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THE INCIDENCE OF IMPROPER POSTURAL ALIGNMENT DUE TO THE INFLUENCE OF LONG-TERM TABLE TENNIS TRAINING

POJAVNOST NEPRAVILNE DRŽE ZARADI VPLIVA DOLGOTRAJNEGA TRENINGA NAMIZNEGA TENISA

ABSTRACT

Considering the lack of articles regarding the affects of unilaterality of movements in racquet sports, this study has the important aim of ascertaining if the repetitive performance of strong, one-arm strokes can negatively affect the body posture of young table tennis players.

The main objectives of this research were to: (a) classify the subjects (table tennis players – TTP, and age-related controls – C) according to their postural alignment status; and (b) determine whether there is any relationship between long-term active table tennis training and the emergence of improper postural alignment (paramorphism) in children and young people.

The sample of subjects comprised 67 TTP, younger cadets and cadets; and 80 C, namely boys of the same age from two elementary schools (all aged 10–14 years). The measurement of the postural status indicators was performed using high-resolution photo-equipment (Kodak Easyshare C513). Digitalised photographs were taken in the coronal and sagittal plane and further processed using the software program "Posture Image Analyser", a photographic method for assessing standing postures.

According to the data yielded by taxonomic and discriminant analysis, it can be concluded that there is: (a) no significant difference between the TTP and the C regarding their clustering into groups by different types of postural alignment; and (b) significant differences were found in several indicators of postural status. Although a considerable incidence of improper postural alignment was detected, it must be stressed that this is a general problem among youth and is not directly related to regular table tennis training. Table tennis training is associated with specific circumstances concerning the problem of improper postural alignment: e.g., a lowered shoulder of the dominant hand and a somewhat hunchbacked basic position in the sagittal plane, all

IZVLEČEK

Ker je člankov o učinkih enostranskih gibov pri športnih igrah z loparjem izredno malo, je med pomembnimi cilji te raziskave ugotoviti, ali lahko ponavljajoči se močni zamahi ene roke negativno učinkujejo na telesno držo mladih namiznoteniških igralcev.

Glavni cilji raziskave so bili: (a) razvrstiti merjence (t. j. igralce namiznega tenisa - INT in kontrolne merjence enake starosti - KM) glede na njihovo telesno držo in (b) določiti, ali obstaja povezava med dolgoletnim dejavnim treniranjem namiznega tenisa in pojavom nepravilne drže (paramorfizem) pri otrocih in mladih.

Vzorec merjencev je obsegal 67 INT (mlajših kadetov in kadetov) ter 80 KM (večinoma dečkov enake starosti; vsi stari 10 do 14 let) iz dveh osnovnih šol. Merjenje kazalnikov drže je bilo opravljeno s pomočjo fotografske opreme visoke ločljivosti (Kodak Easyshare C513). Digitalne fotografije so bile posnete v čelni in sredinski ravnini, obdelane pa so bile s programsko opremo „Posture Image Analyser" – fotografska metoda za ocenjevanje stoječih položajev.

V skladu s podatki taksonomske in diskriminantne analize lahko zaključimo naslednje: (a) ni značilnih razlik med INT in KM pri njihovem uskupinjanju glede na različne vrste drže in (b) značilne razlike so bile ugotovljene pri več kazalnikih drže. Čeprav smo zabeležili veliko pojavnost nepravilne drže, je treba poudariti, da je to pogosta težava pri mladih in ni neposredno povezana z rednim treningom namiznega tenisa. Trening namiznega tenisa poteka v posebnih okoliščinah, ki so povezane s problemom nepravilne drže: npr. znižanje rame dominantne roke in nekoliko grbasta drža v sredinski ravnini – vse to je pretežno povezano z biomehaničnimi in strukturnimi značilnostmi tega športa.

Ključne besede: telesna drža, paramorfizem, namizni tenis, programska oprema (računalniški program)

largely linked to the biomechanical and structural characteristics of the sport.

