Medical Fitness Examination of Commercial Pilots: New Criteria for Evaluation of Vestibular Tests

MICHAEL H. MOSER and GÜNTER R. RANACHER

Univ.-HNO-Klinik, Auenbruggerplatz 20, 8036 Graz, Austria

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In medical fitness examinations of commercial pilots, extensive vestibular investigations should be conducted. In particular, the pendular test, as a weak rotational stimulation method, can disclose central vestibular disorders. Thus, the central nystagmus tracing can be considered as a sign of irritation of vestibular centers, most frequently as a consequence of head trauma, a finding that may influence the decision in the enlistment of the pilot. In contrast, a small nystagmus amplitude tracing is observed in cases of insufficient blood supply, occurring mostly in elderly persons. Therefore, this finding helps to demonstrate and treat arteriosclerotic dizziness in elderly pilots. Cervical-nystagmus—elicited by neck-torsion while keeping the labyrinth fixed at rest—is an objective demonstration of a cervical-spine-syndrome. Aimed therapy, namely chiropractic manipulation, may help the pilot become fit to fly again. Further processing of the data from the vestibular investigations by means of a computer and plotting can provide the so-called cumulative eye position. This enables one to evaluate the compensation capacity which is a measure of the intensity of the vestibular response, important in the assessment of normal function of the vestibular system.

EXTENSIVE VESTIBULAR investigation is seldom carried out within the framework of medical fitness examinations of commercial pilots. As it can be extracted from enlistment on physical examination forms, this is usually limited to simple observation of spontaneous eye movements and caloric tests using Frenzel's glasses. Only rarely are more involved testing and electronystagmographic recording performed. These investigations, however, combined with analysis of caloric labyrinthine responses, provide important information concerning the functional status of the whole vestibular system. In the study of vestibular function, the pendular test (3,12) has found increasing acceptance in recent years. We have been using this test since 1970 in the clarification of neurotologic disorders as well as during the recruiting of commercial pilots (16).

METHODS

We use the pendular test as part of the study of vestibular function, together with analysis of spontaneous nystagmus, caloric responses, neck torsion test, and optokinetic nystagmus. During the pendular test, the subject, sitting on a pendular chair, is subjected to horizontal sinusoidal oscillations (period = 20 s, peak velocity = 56°/s). In each run, nystagmic responses to the right and left, corresponding to the rotational direction, are elicited. Graphic recordings of the nystagmic responses in parallel to the sinusoidal tracing of the pendular oscillations provide an objective recording of vestibular responses over a long time interval. To avoid artifacts during the investigation that interfere with results, the vigilance of the subject is maintained by playing tape recorded instructions for simple mental calculation tasks to be solved (5,13). For the neck torsion test, the head of the patient is held fixed, while the chair is manually swung back and forth. In this manner, isolated torsion of the cervical spine can be achieved. In some pathologic cases, nystagmus is elicited and this is called cervical nystagmus. Further details of this examination procedure have been reported elsewhere (11).

Recording of stimulus tracing and nystagmic responses is made not only in analog form but also digitally on magnetic tape for further computer analysis. These data are processed with a PDP 11/34 computer (20). The number of nystagmus beats, the amplitude and duration of the slow and fast components, as well as the angular velocity of these slow and fast nystagmic phases are evaluated (19). These data are then normalized for the age of the subject. Since the slow nystagmic phases are important in assessing vestibular responses, the fast nystagmic phases are omitted and the slow ones are sequentially assembled, thus obtaining a cumulative eye position tracing. The movements of the pendular chair

