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DIFFERENCES BETWEEN THE CONFIGURATION OF THE RIGHT AND LEFT PLANTAR ARCHES

ABSTRACT. — In spite of the fact that the differences in the configuration of the plantar arch between the right and left feet, on the average, are negligible, substantial individual differences may occur even in normal population. The degree of these differences and their variability are most marked when the Chippaux-Šmiřák's index is used for the evaluation, they are less pronounced during the assessment of Schwartz-Clarke's angle, and even smaller during the use of the planimetric index.

On the basis of studies of the distribution of the degree of individual differences in the configuration of the plantar arch between both sides, determined with the three distinct methods as well as of the analysis of pertinent statistical characteristics, it was possible to establish border-line values of the norm, disharmony and dysmorphogenesis between the configuration of the plantar arch on the right and left sides (tab. 2). *This provides the possibility to avoid erroneous conclusions during the assessment of the configuration of the plantar arch and of its various disorders. The proportion of disharmony and dysmorphogenesis in our population was expressed in terms of per cent* (tab. 3).

The differences between both sides confirm the justification of the introduction of intermediary and lowered types of plantar arches, as well as the pertinentranges of values suggested by several authors. The statements discussed are based on the following consideration: If plantography determines that one foot is flat and the other normal, then the difference between both sides should correspond at least to a disharmony. However when the difference is still within the range of normal, the superior shape of the plantar arch should not be designated as normal, since there are no substantial differences between both sides. Therefore it is necessary to define transitory types.

Within the scope of our series of plantographic studies dealing with the configuration of plantar arches in adult general population, with the influence of body weight on the configuration of the plantar arch, as well as with the occurrence of pes excavatus and of methods of its assessement (Šmahel 1977a, b, 1980) we shall in the following turn our attention to the differences between the right and left sides. In spite of the negligible differences in the mean values of Chippaux-Šmiřák's index, Schwartz-Clarke's angle or planimetric index, marked differences may occur in individual cases. The present communication deals with their extent, distribution and significance. We failed to disclose any report on this subject in the literature available.

Various authors mentioned in their reports the superior shape of the left plantar arch, however, the differences of mean values are very small and in our series attain at most one index unit or two degrees resp., during assessment with the above stated methods. Since the standard deviation amounts to ten or even more units this difference is highly insignificant. It seems that the difference is mainly due to the higher frequency of pes excavatus on the left side which was repeatedly demonstrated (Šmahel 1977b). For these reasons a uniform classification of individual forms of plantar configuration is used not only for both sides but also for both sexes showing equally only negligible differences.

MATERIAL AND METHODS

Our study is based on the assessment of footprints of 60 normal males and 70 normal females ranging in age from 20 to 45 years. The methods used included Chippaux-Šmiřák's index, Schwartz-Clarke's angle and the planimetric index described in detail in our earlier reports and illustrated schematically on *figures 1a, b.* Footprints were recorded with printing ink during the transmission of body weight to the examined foot. Detailed informations are given in our earlier studies quated above.

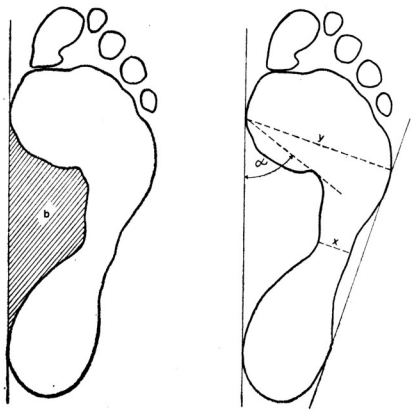

FIGURE 1a, b. *The method used for the evaluation of plantograms*

Chippaux–Šmiřák's index $= \frac{100\ x}{y}$

Schwartz–Clarke's angle $= \alpha$

the planimeric index $= \frac{100\ a}{a + b}$

a = *area of the footprint (white)*
b = *nonimprinted area of the sole (hatched)*
a + b = *approximate area of the sole of the foot.*

