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No Effects of Acute Alcohol Ingestion on Subjective Visual Horizontal Determination During Eccentric Rotation

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Abstract: Evaluating the function of the vestibular part of the inner ear comprises more than the classic analysis of the lateral semicircular canal function. In healthy subjects, positional alcohol nystagmus may be seen after acute alcohol ingestion. Posturography has shown a deteriorated equilibrium after even moderate doses of alcohol, which speculatively could be an effect of otolith disturbance or a central integrative effect. We tested the possibility of an otolith effect by using linear acceleration in the lateral direction by means of eccentric rotation, stimulating mainly the outermost ear's otolith organ.

The subject is seated eccentrically in a rotatory chair facing the direction of rotation. Thus, the otolith organs are stimulated in steady-state rotation. The subject experiences a lateral tilt and, in darkness, is instructed to put a short light bar in the position thought to be that of a water surface, which is identical to the perceived tilt. Twenty healthy subjects (10 men, 10 women) aged 20–29 years were tested before and approximately 1 hour after ingestion of alcohol, the amounts consumed corresponding to an approximate blood alcohol level of 0.05%, well above the maximum permissible level for driving in Sweden.

No significant effects of alcohol were found. The otolith function probably is not affected by moderate alcohol intoxication levels. From this point of view, equilibrium deterioration due to alcohol ingestion in the erect position is caused by a central integrative deficit and not by an otolith effect.

The central nervous system controls the balance ability through three different sensory modalities: proprioception from muscles and ligaments, visual perception, and information from the vestibular system in the inner ear. Functionally, the latter can be divided into the semicircular canals and the otolithic organs. The three semicircular canals detect angular accelerations of the head. The utriculus and sacculus in the vestibulum contain the otolithic organs, which detect linear acceleration forces in three dimensions.

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In injuries involving the peripheral vestibular system, surprisingly little is known about otolith dysfunction as compared to dysfunction of the semicircular canals. The main reason has been lack of clinical test methods; thus, the otoliths often have been forgotten as a possible source of dizziness and equilibrium disorders. For example, the static vestibuloocular reflexes are mediated primarily via the otoliths [1]. The lateral semicircular canals long have been studied through caloric response. Studying the other two canal pairs has been more difficult, but such study has been possible with different rotational techniques. Until recently, studying the otoliths selectively [2] in clinical practice has not been possible. Today, it can be performed by an eccentric rotation procedure. The subject is strapped to a chair placed on an arm 1 m from the center of rotation and then is rotated in complete darkness at a constant angular velocity. In the absence of vision, the subject's main source of sensation

of orientation will be from the otoliths, as no angular acceleration will be experienced.

It already is known that alcohol affects the inner ear as demonstrated—for example, by the lowered threshold for provocation of positional nystagmus after alcohol intake (positional alcohol nystagmus, or PAN). The mechanisms for eliciting PAN have been discussed [3–5]. According to experiments performed by Money et al. [3] and Aschan et al. [6], the ingested alcohol reaches the cupula in a quick, vascular way. As the specific gravity of alcohol is low, the buoyancy of the cupula is increased, the cupula is bent and, via the hair cells, the vestibuloocular reflex causes nystagmus. To prove this theory, Money and Myles [4] administered heavy water, and a nystagmus with the opposite beat direction appeared. Although the otolithic organs may cause eye movements, whether they actually can cause nystagmus has been argued. In the Ödkvist [7] experiments with increased gravity, PAN could be reelicited (supposedly by influence on the cupular function), but the mechanisms might have been a G effect on the otolith organs. In our study, we used the foregoing technique to study the effect of alcohol intake on utricular otolith function.

MATERIAL AND METHODS

Twenty volunteers (10 men, 10 women) aged 20–29 years (mean, 24 years) were enrolled in our study. None of the participants had any history of excessive alcohol intake that could have affected their response to the given amount of alcohol. They received written information about the study.

All participants completed a form in which we asked for a record of vestibular or neurological diseases, other chronic diseases, and daily medication. They were given a simple physical examination, including otoscopy, Weber, Rinne, Romberg, and Frenzel glasses, with no pathological findings. The subjects had not eaten or drunk for at least 4 hours before testing.

