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Clinical Studies of the Righting Reactions

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INTRODUCTION

Although apparently the human body in erect posture seems to be stationary in condition, it moves slightly all the time, not only in normal but in disturbed equilibrium. The mechanism of equilibrium of body is simple in the low species of animals because it is controlled by a primitive organ, for example statocyst in jellyfish. On the other hand, the maintenance of equilibrium in human body becomes much more complicated because of his erect posture standing by only two legs, his erect gait and his need to do skillful actions.

It is generally accepted by various investigators that equilibrium of human body is controlled by the following impulses: 1. labyrinthine discharge from the macules and cristae; 2. proprioceptive impulses from deep tissues, that is to say, muscles, tendons, joints, neck, trunk, and limbs; 3. exteroceptive impulses from skin and surface; and 4. visual impulses from the retina. The correlation of these above mentioned impulses seems to be managed in the higher centers of the central nervous system. The labyrinth is of importance to control in equilibrium of body and the cerebellum is the main organ to maintain in antigravity muscle activity. The muscular tonus, particularly of antigravity muscles, is responsible to maintain the erect posture.

Takata[1)] studied righting reaction of normal subjects in erect posture. Twenty eight normal young adults (14 males and 14 females) were examined in Romberg's and Mann's postures with eyes opened and closed. In order to observe and record the righting reaction, 16 mm high speed motion picture camera-HYCAM (K200-Red Lake Laboratory, Ltd) was used. Motion picture of the subjects in erect posture was taken from a distance of 9 meters with film speed of 150F/sec and films were analyzed by means of a filmotion analyzer (Bell & Howell). According to his description, in normal subjects the ratio of quantity and frequency of body sway in erect posture with eyes opened or closed is 50% in the head, 30% in the neck and 20% in the hip, and in the same subject the body sway in Romberg's posture is less than in Mann's posture without exception.

The labyrinthine discharges in erect posture are described as a righting reaction. Normal human subject in erect posture enable to maintain normal equilibrium by exact righting reaction, on the other hand in the patient with disturbed labyrinth he does not enable to maintain his equilibrium of body and falls to the affected side.

TEST METHODS OF RIGHTING REACTION

Righting reaction of human body in erect posture is clinically examined by static function tests, such as 1) Romberg test, 2) Mann's test, 3) One-leg test, and 4) Goniometer test.

1. Romberg test.

Romberg test is rather classical but it is performed from choice by otologists up to date because of a simple and excellent procedure in the light of present. Usually for this test the subject is required to stand on the flat floor with both feet close together to eliminate the proprioceptive factor as far as possible and with eyes closed to eliminate the visual factor. This test procedure is available to test whether labyrinthine righting reaction is normal or not. Honjo emphasized that human equilibrium in static condition is maintained by a synthetic reaction of labyrinthine righting discharge, proprioceptive impulse and visual impuls, and that therefore, at first in order to examine the synthetic reaction of equilibrium the subject should stand in natural posture without any requirment as to his posture. In his opinion, then the subject keeps his feet close together and eyes closed. The examiner observes and records tendency to fall, direction of falling and body swaying. Since about ten years we are using resistance wire strain-gage type accelerometer for recording righting reaction in Romberg test.

2. Mann's test

In Mann's test the subject in erect posture is required to stand with one foot in front of the other, so that the heel of the anterior foot touches the toe of the posterior foot. Mann's position is rather unstable than Romberg's position, and therefore in our experiences the normal subject, particularly old woman, shows sometimes body sway. It should be kept in mind that results from Mann's test is difficult to understand equilibrium function exactly.

Honjo and Miyahara (1970)[2] studied method of Mann's test in normal subjects and cases with labyrinthine lesion and stated that with regards to procedure of Mann's test it is important to consider which foot the subject put on his body weight.

3. One-leg test

In one-leg test the subject in erect posture is required to stand on one leg alternately. It is necessary that the supporting leg keeps extend and the raised leg flexes maximally at the knee. In our experince righting reaction in erect posture represents most sensitive in this test, particularly with eyes closed.

4. Goniometer test.

It is to credit of Von Stein to have demonstrated in 1882 that goniometer test is useful for examining righting reaction of human body. Thereafter method of advancing technique and clinical use of this test have been sought by many investigators.

Needless to say, the goniometer test is different from the other static function tests, such as Romberg's test and Mann's test as to purpose of examination. The purpose of goniometer test is to examine how a subject keeps up his body posture during passive movement carried out by inclining the plank of goniometer. On the other hand Romberg's test and the others of static function test are performed on in exactly static posture in condition without any passive movement.

