THE ASSESSMENT OF TRUNK AND SHOULDER GIRDLE SYMMETRY OF YOUNG ATHLETES ENGAGED ASYMMETRIC SPORTS

by

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Sports competitive participation may cause changes in body posture in the frontal plane as well as in the sagittal and transverse planes. It should be assumed that performing asymmetric sports will primarily affect the symmetry of posture. The aim of this paper is to study the relationships between the participation in asymmetric sports and the symmetry of posture of athletes.

The study material consisted of 128 young male and female athletes engaged in asymmetric sports (tennis, shooting, fencing, swimming (crawl) - exhaling on one side of the body only) and a comparative group of 57 subjects not participating in sports competively.

A photogrammetric assessment of posture was performed for all subjects, using the Świerc method which is based on the use of the Moire topography.

It was found that the group of athletes taking part in asymmetric sports was characterised by poorer results of the test of body posture in the frontal plane than the control group. For each of the assessed variables the frequency of deviations from the norm and their size indicate greater asymmetry of the trunk of the subjects participating in asymmetric sports.

The variable that differentiates the athletes taking part in asymmetric sports from the control group was the difference in the height of the inferior angle of the scapula and asymmetry in the distance of the scapulas from the spine.

The results of the tests should cause a revision in the perception of the effects of physical activity on posture of athletes and in the development of methods of preventing adverse changes resulting from sports of asymmetric character.

Key words: body posture, asymmetry, Moire topography, tennis, shooting, fencing, swimming.

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Introduction

Human beings are both, asymmetric and symmetric in character. Human morphological asymmetry is known to a large extent. However, studies on functional asymmetry of the human body are still rare. Asymmetry of movement and body position in sport is a significant negative stimulus for the body which most frequently is in its developmental phase (Koszczyc, 1991). Scientific literature related to the problem of muscular force asymmetry and asymmetry of the movement range in such sports as tennis or fencing is quite extensive. The authors frequently find significant muscle hypertrophy and increased mineralisation of bones on the side of the body subjected to more strain in these disciplines. There are however few publications dealing with the problem of changes within body posture, resulting from functional asymmetry in sport.

The process of formation of the body posture depends on genetic as well as internal and external environmental factors, with the facilitating influence of the upbringing process (Krawański, 1990). This author believes that incorrect posture-forming factors in the developmental age may result in the degeneration of the movement apparatous later in life. Incorrectly directed sport activity may potentially cause wearing down of part of structures and degeneration in the motor system in an adult. The generally accepted view that increased physical activity and increased physical fitness are conducive to correct posture, is not always supported by the results of scientific research (Zeyland-Malawka, 1983). Increased physical activity may affect posture of a person taking part in sports in a positive but also in an adverse way. Therefore it is by no means clear-cut that taking part in competitive sports results in better posture.

An additional issue arises from participating in sports in which one side of the body is subjected to more strain, in which the movement is asymmetric. These sports include, among others tennis, shooting and fencing. In these sports not only asymmetric movements are performed, but also at the same time there is asymmetric strain caused by the equipment held in an upper limb and asymmetric body position related to the technique of movement. The results of sport asymmetry may then be increased in these sports. It is interesting to search for the effects of sport asymmetry in relation to the dynamics of movement in a

given sport. Therefore, tennis and fencing, as sports with dynamic movement, and static shooting were selected. Swimming is considered to be a fully symmetric sport, thus favourably affecting the posture. The exception from the symmetry of swimming is the crawl if air is exhaled on only one side of the body. These arguments are the basis for the selection of studied groups in this study, which represent various types of movement asymmetry in sport.

Participating in sports may cause changes in posture both in the frontal plane as well as in the sagittal and transverse planes. It should be assumed that performing asymmetric sports will primarily affect the symmetry of posture in the frontal plane. The aim of this paper is to study the relationship between engagement in asymmetric sports and the symmetry of posture of athletes.

Material and Methods

The study material consisted of 128 male and female athletes participating in competitive sports and, as a comparative group, 57 subjects who do not regularly take part in sport activities (Table 1).

Table 1. Number of subjects in studied groups

		Girls N	Boys N	Age	
				min-max	$\bar{x}$
Asymmetric sports (group A) N = 94	tennis	10	16	17-26	20
	shooting	21	8	12-19	15,7
	fencing	12	17	11-18	15,3
	crawl (exhaling on one side only)	3	7	12-16	14,6
Symmetric sport (group S) N = 34	crawl (exhaling on both sides	13	21	12-16	12,9
Subjects not engaged in competitive sports (group C) N = 57		32	25	11-19	13,5

The main study group consisted of athletes engaged in asymmetric sports. The study also included swimmers specialising in the crawl. The aim of the

selection of this sport was to find out whether exhaling air on one or both sides of the body affects the shape of the spine in the frontal plane. Therefore the swimmers exhaling air on only one side were included in group A, and those who exhale air on both sides form group S. The group of youth not participating in sports (group C) served as a control group.

