/20 s (Hadj-Djilani 1988) (Fig. 1 a.).The sway path (SP) was measured by the length of the path described by the CFP in 20 s and expressed as cm/20 s. SP-AP described the antero-posterior (sagittal) and SP-LAT the lateral components of the aforementioned parameter (Fig. 1 b). The Romberg's quotient (OR) of the sway path (QR-SP) and sway area (QR-SA) compares the parameters of sway with closed and opened eyes and estimates the amount of visual stabilization of posture (Njiokiktjiien and Van Parys 1976). Furthermore, the quotient of sagittal/lateral component of the mean sway path (Q-AP/LAT) was calculated.

Correlations between blood alcohol concentrations and changes in the parameters of sway path and sway area were analysed. Since these parameters in the stabilogram could not be taken as absolute but varied among individuals, chronological changes in body sway were expressed as a ratio of the post-alcohol vs pre-alcohol values. The linear correlation between area (path) increase and the blood alcohol level was also calculated.

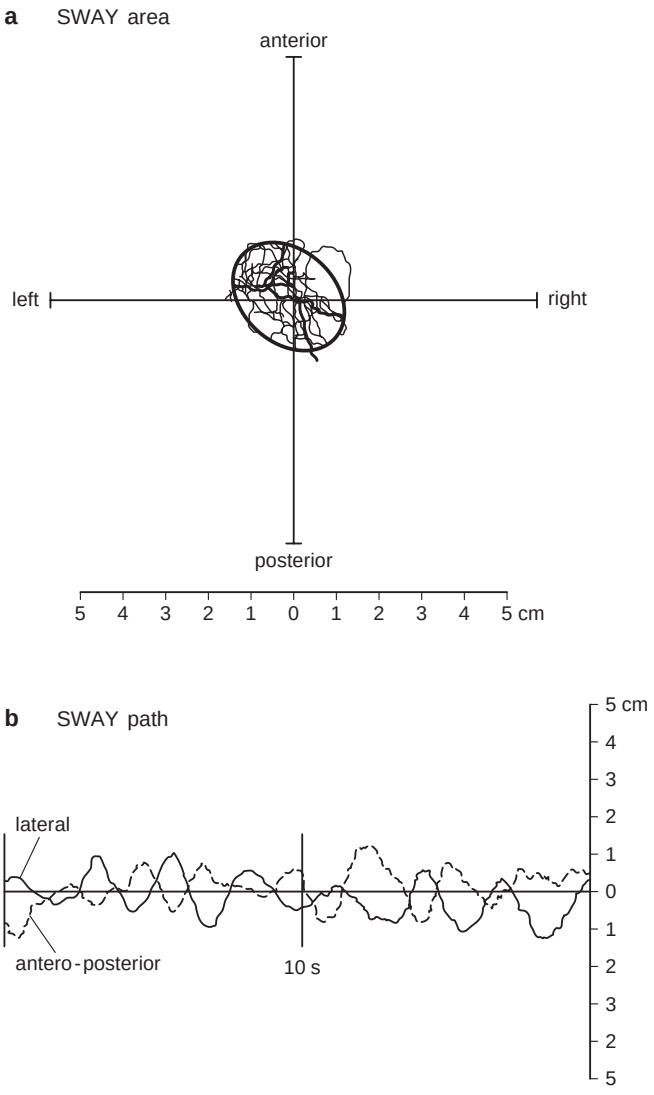

Fig. 1 a, b The diagram represents the ellipse as used for the measure of the sway area. The ellipse is superimposed upon the corresponding statokinesigram obtained from a healthy subject before alcohol ingestion for Romberg-test with eyes closed (1a). The sway path was measured as the length of the path described by the displacement of the projection of the standing subject's center of foot pressure. The sway path was recorded both in the antero-posterior and in the lateral direction (1b). A time interval of 20 s was registered

Experimental procedure

The subjects were asked to fast for 6 h before the experimental sessions were initiated. All experiments were performed in the afternoon. Before the experiment, procedure details were explained orally. First, the Romberg-test procedure consisted of two l-min periods of sway on the stable platform with the subjects' eyes open and closed. After a brief adaptation, time intervals of 20 s each were recorded with eyes open and closed. The subjects were requested to stand with eyes open for the efficiency of the visual and vestibular systems in controlling balance to be tested. After that, the efficiency of the isolated vestibular system in controlling balance was tested with the subjects' eyes closed.