The goniometer test seemed to have an important weak point as to equipment heretofore in use. Therefore judging from reports of many authors, one can conclude that the results obtained by the methods heretofore in use show a large individual variation in normal subjects and a wide range even in the same subjects at different times. It is, therefore, difficult to distinguish between normal and pathological data because the equipment employed by the above mentioned authors was a hand-machine.

To remedy this weak point an electrically driven equipment, or electrical goniometer, was devised by Honjo and Furukawa.

Furukawa (1957)[3], and Honjo and Furukawa (1957)[4] studied goniometer test and reported extensive results obtained by using an electrical goniometer deviced by Honjo and Furukawa (Fig. 1). According to their descriptions, in order to determine the most available angular velocity for differentiating normal from lesions of vestibular system, subjects were inclined by six kinds of angular velocity, such as 1°, 3°, 5°, 10°, 15° and 20°/sec. For their studies 280 normal subjects and 118 patients with vestibular disturbance were tested. From results obtained by their studies, Furukawa concluded that an angular veslocity of 1°/sec is the most available for goniometer test. In addition, Furukawa studied

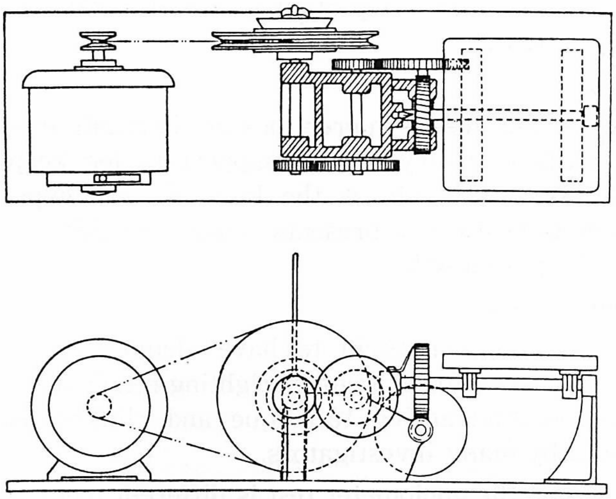


Fig. 1. Electrical goniometer (Honjo and Furukawa 1957)

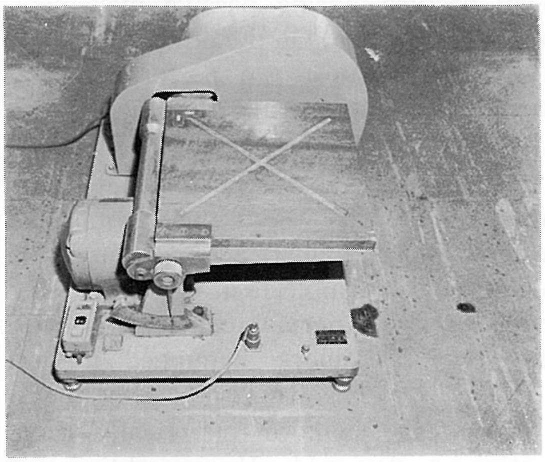


Fig. 2. Improved electrical goniometer (Honjo and Tsujikawa 1961).

some influences of visual factors and electromyographical findings on the legs and trunk in the goniometer test.

In 1961 Honjo and Tsujikawa[5] improved on the electrical goniometer devised by Honjo and Furukawa in 1957. Fig. 2 shows the new electrical goniometer which inclines from horizontal plane to 30° at angular acceleration of 1.4°/sec^2 and a constant angular velocity of 1.0°/sec. From the normal erect posture on the horizontal plank of the goniometer each subject is inclined forwards, backwards and to both sides. During the inclination the subject keeps his eyes open or closed. In goniometer test we record the angles at which the subject falls from the plank.

RECORDING METHODS OF RIGHTING REACTION

Attempts have been made to record the results of righting reaction tests in order to take an objective view of equilibrium responses of human body in static condition since ancient times.

1. Cephalography.

Cephalography was used for recording the results of the static function tests at the beginning. In this method the minute movements of the subject's body in erect posture are recorded as a cephalogram on the surface of a flat paper covered with soot, with the sharp needle being attached to the top of the subject's head. In this way, cephalogram shows a locus of the body movements, and in normal subjects the range of a locus is limited to a small circle while in cases with disequilibrium a locus is described over a wide range.