All subjects were submited to photogrammetric assessment of posture, performed by the Świerc method, based on Moire's topography (Dobosz et al. 1999, Hawrylak et al. 1997, Zarzycki et al. 1983). This method consists of making measurements on the basis of computer photography of the surface and using the phenomenon of interference pattern (moire pattern). Obtaining a three-dimensional picture is possible due to the fact that the device "projects" lines on the subject's back which fall at various angles and are distorted. The picture is recorded and analysed by a computer programme. The subjects were standing.

From the many items of information that photogrammetric assessment provides (54 variables in the frontal, sagittal and transverse planes), the following were selected for analysis:

- angle of trunk inclination from the perpendicular in the frontal plane (ATI) expressed in degrees, i.e. the angle between the perpendicular and a straight line leading through points $C_7 - S_1$ in the observation of the frontal plane,
- maximum deviation of the line of spinuous processes from the perpendicular in the frontal plane (MD) in millimetres,
- location of MD (the number of the vertebra most deviated from the perpendicular),
- difference in height of shoulders (SHD) in millimetres,
- angle of shoulders line inclination from the level (SLA) in degrees,
- difference in height of inferior angles of scapulas (SH) in degrees,
- difference in distance of inferior angles of scapulas from the spine (SD) in millimetres,
- difference in the height of waist triangles (WT) in millimetres.

The photogrammetric method used to evaluate the body posture is an exceptionally detailed and exact examination. This is why only selected variables were analysed, i.e. parameters relating only to the frontal plane, since

only this plane determines the symmetry of body posture or lack thereof. The researchers applied liberalised criteria of result estimation, previously applied by Bibrowicz et al. (1995) and other authors who assumed:

- for the linear variables: difference up to 5 mm – normal state,
  difference up to 10 mm – moderate deviation,
  difference over 10 mm – substantial deviation.

However due to the character of the results obtained for the SD and SHD variables the fourth criterion of evaluation has been added – very substantial deviation – for differences greater than 20 millimetres. For WT, due to large numerical values of this variable, the value of criteria has been doubled (up to 10 millimetres – normal state, up to 20 millimetres – moderate deviation, over 20 millimetres – substantial deviation).

and

- for angular variables: up to 1.5º - normal state,
  up to 3º - moderate deviation,
  over 3º - substantial deviation.

For the SH variable a fourth category was added – very substantial deviation – when its value exceeded 5 degrees.

Numerical values were subjected to statistical analysis using the Kruskal-Wallis test.

Results

Trunk inclination angle (ATI) provides information about the deviation of the $C_7 - S_1$ line from perpendicular in the frontal plane. It was found that for the majority of subjects from all groups the $C_7 - S_1$ line is deviated to the left: 88.3% of subjects in group A, 91.2% in group S, and 82.5% in group C. The size of the small percentage of deviations to the right is always within the norm. The fencers and swimmers exhaling air on one side ("asymmetric swimming") have the most unfavourable results for ATI (the highest average of deviations and the largest number of results outside the norm). The smallest curvatures in the smallest number of subjects were found amongst tennis players and people not taking part in sport (Fig.1 and Fig.2). When all subjects engaged in

asymmetric sports formed one group, in 63.8% of them ATI parameter was found normal, in 34% moderate deviation was found, and in 2.1% substantial deviation was found with the arithmetical average of deviation of 1.2 millimetres. This result is worse than in group C.

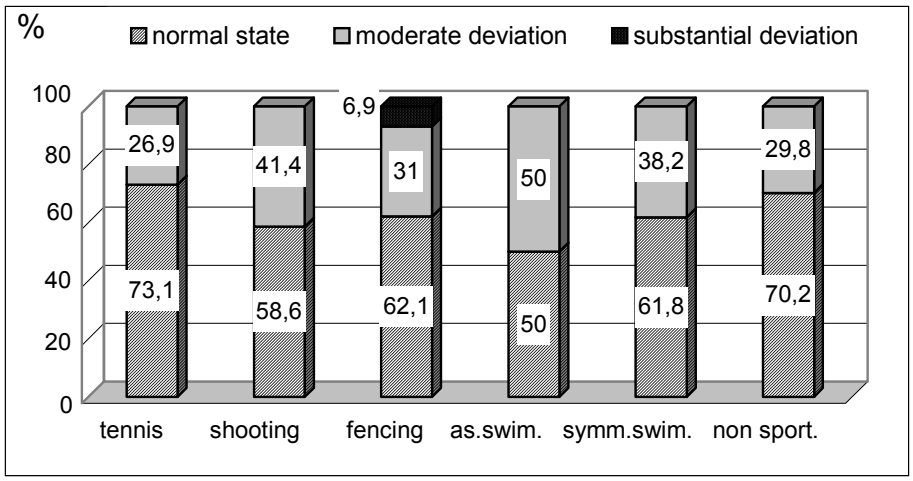

Fig.1. Percentage of frequency of deviation of $C_7 - S_1$ line from the perpendicular (ATI)