Key words: postural alignment, paramorphism, table tennis, software program (computer program)

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INTRODUCTION

The increasing incidence of improper and incorrect body posture among children and youth is recognised as a highly important problem in modern society which, if neglected, can even lead to structural deformities and require long-term orthopaedic medical treatment.

Large deviations from ideal postural alignment induce stress on spinal tissues, resulting in possible headaches, neck pain, back fatigue, structural deformities of the spine, intervertebral discs and spinal ligaments (Griegel-Morris, Larson, Mueller-Klaus, & Oatis, 1992; Kobayashi, Hosoi, Takeuchi, & Okuda, 1996; Troyanovich, Harrison, & Harrison, 1998).

Epidemiologic studies have shown that posture-related problems are very common among schoolchildren (Kristjánsdóttir & Wahlberg, 1993). In that period, poor standing posture affects the spinal tissues in combination with other risk factors such as rapid growth spurts, backpack use and faulty sitting posture (Troussier et al.1999; Viry, Creveuil, & Marcelli, 1999; Mackenzie, Sampath, Kruse, & Sheir-Neiss, 2003; Trevelyan & Legg, 2006). Kratěnová, Žejglicová, Malý, and Filipová (2007) found that 38% of 11-year-old schoolchildren had poor posture.

Although it is generally clear that physical activity unquestionably has a positive influence on several organs and organ systems, sport medicine physicians report a growing incidence of incorrect and improper body posture and deformities in children and young people who participate regularly in sport activities (Kosinac, 2002). Therefore, although the proper application of kinesiological operators (in the form of physical exercise and sports) in kinesitherapy is one of the most reliable foundations for the treatment of certain complaints and diseases, it is also obvious that in some cases and in several sports disciplines the assumption of an exclusively positive effect should be challenged. This is particularly relevant to modern top-level sport which involves regular and maximal – even extreme – workloads and training intensities that can produce negative consequences for children and adolescents at sensitive developmental stages. Close observation of a typical table tennis player shows that their posture (while playing) reveals a peculiarity (Folorunso, Mutiu, & Ademola, 2010).

Few kinanthropometry studies have been performed on table tennis players and even fewer for the ages considered in this study. However, the authors have found some publications carried out for people of a similar age but for other racket sports (Centeno, Naranjo, & Guerra, 1999; Tomkinson, Popovic, & Martin, 2003; Torres Luque, Alacid Cárceles, Villaverde Gutiérrez, & Ferragut Fiol, 2006; Sánchez-Muñoz, Sanz, & Zabala, 2007; De Hoyo, Sanudo, & Paris, 2009).

Although the opinions of experts are contradictory and there is no reliable scientific evidence regarding sport as the direct cause and instigator of scoliosis and kyphosis, there are indications that, together with inherited and genetically determined tendencies, several sports, especially the asymmetrical ones, can negatively influence postural status and therefore cause deformities (Kosinac, 2002). In athletes this can lead to several health issues and problems (e.g., back pain or chronic fatigue) and therefore negatively influence their competitive efficacy and, in some cases, their whole sports career.

The biomechanical and structural characteristics of table tennis are observable in: (a) its asymmetrical nature (the repetitive performance of strong, one-arm strokes); (b) a hunched basic position; and (c) the strong rotation of the hips and lumbar region. As a result, it is quiet likely that table tennis players are additionally exposed to several factors that could initiate the occurrence and development of paramorphism in comparison to the general population (Pradas, Carrasco, Martinez, & Herrero, 2007; Carrasco, Pradas, & Martinez, 2010; Pradas, Martinez, Alcaraz, & Carrasco, 2009; Folorunso, Muitu, & Ademola, 2010). Consequently, the main objective of the present study was to: (a) classify the subjects – table tennis players into several clusters according to their postural alignment status; and (b) determine whether there is any relationship between long-term active table tennis training and the emergence of improper postural alignment (paramorphism) in children and adolescents.