2. Photography-Motion picture.

Motion picture of the human subjects in erect posture has been taken for recording the righting reactions. As already above mentioned, Takata (1973) studied the righting reactions in normal subjects by using 16 mm high speed motion picture camera-HYCAM.

3. Electromyography.

Electromyography is outstanding to analyse the actions of muscular fiber and to determine the characteristics of the reflexes caused by various stimulus. This method has been, therefore, used to study the righting reaction and by using this method a number of reports have been presented by many authors since up to date.

4. Acceleration registrography.

Mechanical-electrical transducer enables to change a mechanical quantity into a electrical quantity. Recently by utilizing this principle, in order to record the body movements of human subjects, various kinds of transducer have been used by many investigators. For example, Coats (1973) recorded body sway of human subjects in both anteroposterior and lateral planes using a standard precision potentiometer connected to the subject. The principle of the strain-gage as a transducer was discovered by Load Kelvin in 1856. Strain-gage has been applied not only in measuring the strain and stress of material under test, but in constructing many kinds of transducers in technology. Since then strain-gage-type transducers have been introduced into the medical studies, for example blood and intra-ocular pressure have been measured and masticatory force has been measured by Katsuki et al (1957). Jongkees and Groen about twenty years ago recorded acceleration components of the head movements in walking of human subjects by using an induction-type accelerometer as a transducer.

Kitahara (1957) was the first to describe an acceleration resistrography. He studied equilibrium of human subjects and recorded the body movements of human subjects on erect posture by using a bonded resistance wire strain-gage type linear accelerometer as a transducer. We propose to explain mechanism of this accelerometer. This accelerometer placed on the top of the subject's head enable to change mechanical quantity of body movements into electrical quantity of resistance (Fig. 3). This accelerometer consists of two pairs of resistance wires placing the

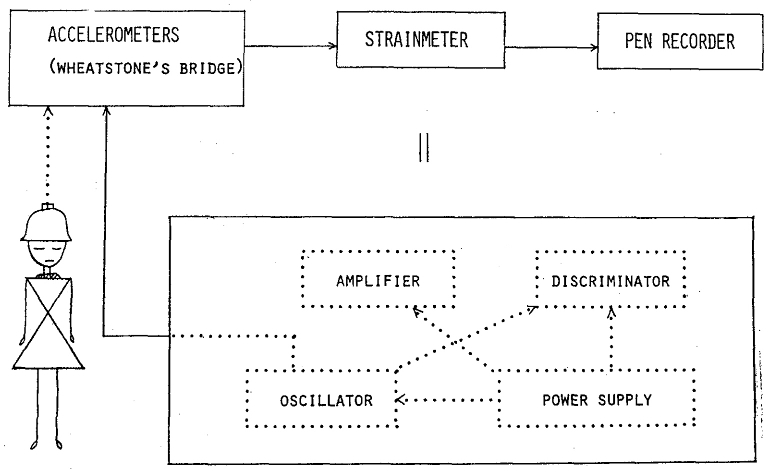


Fig. 3. Diagram of equipments for recording the righting reaction in erect posture.

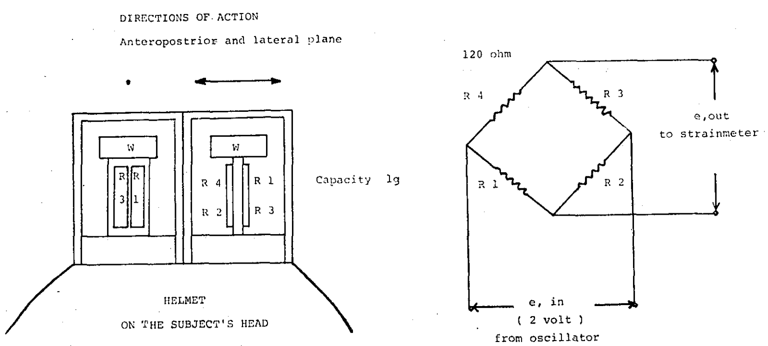


Fig. 4. Diagram of two bonded resistance wire strain-gage type accelerometers.

inertia mass. These two pairs of resistance wires are connected in Wheatston's bridge. If the deviation of the inertia mass occurs on account of head movements, the tension of one pair of resistance wire is increased, while that of the other is decreased (Fig. 4). In this condition, electrical resistance changes and consequently potential is generated in the Wheatston's bridge. The bridge is activated by an oscillator, so that the sine wave of the oscillator frequency is modulated by the signal wave. The output of the bridge circuit is applied to an amplifier and then to silicon diode disriminater (Fig. 3). The output of this descriminater is then led to a pen writing recorder. The output of these instruments is potential which is proportional to the head movements.