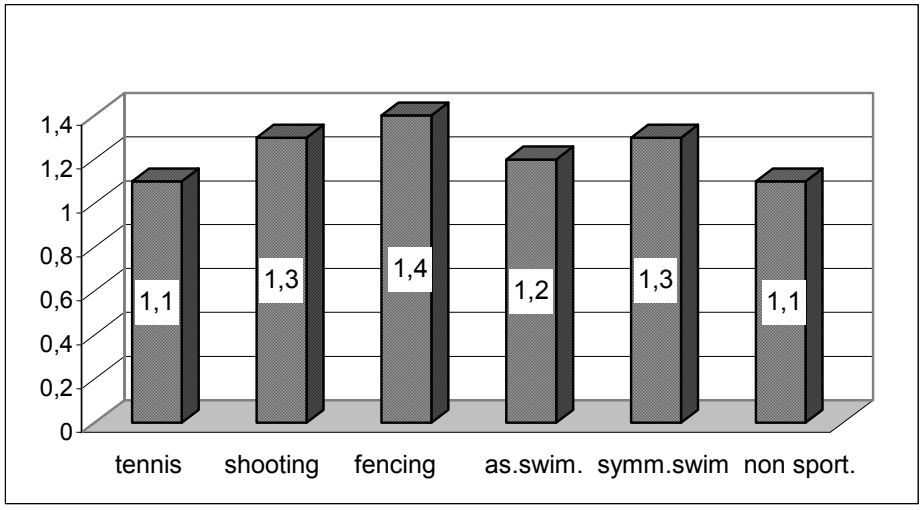

Fig.2. Average arithmetic size of curvature of the spine expressed in the angle of trunk inclination (ATI - degrees)

The deviation of the line of spinuous processes from the perpendicular in the frontal plane (MD) ranges from 0 to 12.8 millimetres. In group A, 66% of results are within the norm, 28.7% display moderate deviation, and in 5.3% of cases substantial deviation was found. The number of cases of substantial deviation differentiates group A from group C (Fig.3). The poorest results are in the group of swimmers exhaling air on one side of the body.

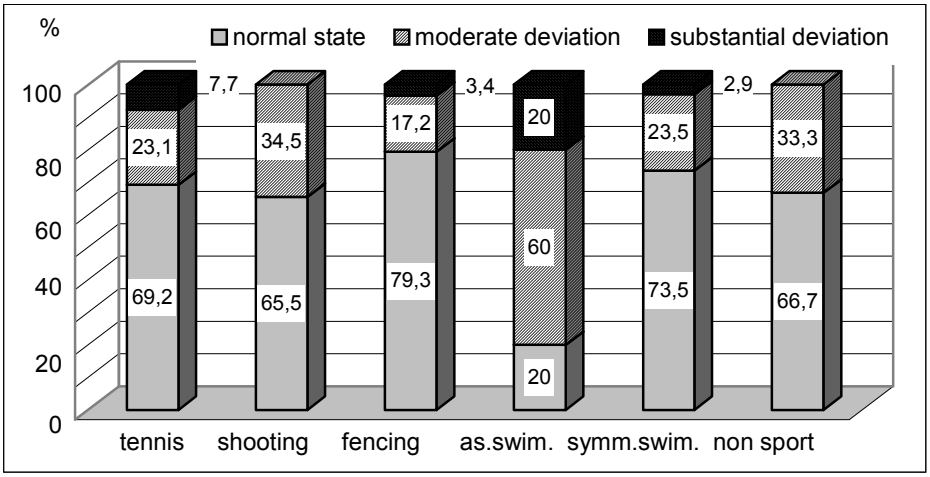

Fig.3. Percentage of frequency of occurrence of maximum deviation of the line of spinuous processes within the norm and outside the norm (MD)