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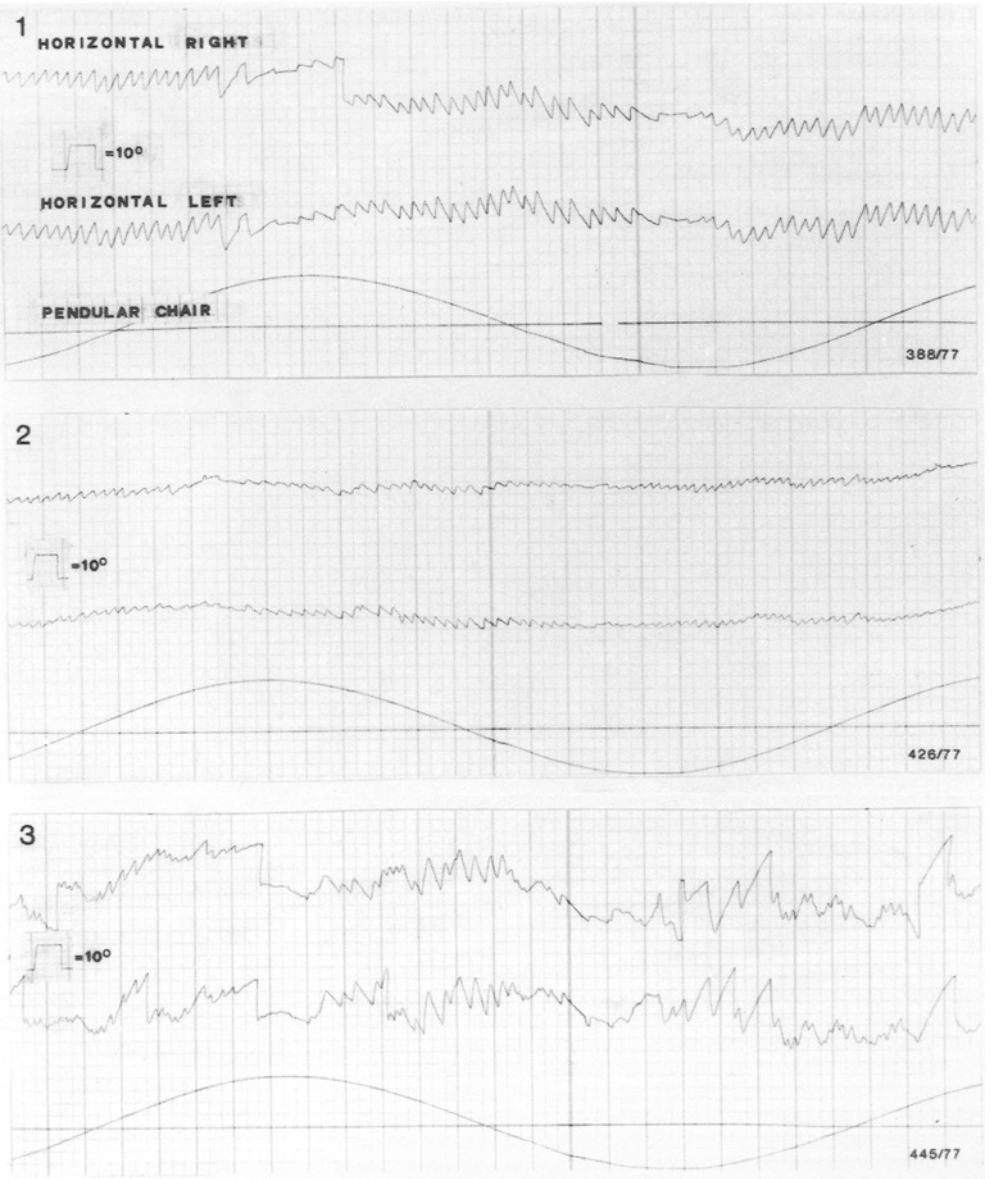

Fig. 1. 1) Normal nystagmogram in the pendular test; 2) small nystagmus writing (petite écriture); 3) central nystagmus writing (écriture centrale).

are oppositely directed with respect to the slow nystagmic phase.

RESULTS

The value of caloric rinsing is undisputed and has been reported many times (1,3,12). However, caloric responses provide information concerning the function of the peripheral receptors of the inner ear, whereas the pendular test is used particularly in the diagnosis of central functioning. This report concentrates on the analysis of the pendular test. Using the pendular test in a normally functioning vestibular system, a regular course of the nystagmic tracing is obtained (Fig. 1); however, in organic or functional disorders, characteristic alterations can be observed. Of particular interest are certain irregular patterns, designated as "central tracing" or écriture centrale (3,7) (Fig. 1). They appear when the vestibular centers are irritated by severe contusion of the brain stem with light head trauma. These changes in the nystagmogram persist for a long time and can still be seen when the EEG has already returned to normal (9). Thus, the recording of this central nystagmus tracing can also be used to demonstrate that, as we express it, the vestibular centers have been previously exposed to irritation.

A second type of abnormal nystagmogram is characterized by the decreased nystagmus amplitude, which is known as small amplitude tracing or petite écriture (6). It can be observed in case of diminished blood flow in the vestibular centers of the brain stem (Fig. 1). The occurrence of small amplitude tracing is quite characteristic in cases of insufficient blood supply to the vestibular centers; it has been demonstrated in a large group of patients and has also been reproduced in animal experiments (8,10).

Cervical nystagmus, i.e. following neck torsion, serves as an objective demonstration of a cervical spine syndrome. This type of nystagmus can only be elicited as a response of abnormally affected cervical receptors during isolated rotation of the cervical spine, and not in relation to the labyrinth which is held fixed at rest during the course of the investigation.