Plantograms were used for the determination of the extent of the individual differences between the right and left foot, with the use of all three methods of assessment. The distribution of the ascertained values is presented in *figure 2,* jointly for males and females since the differences according to sex are insignificant, as is shown below. Individual differences were balanced and it was therefore not stated whether the larger dimension occurred on the right or left side. Calculations were carried out separately in each sex and included: the mean individual difference $\bar{d}$, as well as other statistical characteristics, i.e. standard deviation s and mean error $s_{\bar{d}}$ (zero values were included into these calculations). Absolute values of mean individual differences were tested with the t-test for paired values, the difference according to sex with the usual t-test. Since the results of the latter were not significant *(Tab. 1),* the above mentioned statistical characteristics $\bar{d}$, s, and $s_{\bar{d}}$ were calculated also jointly for both sexes *(Tab. 1).* In order to devise a simple and uniform classification of individual right-left differences which could be used both in males and females, these common data were used throughout the study (this was justified by the not significant differences, between the sexes). As the border-line value for the norm was used the mean individual difference plus one standard devaition. Disharmony is characterized by values within the range of + 1 to + 2 sigma, while differences exceeding $\bar{d}$ + 2s indicate the presence of dysmorphogenesis between the configuration of the plantar arch on the right and left sides *(Tab. 2).* The frequency both of disharmony and of dysmorphogenesis ascertained in our series is presented in table 3. Finally it should be mentioned that all cases of unilateral and bilateral pes excavatus were excluded from the evaluation with Chippaux and Šmiřák's method (i.e. 13 males and 14 females) because in the presence of pes excavatus no differences between both sides are found with this technique.

TABLE 1. *The mean individual difference ($\bar{d}$) between he configuration of the right and left foot determined by the Chippaux-Šmiřák's index of the longitudnal arch, by the Schwartz-Clarke's angle of the transverse arch and by the planimetric index supplemented by the standard deviation (s) and by the mean error ($s_{\bar{d}}$).*

	n*	Chippaux-Šmiřák*			Schwartz-Clarke			planimetric index		
		$\bar{d}$	s	$s_{\bar{d}}$	$\bar{d}$	s	$s_{\bar{d}}$	$\bar{d}$	s	$s_{\bar{d}}$
men	60	4.87	4.33	0.63	4.47	3.97	0.51	3.35	3.49	0.45
women	70	5.07	4.54	0.61	3.69	3.77	0.45	2.90	2.77	0.33
t-test**	t=	0.20	insign		1.14	insign		0.81	insign	
both sexes	130	4.98	4.45	0.44	4.05	3.88	0.34	3.11	3.13	0.27

* For the calculation of the Chippaux-Šmiřák's index the total numbers of probands were reduced because of the elimination of 13 males and 14 females with pes excavatus (both bilateral and unilateral).
** intersexual

TABLE 2. *Range of the norm, disharmony and dysmorphogenesis of the differences in the configuration of the plantar arch between both feet, when evaluated with Chippaux-Šmiřák's and Schwartz-Clarke's methods and on the basis of the planimetric index.*

	Chippaux -Šmiřák	Schwartz -Clarke	planimetric index
mean difference	4.98	4.05	3.11
norm ($\bar{d}$ + 1s)	→ 9.5	→ 8.0	→ 6.0
disharmony	9.6 —14	8.1 —12	6.1 —9
dysmorpho-genesis	14.1 →	12.1 →	9.1 →

TABLE 3. *The frequency rate of disharmony and dysmorphogenesis in the configuration of the plantar arch between the right and left foot (in adults of both sexes).*

	Chippaux-Šmiřák		Schwartz-Clarke		planimetric index	
	n	%	n	%	n	%
normal	87	84.46	113	86.92	110	84.61
disharmony	9	8.74	11	8.46	14	10.77
dysmorpho-genesis	7	6.80	6	4.62	6	4.62

RESULTS

The distribution of individual differences in the configuration of the plantar arch between both sides assessed with the three above mentioned methods is illustrated in *figure 2.* It is apparent at first sight that the results of Chippaux-Šmiřák's method show the highest degree of variability, while those determined with the use of Schwartz-Clarke's angle were somewhat less variable and those obtained with the use of the planimetric index showed the lowest variability. We believe that the latter technique provides the most objective characteristic of the configuration of the sole for practical purposes, yet it is rather tedious and time consuming and was proposed for special purposes only (Smahel, 1980). As is was shown in our previous report the correlation of this index with Chippaux-Šmiřák's index was 0.9 and with Schwartz-Clarke's angle 0.8 resp. The correlation between the results of the two latter methods attained 0.6—0.8.