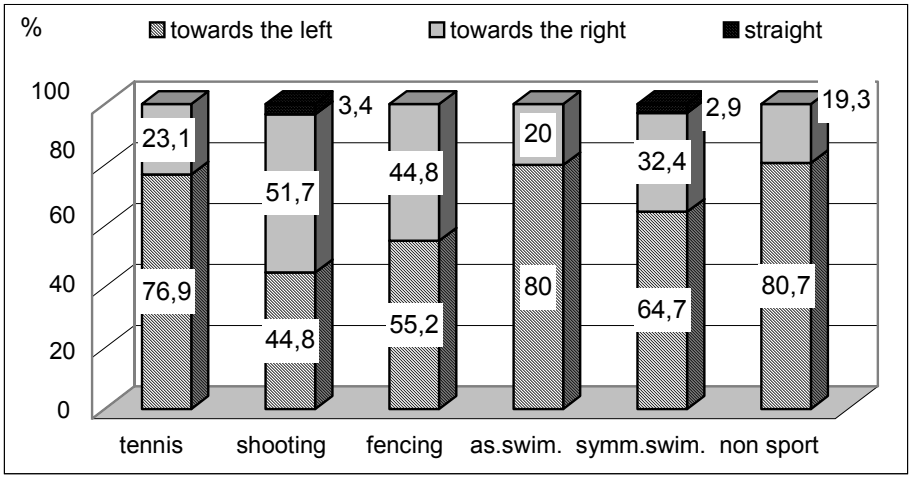

Fig.4. Percentage of frequency of MD deviation to the left and to the right

The spinuous processes, similar to ATI, are more frequently deviated to the left. Left deviation is however the least frequent in group A, it is found in 60.6% of subjects, and more frequently in groups S and C (Fig.4). Groups of shooters and fencers differ from the remaining subjects by the largest number of right deviations.

The location of MD on the length of the spine is different in different groups (Fig.5). In group C it was most frequently found in the lower part of the thoracic section ($Th_7 - Th_{12}$), and in group A, more deviations located in the upper thoracic section ($Th_1 - Th_6$) have been found. The group of shooters was unique, since the largest number of deviations in the upper thoracic section has been found amongst them.

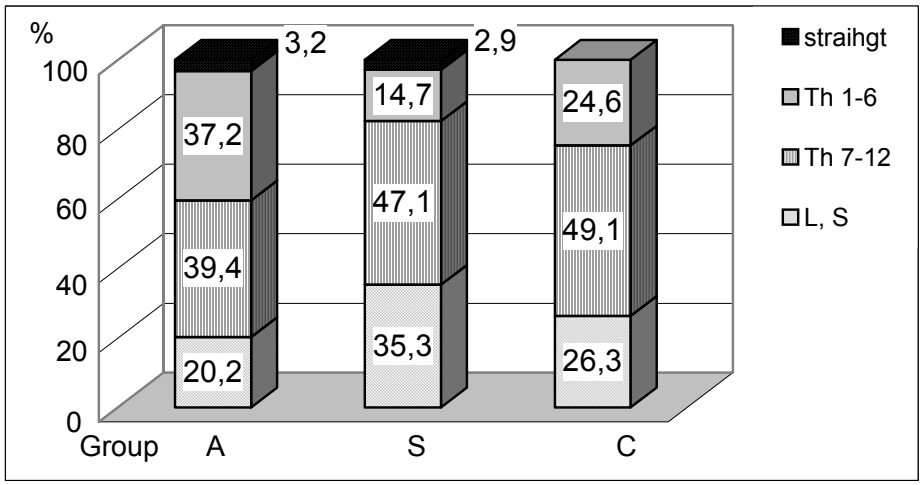

Fig.5. Location of MD on the length of the spine

The asymmetry of shoulder height (SHD) was most frequent in group A (Fig.6). In all groups studied (in groups A, S and C) a higher right shoulder is more frequent than a higher left shoulder (Fig.7.). The exception is the group of tennis players, amongst whom higher left shoulder is more frequent. Whereas in other groups the elevation of raised left or right shoulders is of similar value, in the group of tennis players the elevation of left shoulders is larger (on average 6.6 millimetres elevation of right shoulders, and 12.1 millimetres – left shoulders).

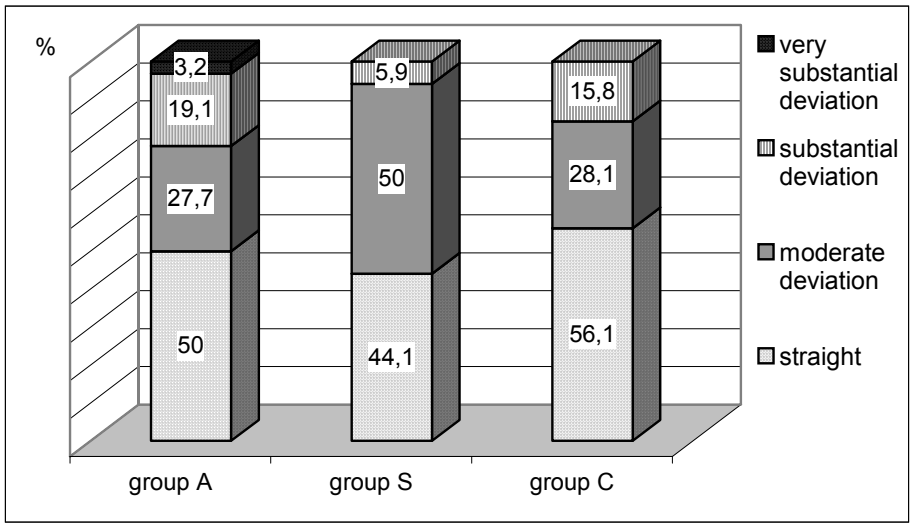

Fig.6. Percentage of frequency of the difference in shoulder height (SHD) in millimetres

