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BODY POSTURES AND ASYMMETRIES IN FRONTAL AND TRANSVERSE PLANES IN THE TRUNK AREA IN TABLE TENNIS PLAYERS

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AUTHORS: Barczyk-Pawelec K., Bańkosz Z., Derlich M.

Faculty of Physiotherapy, University School of Physical Education, Wrocław, Poland

Reprint request to:
Katarzyna Barczyk-Pawelec
Faculty of Physiotherapy, University School of Physical Education
Al. I.J.Paderewskiego 35
51-612 Wrocław, Poland
E-mail: kasia_bar@interia.eu

ABSTRACT: The aim of this research was to assess the body posture within the trunk area in table tennis players and to estimate the correlations between the specific body posture types, their asymmetries and table tennis practice (training experience). To evaluate body posture the photogrammetric method based on the Moiré phenomenon with equipment by CQ Electronic was applied. Tests of significance of difference and correlation were used to estimate the correlation of the observed asymmetries with the training experience. 40 table tennis players and 43 subjects not practising sports participated in the research. The analysis of the results revealed that table tennis players, unlike non-players, are characterized by kyphotic body posture. It probably results from a specific trunk, head and limb position during table tennis matches. Thus, many asymmetries in frontal and transverse planes were observed in the examined table tennis players. Perhaps table tennis, which is characterized by intensive and one-sided trunk muscle work during its performance, is in favour of creating asymmetries. The majority of subjects did not reveal any statistically significant correlations between the observed body posture types, their asymmetries and training experience. However, it was observed that training experience is significantly related to the considerable asymmetry of the inclination angle of shoulder line (KLB). It may result from the negative influence of very intensive, one-sided work and constant work of the shoulder girdle muscles of the playing limb with negligence of exercises of the second limb.

KEY WORDS: table tennis players, moiré topography, body posture, asymmetries, spine, sport training

INTRODUCTION

Table tennis is a sport discipline practised in Poland by about fifteen thousand members registered in the Polish Table Tennis Federation. There are no age restrictions related to this sport, which is proved by the very popular veterans' competitions. Table tennis is considered to be a great form of movement and it can be successfully used in physical education and recreation [1]. It may also be practised as a therapy [9,15].

Professional players start their careers at the age of 6–7 and they train 4–5 hours a day. During summer and winter camps the number of training hours increases up to 6–7 [5,6]. Long-lasting and regular training sessions along with the intensive and at the same time asymmetrical muscle work may cause different types of overloads, which lead to different motor organ injuries and deformations. Large, frequently one-sided, training loads which influence the athletes (including table tennis players) may also affect the body posture and body posture symmetry, for instance muscle proportions.

Considering the issues mentioned above and perceiving the lack of information illustrating and determining table tennis players' body posture, the authors of this research decided to analyse the body posture and selected components related to body posture symmetry.

Aim of the research

On the basis of the presented issues and literature analysis, this research aims to:

1. assess the body posture within the trunk area in table tennis players in comparison to non-practising subjects,
2. determine the relationship between the specific body posture types, asymmetries and table tennis practice.

The following research questions were posed:

1. What is the shape of antero-posterior spinal curvatures in practising and non-practising subjects? Comparison.
2. What are the body posture asymmetries within the trunk area between table tennis players and non-practising subjects?
3. Is there a statistically significant relationship between the specific body posture types and frontal and transverse plane asymmetries and practising table tennis?

Research hypotheses:

1. Kyphotic posture is characteristic for table tennis players probably due to the trunk and head forward position during the game and 'ready' position.
2. A characteristic of table tennis is the intensive and one-sided trunk muscle work during its performance, which may cause asymmetries in the trunk area.
3. Asymmetries observed in table tennis players are related to the length of the training experience.

