



# Laterality and asymmetries of the orthostatic posture

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## ABSTRACT

Man's body has a large number of asymmetries, some are in relation with regulation of the tonic postural activity, we generally name them asymmetries of the orthostatic posture and others are in relation with phenomena of cortical lateralization, we sometimes name them gestural asymmetries. The correlation between these two types of asymmetries is a controversial subject. And actually this study presents facts that are incoherent: either the correlation is very strong or very low between these two types of corporal asymmetries. A possible signification of these inconsistencies is discussed which seems to highlight the role of the vision.

**Keywords:** BODY ASYMMETRIES, VISION, REGULATION OF THE TONIC POSTURAL ACTIVITY

## INTRODUCTION

The postural asymmetries have been the subject of many global studies<sup>(1-6)</sup> or more specific ones in relation with the entries of the upright postural control system (UPCS): the vestibular imbalances<sup>(7, 8)</sup> or the asymmetries of visual entry<sup>(9, 10)</sup>. The specific relations between laterality -- or gestural asymmetries (GA) -- and asymmetries of the orthostatic posture (AOP) as those studied by Jais<sup>(5, 6, 11)</sup>, are less explored and their results stayed contradictory<sup>(12, 13)</sup>.

We chose here to study at first the AOP which are related to the walk to verify their correlation with the dominant eye. It is indeed well-known in some sporting circles that the direction of the gaze controls the trajectory, and many popular sentences reflect an intuition of this correlation: "watch your step", "watch where you put your feet". In addition, a correlation between the inequality of length of the lower limbs and the dominant eye has been already highlighted during podiatric consultations<sup>(14)</sup>.

Under certain conditions, the correlation between the dominant eye and the AOP related to the walk confirms surprisingly powerful, while in other circumstances, this correlation almost disappears. The role of the cortical dominance in this correlation deserves to be discussed, this correlation could simply be due to the role of vision in postural control.

These inconsistencies between the dominant eye and AOP have they any clinical significance?

## MATERIAL AND METHODS

### Population

The files of 8.200 patients consulting at a podiatric office have been retrospectively examined. The patients were consulting for functional disorders of the posture from cervical

muscle tension to foot sufferings including lombo-pelvic junction, the patellofemoral syndrome, etc.

### Cohorts

To name the cohorts we use the very simple notation proposed by Jais which covers all the possible combinations of GA<sup>(5)</sup>: a capital letter indicates that the dominant organ, Eye, Hand, Foot is on the right, for example "EHF", a small letter indicates that the dominant organ, eye, hand, foot is on the left, for example "ehf". Five cohorts have been constituted whose number is varying according to the frequency of combinations which they represent (table 1).

EHF, 88 indicates that 88 subjects having a right dominant eye, a right dominant hand, a right dominant foot have been selected to constitute the cohort named: "EHF".

### Comparison of the cohorts

The EHF cohort has been compared successively to the four other cohorts to study the changes of correlation induced by the change of laterality of a single (EHf; EhF; eHF) or all (ehf) dominant organs.

### Clinical tests

Eight tests, systematically practiced, have been chosen for each patient. They define the hand, foot and eye laterality and the AOP in relation to the walk at the level of the neck, the pelvis and the lower limb.

### Test of the pierced paper

A central hole of 1 cm in diameter is pierced into a card. The patient takes a visual cue approximately 5 meters away, then holding the card with both hands arms outstretched,

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he aligns the hole with the chosen cue and moves the card closer on his face. The eye toward which the hole approaches is considered as the dominant eye.

**Push test**

The patient is standing motionless, the examiner pushes him on the back, the foot which comes first is considered as the dominant foot. This test is repeated at least three times. If the answer does not indicate clearly a foot, then, according to da Cunha and Alves da Silva<sup>(15)</sup>, the foot which is the less sagittal is considered as the dominant foot.

**Write test**

The hand with which the patient writes is considered as the dominant hand.

**Limitation of the rotation of the head**

The patient is standing in spontaneous position, the examiner placed behind him, asks him to turn the head as far as possible on one side and the other. He notices the side of the limitation of the head rotation (which corresponds to a hypertonia of the opposite side).

**External rotation of the hip**

The patient is in a supine position, relaxed, his feet on the table. The examiner notices the foot which is the most in external rotation.

**Inequality of the lower limbs.**

The subject is put successively in decubitus and in ventral decubitus position. The position of the anterior superior and posterior superior iliac spines relative to the position of medial malleolus allows to qualify the relative length of the two lower limbs<sup>(14, 16)</sup>.