Every subject was free to drink an individual amount of alcohol within 2 h. In a subsequent 30 min break no alcohol was consumed. Then the Romberg-test procedure was repeated. After

Table 1 Means and standard deviations of sway parameters before (pre) and after (post) alcohol ingestion under Romberg-test conditions with eyes open and eyes closed

Parameters	Eyes	Alcohol	Alcohol-dose groups			
			Group I n = 7; BAC ≤ 0.4‰	Group II n = 11 0.41‰ ≤ BAC ≤ 0.8‰	Group III n = 7; 0.81‰ ≤ BAC ≤ 1.0‰	Group IV n = 5; 1.01‰ ≤ BAC ≤ 1.59‰
Sway path (cm/20 s)	open	pre	28.07/5.12	28.71/2.90	29.47/2.33	28.16/3.10
		post	26.69/2.33	29.43/2.89	31.23/4.94	32.99/6.25
	closed	pre	32.30/6.03	33.33/4.85	34.13/7.18	33.85/6.16
		post	30.57/4.11	33.73/4.98	35.89/9.90	49.61/5.56
Antero-posterior sway	open	pre	14.65/2.83	15.28/2.40	15.63/2.31	14.41/2.01
		post	13.60/0.97	15.81/1.84	16.83/3.12	17.50/3.74
	closed	pre	17.54/3.71	18.77/3.13	18.70/5.96	18.27/3.08
		post	16.89/3.24	19.19/3.24	19.45/5.69	28.95/6.74
Lateral sway	opem	pre	13.42/2.34	13.43/0.95	13.84/1.07	13.75/1.69
		post	13.09/1.55	13.62/1.39	14.40/1.95	15.50/2.56
	closed	pre	14.76/2.32	14.56/2.39	15.43/2.00	15.58/3.10
		post	13.59/1.24	14.54/2.32	16.44/4.57	19.33/2.86
Sway area (cm2/20 s)	open	pre	6.35/2.56	6.47/1.24	6.78/1.00	6.26/1.36
		post	5.62/1.03	6.81/1.34	7.76/2.54	10.50/3.29
	closed	pre	8.96/3.49	8.70/2.55	9.21/3.47	9.18/3.28
		post	7.31/1.82	8.89/2.58	11.82/6.37	18.63/3.24
Romberg Q.-sway path		pre	1.15/0.06	1.18/0.09	1.19/0.17	1.20/0.11
		post	1.14/0.11	1.12/0.14	1.16/0.15	1.32/0.21
Romberg Q.-sway area		pre	1.34/0.15	1.38/0.24	1.41/0.38	1.44/0.26
		post	1.37/0.18	1.17/0.18	1.36/0.35	1.59/0.54
Quotient antero-post./lateral sway	open	pre	1.09/0.02	1.14/0.16	1.14/0.20	1.05/0.14
		post	1.04/0.08	1.16/0.12	1.16/0.10	1.12/0.07
	closed	pre	1.09/0.02	1.28/0.20	1.21/0.33	1.18/0.05
		post	1.25/0.20	1.31/0.20	1.19/0.19	1.28/0.35

these measurements a blood sample for the determination of blood alcohol concentration (BAC) was taken and measured by headspace gas chromatography.

Statistical analysis of equilibrium examination

The main purpose of this study was to ascertain the effects of alcohol on equilibrium function. Therefore, a statistical analysis was done in order to compare the data of each subject before drinking with those of 30 min after drinking. Figure 1 illustrates the means and standard deviations (SD) of sway parameters.

Data were analysed using 'Student Systat' (version 1.0) software for Macintosh. The differences between pre-alcohol and post-alcohol states were compared by a one-way analysis of variance (ANOVA) and John Turkey's HSD multiple (group-) comparison procedure. The strength of the linear relationship between blood alcohol concentrations and changes in the parameters of sway path and sway area were measured by the Pearson correlation r (with eyes open and eyes closed respectively). A significance testing of the correlation was done with a probability level of 5% being considered as significant.

Results

The blood alcohol concentration (BAC) ranged between 0.22 and l.59‰. The 30 subjects were divided into 4 groups according to their BAC: group I (n = 7; BAC ≤ 0.4‰), group II (n = 11; 0.41‰ ≤ BAC ≤ 0.8‰), group III (n = 7; 0.81‰ ≤ BAC ≤ 1.0‰) and group IV (n = 5; 1.01‰ ≤ BAC ≤ 1.59‰)

When comparing the test results from males and females separately before and after alcohol administration, no differences between the sexes were found (Mills and Bisgrove 1983). Therefore, findings were processed together.