MATERIALS AND METHODS

Subjects. 40 Lower Silesia table tennis players participated in the research. They represented the following clubs: Wrocław, Brzeg Dolny, Jelcz–Laskowice, Stronie Śląskie, Polkowice, Krosnowice, Żmigród and Bolesławiec. The youngest player was 11, the oldest 26 (mean age was 17.4 years). The examined subjects represented different playing styles; they differed in training experience and sports level. The shortest training experience was 1 year, the longest 20 years (mean training experience was 7.1 years). The control group contained 43 subjects of comparable age. None of them practised any sport discipline (mean age in that group was 17.9).

Methods

To assess body posture the photogrammetric method based on the Moiré phenomenon [2,3,8] with equipment by CQ Electronic [11] was applied.

Quality of the body posture in a natural position was assessed. Special markers were used to mark fixed points on each subject's back. The following points were marked: spinous process of the 7th cervical vertebra, spinous processes of spinal vertebrae from Th1 to L5, sacral bone at the height of the gluteal cleft, lower angles of shoulder blades, posterior superior iliac spines and acromion processes. The height of the measurement post was adjusted to each person individually, so the lenses of the projectors were at the height of their backs.

The following parameters were analysed in the sagittal plane (Fig. 1):
— lumbosacral spine inclination – α,
— lumbo-thoracic spine inclination – β,
— upper thoracic spine inclination – γ,
— compensation index – μ,
— thoracic kyphosis – KKP=180-(β+γ),
— Lumbar lordosis – KLL=180-(α+β),
— Spinal height – DCK,
— Percentage DCK to total height - %_height,
— The length of thoracic kyphosis – DKP,
— The real length of thoracic kyphosis – RKP,
— The length of lumbar lordosis- DLL,
— The real length of lumbar lordosis – RLL,
— The dept of thoracic kyphosis – GKP,
— The dept of lumbar lordosis - GLL

The following parameters were analysed in the frontal plane (Fig. 1):
— angle of trunk inclination – KNT,
— inclination of the shoulder line angle – KLB,
— difference in the position of the lower angles of shoulder blades – UL,
— difference in the distance of the shoulder blade angles from the spine – OL,
— difference in the height of the waist triangles – TT,
— angle of pelvis inclination – KNM,
— angle of pelvis rotation – KSM,
— maximum deflection of spinous process line from the line C7-S1– UK

The analysis of the determined parameters and angles enabled us to assess the spinal curvature in the sagittal plane and the magnitude of frontal-plane asymmetry. Referring to Wolański's typology, with Zeyland-Malawka modifications, angle values of inclination of the separate spine parts of the examined subjects enabled us to classify them into the suitable body posture types (kyphotic, lordotic, balanced) and subtypes [14]. Following Bibrowicz [3], the value of the asymmetry in the frontal plane extended to very considerable asymmetry was presented. It was assumed that:
— difference > 0 ≤ 5 mm indicates a lack of asymmetry
— difference > 5 ≤ 10 mm indicates moderate asymmetry
— difference > 10 ≤ 15 mm indicates considerable asymmetry
— difference > 15 mm indicates very considerable asymmetry.

For angle asymmetries (KNT, KSM, KNM, KLB), it was assumed that:
— angle > 0˚ ≤ 1.5˚ mm indicates a lack of asymmetry
— angle > 1.5˚ ≤ 3˚ mm indicates moderate asymmetry,
— angle > 3˚ ≤ 4.5˚ mm indicates considerable asymmetry,
— angle > 4.5˚ mm indicates very considerable asymmetry.