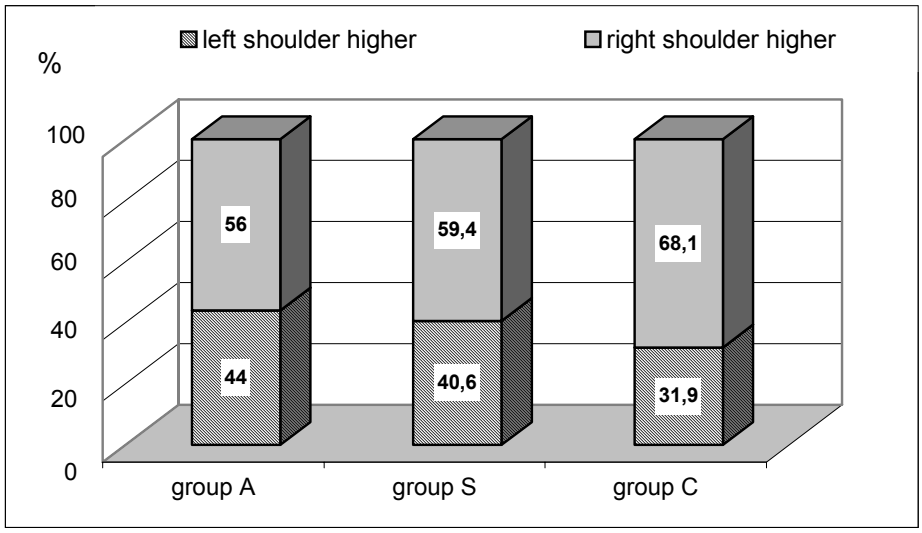

Fig.7. Percentage of frequency of higher position of right and left shoulders

The results of the evaluation of the inclination angle of shoulders line (SLA) support the information obtained earlier as a result of the analysis of the difference in shoulder height (SHD), however they enable more precise numerical presentation of the phenomenon. The numerical value of SLA in

degrees (Fig.8) indicates that in group A average elevation of left shoulders is larger than the elevation of right shoulders, contrary to groups S and C. This phenomenon is stronger in tennis players. These results indicate significant standard deviation within the range of 0.5 to 1.3. It should be remembered that such a significant standard deviation is partly an effect of a unique precision of the method of study used.

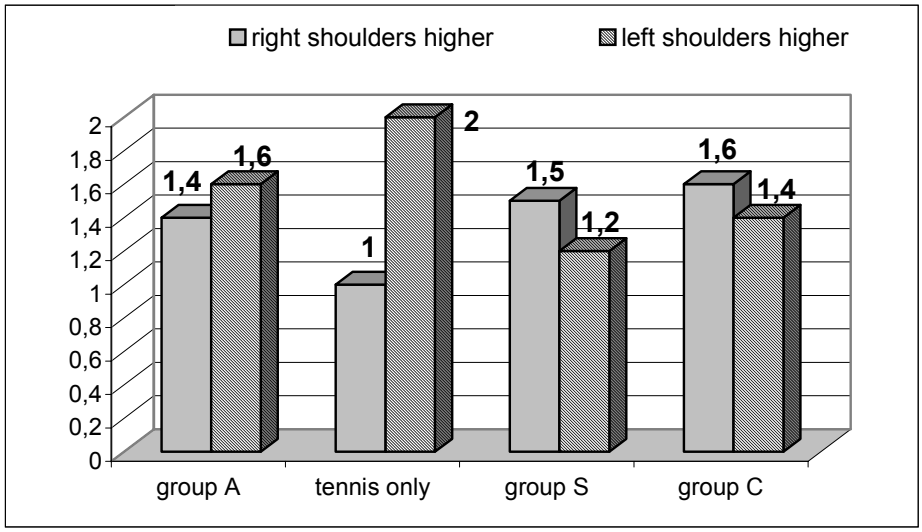

Fig.8. Arithmetic averages of shoulder line inclination angle SLA (degrees)

The difference in the height of inferior angles of the scapula (SH) in degrees displays significant differences depending on the sport as well as differences between athletes and non-athletes (Fig.9). The most unfavourable results are found in the group of tennis players and "asymmetric swimmers". The most correct mutual position of scapulas has been noted in the group of "symmetric swimmers" (group S). In total, in group A 30.9% of results are within the norm, 35.1% results display moderate deviations, 24.5% - substantial deviations, and 9.6% - very substantial deviations. The SH parameter indicates the most significant differences between the "asymmetric" group and the remaining subjects in the study so far. In all three studied groups the left scapula is more frequently situated higher than the right one. This tendency is particularly strong for tennis players and fencers.