METHODS

Sample

The sample of subjects in this study consisted of 67 male table tennis players (TTP) of a high competitive rank for their age groups (younger cadets; 10–12 years of age and cadets; 12–14 years of age). The only requirement for participating in the study was to be officially registered in the Croatian Table Tennis Federation and to have actively participated in table tennis for a minimum of three years. The control group (C) consisted of a convenience sample of 80 boys of the same age from two elementary schools in Split, Croatia; they were not engaged in table tennis training, for the purpose of representing the general population of boys aged 10–14 years.

The boys' parents approved their children's participation in this study and the study was approved by the ethics committees of both the Croatian Table Tennis Federation and the Faculty of Kinesiology at the University of Split.

Procedure

All measurements were performed by the same researcher experienced in the assessment of postural alignment. To establish the reliability of the photographic method for assessing postural alignment, we took six photographs of each subject, namely, three front views and three side views.

The area where the photographs were taken was arranged identically in both the school and sports hall. Markers were placed on the floor to ensure the same positioning of all subjects in front of the camera. A marker was placed in front of a white screen to ensure the contrast of the subjects against the background. A Kodak Easyshare C513 (Kodak Easyshare C513; Eastman Kodak Company, Rochester, NY) digital camera was used. The camera was placed on a tripod 3.1 m from the line marking the position of the subject. It was levelled on the tripod by a spirit level to ensure it was parallel to the floor. The tripod's height was adjusted so the middle of the objective lens was 115 cm above the ground. Before taking the photographs, the researcher placed reflective markers on the following anatomical points on the left and right sides of a subject's body: tip of the pinna, acromion process, anterior superior iliac spine, lateral epicondyle of the femur, and medial malleolus. To enable the precise positioning of the markers, we instructed the subjects to wear shorts ending above the knee and to be naked from the waist up. Once the markers were in place, each subject was asked to stand on the designated spot facing the camera, to take a comfortable habitual standing position, and look straight ahead. After each photograph, the subject was instructed to take a few steps around the hall and then return to the designated spot and resume the position. During the break, the researcher checked the position of all the markers on the subject's body and refastened them if necessary. After the three front-view photographs were taken, the whole procedure was repeated from the lateral perspective. Before taking the side-view photographs, the researcher changed the position of the reflective markers from the medial to the lateral malleolus. For the lateral views, the right side of a subject was photographed for right-hand dominant individuals and the left side for left-hand dominant individuals.

The photographs were analysed by the Posture Image Analyser software which gave good interim reliability as a photographic method for assessing standing posture among male elementary students aged between 10 and 13 years (Paušić, Pedišić, & Dizdar, 2010). This software automatically digitises the reflective markers on a subject's body and calculates the deviation of the anatomical points from the ideal postural alignment defined by Kendall, McCreary, Provance, Rodgers, and Romani (2005). From the front (coronal) view photographs, the software calculates angle deviations from a horizontal line of the lines connecting the same anatomical points on the left and right sides of the body. The angle deviations in the coronal plane were calculated as follows: head and neck deviation on the basis of the tip of the left and right pinna position, trunk deviation on the basis of the acromion process position, pelvis deviation on the basis of the left and right anterior superior iliac spine position, knee joint deviation on the basis of the lateral epicondyles of the femur position, and ankle joint deviation on the basis of the position of the medial malleolus of the left and right legs. From the side-view photographs, the software calculates the distance of anatomical points from the vertical line passing slightly in front of the lateral malleolus. Deviations in the sagittal plane were calculated as follows: head and neck deviation on the basis of the position of the tip of the pinna, trunk deviation on the basis of the position of the acromion process, pelvis deviation on the basis of the position of the anterior superior iliac spine, and knee joint deviation on the basis of the position of the lateral epicondyle (Figure 1).