Basic statistics were used to compute the results and the following tests were applied: Student's t-test of significance of difference and

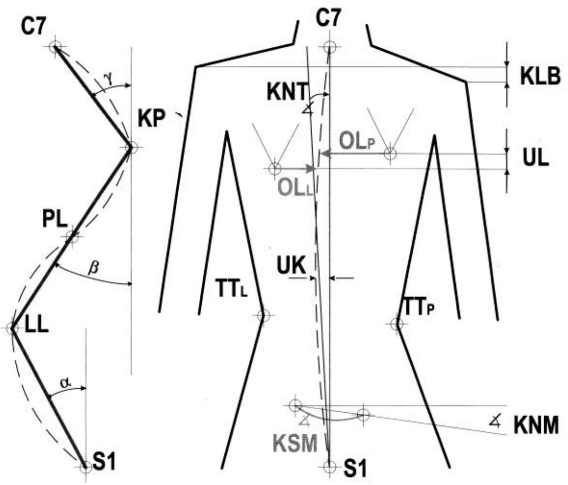

FIG. 1. SPINAL PARAMETERS IN THE SAGITTAL AND FRONTAL PLANE

LSD (least significant difference) test equivalent to Student's t-test for n>2 (more than two variables). Also Spearman's rank correlation coefficient was computed.

TABLE 1. FREQUENCY OF BODY POSTURE TYPES IN THE STUDY AND CONTROL GROUPS

Body posture type	Table tennis players	Control group
Kyphotic	25	11
Lordotic	4	17
Balanced	11	15

RESULTS

The parameters analysed in the sagittal plane, angles α, β, γ and compensation index (μ) enabled us to classify the subjects into three groups, which corresponded to the body types determined by Wolański with Zeyland-Malawka modifications [14]. The greatest number of subjects was observed in the kyphotic group (25 subjects). 11 subjects were assigned to the balanced type. Only 4 players displayed lordotic body posture (Table 1). The frequency of types occurrence in the control group, unlike in the research group, was variable. Lordotic body posture was the most frequent (17 subjects). Balanced type was observed in 15 subjects and kyphotic only in 11 subjects (Table 1).

Then, front-to-back spine curves in players practising table tennis, in comparison to their non-practising peers, were analysed. The results are presented in Tables 2 and 3. Data revealed that angle values observed in the control group were greater than those obtained by the group of players. It was particularly related to the angle inclination of the sacro-lumbar spine and the sum of angles. The two groups differed at a statistically significant level ($p<0.001$) (Table 2). Spine (DCK, %_height) and thoracic kyphosis (DKP and RKP) length parameters were greater and statistically significant ($p<0.01$) for table tennis players (Table 3).

Table 4 contains research results related to the size of trunk asymmetry obtained by the players and non-players. Subjects not performing table tennis, unlike the players, displayed lower asymmetry values. It was mainly related to UL, OL ($p\leq0.05$) and TT ($p\leq0.001$).

Table 5 presents quantitative characteristic of asymmetry in the trunk area observed in both groups. The occurrence frequency of separate values of asymmetries in the two groups was different. Table tennis players displayed no asymmetries in KNT and KNM parameters, while in TT (12 players), KSM (9 players) and OL (7 players) large asymmetries were observed. The control group revealed very considerable asymmetry in the following parameters: KLB and OL (10 subjects each) and TT (8 subjects) (Table 5).

The research also aimed to evaluate the relationship between an asymmetry and training experience of table tennis players. The researchers tried to determine whether the groups which differed in the level of asymmetry, also reveal statistically significant difference in training experience. In the range of the KNT parameter players classified to a "standard" group were characterized by the longest (about 7.5 years) training experience. Those with the shortest (about 5 years) training period showed considerable asymmetry. The analysis of training experience did not reveal any statistically significant differences between the examined groups (Table 6).