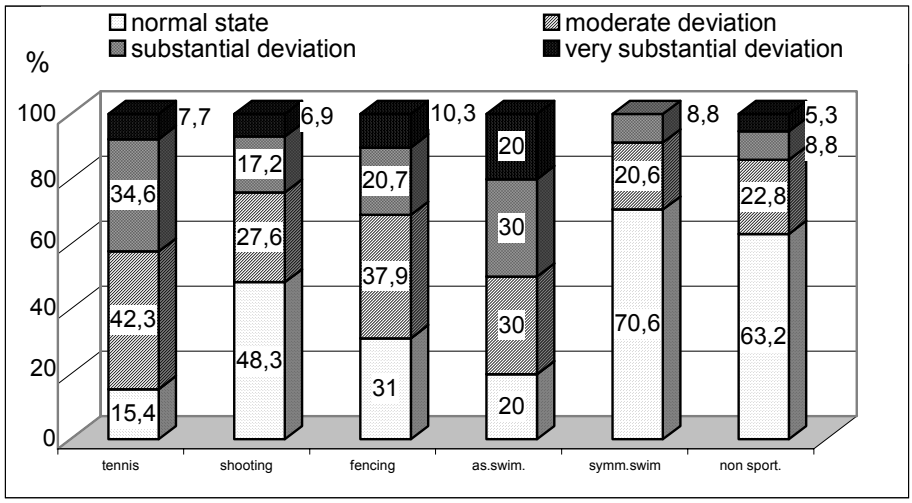

Fig.9. Percentage of frequency of correct and abnormal mutual position of scapulas (SH)

In sport groups (A and S) the elevation of left scapulas has higher numerical value than elevated right scapulas (right scapulas: 2.6 degrees in group A and 1.3 degrees in group S, left scapulas: 3.1 and 1.9 degrees, respectively) In group C this is reversed (right scapulas: 2.9 degrees, left scapulas: 2.2 degrees).

Unequal distances between inferior angles of scapulas from the spine (SD) turn out to be a frequent phenomenon in all studied groups, though its frequency is particularly high in tennis players and swimmers exhaling air on one side (Fig.10). In all studied groups the right scapula is situated further from the spine than the left scapula. This tendency is stronger in tennis players and in both groups of swimmers. Amongst those who do not take part in any sport the number of cases in which the right scapula is further from the spine is only insignificantly greater.

The difference in height of waist triangles (WT) is most frequently within the norm in group C, and least frequently in group A (Fig.11). In the four studied asymmetric sports the proportions of the difference within the norm, moderate deviation and substantial deviation are similar. The direction of WT (left or right waist triangle higher) is not related to the direction of other variables of body posture studied. However, in 60% of the subjects the direction of WT is related to the direction of MD in that way that higher waist triangle is

located on the side of the convexity of spine curvature in the frontal plane. The studied groups and sports differ from each other by a number of higher left and right WTs. Tennis players are characterised by a largest number of higher left WTs, and both groups of swimmers – higher right WTs.

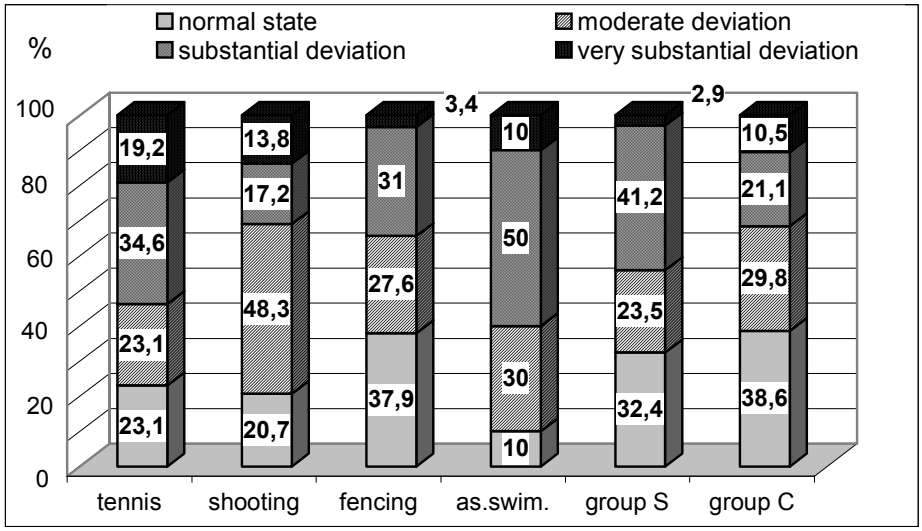

Fig.10.Percentage of frequency of the same or different distance between scapulas and the spine (SD)