With respect to the path of body sway, the ANOVA results for post-alcohol versus pre-alcohol values indicated an interaction between vision and alcohol concentration (Table 1, Fig. 2 a). The parameter SP increased only slightly with increasing blood concentration of alcohol, as long as visual control guaranted for postural stabilization (Fig. 2 b – top). The results of the different alcohol-dose groups did not reach a level of significance. By contrast, a prominent and significant increase in SP could be detected in the large-alcohol-dose group (group IV) after eye-closure (Fig. 2 b – bottom). The means of individual antero-posterior/lateral quotients implied that the increase of sway path with eyes closure after alcohol ingestion was mainly due to an increase in the antero-posterior components (Table 1). However, the values of the quotients revealed no statistical significance. Table 2 shows the results of the one-way analysis of variance and of multiple group com-

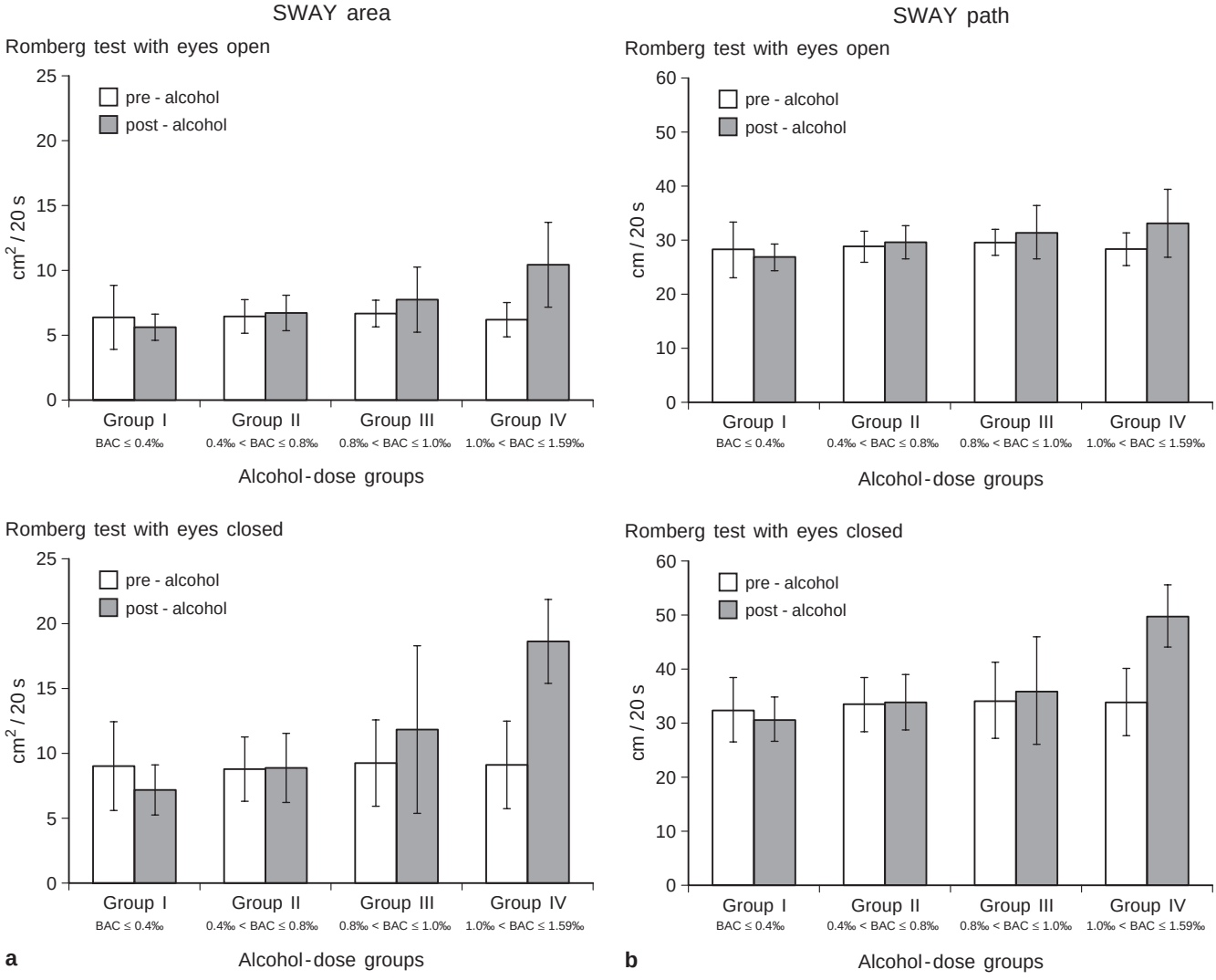

Fig. 2 a, b Means and standard deviations of the sway area (2a) and the sway path (2b) recorded with the subjects' eyes open and closed respectively before (pre) and after (post) alcohol ingestion. The four different alcohol-dose groups are compared

parisons. Despite the fact that the values of the F-ratio after eye closure revealed a significant difference in sway path between the different dose groups, only the subjects with BAC above 1.0‰ (group IV) could be clearly differentiated from the others.

With the highest blood alcohol concentration (group IV), significant differences in results of SA were found in the Romberg test both with eyes open and eyes closed (Fig. 2 a). Multiple comparisons (Table 2) revealed that the large-alcohol-dose group could be differentiated from groups with BAC lower than 0.8‰ (group I and group II). There was no significant distinction between group III and group IV. As both antero-posterior and lateral sway direction increased evenly with a small but not statistically significant predominance of the antero-posterior component, it should be noted that the area increase was due to nonspecific directional change.

