

# POSTUROGRAPHIC CHARACTERISTICS OF WHIPLASH PATIENTS

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## ABSTRACT

47 middle aged patients (Mean C.A. = 40.8; SD = 12.8) referred to the Jerusalem Posturographic Clinic for orthopedic and postural examinations were tested with the Tetrax Interactive Balance System based on the assessment of the interaction of vertical pressure fluctuations on four independent platforms, one for each heel and toe part, respectively.

33 patients suffered from moderate to severe whiplash injuries, whilst 14 were non traumatized patients with neck problems. due to degenerative processes linked with aging,.

30 age matched normal subjects with no known pathology served as controls.

Results showed that whiplash patients are characterized by a typical postural syndrome, which clearly and significantly differentiates between them and the non traumatized neck patients (as well as the normal Ss) :

- a) A conspicuous destabilization caused by the occlusion of vision.
- b) Turning the head in the saggital plane (up/down) leads to a more pronounced postural disturbances in comparison the postural irritation induced by turning the head horizontally ( left/right).
- c) There is a tendency to put excessive weight on the heels, even when turning the head backwards, a non functional postural response increasing the risk of fall.
- d) The coordination movements between heels and toes (synchronisations ) are impaired,.

Non traumatized neck patients differ from normal subjects only by a marginally significant lower stability on positions involving head turning, with no specific directional effect. Whilst the deviant postural responses in the whiplash group are affected by the severity of the injury, there is no relationship between the latter and the time elapsed since the accident. In the total patient population there is also no relationship between age and the postural scores. However within separated patient groups, worse postural performance tends to be positively correlated with age in the non traumatized neck patients - a plausible finding - whilst in the whiplash group the relationship is strikingly inverse, indicating that functions related to postural control are more severely impaired in younger victims of accidents.

## INTRODUCTION

Whiplash injury is a central problem of contemporary medicine in light of the growing volume of surface traffic and the subsequent increase of fatal road accidents on the one hand and the high complexity of its diagnostic, therapeutic and medico-legal implications which still await satisfactory elucidation, on the other(1)(2). The neuro-anatomical focus of the whiplash trauma is the cervical region which, besides containing the muscles and vertebrae which support the head, harbours all the neurological pathways and blood vessels connecting the brain with the rest of the body, besides an array of nuclei controlling posture and coordination of the lower extremities, in spite of being anatomically remote from the neck. Thus theoretically, there is no system or function of the human body which could NOT be affected by the whiplash trauma, not to speak of the psychological impact of the accident and its handicapping sequelae (3)(4). This fact by itself is already a source of major practical complications: The whiplash patient is prone to be diagnosed and treated by an array of medical specialists, each responsible for the specific neurophysiological aspect of the injury. (i.e. orthopedics, ENT specialists, neurologists, psychiatrists, specialists in rehabilitation, physical medicine, vascular diseases, etc.) However there is no obligatory or recommended administrative and clinical coordination of the multidisciplinary medical effort involved. This lack of coordination is the cause of many problems:

- a) The patient is "shopping" from one doctor to the other without finding relief to his suffering, often being tortured by conflicting medical advice.
- b) There is an imminent danger of iatrogenic aggravation, due to one specialist ignoring a basic problem which is not within the range of his competency, eventually recommending contra-indicative treatment.
- c) Consequently both, patients and insurance companies may incur large unnecessary expenses.

A second problem area are the limits of adequate diagnostic instrumentation to clarify the various symptoms. Many evaluations of the Whiplash patient are based mainly on clinical examinations and impressions. The most popular tools used to objectify the patients complaints are X rays, CT and MRI examinations, as well as the electro-nystagmographic techniques (5). However their ultimate reliability and validity in the specific case of whiplash traumatization is not satisfactory. The fact that the ENG focuses on vestibular-oculomotor and much less or not at all on the vestibular-cervical and vestibular-spinal loops essentially involved in whiplash injuries is a case in point.

The third problem is the long term effect of the whiplash trauma which may last up to ten years and more (6)(7). Here again we are faced with the

inadequacy of traditional diagnostic tools. Practice has shown that grave subjective complaints persist in the Whiplash patients which are far beyond doubt to be fake or aggravation, as in most cases the patient has already been financially compensated for his disease and has no motive to simulate (8)(9). Still most if not all objective diagnostic procedures yield negative results.

The fourth problem is the psychological effect of the accident, which may cause fears anxieties often defined as Post Traumatic Stress Disorder (PTSD). Furthermore the restriction of physical activity, work capacity and social interaction imposed by the symptoms, is an additional source of psychological tension, frustration and worries (10)(11)(12).

The differential diagnosis and assessment of the true versus artificial symptoms is a basic problem for the medico-legal expert. Also in this area reliable instrumentation is lacking and the expertise is based on the subjective impression of the specialist based more or less on the subjective complaints of the patients, as interpreted by the former.