KLB analysis showed that players with the longest mean training experience (9 years) displayed considerable asymmetry in KLB range, those in the "standard" group characterised by the shortest expe-

TABLE 2. STATISTICAL CHARACTERISTICS OF ANGULAR PARAMETERS OF SPINAL CURVATURES IN TABLE TENNIS PLAYERS AND NON-TRAINING SUBJECTS

Parameter	Table tennis players	Control group	t-Student test	p-value
α angle	11.3 ± 9.	22.9 ± 18.2	-3.554	<0.001
β angle	10.1 ± 2.2	10.8 ± 4.1	-0.967	ns
γ angle	14.1 ± 7.1	15.6 ± 4.9	-1.252	ns
Sum of angles	35.5 ± 9.8	49.3 ± 17.7	-4.308	<0.001
KKP	155.8 ± 4.5	153.6 ± 8.1	1.528	ns
KLL	161.7 ± 12.5	163.4 ± 30.0	-0.322	ns

Note: Data represent mean ± standard deviation; angles: α - lumbosacral spine inclination, β - lumbo-thoracic spine inclination, γ - upper thoracic spine inclination; KKP - thoracic kyphosis , KLL - lumbar lordosis

TABLE 3. STATISTICAL CHARACTERISTICS OF THE SPINAL CURVATURES' LENGTH PARAMETERS OF TABLE TENNIS PLAYERS AND NON-PRACTISING SUBJECTS

Parameter	Table tennis players	Control group	t-Student test	p-value
DCK	438.8 ± 40.3	403.6 ± 37.8	4.085	<0.001
%_height	26.6 ± 9.3	25.6 ± 18.2	3.777	<0.001
DKP	151.3 ± 26.5	128.6 ± 23.6	4.117	<0.001
RKP	262.3 ± 36.1	240.8 ± 31.6	2.882	<0.01
DLL	67.5 ± 19.2	73.0 ± 25.6	-1.086	ns
RLL	176.5 ± 19.3	162.8 ± 29.2	2.477	<0.05
GKP	18.3 ± 5.1	19.6 ± 8.3	-0.837	ns
GLL	21.2 ± 5.8	17.8 ± 9.6	-1.923	*0.06*

Note: Data represent mean ± standard deviation; DCK - spinal height, DKP - length of thoracic kyphosis, RKP - real length of thoracic kyphosis, DLL - length of lumbar lordosis, RLL - real length of lumbar lordosis, GKP - dept of thoracic kyphosis, GLL - dept of lumbar lordosis

TABLE 4. STATISTICAL CHARACTERISTICS OF THE EXAMINED ASYMMETRIES IN THE TRUNK AREA IN TRAINING AND NON-TRAINING SUBJECTS

Parameter	Table tennis players	Control group	t-Student test	p-value
KNT	1.1 ± 1.0	0.9 ± 0.8	1.412	ns
KLB	7.1 ± 6.4	5.9 ± 5.2	0.945	ns
UL	6.6 ± 5.9	4.4 ± 4.3	2.065	<0.05
OL	9.21± 6.6	6.3 ± 5.2	2.211	<0.05
TT	10.6 ± 8.9	4.7 ± 4.0	3.953	<0.001

Note: Data represent mean ± standard deviation; KNT - angle of trunk inclination, KLB - inclination of the shoulder line angle, UL - difference in the position of the lower angles of shoulder blades; OL - difference in the distance of the shoulder blade angles from the spine, TT - difference in the height of the waist triangles

TABLE 5. QUANTITATIVE CHARACTERISTICS OF ASYMMETRY VALUES OBTAINED BY TRAINING AND NON-TRAINING SUBJECTS (TS – TABLE TENNIS PLAYERS, GK – CONTROL GROUP)

Parameter	Asymmetry value							
	No asymmetry		Moderate asymmetry		Considerable asymmetry		Very considerable asymmetry	
	TS	GK	TS	GK	TS	GK	TS	GK
KNT	27	17	11	16	2	7	0	3
KLB	17	10	11	14	6	9	6	10
UL	18	14	14	20	6	6	2	3
OL	9	11	16	8	8	14	7	10
TT	11	12	14	9	3	14	12	8
KNM	30	17	6	13	4	11	0	2
KSM	13	11	10	19	8	9	9	4
UK	14	17	22	14	3	8	1	4