While qualitative alterations of the nystagmus trace are good for localized diagnostic value, the cumulative

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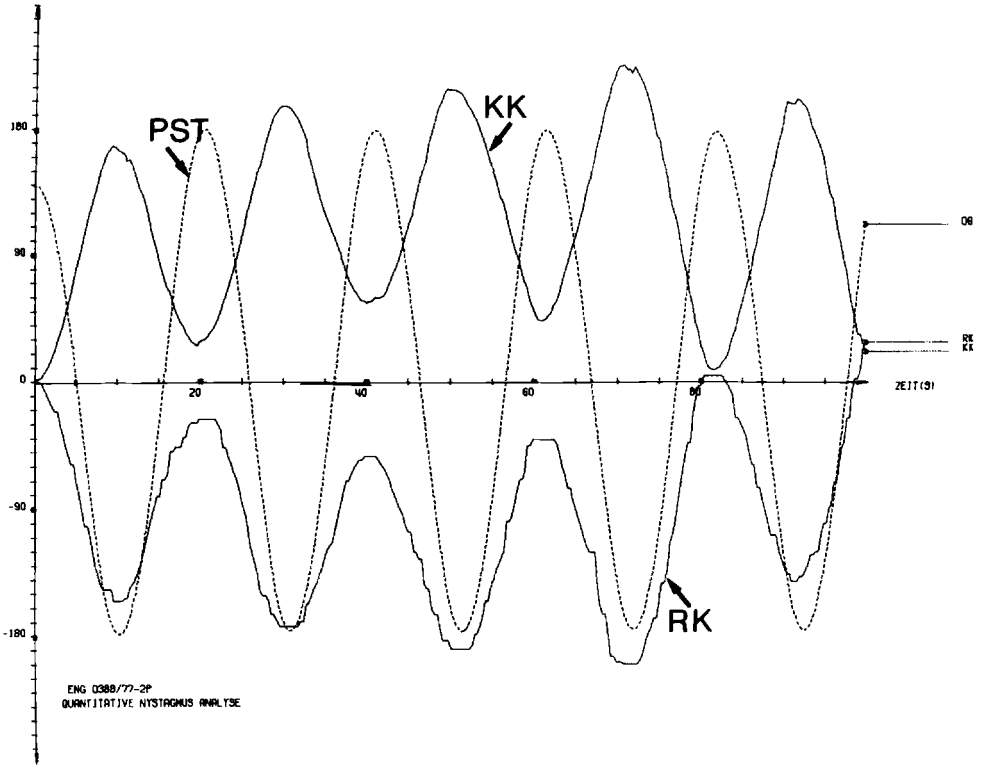

Fig. 2. KK: cumulative tracing of the slow nystagmic phases; PST: pendular chair oscillations; RK: opposite curve obtained by accumulation of the fast nystagmic phases.

eye position tracing furnishes an excellent general appreciation of total vestibular responsiveness (Fig. 2). This is based on the knowledge that competent vestibular function expresses itself through compensation of head rotation (= pendular chair movement) by eye movements (= slow nystagmic phase). If the vestibular system function is completely normal, then capacity to compensate according to age is fully present. Full compensation (100%) would mean that, for instance, in correspondence to a rotation of the head of 180° during the pendular test, the excursion of the eyes, to the opposite side during the slow nystagmic phase, should cover 180°. Actually, the compensation capacity of the eyes, strongly dependent upon age, reaches up to 80% in young patients and decreases to 20% in older patients (19). This age dependence is illustrated in Fig. 3. By calculating compensation capacity separately for responses to the right and to the left, both sides can be immediately compared. Thus, lateral differences can be estimated and, in addition, separate determinations of intensity of vestibular responses and their deviation from the normal are obtained.

Significance for fitness of pilots: Caloric exposure of the labyrinth is used as a vestibular test during the enlistment examination of Austrian pilot applicants. With this test a relatively inaccurate method is used, since only peripheral excitability of the labyrinth is being tested. Also, the value of spontaneous nystagmus is lim-