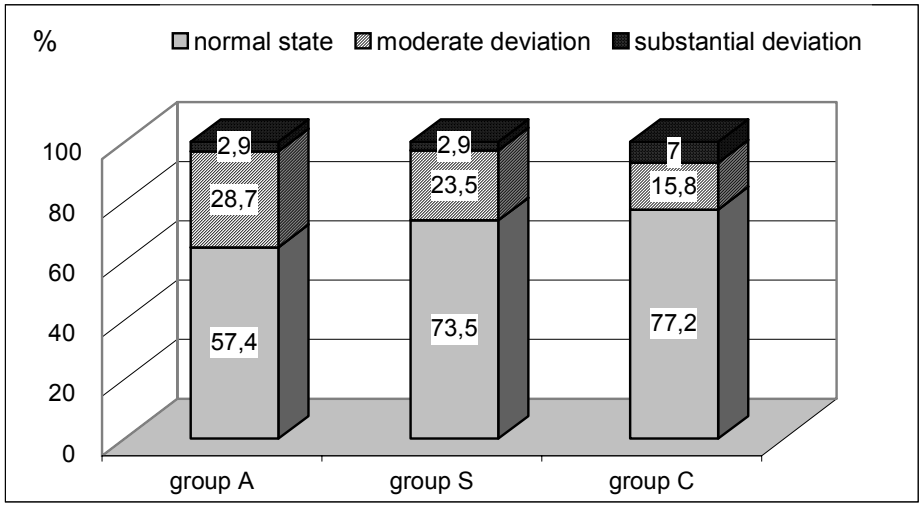

Fig.11. Percentage of frequency of the same or different height of waist triangles (WT)

The distribution of the results of the studied variables was compared using a non-parameter Kruskal-Wallis test. The differences were found to be statistically significant (Table 2).

Table 2. Values in the Kruskal-Wallis test

ATI	MD value	MD location	SHD	SLA	SH	SD	WT	length of the spine/body height
12,5*	15,3**	13,4*	13,8*	14,1*	16,6**	17,9**	13,9*	47,1**
statistically significant difference: * difference of $p \leq 0,05$, ** difference of $p \leq 0,01$								

The statistical comparison of variables related to body posture between girls and boys did not indicate any significant differences. This made it possible to search for the influence of sports, rather than influence of gender which is not the subject of this study.

Discussion

Amongst the subjects eight people are left-handed. An individual analysis of the results of their tests indicates that for all of them the value of ATI is within the norm, for seven of them the $C_7 - S_1$ line is deviated to the left, and is completely vertical for one person. In the left-handed also the majority of MD deviations noted was to the left (87.5%). These results are similar to those of the right-handed subjects. The other body posture variables do not display any regularities and are similar to the results of the whole population. After the detailed analysis of the results of tests of left-handed subjects, it has to be noted that three left-handed tennis players are distinguished by a right scapula more distant from the spine (the left scapula closer to the spine), which proved typical for the results of all subjects and tennis players. One left-handed athlete participating in shooting has a completely straight spine and vertical trunk and her other parameters are within the norm, except slightly higher located left scapula. Amongst three left-handed fencers, two are characterised by good trunk symmetry, one of them has his right shoulder and his right scapula higher and also his right scapula is more distant from the spine than the left one. All three

fencers have visibly higher left waist triangles. In fencers higher left and right waist triangles occur almost as frequently. One left-handed swimmer (who exhales air symmetrically) has a large deviation of the spine to the left and very significant asymmetry of mutual position of scapulas (the right scapula is lower and more distant from the spine). This cannot however be the result sport training, but results from functional asymmetry in other life activities or morphological asymmetry. Thus, with this number of left-handed subjects, it is difficult to draw any binding conclusions. We should focus on reliable conclusions relating to the right-handed majority. It may be assumed that with a larger number of left-handed subjects some variables that differentiate them from the right-handed would have been found.

The results in the small group of swimmers who exhale asymmetrically, i.e. always on the same side of the body, were additionally studied in detail. The group included young subjects aged 14 (2 subjects) and 15 (8 subjects), thus their style specialisation has been established. The analysis of the results carried out so far indicated significant changes in their body posture. It has been noted that irrespective of the side on which the air is exhaled (left or right) in all subjects the angle of trunk inclination ATI indicates the deviation of the spine from the perpendicular to the left. In swimmers who inhale air on the left the results of the evaluation of body posture indicate larger deviation from the norm than in swimmers who exhale on the right. This refers mainly the position of the scapulas (SH and SD) and the value of the side curvature of the spine (MD). These are however slight differences. The significant difference is the smallest deviation of the spine from the perpendicular, i.e. the best ATI result in these subjects (swimmers exhaling on the left).