Note: KNT - angle of trunk inclination, KLB - shoulder line angle inclination, UL - difference in the position of the lower angles of shoulder blades, OL - difference in the distance of the shoulder blade angles from the spine, TT - difference in the height of the waist triangles, KNM - angle of pelvis inclination, KSM - angle of pelvis rotation, UK - maximum deflection of spinous process line from the line C7-S1

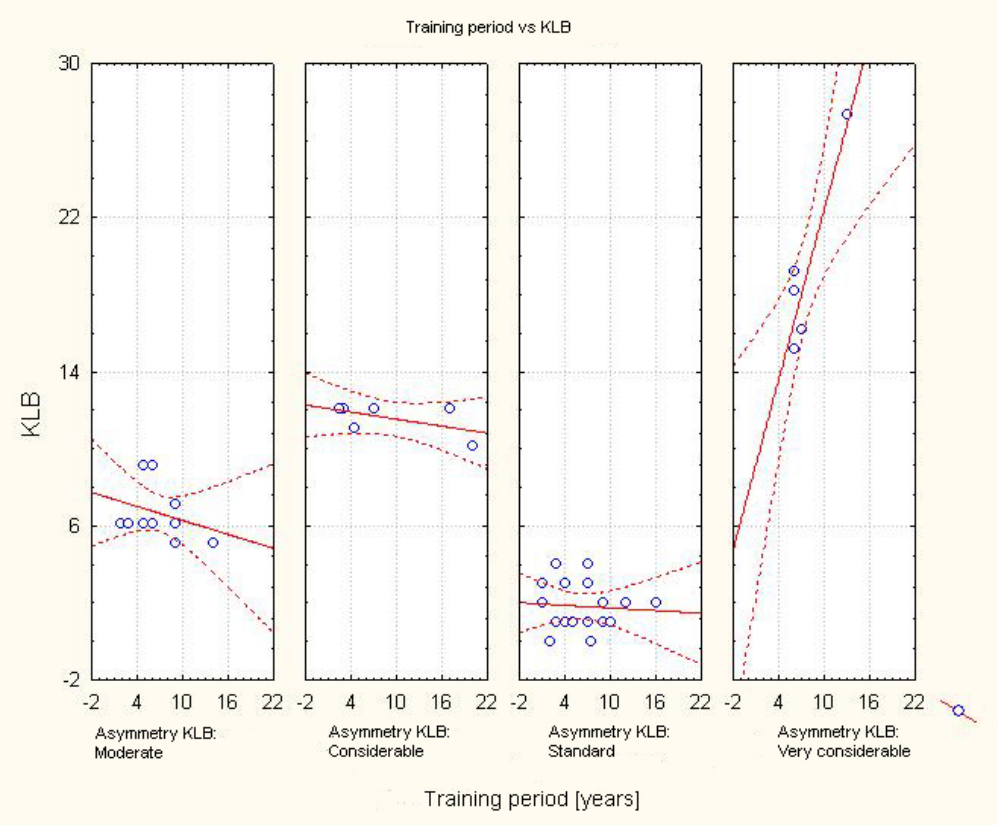

FIG. 2. GRAPH OF CORRELATION BETWEEN THE DEGREES OF PLAYERS' ASYMMETRY IN THE RANGE OF KLB AND LENGTH OF TRAINING PERIOD
Note: KLB - inclination of the shoulder line angle

rience (about 6 years) (Table 6). No statistically significant differences were observed between the asymmetry groups in reference to the training experience. However, a positive significant correlation between the length of training experience and KLB asymmetry in the "very considerable" group (Fig. 2) was observed. The value of this correlation was 0.902 with significance level p=0.05.

In the UL range the longest mean training period was observed in the players with considerable UL asymmetry (9 years). Very considerable asymmetry was observed in players with the shortest training experience (6 years). No statistically significant differences between the research groups were noted from the length of training experience point of view (Table 7).