Romberg's quotient of sway path and sway area, which refers to the ratio of eyes closed and eyes open, remained relatively constant after alcohol ingestion with no differences between the different dose groups. It seems that increase in body sway was equal both under eyes-closed and eyes-open conditions.

Correlations between BAC values and changes in each parameter of the stabilogram were analysed with respect to the subjects' eyes both open and closed. In Fig. 3 the ratios of the sway-area (Fig. 3 a) and sway-path increase (Fig. 3 b) were plotted on the ordinate. The ratios denote after-alcohol vs before alcohol values. Corresponding BAC values are shown on the abscissa. Data include all samples taken from 30 subjects standing with eyes open (Fig. 3 a, b – top) and eyes closed (Fig. 3 a, b – bottom). Under Romberg-test conditions with eyes open, there was a significant positive correlation between sway-area (sway-path) increase and BAC (sway-area: r = 0.652, $p < 0.01$, sway-path: r = 0.545, $p < 0.01$). Although correlation coefficients were smaller, there were also significant positive correlations between BAC and these parameters measured with eyes closed (sway-area: r = 0.429, $p < 0.05$, sway-path: r = 0.426, $p < 0.05$).

Table 2 Analysis of variance (ANOVA) for the results comparing the four different alcohol-dose groups. The values of the F-ratio (significance at the 5% level), with 3 numerator degrees of freedom and 26 denominator degrees of freedom are indicated – n.s. = not significant. Group comparisons based on John Turkey's HSD multiple comparison procedure

Parameters	Eyes	Alcohol	F $p < 0.05$ [DF(3/26)]	Multiple comparisons $p < 0.05$
Sway path	open	pre	n.s.	
		post	n.s.	
	closed	pre	n.s.	
		post	6.38	Group IV > Group I, Group II, Group III
Antero-posterior sway	open	pre	n.s.	
		post	n.s.	
	closed	pre	n.s.	
		post	5.22	Group IV > Group I, Group II, Group III
Lateral sway	open	pre	n.s.	
		post	n.s.	
	closed	pre	n.s.	
		post	3.71	Group IV > Group I, Group II
Sway area	open	pre	n.s.	
		post	4.67	Group IV > Group I, Group II
	closed	pres	n.s.	
		post	7.83	Group IV > Group I, Group II
Romberg Q. – sway path		pre	n.s.	
		post	n.s.	
Romberg Q. – sway area		pre	n.s.	
		post	n.s.	
Quotient antero-post./lateral sway	open	pre	n.s.	
		post	n.s.	
	closed	pre	n.s.	
		post	n.s.	

Discussion

One of the effects of ethanol intoxication is a general impairment of static balance control, characterized by an increased postural sway and the inability to coordinate postural and voluntary activity (Begbie 1966; Woollacott 1983).

When studying the effects of alcohol, even in equilibriometric research it is important to ascertain the influence of psychological factors. Thus the ability to remain in stable equilibrium is strongly influenced by voluntary effort. In the western world alcohol is by tradition associated with a worsened ability to perform certain tasks. However, in the present study the subjects were asked to perform as well as possible and they seemed cooperative enough. It was also important for the study to use subjects with similarly moderate drinking habits, since excessive drinking induces alcohol tolerance, which would have yielded another reaction pattern. Surprisingly, first-degree relatives of alcoholics have been shown to display less pronounced impairment upon alcohol intake of body sway parameters than subjects of a control group (Lex et al. 1988; Schuckit 1985). This might of course indicate a mechanism by which alcoholism evolves, allowing the subject to increase his consumption of alcohol without experiencing the side effects to their full extent. None of the subjects in this study was addicted to alcohol, nor did they have first-degree relatives that were.

Correlations between blood alcohol values and changes in the parameters of sway path and sway area were analysed (Fig. 3). Great variations still exist among volunteers, even with the application of a ratio of post-alcohol and pre-alcohol value for each parameter. On average however, the sway area as well as the sway path changed in accordance with the BAC, especially for the large alcohol-dose group (group IV). There was a significant positive correlation between sway-area (sway-path) increase and BAC both for eyes open and eyes closed. Little change was found in all parameters for the small-alcohol-dose groups (groups I, II and III) (e.g. Fig. 2 a, b). Thus, it can be postulated that body sway does not increase significantly when the BAC is less than 0.8‰. These results are in perfect agreement with previous findings (Kubo et al. 1989; Ledin and Ödkvist 1991). Hamann et al. (1984) found comparable results in persons habituated to alcohol and also reported a critical BAC for a significant increase in body sway above 1.0‰.