**Hypertonia of the pyramidal muscle**

The patient is in ventral decubitus position, his legs are bent to a 90-degree angle, hamstring relaxed. The examiner imparts a passive movement of internal rotation to the thighs and sees which one turns the least.

**Strength of the flexor hallucis (ou hallucis) longus muscle**

The patient is sitting, vertebral column arched, horizontal look, teeth in usual mandibular position, knees and bare feet bent to a 90-degree angle. The examiner places his index and middle fingers under the pulp of the big toe and asks the

patient to press strongly<sup>(17)</sup>. The difference in force a clinician is able to measure is as precise — about 100g — than that of a dynamometer<sup>(18)</sup>.

**Statistical analysis**

The qualitative variables describing the results of the clinical tests by the side (right or left) and the importance of the hypertonia of the AOP, named “AOP variables” have been used as ordinal qualitative variables, except for the contingency tables from which questionable results are eliminated.

The principal component analyses focused on laterality factor with two modalities, right or left, after verification of normality, and if necessary the normalization, of distribution of the AOP variables. To ensure greater clarity in the presentation of graphics, the subjects too superimposed on plane-projection, to the point of being confused, have been dissociated.

The frequencies of contingency tables have been studied, depending on the available number of subjects, either by  $\chi^2$  test or by likelihood ratio using  $G^2$  statistics of Wilks which follow the law of  $\chi^2$ .

**RESULTS**

**Comparison of the cohorts EHF and ehf**

The principal components analysis on the projection corresponding to F1 and F2 axes really distinguishes the EHF and ehf cohorts, noted respectively R and L (fig.1). The separation of the cohorts appears along the F1 axis, principally correlated with PY (0.832) and LF (0.800).

Plane-projection of the subjects of the EHF cohort (R) and ehf cohort (L) located in a five dimensional point cloud according to their coordinates on the AOP axes, noted: NE = limitation of the head rotation; RC: External rotation of the hip; PY: Hypertonia of the pyramidal muscle; JC: Inequality

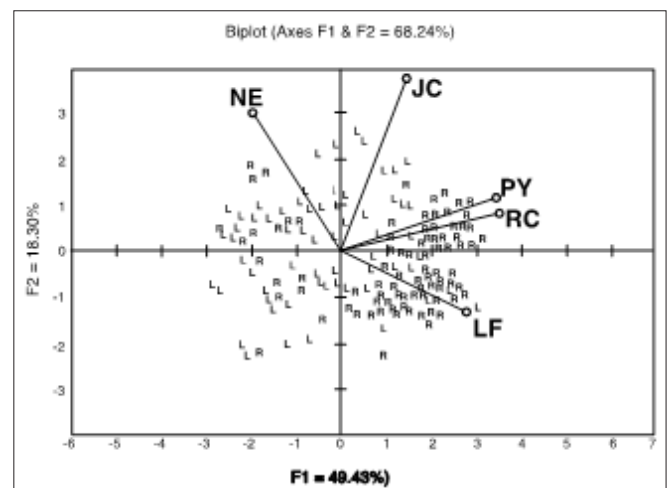


Figure 1. Principal component analysis of laterality factor with two modalities, R and L, of the EHF and ehf cohorts, described by the AOP variables.

Table 1. Composition and number of the 5 cohorts.

Name of the cohort	EHF	Ehf	EHf	EhF	Ehf
Number	88	69	31	60	60



of the lower limbs; LF: Strength of the flexor hallucis longus muscle. This projection, on the F1 and F2 axes, only presents 68.24% of the point cloud variability.

The  $\chi^2$  test (Table 2) confirms that the dichotomy R/L observed on principal component analysis is not an artifice of projection; there is a very strong correlation between the AOP and lateralities.

**Comparison of the cohorts EHF and EhF**

The principal components analysis, on the projection corresponding to F1 and F2 axes, does not distinguish the EHF and EhF cohorts, noted respectively R and L (fig. 2).

Plane-projection of the subjects of the EHF cohort (R) and the EhF cohort (L) located in a five dimensional point cloud according to their coordinates on the AOP axes, noted: NE = limitation of the head rotation; RC: External rotation of the hip; PY: Hypertonia of the pyramidal muscle; JC: Inequality of the lower limbs; LF: Strength of the flexor hallucis longus muscle (table 3). This projection on the F1 and F2 axes only presents 67.94% of the point cloud variability.