In this paper we present some preliminary findings documenting the potential contribution of a recently developed posturographic method (TETRIX INTERACTIVE BALANCE SYSTEM)\* to the elucidation of the medical and medico-legal problems outlined above. We shall first describe the specific parameters and the general rationale of the method and hereafter proceed to report the statistical results obtained by its application in a sample of Whiplash patients, as compared to normal subjects and to non traumatized patients with neck problems, mainly due to endogenous, degenerative processes.

## **METHOD**

The basic rationale of Interactive Posturography is different from traditional posturographic methods which essentially measure of the displacement patterns of the point of gravity, in that it focuses on the interaction of sway patterns obtained on four independent platforms, one for each heel and toe part.

The five basic parameters of Interactive Posturography (alternatively designated in literature as "Tetra-ataxiometry") are described below:

### *(1) GENERAL STABILITY*

General stability measures the amount of sway over the four plates and is an indicator of the subject's overall steadiness. It is independent of the subject's weight and height. The higher its value the greater the subject's INSTABILITY. This parameter correlates substantially with measures of "AREA OF SWAY", "LENGTH OF SWAY", "SWAY VELOCITY",

"DISPLACEMENT PATTERNS OF THE POINT OF GRAVITY", etc. obtained by traditional posturographic systems (13). However, General Stability, by virtue of being an independent parameter among other tetra-ataxiometric measures, described later, has turned out to be a valuable and valid measure of postural COMPENSATION. I.e. it may be normal, whilst other tetra-ataxiometric criteria may show aberrations, indicative of covert, eventually well compensated pathology. The Index of General Stability is assessed by computing the integral of vertical pressure fluctuations at a sampling rate of 34 Hz, taking into account the weight of the subject.

## (2) SYNCHRONISATIONS

By virtue of obtaining four separate traces of body oscillations, produced by the two heel and toe plates of the Interactive Balance System, it is possible to compare the output of two separate plates as to their respective interactive pattern. This comparison yields six possible measures, by juxtaposing heel and toes of each foot (2), the two heels and toes respectively (2) and heel vs. contra-lateral toes - (2) (diagonal synchronisations). When comparing these paired traces it becomes evident that the relationship within these pairs is either mutually "compensatory" or mutually "co-active", i.e. the traces may proceed in somewhat symmetrical fashion (compensation) or else run quasi parallel. (co-action). The mathematical expressions of these interactions are "Synchronisation Indices", which range from -1000 (perfect compensation) to +1000 (perfect coactivity). Synchronisation values around zero would indicate *absence* of synchronisation, *i.e. desynchronisation*. These measures appear to be sensitive to disturbances of the coordination and concertation of the muscle system controlling the steadiness of the lower limbs and body parts. Such disturbances may be due to orthopedic problems, but may also be related to central nervous dysfunctions (14).

## (3) FOURIER TRANSFORMATIONS

The Fourier Transformation Scores reveal the intensity of postural sway within frequency ranges known to be sensitive to typical abnormal patterns postural sway. These ranges are:

- Low Frequencies - below 0.1 Hz
- Lower Medium Frequencies - 0.1 - 0.5 Hz
- Higher Medium Frequencies - 0.5 - 1.00 Hz
- High Frequencies - above 1.00 Hz

According to empirical research based on various posturographic methods it appears that excessive sway in these frequency ranges reflects intensified activity within the major postural subsystems, either due to

pathology or to compensatory efforts. High intensity at LOW range generally reflects normal functioning of the postural system, controlled by intact visual-vestibular interaction. Deviant intensity within the LOW MEDIUM (0.1/0.5 Hz) range indicates activity of the peripheral vestibular system which typically occurs under moderate postural stress or in case of peripheral vestibular disturbances. Intensified sway at HIGH MEDIUM RANGE (0.5/1 Hz) reflects the mobilisation of somatosensory reactions mediated by the motor apparatus of the lower extremities, the spine and lower back. HIGH FREQUENCY OSCILLATIONS are generally a sign of central nervous involvement, eventually manifest in postural tremor.

#### *(4) WEIGHT DISTRIBUTION.*

Weight Distribution Measures are expressed in the form of weight percentages put on each of the four foot-plates and are self explanatory. It is possible to observe asymmetry in weight distribution between left and right foot, between heels and toes, between heel and toe of each foot, as well as diagonal anomalies.

#### *(5) POSTURAL RESPONSE PATTERNS ON EIGHT POSITIONS*

An additional dimension of the Interactive Balance System is the pattern analysis of the postural performances measured by the above described parameters over eight standard positions described below.