The above described variability is documented by statistical characteristics presented in *table 1.* The mean individual difference amounts to 5 index units of Chippaux-Šmiřák's index and to 4° of Schwartz-Clarke's angle and only to 3 index units of the planimetric index (identical results are obtained in each sex separately). The corresponding standard deviation yielded the same value, and was only by 0.5 units lower in Chippaux-Šmiřák's index. This is due to the logical asymetric distribution of these characteristics *(Fig. 2).* All mean individual differences $\bar{d}$ are highly significant ($p < 0.001$), while the differences between both sexes were not significant *(Tab. 1).*

The principles described under methods were used for the determination of border-line values of the norm, as well as of those for disharmony and dysmorphogenesis in the configuration of the plantar arch between the right and left feet. They are presented in *table 2* and an account of their significance is given below. The last table shows the frequency of disharmony and dysmorphogenesis in our population sample consisting of normal adults of both sexes. According to all three methods of assessment the frequency of disharmony is about 10 per cent and that of dysmorphogenesis about 5 per cent.

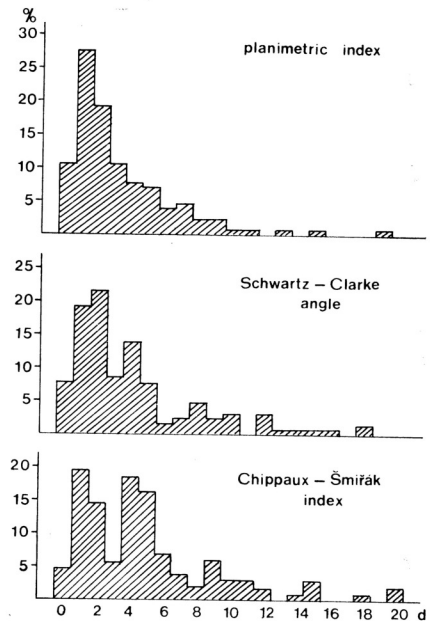

FIGURE 2. *Distribution of individual differences in the configuration of the plantar arches between the right and left feet in adults of both sexes according to Chippaux–Smiřák's index, Schwartz–Clarke's angle and planimetric index. The differences marked on the abscissa are graded by one index unit or by one degree.*

DISCUSSION

The tests disclosed that the determined individual differences in the configuration of the plantar arch between the right and left sides are highly significant and may attain high values even in normal populations in spite of the fact that the differences between mean values of those signs used for the characterization of the plantar arch are negligible. In order to avoid erroneous conclusions these facts should be kept in mind during the assessment of distinctly affected individuals. It is therefore important to be aware of the extent of differences which are still within the range of normal, as well as of those representing a disproportion and of those indicating dysmorphogenesis. However it is not possible to diagnose a pathological condition per se on the basis of differences between both sides. We shall discuss the consequences of these findings in the following paragraph.

For the determination of a pathological shape of the plantar arch is of essential importance the assessment of its configuration with the use of one of the standard methods (Chippaux-Šmiřák's and Schwartz-Clarke's). This brings us to the actual problem. When plantography leads to the determination that one foot is flat while the other is normal, than the difference between both sides should reveal either disharmony or dysmorphogenesis; however, when the difference is within the range of normal than the plantar arch which shows a better shape cannot be designated as normal, since it does not differ substantially from the other. For this purpose it is not possible to accept a single value as a definite border-line between normal and flat foot, since even in the presence of a slight difference between both sides, one foot might be considered as pathological and the other as normal. It is therefore fully justified to define transitory types of plantar arches which were recently proposed by Bavor and Hořava (1974) after an assessment with Chippaux-Šmiřák's index based on standard evaluation of footprints and on studies of plantar blood supply.

Our findings also confirm the validity of the gradually established range of values of transitory types. According to Bavor the intermediary longitudinal arch is characterized by values ranging from 30 to 40 index units i.e. within the range of ten index units and our calculated difference between the right and left side which is still within the range of the norm can attain 9.5 units. Similarly the intermediary form of the transverse arch designated by Clarke as varying from 35 to 42° i.e. within the range of 7 degrees is in agreement with our results (the normal range of difference between both sides amounts to 8°). According to these two standard methods the values of the lowered plantar arch vary within 5 index units (40—45 i.u., Novotný 1965) and 5° resp. (30—35°, Clarke 1933), which is in good agreement with standard deviations of differences between both sides and represents a configuration exceeding by 2 to 3 sigma the average. This analysis confirms that the present subdivision, as well as the border-lines between individual types of the plantar arches (i.e. normal, intermediary, lower and flat) which were gradually proposed by Schwartz et al. (1928), Clarke (1933), Chippaux (1947), Šmiřák (1960), Novotný (1965) and Bavor and Hořava (1974) are in agreement with the given reality and appears definitive. They were used in our first study dealing with the frequency of these individual types in the Czech population (Šmahel 1977a).

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