**Comparison of the cohorts EHF and EHF**

The principal components analysis, on the projection corresponding to F1 and F2 axes, does not distinguish the cohorts EHF and EHF, noted respectively R and L (fig. 3).

Plane-projection of the EHF cohort (R) and the EhF cohort (L) subjects located in a five dimensional point cloud according to their coordinates on the APO axes, noted: NE = limitation of the head rotation; RC: External rotation of the hip; PY: Hypertonia of the pyramidal muscle; JC: Inequality of the lower limbs; LF: Strength of the flexor hallucis longus muscle (table 4). This projection, on the F1 and F2 axes, only presents 65.16% of the point cloud variability.

**Comparison of EHF and eHF cohorts**

The principal components analysis, on the projection corresponding to F1 and F2 axes, really distinguishes the EHF and eHF cohorts, noted R and L respectively (fig.4). The separation of the cohorts appears along the F1 axis, principally correlated with PY (0.883) and LF (0.811).

Plane-projection of the EHF cohort (R) and the eHF cohort (L) subjects located in a five dimensional point cloud according to their coordinates on the AOP axes, noted: NE = limitation of the head rotation; RC: External rotation of the hip; PY: Hypertonia of the pyramidal muscle; JC: Inequality of the lower limbs; LF: Strength of the flexor hallucis longus muscle (table 5). This projection, on the F1 and F2 axes, only presents 70.03% of the point cloud variability.

**Table 2.** Contingency table crossing the five qualitative AOP variables of the EHF and ehf cohorts.

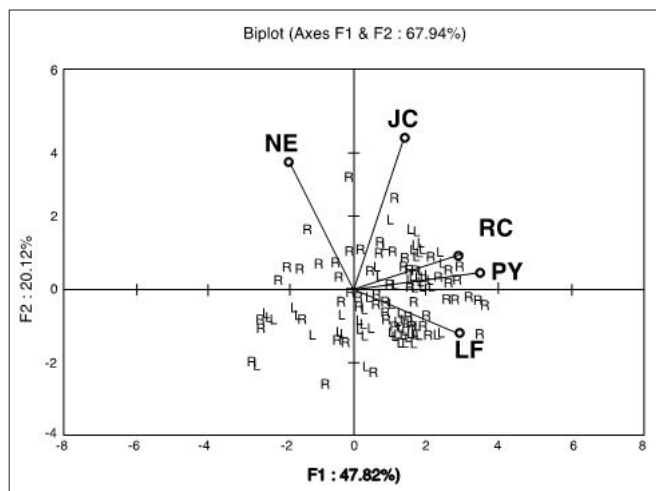
	NE		LF		JC		RC		PY	
	L	R	L	R	L	R	L	R	L	R
EHF	70	10	17	67	2	29	18	65	16	53
ehf	28	29	53	9	12	18	28	37	20	29

Questionable responses have been eliminated.  $\chi^2$  test. ( $\chi^2 = 107.55$ ; ddl: 9;  $p > 0.0001$ .)

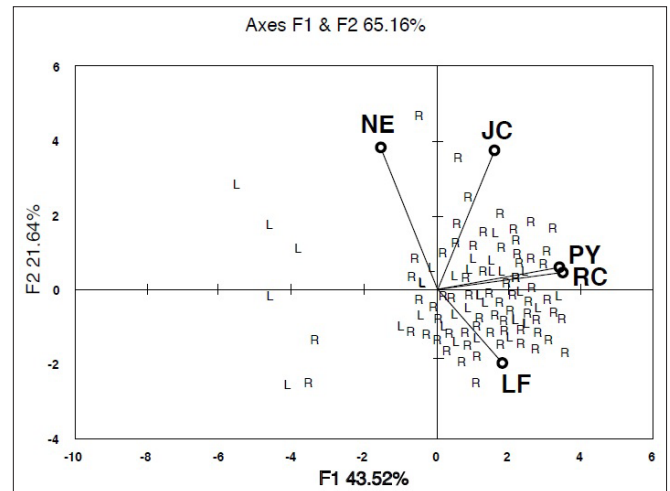
**Table 3.** Contingency table crossing the five AOP of the EHF and EhF cohorts.

	NE		LF		JC		RC		PY	
	L	R	L	R	L	R	L	R	L	R
EHF	70	10	17	67	2	29	18	65	16	53
EhF	49	6	17	39	3	25	13	47	5	34

G<sup>2</sup> test of Wilks; (G<sup>2</sup>=6.25; ddl: 9; ns).