- 1. Eyes open, solid surface. (NO)* This is the easiest position. The postural response on this position is often used as a point of reference, to compare the performance on the more stressful items.
- 2. Eyes closed, solid surface. (NC)* This is the classical Romberg Test, which can be measured objectively, by dividing the Stability on NC by the Stability on NO, which yields a measure designated in posturographic literature as *Romberg Quotient* (17).
- 3. Eyes open, elastic surface (on foam-rubber pads) (PO).* Abnormal findings during this test may stem from visual problems as in this position somato-sensory input is restricted and visual input becomes more crucial. On the other hand, patients with orthopedic problems tend to improve their performance, as the elastic support may be easier tolerated in cases of motor handicap than the stress induced by hard and harsh surfaces.
- 4. Eyes closed, elastic surface (PC).* This position implicitly involves vestibular stress, as both, visual and somato-sensory input are restricted.

5. and 6. *Head turns right and left, respectively, at about 45 degrees, eyes closed.* (HR and HL) These positions are informative when performances on HR and HL are discrepant, whilst normal Ss do not show any difference in postural responses on these two items.

7. *Head backwards at about 30 degrees, eyes closed.* (HB). This position is difficult, because on the one hand the visual input is excluded whilst the peripheral vestibular system is irritated, as the semicircular canals are put in an abnormal position. On the other hand this position produces stress on the cervical-vestibular circuits to which Whiplash injuries are particularly sensitive. In this position weight is normally displaced forwards to compensate for the backward tilt. In persons with high risk of falling, a contra-effective weight displacement in posterior direction can be observed.

8. *Head downwards at about 30 degrees, eyes closed* (HF). This position also is similar to HB in its sensitivity to cervical, especially cervical vestibular problems.

For a detailed description of the Tetrax Interactive Balance System see (15).

## SUBJECTS

Subjects in this study are 48 patients referred to the Jerusalem Posturographic Clinic for general clinical evaluation, as well as for special orthopedic and posturographic examinations. They represent a random sample of the routine intake of the clinic. 33 of the patients were victims of road accidents, showing typical signs of whiplash injuries. 16 patients suffered from mild to severe neck problems caused by natural degenerative changes due to age without any previous history of trauma.

The Whiplash sample was further subdivided into two groups: Cases with severe vs moderate pathology. The clinical criteria of this subdivision were as follows: Mobility of neck and upper trunk. General mobility. Complaints of chest pains, headache, vertigo and dizziness, general work capacity, X rays showing degree of injury to spine.

Finally 30 subjects matched for age and sex with the clinical cases served as controls. They had no history of psychological or physical problems. (See Table 1)

		N	mean ± SD
ORIGINAL SAMPLE	WHIPLASH SEVERE	14	38 ± 10.3
	WHIPLASH MODERATE	19	37 ± 12.5

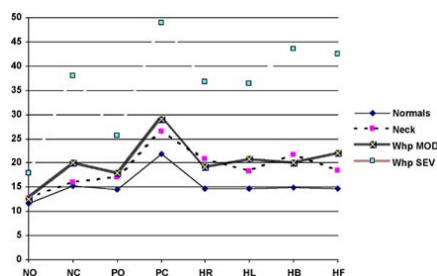
*Table 1 Sample  
\*: age difference  
significant at  $p < .01$*

	NON TRAUMATIZED NECK PATIENTS	14	49* ± 8.7
	NORMALS	30	37 ± 9.5
AGE MATCHED CLINICAL SAMPLE (Ss under age of 30 excluded)	WHIPLASH SEVERE	11	45 ± 9.16
	WHIPLASH MODERATE	12	48 ± 5.12
	NON TRAUMATIZED NECK PATIENTS	14	49 ± 8.7

As the sample was based on random intake, the chronological age of the neck patients turned out to be significantly higher, an expectable consequence of the etiology of their pathology related to aging. (Table 1). In order to allow for a rigorous statistical comparison of the two clinical groups, an age matched subsample was selected post hoc, by excluding traumatized patients under the age of 30, which reduced the whiplash sample from 33 to 23. (See Table 1). Subsequently results were separately computed and numerically plotted for the original population and the age matched clinical subsample. (See Tables 2 to 6) However as neither significant nor systematic differences were observed between the results obtained in the subsample and in the original population, Figures present only the findings obtained in the latter. In addition to chronological age, temporal distance from the accident was taken into consideration as an additional intervening variable. The latter ranged from to 2 weeks to 3 years. (Data not tabulated).

## RESULTS

As shown on Table 1 and Figure1 Whiplash patients (WHP) are significantly less stable than both, not traumatized neck patients (NTNP) and normal controls. Inspecting results separately for moderately and severely injured WHP, (Table 1 and Figure 2), the moderately traumatized tend to merge with the NTPP, except for the position of standing with eyes closed on solid surface (NC) and turning the head downwards (HF).