A low-torque rotatory chair held the subject 100 cm from the vertical rotational axis facing the direction of constant rotation. Rotation was started with an angular acceleration of 10°/sec^2, until an angular velocity of 120°/sec was reached. On the basis of these variables, the theoretical tilt angle is 24.1 degrees [8]. Deceleration was performed accordingly, with the room totally dark. Approximately 60 cm in front of the subject's eyes, a dim light-emitting diode bar was illuminated for the subject to adjust (via a hand-held three-button keyboard) to the direction thought to be that of a water surface. By definition, a perceived tilt outward (i.e., a "correct" response) results in a positive angle. Via software in an IBM-compatible computer, an operator administered the test and read the set angles of the light-emitting diode bar. The subject was strapped to the chair to minimize body movements, and the head was strapped in an adjustable frame.

Subjects were attached firmly to the chair in a totally dark room. Eight measurements of the perceived horizontal were performed before rotation was started; then the mean and standard deviation were computed. The rotation was started and, after 1 minute of constant speed, another eight measurements were taken. The chair was decelerated and, 1 minute after a complete stop, another eight measurements were conducted. After a total of 5 minutes of standstill, the last eight measurements of the perceived horizontal were performed. After both tests, the subjects were to grade the strength of discomfort or rotational feeling that they perceived.

Every subject was tested twice and, approximately 40 minutes before one of the tests, they were to ingest a specific amount of alcohol (0.86 ml 70% alcohol per kilogram of body weight) in 15 minutes. The alcohol level in the expired air was tested with an alcometer. Of the subjects, 10 ingested alcohol the first time they were tested, and the other 10 the second time. This division was aimed at avoiding learning effects. Any alcohol intake was forbidden for at least 24 hours before testing.

ANOVA examined the effects of gender, test order, and alcohol presence. A probability level of 5% was considered significant.

RESULTS

None of the test persons experienced any feeling of discomfort or dizziness during the tests. One of the women felt nauseous and dizzy (to the same degree) after both tests. In both instances, these feelings disappeared spontaneously after approximately 30 minutes. One of the male test persons stated that during rotation and alcohol intoxication, he totally lost orientation during two of the eight measurements. Alcometer values before and after the test with alcohol intoxication varied between 0.04–0.075%.

On the basis of ANOVA, no effects of gender, test order, and alcohol were found. The mean response amplitude (the test values during rotation minus the test values before rotation) are presented in Table 1. The difference (due to alcohol) thus was not significant.

Table 1. The Response Amplitude (in degrees) for Test Subjects (N = 20)

	Mean	SD
No alcohol	19.17	4.46
With alcohol	19.54	4.93
Difference	0.37	4.65

DISCUSSION

In the eccentric rotation procedure, the utricular otolithic organs are stimulated by a constant linear acceleration, and the semicircular canals are not affected. Visual perception is not helpful, as the room is completely dark. Some proprioceptive cues might influence the perceived horizontal, because the body and head are held firmly to the chair [9].

As no difference was observed between the group intoxicated with alcohol in the two tests, the test persons do not seem to be habituating to the test procedure. Otherwise, habituation perhaps could outweigh the alcohol effect.

The doses of alcohol were related to body weight so as to yield the same level of intoxication in the different test persons. The dose amount was based on earlier controlled human alcohol experiments [6,10]. The alcometer showed reasonably uniform blood alcohol concentrations. The subjects were instructed not to drink any alcohol for at least 24 hours before both tests, but we did not test their alcohol levels before starting the procedure. However, we trusted the test subjects to have followed the given instructions.

In earlier studies, PAN has been elicited only in the lateral position. This position was not included in our study. Earlier studies suggested that PAN is elicited from the cupula [3,4], and our study does not contradict this.

We used only one direction of rotation—counterclockwise (same in both tests); thus, principally we have tested only the subjects' right ear. Because none of the 20 subjects revealed any case history of neurological or vestibular disease, this choice probably did not constitute a source of error.

The vestibular disturbances caused by alcohol, as shown by Aschan et al [6], Money and Myles [4], Ledin and Ödkvist [5], and Ödkvist [7], obviously have mechanisms other than otolithic. The nystagmus presumably is of cupular origin, and the postural disturbances probably are of central nervous system origin, as shown by Ledin and Ödkvist [5].

To our knowledge, the effect of alcohol on otolithic function has not been studied before, and we have no other results with which to compare. The conclusion of this study is that alcohol intoxication does not affect the utricular otolithic organs significantly, as tested by determination of subjective horizontal during eccentric rotation.

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