In the examined OL parameter the "standard" group table tennis players were characterized by the longest training period (9.5 years). The remaining groups of players displayed similar training experience, which was about 6 years. No statistically significant differences between the selected groups were observed.

TABLE 6. THE LENGTH OF TRAINING EXPERIENCE IN DIFFERENT ASYMMETRY GROUPS IN THE RANGE OF KLB AND KNT

Asymmetry	KLB		KNT	
	n	mean ± SD	n	mean ± SD
Standard	17	6.3 ± 4.1	27	7.6 ± 4.7
Moderate	11	7.0 ± 3.4	11	6.3 ± 3.6
Considerable	6	9.0 ± 7.6	2	4.8 ± 3.2
Very considerable	6	7.5 ± 2.7	0	

Note: KLB - inclination of the shoulder line angle, KNT - angle of trunk inclination

TABLE 7. LENGTH OF TRAINING EXPERIENCE IN DIFFERENT ASYMMETRY GROUPS IN THE RANGE OF UL AND OL

Asymmetry	UL		OL	
	n	mean ± SD	n	mean ± SD
Standard	18	7.0 ± 4.4	9	9.5 ± 4.2
Moderate	14	6.5 ± 4.4	16	6.2 ± 4.6
Considerable	6	9.1 ± 4.8	8	6.5 ± 4.7
Very considerable	2	6.0 ± 1.4	7	6.6 ± 3.2

Note: UL - difference in the position of the lower angles of shoulder blades, OL - difference in the distance of the shoulder blade angles from the spine

TABLE 8. THE LENGTH OF TRAINING EXPERIENCE IN DIFFERENT ASYMMETRY GROUPS IN THE RANGE OF TT AND KNM

Asymmetry	TT		KNM	
	n	mean ± SD	n	mean ± SD
Standard	11	7.1 ± 4.9	30	7.1 ± 4.7
Moderate	14	6.8 ± 4.7	6	7.5 ± 2.6
Considerable	3	5.8 ± 3.3	4	6.8 ± 4.6
Very considerable	12	7.8 ± 4.0	0	0

Note: TT - difference in the height of the waist triangles, KNM - angle of pelvis inclination

TABLE 9. LENGTH OF TRAINING EXPERIENCE IN DIFFERENT ASYMMETRY GROUPS IN THE RANGE OF UK AND KSM

Asymmetry	UK		KSM	
	n	mean ± SD	n	mean ± SD
Standard	14	6.0 ± 4.4	13	5.5 ± 2.8
Moderate	22	7.9 ± 4.5	10	5.4 ± 2.3
Considerable	3	6.2 ± 3.3	8	10.4 ± 5.6
Very considerable	1	7.0	9	8.4 ± 5.1
Entire group	40	7.1 ± 4.4	40	7.1 ± 4.4

Note: UK - maximum deflection of spinous process line from the line C7-S1, KSM - angle of pelvis rotation

Analyzing TT parameters it was concluded that subjects with the longest mean (about 8 years) training experience displayed very considerable TT asymmetry, while considerable asymmetry was observed in the shortest training experience players (about 6 years). No statistically significant differences were observed between the examined groups and training period.

The analysis of the KNM parameter showed that players from all groups were characterized by similar (about 7 years) training experience. No statistically significant differences were noted between the players in reference to the analysis of their training experience (Table 8).

Considering UK parameters the players with moderate and very considerable asymmetry performed table tennis the longest (about 7-8 years). Subjects with the shortest training period (6 years) displayed no or considerable asymmetry. Regarding training experience, no statistically significant differences were observed in the selected groups. In the range of KSM parameter players with the longest training period (10 and 8 years respectively) exhibited considerable and very considerable asymmetry. However, players in "standard" and "moderate" groups indicated the shortest training experience (about 5 years) (Table 9). Performance of the NIR test revealed statistically significant differences in reference to the training experience between the groups: "standard" and "very considerable asymmetry" and "moderate" and "considerable" asymmetry ($p=0.012$ in both cases).