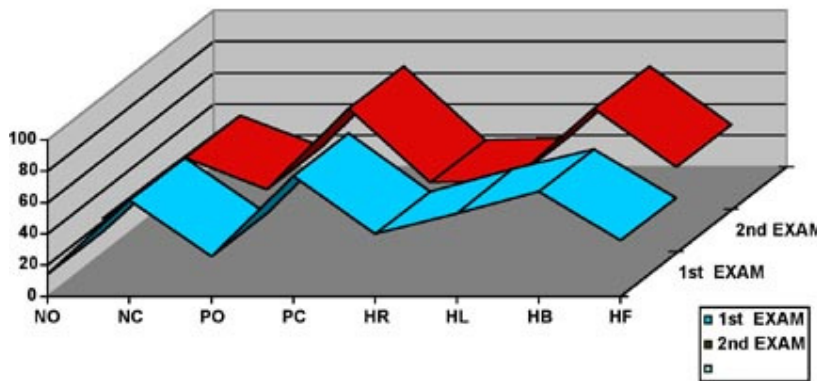
*FIG. 1 - Patterns of general stability in normals, patients with neck problems and patients with moderate and severe whiplash injuries.*

On the other hand a rather pronounced typical "Posturographic Whiplash Pattern" emerges in the group of the severely traumatized subjects: It is characterized by two steep peaks within the range of the four positions with head straight (NO, NC, PO, PC). The two peaks are produced by the sharp discrepancy between the performance with eyes open vs eyes closed (NO vs NC and PO vs PC). Furthermore the effect of turning the head has a generally destabilizing effect which is conspicuously more severe, when the head is turned in the *saggital* plane. (Up-down, i.e. positions HB and HF).

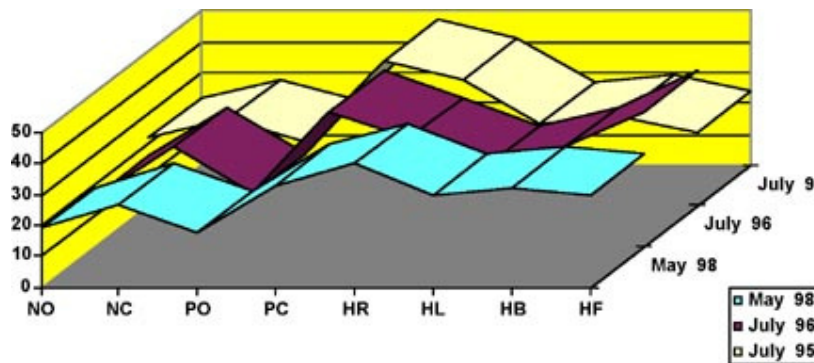
POSITION	(a)WHP. SEV.	(b) WHP. MOD.	© N.T.N.P.	(d) NORMALS	F3.73 *of one way ANOVA
	N=14 N=11 M SD	N=19 N=12 M SD	N=14 M SD	N=30 M SD	
EYES OPEN [NO]	bcd <b>18.0</b> (4.5) bcd <b>17.1</b> (4.3)	<b>12.8</b> (2.7) 12.5 (2.4)	<b>12.4</b> (4.0)	<b>11.2</b> (4.7)	7.48
EYES CLOSED [NC]	bcd <b>37.4</b> (17.0) bcd 39.0 (18.4)	cd <b>20.0</b> (6.2) 19.7 (6.4)	<b>14.9</b> (6.1)	<b>15.2</b> (4.8)	22.85
EYES OPEN ON PADS [PO]	bcd <b>25.2</b> (9.0) bcd 22.9 (8.0)	d <b>18.1</b> (5.4) 17.1 (4.5)	<b>16.8</b> (4.2)	<b>14.5</b> (4.1)	11.79
EYES CLOSED [PC]	bcd <b>48.4</b> (23.4) bcd 50.3 (23.4)	d <b>29.2</b> (6.0) d 28.5 (6.2)	<b>25.6</b> (15.9)	<b>21.9</b> (8.2)	13.01
HEAD RIGHT [HR]	bcd <b>37.1</b> (16.5) bcd 38.5 (17.0)	d <b>19.2</b> (6.7) 19.1 (9.5)	<b>19.2</b> (11.2)	<b>14.7</b> (6.3)	16.81
HEAD LEFT [HL]	bcd <b>35.7</b> (18.1) bcd 36.8 (18.8)	d <b>20.8</b> (7.9) d 20.3 (18.5)	<b>17.7</b> (7.2)	<b>14.7</b> (4.9)	15.70
HEAD UP [HB]	bcd <b>43.4</b> (27.1) bcd 46.5 (28.9)	d <b>19.9</b> (7.6) d 19.6 (5.5)	<b>20.1</b> (12.9)	<b>14.8</b> (4.8)	14.55
HEAD DOWN [HF]	bcd <b>41.9</b> (20.7) bcd 40.6 (21.7)	d <b>22.3</b> (19.9) d 20.9 (18.0)	<b>17.1</b> (7.1)	<b>14.7</b> (5.4)	19.71

*TAB.2 - General stability in normals, whiplash & non-traumatized neck patients. (Higher scores indicate greater instability)  
 p of all F values <.001. a, b, c, d indicate significance of difference (post hoc t - test) at p =.05 at least in relation to number on same row in column designated by respective letter.  
 On all subsequent tables numbers in italics refer to the matched clinical sample*

This pattern is well reflected on the records of two whiplash patients shown on Figures 2a and 2b, retested twice and three times respectively at intervals ranging from 2 to 12 weeks.