In order to measure body movements of subjects, two accelerometers of which directions of action are lateral or anteroposterior planes are used. These accelerometers are firmly to the head of the subject, so that when the subject body moves they incline.

According to Kitahara, curves obtained by acceleration resistrography are named "acceleration resistrogram", and curves on the resistrogram are divided into two types: 1. a high frequency wave; and 2. a low frequency one. The high frequency wave is caused by any kind of linear accelerations, be it the gravitational acceleration or the acceleration of non-uniform movements. An amplitude of this wave is considered to be an index to the amount of head swaying.

The low frequency wave is also caused by any kind of linear accelerations as well as the former wave.

RESULTS OF OUR PRESENT STUDIES ON RIGHTING REACTION RECORDED BY ACCELERATION RESISTROGRAPHY.

In the last decade, the studies of righting reaction on erect posture have been engaged in our Department of Yamaguchi University Medical School and a number of papers have been reported by our colleagues.

In order to record the righting reaction in human subjects, a bonded resistance wire strain-gage type accelerometer (Kyowa Dengyo AS-1C) was used (Fig. 3. and 4). Mechanical characteristics of the accelerometer used by our Department are as follows: 1. Capacity, 1g; 2. Frequency range, 0–57 Hz; 3. Input resistance, 121.7 ohm and output resistance, 121.7 ohm; 4. Sensitivity of output, full scale 0.4605 mA/V (Strain 92×10^{-6}); 5. Non-linearity, 1.0% full scale.

A dynamic strain amplifier (KYOWA DENGYO DPM-110A) was used

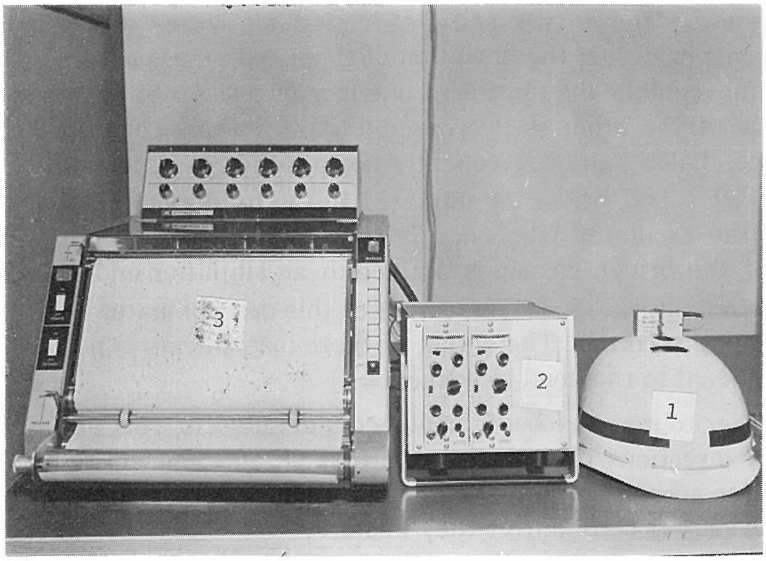


Fig. 5. Equipments for examination of righting reaction.
1. Accelerometers fixed on the helmet.
2. Dynamic amplifier.
3. Pen writing recorder.

as an oscillater, amplifier and discriminater. The output of the dynamic strain amplifier is led to a pen writing recorder (Fig. 5).

Examination methods of righting reaction in our Department are 1. Romberg test, Mann's test and goniometer test with eyes open and closed.

1. Tsujikawa (1965[6] and 1966[7]) studied righting reaction by static function tests in normal subjects by using acceleration resistrography. The subjects tested were 20 normal adults aged from 22 to 33 years.

The subject stands on for 40 seconds in Romberg and Mann's tests, and stands on the plank of goniometer till falling down from the plank. In each test an acceleration resistrogram (ARG) was recorded.

Waves of each ARG are composed of two elements, such as deviation and amplitude. Tsujikawa estimated deviation and amplitide in each ARG at a constant interval of two seconds, and sum them up every ten seconds; the first (Section I), the second (Section II), the third (Section III) and the fourth (Section IV). After that he calculated a mean value and standard deviation, and also did the t-test for statistical evaluation.

a. Acceleration registrograms (ARG) in Romberg test.