The achievment of the present study consists in the new finding that within the range of intoxication tested here, the alcohol-induced ataxia could not entirely be compensated by visual stabilization. Thus the ANOVA (for comparisons of post-alcohol versus pre-alcohol) revealed significant differences in the results of sway area (Fig. 2 a) in the Romberg test not only with eyes open ($p < 0.05$) but also with eyes closed ($p < 0.01$). These are impressive levels of sensitivity, particularly in consideration of the relative small number of subjects (n = 30) and the

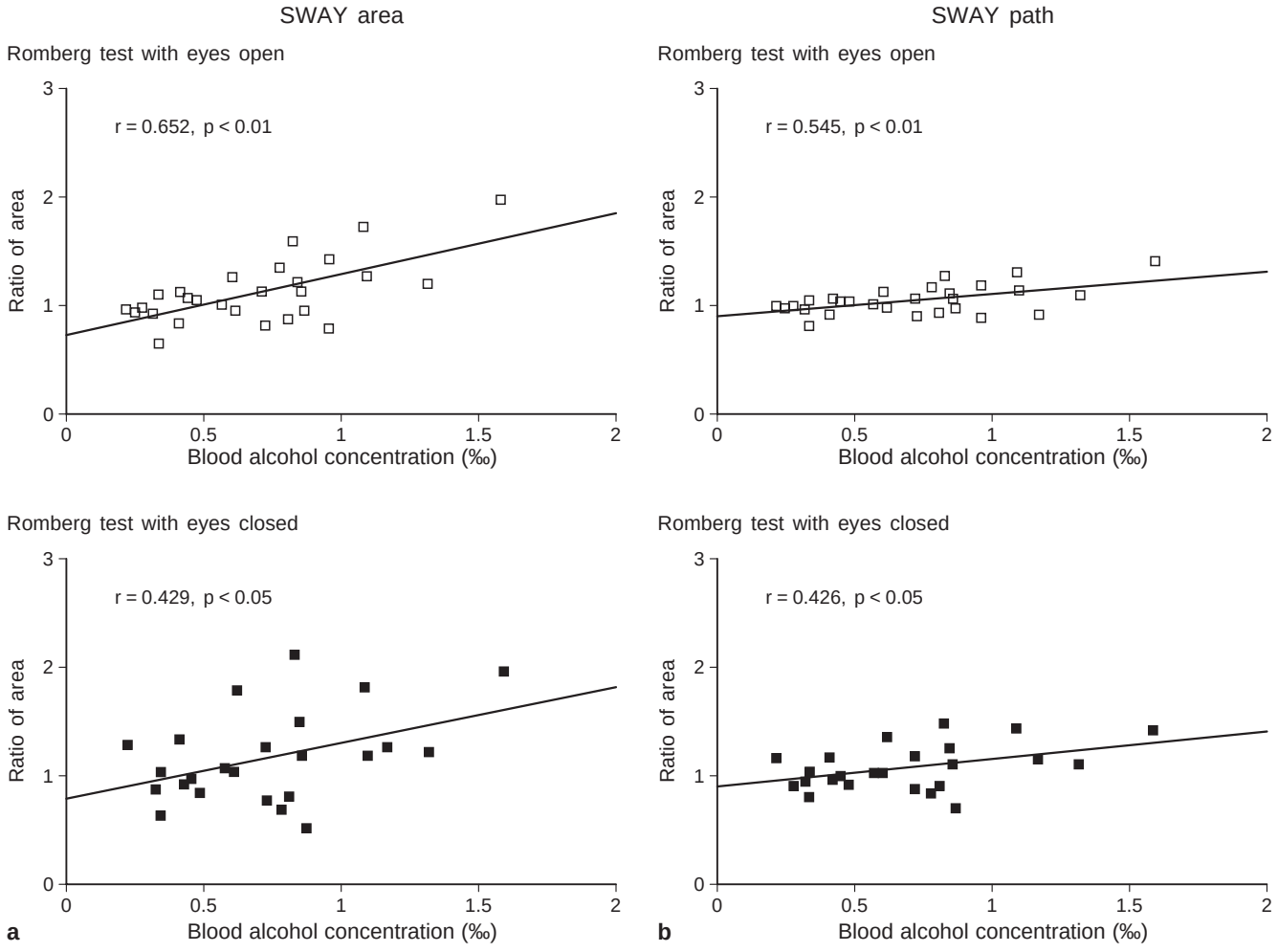

Fig. 3 a, b Relationship between posturographic change of the sway are (3a) respectively the sway path (3b) and the blood alcohol concentration (‰) (abscissa). The ratio of area (path), which denotes post-alcohol versus pre-alcohol values, is plotted on the ordinate. Data include all samples taken from 30 subjects standing with eyes open and eyes closed. The correlation coefficient (r) and the level of significance (p) is indicated

resulting low statistical power. The Romberg's quotient of area, which was the ratio of eyes closed versus eyes open, remained relatively constant because of the global increase of postural sway.