**Figure 2.** Principal component analysis of the laterality factor with two modalities, R and L, of the EHF and EhF cohorts, described by the AOP variables.



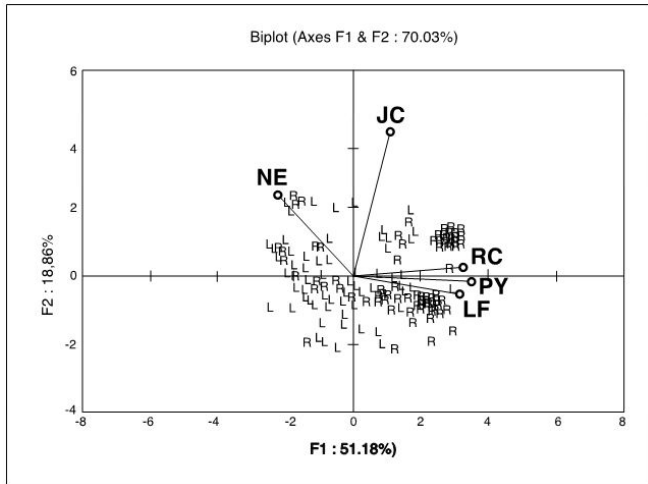
**Figure 3.** Principal component analysis of the laterality factor with two modalities, R and L, of the EHF and EHF cohorts described by the AOP variables.



**Table 4.** Contingency table crossing the five AOP of the EHF and EhF cohorts.

	NE		LF		JC		RC		PY	
	L	R	L	R	L	R	L	R	L	R
EHF	70	10	17	67	2	29	18	65	16	53
Ehf	28	2	6	24	1	9	5	23	5	21

G<sup>2</sup> test of Wilks. (G<sup>2</sup>=1.59; ddl: 9; ns).



**Figure 4.** Principal component analysis of the laterality factor with two modalities, R and L, of the EHF and eHF cohorts, described by the AOP variables.

**Table 5.** Contingency table crossing the five AOP of the EHF and eHF cohorts.

	NE		LF		JC		RC		PY	
	L	R	L	R	L	R	L	R	L	R
EHF	70	10	17	67	2	29	18	65	16	53
eHF	31	18	50	8	12	13	32	25	27	11

χ<sup>2</sup> test (χ<sup>2</sup> = 125.73; ddl: 9; p<0.0001).

## DISCUSSION

According to controversies noted in literature, we find that the correlation between AOP and the GA depends on the compared cohorts. This absence of necessity of a strong correlation between AOP and GA suggests that these asymmetries have some sort of independence. And therefore, it is said that the frequency of right-handed/left-handed is in the range of 50/50% for the AOP<sup>(2, 9)</sup> whereas it is in the range of 90/10% for the GA<sup>(19)</sup>. This relative independence between the AOP and the GA is confirmed by Janin’s researches on lateralities and Gentaz’s on the postural eye<sup>(9, 20)</sup>.

For a correlation to appear between AOP and GA, it needs just that the dominant eye should not be on the same side in each compared cohorts, for example when we compare the EHF and ehf cohorts (table 2) or the EHF and eHF cohorts (table 5). If the dominant eye is on the same side in the compared cohorts, regardless of the hand or foot dominant side, the correlation between AOP and GA disappears, for

example when we compare the EHF and EhF cohorts (table 3) or the EHF and EhF cohorts (table 4).

This importance of the dominant eye in the determination of the correlation between AOP and GA can be compared to what we know of the role of vision as entry of the UPCS. The vision, regardless the side of the dominant eye, organizes the AOP<sup>(1, 2, 3, 21, 22)</sup>.

This work explores a series of GA combinations which dissociate the side of the dominant organs — they are not all on the right or on the left —, these “dissociated combinations” are less frequent than the two others; we have no right to conclude that they are “abnormal” but we can recall that a Jaïs’s work pointed out that the frequency of some functional postural disorders were more important within some of these dissociated combinations<sup>(5)</sup>, and Vignaux appears to propose equivalent observations<sup>(23)</sup>, that deserves to be reworked.

## CONCLUSION

When we compare cohorts of subjects showing different GA combinations, we see a very strong force of the eye in the determination of the correlation between GA and AOP, probably in connection with the role of the UPCS visual entry in the determination of AOP. The eye establishes a link between GA and AOP, without it these two corporal asymmetry phenomena seem to be independent. Further studies are necessary to specify which asymmetries must be correlated with GA or AOP and to decide if a special vocabulary, different of the dominance one, must be used to designate the AOP.

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