When evaluating the results of tests conducted on athletes taking part in asymmetric sports it should be noted that the greatest amount of irregularities has been found in the group of swimmers who exhale air on one side of the body. The results of each of the studied variables in this group are very unfavourable. The literature also includes publications which deny the popular belief in particularly favourable effects of swimming on body posture (Becker, 1985 and Becker 1986).

Tennis players are characterised by significant irregularities in position of scapulas and asymmetry of waist triangles with a reasonably correct (vertical)

position of spine. Tennis players are characterised by a visibly higher left shoulder. The group of shooters is distinguished by the most frequent deviation of the spine to the right. In this group there is also a tendency to most frequent side curvature of the spine in the upper part of thoracic spine. These results are similar to the results of tests carried out by other authors who deal with the body posture of tennis players (and the fencers) such as Priest and Nagel (1976) and Azemar (1979). These authors have noted lateral curvature of the spine and dislocations within the shoulder girdle of the over-strained side of the body of the studied athletes.

The study of body posture has also been taken up by Hossa and Demczuk-Włodarczyk (1996), Stokłosa and Gieremek (1992) and Gieremek et al. (1992). The above authors have found body asymmetry and significant tendencies to faulty posture in athletes participating in shooting. What they recommend is rationalisation of shooting training by including in it more general-development and compensating exercises. They postulate developing a comprehensive prophylactic action to prevent irregularities in body posture of shooters and intensification of these irregularities.

Fencers are mainly characterised by significant deviation of spine in the frontal plane (ATI) and asymmetry of waist triangle. Also mutual position of scapulas is asymmetric. Their spines, more frequently than in other groups studied, are curved to the right (similar to the shooters). The study of body posture of shooters has also been performed by Zeyland-Malawka (1990). She noted frequent curvature of spine, predominantly to the left. She has presented the changes in the shape of spine during a fencing stance and during a lunge, which are thought to be the reason for scoliotic posture that may turn into real scoliosis in future.

The variable that differentiated the athletes engaged in asymmetric sports from the control group in a most substantial way was the difference in the height of inferior angles of scapula (SH) in degrees. Also asymmetry of distance between scapulas and the spine differentiated group A from group C in a significant way. Asymmetric movement in sports selected for the study relates mainly to upper limbs. Therefore, the most frequent deformations take place within the girdle of the upper limb, and are less evident in the position of the spine.

The statistical analysis indicates that there are significant differences between the studied groups in terms of the MD value and its location. The most substantial deviations, of arithmetical average of 5.3 mm, are found in the lower part of thoracic spine (Th_{7-12}), the smallest deviation is found in the lumbosacral spine ($\overline{X}$ = 2.8 mm). This tendency has been noted in all groups studied.

The direction of ATI (left or right) as well as the direction of MD do not always display a relationship with right- or left-handedness of a subject. In some sports only a numerical majority of deviations in one of the directions is noted. However in all studied groups the $C_7 - S_1$ line is most frequently directed to the left. The study of 47 healthy middle-aged women carried out by the authors of this paper showed more frequent statistically significant deviation of $C_7 - S_1$ line to the left. Zeyland-Malawka (1990) also has not found a strict principle or relationship between the direction of spine curvature and the right-handedness of fencers. Pretkiewicz-Abacjew and Zeyland-Malawka (1993) when studying the asymmetry in body posture of school children, also noted twice as many left deviations as the right ones. One may venture an assumption that the deviation of the spine to the left is more frequent and probably determined by the right-handedness of people.

The photogrammetric method makes it possible to establish the length of the spine and what percentage of the body height the length of the spine is. The statistical analysis indicated that the value of ATI does not correlate with the age of the subject, his or her body height, or length of spine. However in the subjects engaged in asymmetric sports ATI correlates with the length of the spine expressed as a percentage of body height (r = -0.23). This means that the spine which is shorter in relation to body height is more prone to deviations in the frontal plane than a spine longer in relation to body height.

Conclusions

To summarise we have to state that the group of athletes participating in asymmetric sports is characterised by worse results of the evaluation of body posture in the frontal plane than the control group. Among the results of each of the seven variables, the frequency of deviations from the norm or the size of

deviations indicate more significant asymmetry of the trunk of the subjects in group A.

It should be assumed that body posture, body build and technique of movement are such a complicated system and depend on so many factors that at the present stage of research it is not possible to establish the tendency of effects of asymmetric movements on body symmetry. Each subject should be treated and analysed individually, in the same way as therapeutic and corrective exercise is selected individually for each case of scoliosis. Nevertheless the results of the study should cause a revision in the perception of the effects of physical activity on body posture of athletes and cause a development of methods of prevention of adverse changes resulting from asymmetric sports.

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