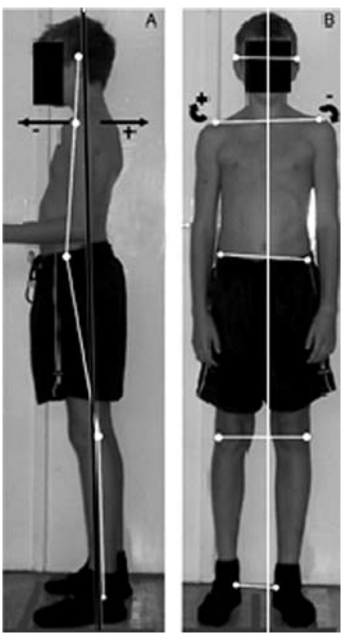

Figure 1: Photographs were taken of each subject in sagittal (A) and coronal (B) views. (The positions of the reflective markers are shown as white dots. Arrows denote the directions of postural deviations for which we calculated positive/negative values (Paušić, Pedišić, and Dizdar, 2010)).

For an ideal postural alignment the values of all postural deviations should equal 0.

All the photographs were also analysed in the same way by the UTHSCSA ImageTool software. Marker positions on all the photographs were digitised by the same researcher. Because the digitising of marker positions in the ImageTool software is performed manually, the accuracy of the Posture Image Analyser software when automatically recognising the marker positions was checked.

Variables

The sample of variables consisted of posture status indicators. Measurements were conducted according to the reference points of the body regarding the gravity line in the sagittal and coronal planes (Auxter, Pyfer, & Huettig 1997; Palmer & Epler, 1998) and comprised numerical values for five reference points in the coronal (frontal) plane and four reference points in the sagittal plane (Figure 2).

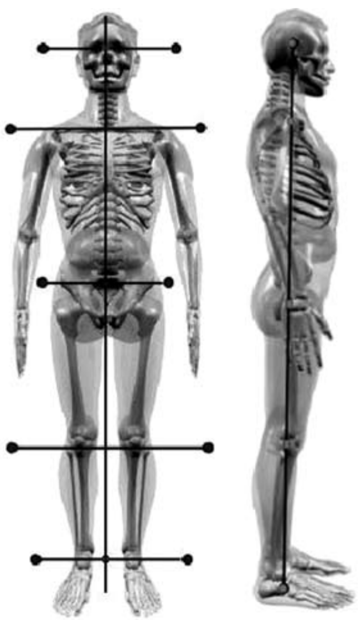

Figure 2: Reference points in the coronal (picture on the left) and sagittal planes (picture on the right), including the gravity line (vertical blue line)

Posture status indicators in the ***coronal*** (frontal) plane:

- **Head and neck** deviation – the indicator of the divergence between the: (a) left and right pinna position; and (b) horizontal line. This indicator was measured by a computer program in degrees.
- **Trunk** deviation – the indicator of the divergence between: (a) the line that connects the left and right acromion; and (b) the horizontal line. This indicator was measured by a computer program in degrees.
- **Pelvis** deviation – the indicator of the divergence between the: (a) line that connects the left and right spina iliaca anterior superior; and (b) horizontal line. The indicator was measured by computer program in degrees.

- **Knee joint** deviation – the indicator of the divergence between the: (a) line that connects the left and right epicondylus lateralis; and (b) horizontal line. This indicator was measured by a computer program in degrees.
- **Ankle joint** deviation – the indicator of the divergence between the: (a) line that connects the left and right malleolus medialis; and (b) horizontal line. This indicator was measured by computer program in degrees.

Posture status indicators in the ***sagittal*** plane:

- **Head and neck** deviation – the indicator of the divergence between the: (a) position of the tip of the pinna; and (b) gravity line. This indicator was measured by a computer program in numerical units.
- **Trunk** deviation – the indicator of the divergence between the: (a) acromion; and (b) gravity line. This indicator was measured by a computer program in numerical units.
- **Pelvis** deviation – the indicator of the divergence between the: (a) spina iliaca anterior superior; and (b) gravity line. This indicator was measured by a computer program in numerical units.
- **Knee joint** deviation – the indicator of the divergence between the: (a) epicondylus lateralis; and (b) gravity line. This indicator was measured by a computer program in numerical units.

The ideal standing posture should allow for the maintenance of balance using the least musculoskeletal effort without a feeling of discomfort. The ideal alignment of body segments in a standing posture should coincide with a vertical line passing through the centre of gravity of the body. From a lateral view, the ear, axis, shoulder, bodies of lumbar vertebrae, hip, knee, and the point just in front of the lateral malleolus should be situated on the same vertical line (Figure 2). In the coronal plane, the posture should be bilaterally symmetrical (Paušić, Pedišić, & Dizdar, 2010).