ARG in Romberg test with eyes opened or closed are composed of waves associated with a slight deviation, short amplitute (less than 0.1 g)

Table. 1. Deviation and Amplitude obtained from ARGs of normal standing position. Mean value in each Section

	Section Eyes	I 0″-10″	II 10″-20″	III 20″-30″	IV 30″-40″
1. Deviation*	Opened	0. 95±0. 07	1. 45±0. 10	1. 23±0. 11	2. 50±0. 15
	Closed	1. 30±0. 03	1. 85±0. 09	2. 05±0. 13	2. 85±0. 18
2. Amplitude**	Opened	2. 05±0. 22	1. 08±0. 11	0. 91±0. 13	1. 08±0. 15
	Closed	2. 08±0. 22	1. 08±0. 16	1. 00±0. 11	1. 55±0. 13

Notes: *) distance from the basal line (unit± mm).
**) acceleration (unit=0. 01g)

Table. 2. Results of the t-test (α=0. 05, t =2. 023) concerning the amplitude of ARGs in normal standing position.

1. Correlation between two sections, respectively.

	I : II	I : III	I : IV	II : III	II : IV	III :
Eyes Opened	2. 2436*	2. 7708*	2. 1704*	0. 6952	0. 7503	0. 4956
Eyes Closed	2. 3384*	2. 5812*	2. 4410*	0. 3884	1. 5172	1. 0632

2. Correlation between the groups of eyes opened and closed in each Section.

	I	II	III	IV
	0. 3128	0. 5518	0. 7035	1. 2720

Notes: *; Statistically, significant. No mark; Statistically, non-significant.

and 40 seconds without falling. Table I shows the periodical changes of deviation and amplitude of ARG in Romberg test. The deviation reveals a tendency to increase at time goes on, and the deviation during the eyes closed is generally larger than that of the eyes opened. In both of eyes opened and closed, the amplitude of section I is twice larger than the others (Sections II-IV). By t-test (Table 2) the following results are demonstrated: 1. Significant difference is proved in the amplitutes between Section I and the others, however, it is denied among Section II, III anb IV; 2. In eavh Section on significant difference is proved in the amplitudes between the groups of eyes opened and closed.

b. Acceleration resistrogram (ARG) in Mann's test.

Regardless of the foot situated anteriorly, ARGs in Mann's test with eyes opened are essentially similar to the ARG of Romberg test. However, the former is composed of somewhat larger waves in amplitude that the later.

Table. 3. Deviation and Amplitude Obtained from ARGs in Mann's Position. Mean value in each Section.

	Foot situated anteriorly	Section / Eyes	I 0°–10°	II 10°–20°	III 20°–30°	IV 30°–40°
1. Deviation*	Left	Opened	0.58±0.08	0.93±0.12	1.50±0.13	2.30±0.22
		Closed	1.67±0.10	1.08±0.20	2.00±0.19	2.70±0.25
	Right	Opened	1.15±0.13	1.55±0.14	1.58±0.14	1.88±0.16
		Closed	1.85±0.15	1.88±0.08	2.00±0.10	2.88±0.12
2. Amplitude**	Left	Opened	2.55±0.15	1.33±0.13	1.55±0.15	1.80±0.16
		Closed	4.55±0.19	2.91±0.15	3.13±0.21	3.30±0.24
	Right	Opened	2.51±0.17	1.25±0.13	1.13±0.08	1.71±0.15
		Closed	4.33±0.37	2.46±0.17	2.91±0.27	3.33±0.01

Notes: *) distance from the basal line (unit=mm)
**) acceleration (unit=0.01g)

Table. 4. Results of the t-test (α=0.05, t=2.023) concerning the amplitude of ARG is in Mann's position.

1. Correlation between two Sections, respectively.

Eyes	Foot situated anteriorly	I : II	I : III	I : IV	II : III	II : IV	III : IV
Opened	Left	3.5031*	2.8059*	2.2614*	0.7268	2.2250*	2.0055
	Right	2.7013*	3.1657*	2.6321*	0.4928	2.0019	2.4102*
Closed	Left	3.2561*	2.9974*	2.6834*	1.3200	0.6898	0.9230
	Right	3.0968*	2.8644*	2.6432*	1.3130	2.6185*	0.6659

2. Correlation between the groups of eyes opened and closed in each Section

Foot situated anteriorly	I	II	III	IV
Left	3.5338*	3.7998*	2.8631*	2.9092*
Right	3.8520*	3.0513*	3.5541*	3.0024

3. Correlation between the groups of the left and right foot situated anteriorly in each section

	I	II	III	IV
Eyes opened	0.3104	0.2981	2.205*	0.4638
Eyes closed	0.2598	2.3317*	0.3476	0.3792

Notes: *) Statistically, significant.
No mark; Statistically, non-significant.