Multiple comparisons indicated that the large-alcohol-dose group (group IV) could be differentiated from groups with BAC lower than 0.8‰ (group I and group II).

Very early recordings of postural control under the influence of alcohol have employed a method called 'sphallography' (Schmidt 1956) and recently also dynamic posturography after the test subjects have drunk given amounts of alcohol. The finding of the present study contrasts with the data from the static conditions in dynamic posturography, in which no effect was observed (Goebel et al. 1995; Tianwu et al. 1995). Using dynamic conditions, however, distinct disturbances of acute low level alcohol ingestion were shown (Goebel et al. 1995; Ledin and Odkvist 1991; Tianwu et at. 1995). Seidl et al. (1994) used the Cranio-Corpo-Graphy method in order to evaluate the influence of acute high level alcohol ingestion (0.89‰ < BAC < 2.17‰) on postural control under Romberg-test conditions. Their results, in perfect agreement with those of the present study, also revealed an increase in body sway both in antero-posterior and lateral directions.

By contrast, Diener et al. (1983) noticed that the increase in sway with eyes closed following an acute intoxication with alcohol was almost exlusively due to an increase in antero-posterior sway. In addition, the above-mentioned authors observed that an alcohol-induced ataxia could be compensated totally by visual stabilization. Thus, they concluded that the acute effect of alcohol largely resembled that in patients with an atrophy of the anterior lobe of the cerebellum (the spinocerebellum) due to chronic alcohol abuse (Victor et al. 1959). The mostly unaffected visual compensation and the vast predominance of antero-posterior sway should be pathognomic for lesions of the spinocerebellum (Dichgans et al. 1976; Mauritz et al. 1979).

The present findings do not unreservedly support the hypothesis as put forward by Diener et al. (1983) that acute intoxication with alcohol primarily affects the spin-

ocerebellum just as it may occur with chronic intoxication. Thus, in the present study the increase in sway path after alcohol ingestion and with eyes closed showed an omnidirectional sway. Furthermore, the parameter of sway area revealed no compensation of the ethanol-induced ataxia by means of visual stabilisation. The same features were found in patients with a lesion of the vestibulo-cerebellum (archicerebellum) forming the lower vermis (Diener et al. 1984; Hufschmidt et al. 1980). Therefore, it may be concluded that the acute intoxication with alcohol mainly affects the vestibulo-cerebellum. In this respect, the finding that the Romberg's quotient of area remained relatively constant is consistent with other studies. Diener et al. (1984) pointed out that with lesions of the lower vermis, visual stabilization played a minor role. However, the conclusion of Diener et al. (1983) that the acute effect of alcohol largely resembles that of a chronic intoxication with a chronic lesion of the cerebellar anterior lobe has to be considered tentatively.

It is well known that considerable variation exists in terms of the acute effects of alcohol on individuals. In view of the present study, it is worth noting that in seven volunteers of the two lower dose groups the sway path and the sway area were reduced after alcohol ingestion. These observations may be consistent with proposals that at low doses, alcohol has a facilitatory effect on performance that can be ascribed to a psychomotor stimulation (Pohorecky 1977). Thus the observed reduction in postural ataxia after the intake of low dose of alcohol could be interpreted as a transient stimulatory action of ethanol. By contrast, higher doses of ethanol induce a depressant effect of the regulatory activity of the balancing system expressed as an increase in body sway. In his sophisticated work Pohorecky (1977) listed several examples in favor of this hypothesis of a dose-dependent 'biphasic' action of ethanol. Thus, a number of behaviors in experimental animals are potentiated by low doses of ethanol. Higher doses of alcohol, by contrast, depress these same behaviors. This is true e.g. for spontaneous motor activity (Buckalew and Cartwright 1968; Carlsson et al. 1972) and also for tasks involving motor activity such as operant avoidance performance (Holloway and Wansley 1973; Leander et al. 1976). Moreover man's psychological state also shows a biphasic response to ethanol (Lindman and Mellberg 1976; Lindmann and Taxell 1976; Smith et al. 1975).

Among electrophysiologists, the most frequently presented hypothesis for the stimulatory period after low doses of ethanol is that of disinhibition. According to this view, stimulatory effects of ethanol result from depression of tonic inhibitory mechanisms. The best evidence for such a mechanism comes from studies on the spinal cord. Polysynaptic segmental reflexes under modulatory control of supraspinal centers are facilitated by low ethanol levels in blood because of the elimination of descending inhibitory influences from supraspinal centers before the depression of the spinal cord itself occurs at higher ethanol levels (Kolmodin 1953).