Data processing methods

The photographs obtained were processed by the software program "Posture Image Analyser" which showed satisfactory interim reliability as a photographic method for assessing the standing posture among male elementary students aged between 10 and 13 (Paušić, Pedišić, & Dizdar, 2010). The results for each indicator of posture alignment were computed by the statistical software package Statistica 7 (StatSoft).

The results were calculated by discriminant analysis (by means of Bartlett's χ^2 test) and included the following parameters; variance of the discriminant function *(λ),* canonical correlation coefficient *(Rc)* and Wilk's lambda coefficient *(Wλ)* discriminant functions, correlations of the variables with discriminant functions (matrix of the structure), centroids of the groups on the discriminant functions, and descriptive parameters: means (AS), and standard deviation (SD). The types of postural alignment in the coronal and sagittal planes were obtained by taxonomic analysis, by the K-Means method, with the selection of three clusters.

RESULTS

The calculated body posture indicators are divided into two groups depending on the plane in which the photo was taken. Therefore, they are independent and can divide the subjects into several groups based on their type of body alignment. The types of body alignment were defined by taxonomic analysis and three types of body alignment were identified, separately in each plane. The types obtained and the categorisations in each type (expressed in percentages) are presented in Tables 1 and 2.

Table 1: The percentage of subjects belonging to the different types of coronal (frontal) postural alignment

Types of coronal postural alignment	$\%_{GP}$	$\%_{TT}$
correct coronal postural alignment	29.4	34.3
mildly scoliotic postural alignment	37.6	28.4
mildly two-sided scoliotic postural alignment	33.0	37.3
Total	100.0	100.0

Legend: GP – general population of boys, TT – boy table tennis players

It is obvious that in both groups (TTP and C) the majority of subjects deviate from the ideal standing posture in the coronal plane (Table 1.). When observing the boys in the sample of table tennis players, only slightly more than one-third (34.3%) can be said to have had the correct coronal (frontal) posture. However, this is still a better result than that obtained in the general population of boys where less than 30% (29.4%) of the subjects can be considered as having a correct coronal posture.

Table 2: The percentages of subjects belonging to the different types of sagittal postural alignment

Types of sagittal postural alignment	$\%_{GP}$	$\%_{TT}$
correct sagittal postural alignment	29.3	26.9
mildly incorrect sagittal postural alignment	41.8	41.8
highly incorrect sagittal postural alignment	28.9	31.3
Total	100.0	100.0

Legend: GP – general population of boys, TT – boy table tennis players

Regarding the sample of table tennis players, the situation is far worse in the sagittal plane (Table 2) since only slightly more than one-quarter of the players can be considered as having the correct sagittal posture (26.9%), while almost one-third have a highly incorrect posture status (31.3%). In the sample representing the general population of boys, the situation is marginally, but not significantly, better since the majority of subjects deviate mildly or highly from the ideal standing posture in the sagittal plane.

To establish the differences between the two samples of boys (TTP and C), the structure of discriminant functions was defined and calculated separately for the coronal and sagittal indicators of body posture. The results presented here show that the discriminant functions are statistically significant (Table 3); therefore, significant differences between the two samples (TTP and C) can be identified for some of the indicators studied (Tables 4 and 5).