ARG with the eyes closed shows larger waves than that of eyes opened. These waves are entirely of medium amplitde.

Table 3 shows the periodical changes of deviation and amplitude of ARG in Mann's test. The deviation reveals a tendency to increase as time goes on, and the deviation during the eyes closed is larger than that of the eyes opened. In both of the eyes opened and closed, the amplitude of Section I is twice larger than that of Sections II and III. In each Section the amplitude of the group of eyes opened is larger than that of the eyes closed. By the t-test (Table 4) the following results are summarized: 1. Significant difference is proved in the amplitude between the group of Section I and the others, however, it is denied among Sections II, III and IV; 2. In each section significant difference is proven in amplitude between the groups of eyes opened and closed; 3. In each Section no significant difference is proved between the groups of the left and right foot situated anteriorly.

c. Acceleration registrogram (ARG) in goniometer test.

ARG in goniometer test is essentially different from ARG in Romberg and Mann's tests due to the waves of large amplitude (more than 0.25g) which indicates a falling of the subjects from the plank of the goniometer. Table 5 shows periodical changes of the deviation and amplitude of ARG in goniometer test. As shown in Table 5 inclination of the body movements at Section II is twice larger than that of Section I and inclination of the body at the time of eyes closed is larger than that of eyes opened. In both of the eyes opened and closed, the amplitude of Section II is larger than that of the eyes closed. By the t-test (Table 6) the following conclusions are obtained: 1. No significant difference is proved in amplitude of the ARG in the goniometer with eyes opened between the groups of Sections I and II. On the other hand, significant dlfference is proved in amplitude of the ARG in goniometer test with eyes closed between the Sections I and II. In each Section significant difference is proved in amplitude of ARG in goniometer between the groups of the eyes opened and closed; 2. In each Section no significant difference is proved between the groups of the left and right inclination of the goniometer.

2. Nishimura (1967)[8] studied righting reactions in patients with vertigo by recording acceleration resistrogram (ARG). He examined 86 patients, such as, circumscribed labyrinthitis 6, Meniere's disease 13, head injury 8, congenital deafness 28, sudden deafness 3, streptomycin poisoning 3, labyrinthine lues 2, cervical vertigo 3, spinal ataxia 1, epilepsia 5, congenital nystagmus 5, and cardiovascular diseases 9.

Table. 5. Deviation and Ampltiude obtained from Gonio-ARGs.
Mean value in each section.

	Side of Inclination	Section / Eyes	I 0°-10°	II 10°-20°
1. Deviation*	Left	Opened	2.23±0.23	5.83±0.34
		Closed	3.20±0.28	8.56±0.53
	Right	Opened	3.54±0.30	5.75±0.44
		Closed	3.50±0.29	8.73±0.46
2. Amplitude**	Left	Opened	4.13±0.33	4.33±0.41
		Closed	6.75±0.78	9.30±0.64
	Right	Opened	4.05±0.47	4.47±0.57
		Closed	6.78±0.58	9.66±0.57

Notes: *) distance from the basal line (unit=mm)
**) acceleration (unit=0.01g)

Table. 6. Results of the t-test (α=0.05, t=2.023) concerning amplitude of Gonio-ARGs.

1. Correlation between the sections.

Eyes	Side of inclination	I : II
Opened	Left	1.3328
	Right	0.9769
Closed	Left	2.5637*
	Right	3.0019*

2. Correlation between the groups of eyes opened and closed in each section.

Side of inclination	I	II
Left	3.2117*	4.8296*
Right	3.4099*	3.9160*

3. Correlation between the groups of the left and right inclination in each section.

Eyes	I	II
Opened	0.1580	0.5316
Closed	0.8221	1.2211

Notes: *) Statistically significant.
No mark; Statistically, non-significant.

a. ARG in cases with circumscribed labyrinthitis.

In Romberg position, waves of ARG in this disease shows that deviation of the waves are slightly more than that in normal subjects. In Mann's position, waves of ARG reveals a definite deviation to the affected side, particularly with eyes closed. In Goniometer test, it is clear that deviation of the waves of ARG shows the difference between inclination to the affected side and that to the opposite side, particularly with eyes closed.

b. ARG in cases with Meniere's disease.