Furthermore, Schäfer and Meyer (1974) as well as Hamann et al. (1984) assumed that alcohol affects 'postural reflexes' in roughly the same manner as some narcotics, having two basic effects. Small doses of ethanol led to an increase of 'postural reflexes' and accelerated also compensation processes of vestibular lesions. The authors observed paralysis of most of the 'labyrinthine reflexes' when high doses were used.

The results of the current study suggest that the total sway pattern after alcohol ingestion can be characterized best by a combination of several parameters. Above all, sway path and sway area have proven to be reliable indicators in order to describe the regulatory activity of the balancing system. The area surrounded by the outer circle in the posturogram was the most sensitive parameter to BAC changes in the present experiment. As the parameter of sway area showed, an increase in body sway after alcohol ingestion appeared both with eyes closed and with eyes open. In addition, the parameter of sway path revealed that the antero-posterior and the lateral sway increased evenly. These findings suggest that the site affected by alcohol can be located in the central vestibular system, perhaps mainly in the (vestibulo-) cerebellum. The fact that vestibular nucleus neurons are far more sensitive to alcohol than the neurons in the trigeminal and medial geniculate nuclei (Ikeda et al. 1981) supports this hypothesis.

The present findings can be considered as an extension of previous studies focusing on the clinical diagnosis of postural ataxia after the intake of alcohol and casting new light on the site of action of alcohol. Thus, the benefits gained from testing vestibulospinal function by means of posturographic methods may be of special importance in the study of alcoholism.

With respect to everyday practice, the conclusion can be drawn that the posturography for forensic purposes, for instance in examining drivers with alcohol in their blood, is recommended only with reservation because of the interindividual dispersion of the present results. These marked individual differences in the postural response to alcohol appear to be hereditary (Heath and Martin 1992) and to depend both on the familial history of alcoholism (Schuckit 1985) and on daily consumption levels (Moskowitz 1974). All these differences may well be involved in otoneurologic diagnostics and play an important role in vestibulospinal examinations. Nevertheless, computerized static posturography has a value as an objective measure of balance, and in particular the purported ability to document cases of an inadequate postural reaction by alcoholic beverages has been confirmed.

References

Aschan G. Bergstedt M, Goldberg L, Laurell L (1956) Positional nystagmus in man during and after alcohol intoxication. Q J Stud Alcohol 17:381–451

Barnes G (1984) The effects of ethyl alcohol on visual pursuit and suppression of the vestibulo-ocular reflex. Acta Otolaryngol Suppl (Stockh) 406:161–166

Barnes G, Crombie J, Edage A (1985) The effects of ethanol on visual-vestibular interaction during active and passive head movements. Aviat Space Environ Med 20:695–701