*FIG. 2 A - Posturographic profile of stability in a whiplash patient retested after two weeks*



*FIG. 2 B - General Stability of Whiplash Patient retested three times at intervals of 12 and 22 months.*

POSITION	(a) WHP. SEV.	(b) WHP. MOD.	(c) N.T.N.P	(d) NORMALS	F 3, 73
	N=14 N=11 M SD	N=19 N=12 M SD	N=14 M SD	N=30 M SD	
NO	<i>b,c,d</i> <b>27.3</b> (11.37)	<b>19.1</b> (8.65) 12.9 (7.60)	<b>18.7</b> (10.70)	<b>17.4</b> (8.65)	1.69 N.S.

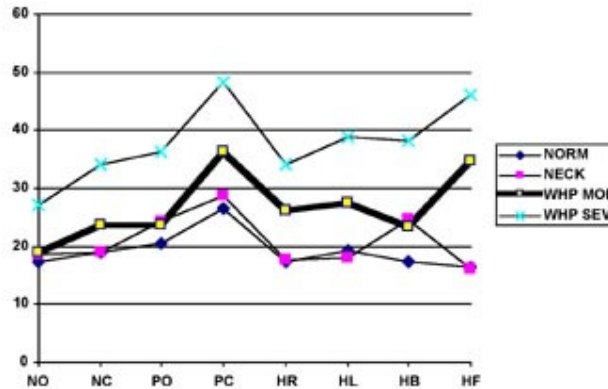
	24.5 (10.79)				
NC	<b>34.0</b> (20.32) <i>c,d</i> 34.8 (22.25)	<b>23.6</b> (12.05) 25.5 (13.48)	<b>19.1</b> (10.25)	<b>19.0</b> (9.84)	4.80 *
PO	<i>b,d</i> <b>36.4</b> (20.24) <i>b,d</i> 33.8 (19.68)	<b>23.7</b> (9.60) 22.9 (10.31)	<b>24.2</b> (11.50)	<b>20.7</b> (9.58)	5.20 **
PC	<i>b,d</i> <b>48.2</b> (26.18) <i>c,d</i> 46.8 (22.36)	<b>36.4</b> (14.39) 32.1 (12.78)	<b>28.8</b> (14.81)	<b>26.4</b> (13.94)	5.75 ***
HR	<b>34.2</b> (20.83) <i>c,d</i> 33.2 (16.82)	<b>26.2</b> (15.04) 27.0 (17.56)	<b>17.6</b> (10.46)	<b>17.3</b> (8.03)	6.14 ***
HL	<b>38.8</b> (24.17) <i>b,c,d</i> 38.0 (23.05)	<b>27.6</b> (13.91) 25.3 (17.85)	<b>18.1</b> (11.0)	<b>19.3</b> (9.32)	7.07 ***
HB	<b>38.3</b> (31.12) <i>b,d</i> 38.8 (30.60)	<sup>d</sup> <b>23.3</b> (9.42) 21.4 (7.89)	<sup>d</sup> <b>24.7</b> (14.27)	<b>17.4</b> (6.72)	5.53 ***
HF	<b>46.1</b> (27.78) <i>c,d</i> 42.4 (24.86)	<b>34.7</b> (23.19) <i>c,d</i> 28.9 (15.41)	<b>16.7</b> (5.90)	<b>16.3</b> (7.60)	11.78 ***

*Table 3 - Intensity of low frequency sway (0,1 Hz) in normals, whiplash and non traumatized neck patients.*

*\* p =.05 \*\* p =.01 \*\*\* p =.001 Legend of letters see Table 2*

Although the «posturographic whiplash pattern» does not seem to characterize the moderate WHP when considering their general stability, ( Table 1 Figure 1) it is clearly visible when inspecting the pattern of low frequency intensities of the Fourier Spectrum on Table 3 and Figure 4. These findings are in line with Gagey's observations, who reports that low frequency sway ( 0.2 Hz) is typically increased in whiplash patients (16).