Romberg position, it is difficult to differentiate between the waves in this disease and that in normal subjects, even with eyes closed. In Mann's position, deviation of the waves in ARG corresponds to the fall direction of subject's body, particularly with eyes closed, which indicates the affected side. In Goniometer test, ARG shows that in active periods waves deviates to the affected side particularly with eyes closed and in periods of remission deviation of the waves corresponds to that of normal subjects.

c. ARG in cases with head injury.

In these cases, waves of ARG represent various patterns due to the localization of the injury, for instance in cases with the head injury in the temporal area waves of the ARG deviate mostly to the affected or opposite sides and on the other hand in cases with the parietal or occipital areas a large amplitude is seen in the waves of ARG.

d. ARG in deafmutes.

With regard to the labyrinthine responses, deafmutes are classified into three groups, such as 1) normal response, 2) hypo-response and 3) no response.

In deafmutes with normal or hypo-response of the labyrinth, waves of ARG correspond to these in normal subjects. On the other hand in deafmutes with no response of the labyrinth, falling down during Romberg or Mann's position is present in a half of cases (56%) and a large body sway movements are seen in the remainders. Therefore wave of ARG in deafmutes with no response of the labyrinth reveal shorter than that of normal subjects.

e. ARG in cases with sudden deafness.

In cases with severe vertigo, waves of ARG represent deviation to the affected side.

f. ARG in cases with streptomycin poisoning.

In cases with this disease, waves of ARG show slightly deviation to the affected or opposite sides.

g. ARG in cases with cardiovascular diseases.

In generally, in cases with these diseases waves of ARG represent slightly deviation to laterally or back wards.

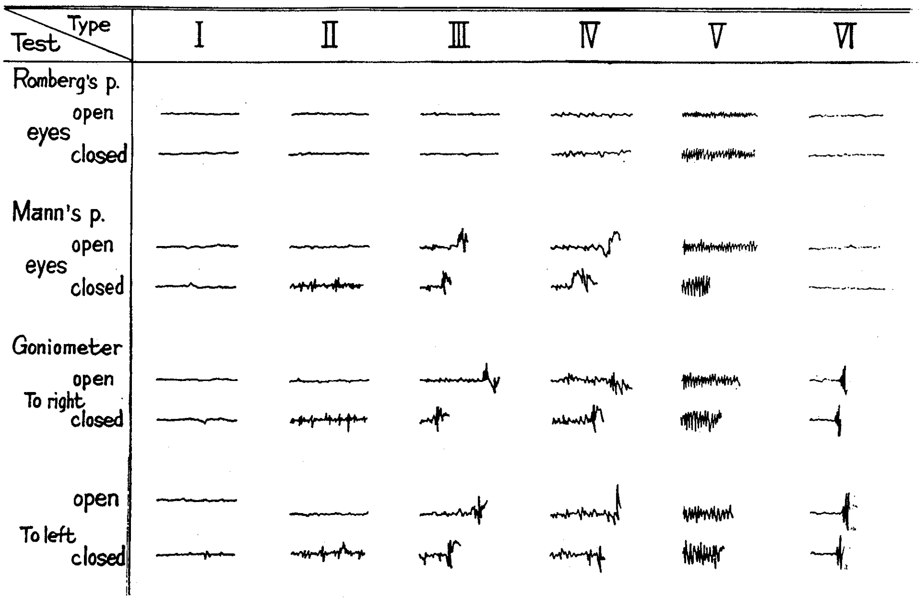
3. Honjo and Ishihara (1971)[9] studied righting reaction in cases with complaining vertigo by using acceleration resistrography. All subjects were examined by Romberg and Mann's positions and by Goniometer test. Acceleration resistrogram (ARG) obtained by the above mentioned methods are divided into six types in comparison with those of normal subjects (Table 7).

Type I. Waves of ARG obtained by three tests are within normal limits with eyes opened or closed.

Type II. Waves of ARG obtained by Mann's position and Goniometer test with eyes closed show larger than those of normal in amplitude and frequency otherwise in normal.

Type III. Waves of ARG obtained by Mann's position with eyes opened or closed and Goniometer test with eyes opened or closed reveal larger than those of normal subjects in frequency and amplitude notwithstanding ARG of Romberg position is normal.

Table. 7. Classification of 54 patients with Type of ARG.
Schematic view for six types of
A.R.G. test's results on 54 cases of dizziness



Type IV. Waves of ARG obtained by three tests above mentioned show larger than those of normal in frequency or amplitude.

Type V. Waves represent abnormal peculier spike in all tests.

Type IV. Waves of ARG obtained by only Goniometer test show larger than normal in frequency and amplitude with eyes opened and closed.