Begbie G (1966) The effects of alcohol and of varying amounts of visual information on a balancing test. Ergonomics 9:325–333
Brandt T (1991) Positional and alcohol nystagmus. In: Brandt T (ed) Vertigo, its multisensory syndromes. Springer, London, pp 154–156
Buckalew L, Cartwright G (1968) General and differential behavioral effects of five ethanol dosages on the albino rat. Physiol Rep 23:1151–1154
Carlsson A, Engel J, Svensson T (1972) Inhibition of ethanol-induced excitation in mice and rats by alpha-p-tyrosine. Psychopharmacologia 26:307–312
Dichgans J, Diener H (1985) Postural ataxia in late atrophy of the cerebellar anterior lobe and its differential diagnosis. In: Igarashi M, Black FO (eds) Vestibular and visual control of posture and oculomotor equilibrium. Karger, Basel, pp 282–289
Dichgans J, Mauritz K, Allum J, Brandt T (1976) Postural sway in normals and atactic patients: analysis of the stabilizing and destabilizing effects of vision. Agressologie 17:15–24
Diener H, Dichgans J (1990) Pharmacological and toxicological effects on cerebellar function. In: Brandt T, et al. (eds) Disorders of posture and gait. Georg Thieme, Stuttgart New York, pp 334–339
Diener H, Dichgans J, Bacher M, Hülser J, Liebach H (1983) Mechanisms of postural ataxia after intake of alcohol. Z Rechtsmed 90:159–165
Diener H, Dichgans J, Bacher M, Gompf B (1984) Quantification of postural sway in normals and patients with cerebellar diseases. Electroencephalgor Clin Neurophysiol 57:134–142
Fried R, Arnold W (1987) Der objektivierbare Rombergtest (Posturographie) mit der neuen „Luzerner Meßplatte“. Laryngorrhinootologie 66:433–436
Goebel J, Dunham D, Rohrbaugh J, Fischel D, Stewart P (1995) Dose-related effects of alcohol on dynamic posturography and oculomotor measures. Acta Otolaryngol Suppl (Stockh) 520:212–215
Hadj-Djilani A (1988) Multiparametrical study of posturography using force platform: recording with and without vestibular caloric stimulafion. Neuroorthopedics 6:93–100
Hamann K, Schmeißer K, Krausen C, Rusche G (1984) Posturographische Studie an alkoholgewOhuten Versuchspersonen bei unterschiedlichen Blutalkohol-konzentrafionen. Laryngorhinootologie 63:68–70
Heath A, Martin N (1992) Genetic differences in psychomotor performance decrement after alcohol: a multivariate analysis. J Stud Alcohol 53:262–271
Holloway F, Wansley R (1973) Differential sensitivity of different discrimination behaviors to the effects of ethanol. Bull Psychon Sci 2:159–162
Hufschmidt A, Dichgans J, Mauritz K, Hufschmidt M (1980) Some methods and parameters of body sway quantification and their neurological applications. Arch Psychiatr Nervenkr 228:135–150
IkedaY, Sasa M, Takaori S (1981) Selective effect of ethanol on the vesfibular nucleus neurons in the cat. Jpn J Pharmacol 30:665–673
Kubo T, Sakata Y, Matsunaga T, Koshimune A, Sakai S, Ameno K, Ijiri I (1989) Analysis of body sway pattern after alcohol ingestion in human subjects. Acta Otolaryngol Suppl (Stockh) 468:247–252
Leander J, McMillan D, Ellis F (1976) Ethanol and isopropanol effects on schedule-controlled responding. Psychopharmacology 47:157–164
Ledin T, Ödkvist L (1991) Effects of alcohol measured by dynamic posturography. Acta Otolaryngol Suppl (Stockh) 481:576–581
Ledin T, Loftas P, Öhman S, Ödkvist L (1983) Modified dynamic posturography and the rattle test: effects of alcohol. In: Woollacott M, Horak F (eds) Posture and gait: control mechanisms. University of Oregon Books, Portland, pp 195–198
Lex B, Lukas S, Greenwald N, Mendelson J (1988) Alcohol-induced changes in body sway in women at risk for alcoholism. J Stud Alcohol 49:346–356
Lindman R, Mellberg B (1976) The effects of alcohol and threat-induced stress on mood and psychophysiological functions. Psykol Rapp 6:1–20
Lindman R, Taxell H (1976) Subjective mood as a function of cognitive stress, alcohol, and time. Psykol Rapp 7:1–10
Mauritz K, Dichgans J, Hufschmidt A (1979) Quantitative analysis of stance in late cortical cerebellar atrophy of the anterior lobe and other forms of cerebellar ataxia. Brain 102:461–482
Mills K, Bisgrove E (1983) Body sway and divided attention performance under the influence of alcohol: dose-response differences between males and females. Alcohol Clin Exp Res 7:393–397
Money K, Myles W (1974) Heavy water nystagmus and effects of alcohol. Nature 247:404–405
Moskowitz H (1974) Acute tolerance to behavioral impairment by alcohol in moderate and heavy drinkers. DOT Technical Report HS 801 160
Njiokiktjiien C, Van Parys J (1976) Romberg's sign expressed in a quotient. II Pathology. Agressologie 17D:19–24
Pohorecky L (1977) Biphasic action of ethanol. Biobehav Rev 1:231–240
Schäfer K, Meyer P (1974) Compensation of vestibular lesions. In: Kornhuber H (ed) Handbook of sensory physiology, vol. VI/2. Springer, Berlin Heidelberg New York, pp
Schmidt O (1956) Die elektrische Registrierung alkoholbedingter Gleichgewichtsstörungen. Dtsch Z Gerichtl Med 45:231–235
Schuckit M (1985) Ethanol-induced changes in body sway in men at high alcoholism risk. Arch Gen Psychiatry 42:375–379
Seidl S, Müller M, Reinhardt G (1994) Untersuchungen der Gleichgewichtsregulation bei akuter Alkoholintoxikation mit der Methode der Cranio-Corpo-Graphie. Blutalkohol 31:186–195
Smith R, Parker E, Noble E (1975) Alcohol and affect in dyadic social interaction. Psychosom Med 37:25–40
Tianwu H, Watanabe Y, Asai M, Shimizu K, Takada S, Mizukoshi K (1995) Effects of alcohol ingestion on vestibular function in postural control. Acta Otolaryngol Suppl (Stockh) 519:127–131
Umeda Y, Sakata E (1978) Alcohol and the oculomotor system. Ann Otol Rhinol Laryngol 87:392–398
Victor M, Adams R, Mancall E (1959) A restricted form of cereballar cortical degenerafion occuring in alcoholic patients. Arch Neurol 1:579–688
Wilkinson I, Kime R, Purnell M (1974) Alcohol and human eye movement. Brain 97:785–792
Woollacott M (1983) Effects of ethanol on postural adjustments in humans. Exp Neurol 80:55–68