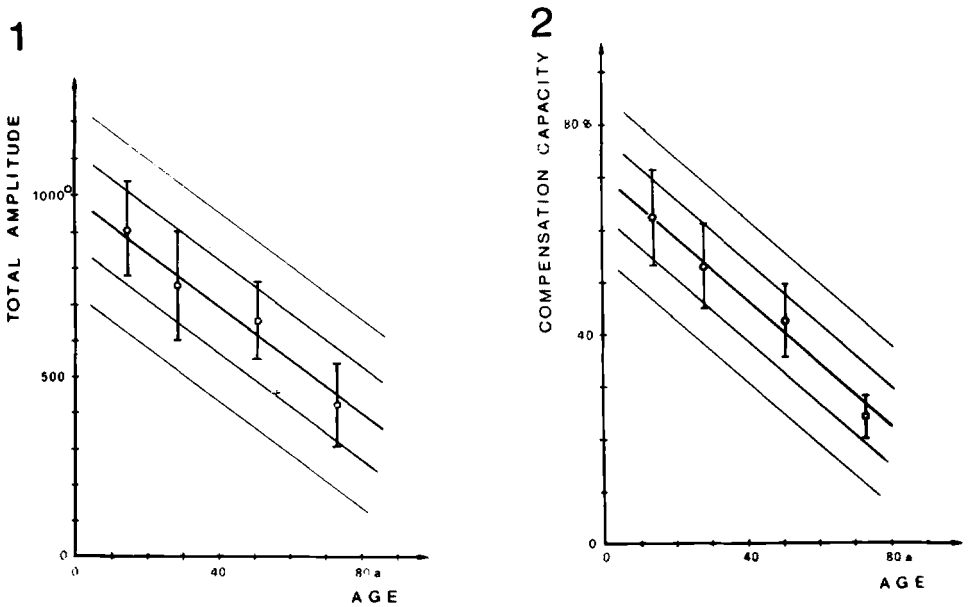

Fig. 3. Age dependence of (1) amplitude, and (2) compensation capacity.

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ited, since this is observed in 50% of healthy subjects (18). Even during the application of rotational tests with stops from high velocities, the post-rotory nystagmus discloses, at best, only lateral differences.

In contrast, the pendular test demonstrates by alteration in the quality of the nystagmus tracing, whether there is an irritation of vestibular centers, while the subject maintains a high level of mental vigilance. A central nystagmus record as an abnormal finding during the enlistment examinations is reason enough for the examiner to return to the pilot candidate, this time asking particularly for head trauma, which may have been originally omitted or denied. Even when no complaints are reported, a pilot applicant with a head trauma history is difficult to evaluate and should be submitted to a detailed neurological appraisal.

The value of the small nystagmus amplitude record as a sign of insufficient blood supply to the vestibular centers depends principally on the physical fitness of the pilot. In elderly patients who often complain of discrete dizziness, the petite écriture is quite typical and points directly to its genesis. Thus, prompt treatment of the brain stem blood flow disorder is indicated. If there is clear improvement, in our opinion, the pilot is fit to fly again.

However, since central changes of the nystagmus tracing during the pendular test can also be observed in organic disorders of the vestibular centers of the brain stem (15), extensive clinical tests—including EEG, ophthalmologic exams, skull, petrous bone and cervical spine X-ray films, and a neurological examination—are certainly required. Cervical spine syndrome is also relatively frequent in younger patients. For the diagnosis, cervical spine X-ray films are only minimally helpful, since even healthy subjects demonstrate a great variety of pathologic changes. Therefore, in addition to a functional view of the cervical spine, special attention should be given to the quite-typical anamnesis and careful manual examination should be performed. Recording cervical nystagmus during the course of vestibular examinations then provides objective support to the diagnosis of cervical spine syndrome (4,11,14).

After establishing the exact diagnosis, aimed chiropractic manipulation is an ideal treatment possibility (17) towards recovery of fitness for flying. Further processing of the data resulting from the various vestibular tests by digital computer allows more accurate evaluation of all parameters. The most useful display form in our laboratory proved to be the cumulative eye position tracing, since it contains information about (a) amplitude (Gesamtamplitude), (b) angular velocity of the slow component, (c) its time course over a long time interval, and (d) the compensation capacity. The last parameter is reported as percent value and is important since it is an indication of the actual functional capacity of the vestibular system which, in turn, is of significance concerning the pilot's amplitude.

The compensation capacity, determined separately for both sides, behaves with respect to symmetry differently from, e.g. the frequency. Some patients show strong asymmetry with respect to the number of nystagmic beats, the compensation capacity remaining however essentially equal for both sides. This means that applicants rejected on account of a lateral asymmetry above 15 or 20% could possibly have actual vestibular capacity essentially symmetrical. On the other hand, we have observed asymmetries of compensation capacity with an approximately symmetrical number of nystagmic beats.

SUMMARY

In medical fitness examinations of commercial pilots, extensive vestibular investigations should be conducted. The pendular test requires special equipment, which is not always available. However, if laboratories are capable of performing such tests, central vestibular disorders can be disclosed. Thus, the central nystagmus tracing can be considered a sign of irritation of vestibular centers, most frequently as a consequence of head trauma, a finding that may influence the decision during selection of the pilot. In contrast, a small nystagmus amplitude tracing is observed in case of insufficient blood supply, occurring usually in elderly persons. Therefore, this finding helps to demonstrate and treat arteriosclerotic dizziness in older pilots.

Cervical-nystagmus, elicited by neck torsion while keeping the labyrinth fixed at rest, is an objective demonstration of a cervical-spine syndrome. Aimed therapy, namely chiropractic manipulation, may help the pilot become fit to fly again if he is diagnosed with this condition.

Further processing of the data from vestibular investigations by means of a computer and plotting can provide the so-called cumulative eye position. This allows one to evaluate the compensation capacity which is a measure of the intensity of the vestibular response, important in the assessment of normality of function of the vestibular system.

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