Ishihara (1975)[10] studied reghting reactions in cases complaining vertigo by using acceleration resistrography. He examined 54 patients (28 males and 26 females) ranged from 15 to 65 years of age. Diagnostic category of the patients examined is as follows: 1. Meniere's disease, 17; 2. Head injury, 14; 3. Chronic middle ear infection, 6; 4. Labyrinthine lesions, 6; 5. Cardiovascular diseases, 6; and ohers 5.

Table. 8. Classification of 54 patients with Type of ARG.

Type	Number	Meniere's disease	Head injury	Chronic middle ear infection	Labyrinthine lesions	Cardiovascular diseases	Others
I	15	6	4	3	1	1	
II	17	6	5	2	1	1	2
III	9	2	2	0	3	1	1
IV	4	0	2	1	0	1	0
V	2	0	0	0	0	0	2
VI	7	3	1	0	1	2	0
Total	54	17	14	6	6	6	5

ARG of these 54 patients are composed of the types (Honjo and Ishihara) shown in Table 8.

Judging from results obtained by his studies on classification of ARG in patients complaining vertigo, it is of importance to keep in mind that the types of ARG (Honjo and Ishihara) represent a standard of disturbances in righting reaction without regard to diagnostic category.

4. Yamada (1968)[11] studied optokinetic influences on righting reactions in 20 normal subjects (medical students in our University), 10 deafmutes and 98 patients with complaining vertigo. As optical cylinder, an optical drum 150 cm in diameter and 80 cm height was used. There were twelve vertical black strips, 5 cm wide in the inside of the drum. It was placed a tripode by means of a hang from the ceiling. The drum was rotated around the subjects with two kinds of speed such as 30°/sec and 120°/sec. All subjects stood on Mann's position for 30 sec.

Table. 29. Falling time of subjects under condition that optical cylinder rotates with 30°/sec.

Subject	Number	1–10	11–29	30–(seconds)
Normal	20	0	1	19
Deafmute	10	2	1	7
Head injury	22	5	3	14
Meniere's D	20	2	4	14
Hypertension	13	1	2	10
Hypotension	8	0	1	7
ST. poisoning	8	1	2	5
Sudden deaf.	7	1	2	4
Congenital Nyst.	7	0	1	6
Sea sickness.	3	1	0	2
Hormonal D.	3	0	0	3
Eye disease	3	1	0	2
Circumscribed labyrinthitis	2	2	0	0
Tabes dorsalis	1	0	1	0
Multiple sclerosis	1	0	0	1
Total	128	16	18	94

Table. 10. Falling time of subjects under condition that optical cylinder rotates with 120°/sec.

Subject	Number	1–10	11–29	30–(seconds)
Normal	20	1	4	15
Deafmute	10	1	1	8
Head injury	22	8	2	12
Meniere's D.	20	7	7	6
Hypertension	13	5	4	4
Hypotension	8	0	2	6
ST. potsoning	8	3	0	5
Sudden deafness	7	4	0	3
Congenital N.	7	1	1	5
Sea sickness	3	1	1	1
Hormonal D.	3	0	0	3
Eye disease	3	2	0	1
Circumscribed labyrinthits	2	2	0	0
Tabes dorsalis	1	1	0	0
Multiple sclerosis	1	0	0	1
Total	128	36	22	70

Falling time of the subjects tested under condition that optical cylinder rotates with 30°/sec is illustrated in Table 9. As shown in Table 9, the majority of normal subjects enable to stand on for above 30 sec, except one subject falls down during 11–29 sec. In 10 cases of deafmutism, two cases fall down within 10 sec and one case falls during 11–29 sec. As to 98 patients with vertigo, fourteen patients fall down within 10 sec and sixteen patients fall down during 11–29 sec. The remainders (68 patients) enable to stand in Mann's position for above 30 sec. Falling time of the subjects tested under condition of cylinder rotation with 120°/sec is illustrated in Table 10. As shown in Table 10, the majority of normal subjects enable to stand on for above 30 sec, except one subject falls down within 10 sec and four subjects fall during 11–29 sec. In 10 cases of deafmutism, each one casi falls down within 10 sec and during 11–29 sec. The remainders (8 cases) enable to stand for above 30 sec. In 98 patients with vertigo, thirty four patients fall down within 10 sec and seventeen patients fall down during 11–29 sec. The remainders (47 patients) enable to stand on for above 30 sec.

SUMMARY

In this paper, clinical studies of righting reactions which have been investigated by our colleagues in the Dept. of Otolaryngology for the last decade were reviewed.

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