*FIG. 3 -  
Pattern of  
intensity of  
low  
frequency  
sway in  
normals,  
patients  
with neck  
problems  
and patients  
with  
moderate  
and severe  
whiplash  
injuries.*



As Stability Scores (in contrast to the Fourier measures) are indicators of compensatory forces (14), it appears that the moderate WHP have learned to compensate and to control their symptoms, as evident in their relatively good stability (Fig 1), whilst still manifesting the deviant postural whiplash pattern on their Fourier scores (Fig 4).

Closer inspection of Table 2 and Figure 1 reveals that the WHP differ conspicuously from both, the NTNP and the normal controls when comparing the effect of occluded vision on postural performance, whilst standing on solid surface. (NO vs NC). This effects can be conveniently assessed by the Romberg Quotient (RQ), already described above (17). As shown on Table 4 and Fig 4, whilst the RQ of the NTNP is completely normal, the latter is significantly deviant in both the moderate and severe WHP, differentiating also within the WHP group between the moderately and severely injured in expected direction.

(a) WHP. SEV.	(b) WHP. MOD.	© N.T.N.P.	(d) NORMALS	F 3, 73
N=14 N=11 M SD	N=19 N=12 M SD	N=14 M SD	N=30 M SD	
<i>bcd</i> <b>22.8</b> (13.75) 24.7 (14.7)	<i>c</i> <b>15.8</b> (4.1) 16.1 (4.7)	<b>12.1</b> (2.26)	<b>13.7</b> (3.90)	7.47 8.61

TAB. 4 - Romberg quotient in normals, whiplash and non traumatized neck patients. p of F VALUES <.001

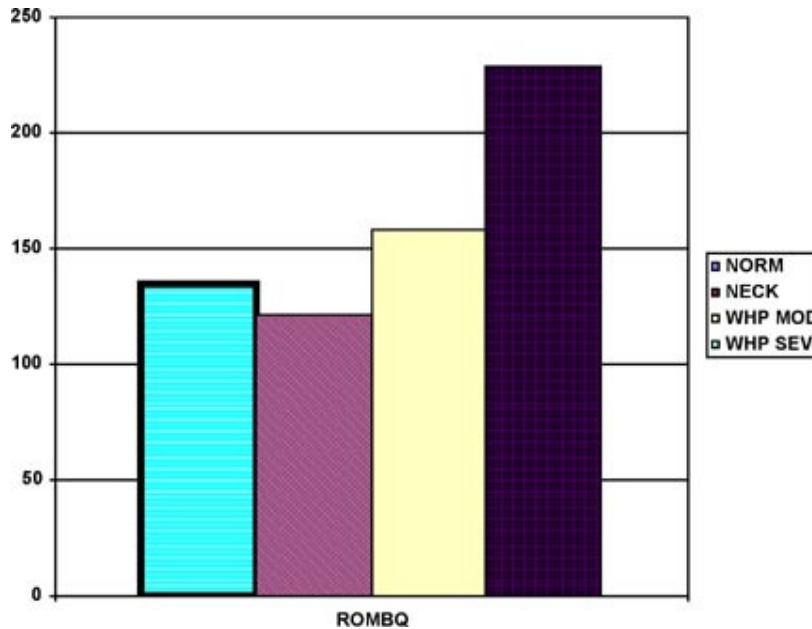


FIG. 4 - Comparison of Romberg quotients in normals, patients with neck problems and patients with moderate and severe whiplash.

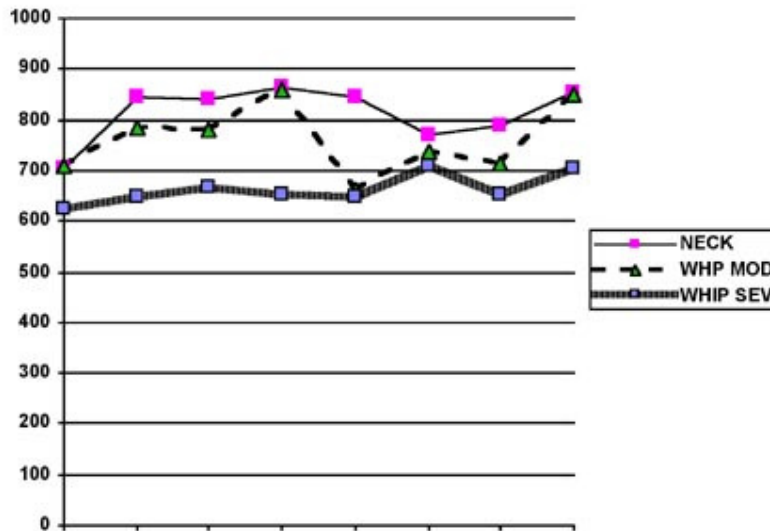
Another tetraaxiometric parameter which differentiates between the WHP and NTNP is "Synchronisation", described above. As shown on Table 5 and Fig. 5, synchronisation in the severe WHP is significantly lower on the two positions with head straight and eyes closed (NC and PC), as well as with head turned right and upwards (HR, HB), in comparison to both, normals and NTNP, the latter showing consistently normal synchrony scores.