DISCUSSION

Spinal deformations are indirectly or directly influenced by the performance of sports which are characterized by asymmetrical loads [4,10,12]. They include table tennis, tennis, volleyball, and javelin throw [4]. The spine of a table tennis or tennis player is exposed to the strong influence of compressive and shearing forces. It is due to the frequent performance of twists and flex movements and significantly greater work of one limb (playing hand) in comparison to the second one [4,10,12]. Due to the considerable training loads it may cause different types of injuries, body asymmetries and deformations. The standard position of a table tennis player, i.e. head and shoulders forward [1,5,6], is also important for the spinal mechanics and the extent of spinal curvature.

The analysis of body posture results of table tennis players revealed that the greatest number of players displayed kyphotic and balanced body postures. Similar results were obtained by the researchers examining judokas' body postures [2,16]. A judoka's body position during the fight is quite similar to the ready position taken by table tennis players. Frequently taking kyphotic positions, with head and shoulders forward, may seem significant despite the fact that no statistically significant relationship of body postures and training experience was confirmed in the examined players. However, as presented herein, large differences in the frequency of occurrence of the kyphotic position between players (25 subjects of such body type) and the control group (11 subjects of kyphotic type) indicate that such a relationship may exist. The assessment of the asymmetry occurrence and comparison of both examined groups did not display any characteristic tendencies. The great majority of examined subjects with very considerable asymmetry occurred in the range of TT and KSM parameters.

The examined parameters in the frontal and transverse plane, except pelvis (KNM) and trunk inclination angle (KNT), revealed that

among the examined players asymmetry was observed in most of them. These results were statistically insignificant in relation to the training experience of these players. However, frequent occurrence of asymmetries is supported by the great number of players who were not classified in the standard group. It may also be assumed, as has been suggested by different researchers, that such asymmetries, created due to the frequent, habitually incorrect body posture, may result from scoliosis [10]. It is worth pointing out that without correction of posture habits, an asymmetry may extend and lead to visible side-to-side curvature of the spine [10]. Moreover, it was confirmed that training experience has a statistically significant relationship with an increasing number of asymmetries of the shoulder line angles (KLB). In this case a positive correlation of these features can be observed. It may result from the negative influence of very intensive, one-sided work and constant work of shoulder girdle muscles of the playing limb with negligence of exercises of the second limb. Hence, information on the positive influence of table tennis on the human body published in different papers [1,9,15] may refer to its recreational form. On the basis of this research, table tennis practised professionally, so many hours a day for many years, may produce different types of asymmetries which may lead to further and more permanent symmetry disturbance and consequently cause permanent changes in motor organs. Hudetz suggests introducing a double-sided training technique [6]. Such training prevents the development of asymmetries and enables players to master strokes and to correct technical mistakes quicker, which result from better stimulation of both cerebral hemispheres. People with relatively correct body posture, especially children, ought to remember that table tennis is an asymmetrical sport and regarding our above discussion may cause asymmetries if a double-sided method is not applied. As a consequence, it may cause many different defects of body posture and scoliosis.

CONCLUSIONS

1. The analysis of the results revealed that kyphotic body posture is characteristic for table tennis players. It probably results from the specific trunk, head and limb position during a table tennis match and from taking the 'ready' position (trunk, head and limbs forward).
2. Many asymmetries in frontal and transverse planes were observed in the examined table tennis players. Perhaps table tennis, which is characterized by intensive and one-sided trunk muscle work during its performance, is in favour of creating asymmetries.
3. The majority of subjects did not reveal any statistically significant correlations between the observed body posture types, their asymmetries and training experience.
4. However, it was observed that training experience is significantly related to considerable asymmetry of the inclination of the shoulder line angle (KLB). It may result from the negative influence of very intensive, one-sided work and constant work of the shoulder girdle muscles of the playing limb with negligence of exercises of the second limb.

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