POSITION	(a) WHP. SEV.	(b) WHP. MOD.	© N.T.N.P.	(d) NORMALS	F3.70
	N=14 N=11 M SD	N=19 N=12 M SD	N=14 M SD	N=30 M SD	
NO	<b>625</b> (269) 602 (267)	<b>710</b> (244) 687 (287)	<b>706</b> (245)	<b>704</b> (183)	N.S. N.S.
NC	<b>650</b> (220) 642 (228)	<b>785</b> (141) 813 (128)	<b>843</b> (106)	<b>706</b> (206)	3.60 3.49
PO	<b>669</b> (396) 708 (333)	<b>778</b> (138) 781 (156)	<b>842</b> (137)	<b>729</b> (203)	N.S. N.S.
PC	<b>652</b> (297) 686 (232)	<b>861</b> (80) 851 (89)	<b>865</b> (119)	<b>789</b> (165)	4.77 3.12
HR	<b>650</b> (245) 676 (260)	<b>662</b> (246) 714 (178)	<b>845</b> (135)	<b>765</b> (142)	3.16 2.33
HL	<b>708</b> (270)	<b>738</b> (208)	<b>770</b> (161)	<b>694</b> (190)	N.S.

	686 (246)	746 (152)			N.S.
HB	<b>705</b> (254) 730 (250)	<b>848</b> (83) 857 (64)	<b>856</b> (108)	<b>796</b> (178)	3.16 N.S.
HF	<b>653</b> (324) 648 (333)	<b>712</b> (226) 689 (264)	<b>787</b> (151)	<b>714</b> (186)	N.S. N.S.

*TAB. 5 - Synchronisation scores in normals, whiplash & non traumatized neck patients  
p of F Values =.05*

The synchronisation responses of the moderately injured WHP is not clear cut. In positions with head straight their synchronisations are normal and close to the NTNP. Head turning, especially to the left tends to induce desynchronisation, widening the gap in comparison to the NTNP, whilst narrowing it in comparison to the performance of the severely injured WHP. As these trends are statistically not significant, it is difficult to explain them.



*FIG. 5 - Synchronisation in non-injured patients with neck problems and patients with moderate and severe whiplash injury.*

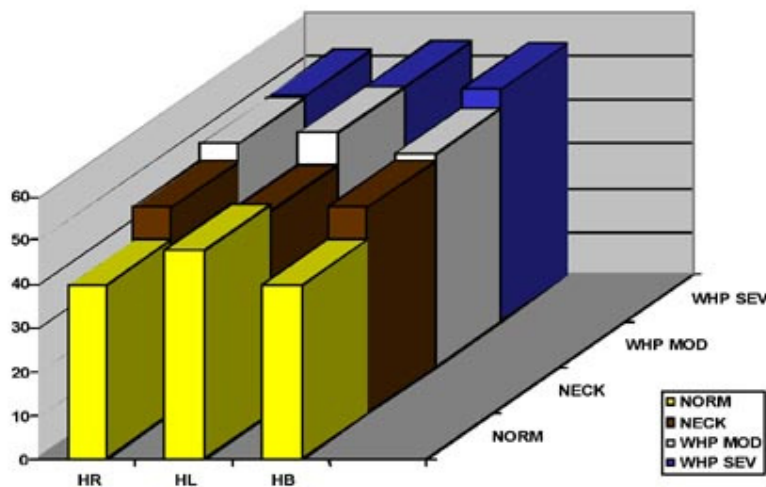
Finally, as presented on Table 6 and Fig. 6 in positions of right lateral and upward head turn an excessive transfer of weight on the heels can be observed in the the severe WHP, as compared to the NTNP and normals, which however disappears after the exclusion of the younger Whiplash subjects.

Such a postural response is obviously contra-effective to keeping the body erect. Lifting the head up and back is normally compensated by transferring the point of gravity in anterior direction to prevent the

dangerous fall backwards. Falling forwards, anticipated by a natural anterior weight shift, on the other hand, is protected by automatically outstretching our hands as buffers, a reaction known as the "parachute reflex" already present in the infant. It appears as if in the the WHP the parachute reflex and its antecedent, the forward weight shift, has been inhibited or is non functional. This might in part explain the high incidence of falling in whiplash patients, often inducing a secondary trauma and serious complications of the primary insult.

POSITION	(a) WHP. SEV.	(b) WHP. MOD.	© N.T.N.P.	(d) NORMALS	F 3. 73
	N=14 N=11 M SD	N=19 N=12 M SD	N=14 M SD	N=30 M SD	
HR	<b>51.5</b> (10.83) 4.8 (10.9)	<b>50.9</b> (12.56) 49.6 (5.44)	<b>47.4</b> (8.66)	<b>39.8</b> (12.29)	5.14 NS
HB	<b>53.0</b> (15.88) 47.7 (4.44)	<b>48.9</b> (12.47) 49.9 (4.18)	<b>47.4</b> (11.36)	<b>40.1</b> (8.97)	4.57 NS

*TAB 6 - Weight percentage on heels on positions head right and head back in normals, whiplash and non traumatized neck patients.  
p of F Values <.01*



*FIG. 6 - Comparison of weight shifts on heels in normals, neck patients and patients with moderate and severe whiplash on positions with head turn to the right, left and*

*backwards.*

As to the time elapsed between trauma and date of clinical examination, no relationships were found between this variable and all the other intervening and dependent variables of the study, namely chronological age, degree of injury and handicap, as well as all the investigated posturographic parameters.

Chronological age, the main intervening variable appears to be well controlled by the parallel evaluation of the original and age matched clinical sample, demonstrating that the findings of the study are not affected by age. with the possible exception of the "non functional heel shift" described above, apparently linked to an "inverse" age effect, i.e. being more pronounced in subjects injured during their twenties. However by further investigating age effects by computing correlations between age and posturographic variables WITHIN SEPARATE clinical groups (WHP vs NTNP) the following results were obtained (data not tabulated) :

As to the Romberg Quotient, Heel Pressure and Fourier Frequencies no correlations were found between age and these parameters within the separate clinical groups. However Stability measures for positions PC (eyes closed on pads), HR (head right) and HB (head back) correlated significantly ( $p < 0.5$ ) and negatively with chronological age in the NTNP, i.e. it appears that the ELDER patients tend to be less stable, eventually are less able to compensate. In the Whiplash group this relationship was insignificant but consistently POSITIVE reflecting weaker stability in the YOUNGER patients. This "discrepancy" of the age effects between the two groups stands out conspicuously, when evaluating synchrony scores: Within the NTPT group the correlation between age and synchronisation is  $r = -.75$  ( $p < .01$ ), i.e. the *elder* the patient, the weaker his pedal coordination. In the Whiplash group the relationship is strikingly inverse, i.e.  $r = +.44$  ( $p < .05$ ), i.e. the *younger* the subject, the greater the impairment of normal synchronisation movements. It is evident that these mutually inverted age effects are canceled out in the collapsed sample, where zero correlations obtain throughout for all relationships between age and posturographic parameters. Neither are these age effects unmasked by the exclusion of the younger whiplash subjects from the sample, except possibly in the context in of assessing the heel displacement effects, which by the way are consistent with the direction the correlations. Whilst the findings in the Neck Patients are plausible and might be anticipated, - elder NTPT are more severely affected by their disease, - the result in the Whiplash group point in an unexpected, possibly unknown or not duly noticed direction, i.e. that younger subjects appear to be more vulnerable to whiplash injuries. A possible explanation of this greater vulnerability might be the elasticity of

the soft tissues at younger age, which eventually reduces the resistance to the concussion.

## **CONCLUDING REMARKS**

1st) The study revealed a typical posturographic Whiplash Profile, indicating that postural stability is typically affected by ocular occlusion and saggital head turning.

2nd) Furthermore it was shown that the classical Romberg test, as objectively assessed by the Romberg Quotient, is highly abberant in the Whiplash patient and correlates conspicuously with the degree of injury. This finding suggests, that the possibility of transient or eventually lasting damage to the CNS, should not be easily excluded in the severely injured whiplash case. (18) (19). The negative Romberg definitively characterizes the non injured neck patient as a reliable criterion of differential diagnosis.

3rd) The IBS reveals a reduction in the efficiency of flexible heel toe coordination in the whiplash case, which is more pronounced in the younger patient. Again it is absent in the non traumatized neck patient.

4th) A contra-effective excessive weight shift on heels seems to be involved in whiplash injuries, responsible for the high risk of falling in this clinical group. The phenomenon, again, it is "paradoxically" related positively to lower age.

5th) The fact that the IBS parameters, characterizing the whiplash patient are highly specific, mutually independent and essentially not related to postural sway per se, guarantees that the Whiplash profile cannot be faked and that simulators can be easily detected. In addition it is obvious that the complex IBS test profile cannot be reproduced by the simulator upon request and retest.

Finally, as these postural patterns may persist, eventually in weakened form, after considerable time after the accident (5 to 10 years) IBS posturography, may help to explain and to justify the symptoms of patients whose injury occurred many years before and whose complaints are generally not verified by traditional clinical tests.

Generally it may be stated, that IBS posturography may serve as a valuable ancillary tool to elucidate and evaluate the general and medico-legal problems of Whiplash injuries.

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