Table 3: Test of significance for the discriminant functions

	λ	R_C	Wλ	χ^2	df	p
DF_C	0.18	0.39	0.85	23.5	5	0.00
DF_S	0.97	0.70	0.51	96.8	4	0.00

Legend: C – coronal indicators of postural alignment, S – sagittal indicators of postural alignment

Table 4: Basic descriptive parameters (mean – AS and standard deviation – SD) with identification of the discriminant function structure (DF), and analysis of the variance (ANOVA) in the coronal indicators of body posture

Indicators	AS_{GP}	SD_{GP}	AS_{TT}	SD_{TT}	F	p	DF
Head and neck	-0.20	2.15	-0.85	2.86	2.2	0.14	0.31
Trunk	0.35	1.60	0.98	2.37	3.7	0.05	-0.37
Pelvis	-1.47	1.46	-0.64	2.24	3.5	0.06	-0.53
Knee joints	-1.04	1.51	0.10	2.39	10.4	0.00	-0.69
Ankle joints	-1.23	1.61	-1.63	2.99	1.8	0.19	0.20
						C_{GP}	0.39
						C_{TT}	-0.46

Table 5: Basic descriptive parameters (mean – AS and standard deviation – SD) with identification of the discriminant function structure (DF), and analysis of the variance (ANOVA) in the sagittal indicators of body posture

Indicators	AS_{GP}	SD_{GP}	AS_{TT}	SD_{TT}	F	p	DF
Head and neck	-3.88	2.71	-6.05	3.14	0.09	0.77	0.38
Trunk	-4.11	2.45	-8.05	2.72	68.32	0.00	0.78
Pelvis	-3.23	2.87	-4.82	3.04	3.24	0.07	0.27
Knee joints	-1.72	2.04	-0.39	1.41	27.63	0.00	-0.38
						C_{GP}	0.89
						C_{TT}	-1.07

DISCUSSION

According to the results presented in Tables 1 and 2, it is evident that in both groups (TTP and C) the same types of body posture alignment exist, and that there is a very large percentage of boys from both groups with an improper body posture alignment in each of the planes (coronal and sagittal).

In the coronal plane, postural deviations were calculated as angle deviations of the lines connecting the same anatomical points on the left and right sides of the body from a horizontal line. In the sagittal plane, postural deviations were calculated as the distances of the relevant markers from the ideal plumb line. For an ideal postural alignment, the values of all postural deviations should equal 0.

In the coronal indicators of postural alignment, the most important factors in the significant differences among the samples are divergences in the positioning of the trunk (shoulders) and knees (Table 4). These indicators in the coronal plane show significant angle deviations from a horizontal line of the lines connecting the same anatomical points (acromion process position & lateral epicondyles of femur position) on the left and right sides of the body.

The positioning of the knees in the coronal plane is more correct in the table tennis players than in boys drawn from the general population, but the table tennis players show greater divergence in their shoulders (1.38 and 0.35 degrees, respectively). Positive values in degrees (Table 4) indicate in both samples an inclination of the left shoulder compared to the right, but this is much more emphasised in the sample of table tennis players. The main reason probably arises from the simple fact that most of these players are right-handed and have relatively more developed muscles on the right side of their torso which pull the peak of the shoulder of the playing arm down and back. When the muscles are not developed evenly on both sides of the trunk this results in an asymmetrical postural alignment in the shoulder region of the coronal plane. A somewhat lower shoulder of the dominant hand is often clearly observable in table tennis players.

The factor which contributes most to the significant differences among the samples in the sagittal parameters is the indicator of trunk divergence (Table 5). The same conclusion was reached by Foloorunso, Mutiu, and Ademola (2010), who concluded that the characteristic posture of the athlete and the high level of physical activity of the dominant limb may predispose the player to special biomechanical changes that can lead to chronic pain and discomfort. This indicator of sagittal postural alignment shows significant differences between the groups in angle deviations from the vertical line (the ideal plumb line of posture in the sagittal plane). Both groups show negative values in degrees, indicating a forward inclination of the trunk, but this divergence is significantly more emphasised in the sample of table tennis players. The pelvic tilt on the hip and knee of the dominant side may lead to accelerated degenerative changes on the dominant side. The other factor that contributes significantly to differences among the samples in the sagittal parameters is the indicator of knee divergence, which is more correct in the table tennis players than in the controls. Kobayashi et al. (1996) reported that, for table tennis players, the muscular activity of their lower limbs may not be sufficient to stress the bones and recommends including resistance training alongside table tennis training to improve fitness and enhance bone mass; this would also contribute to a proper postural alignment.

Generally, the mean values for the upper part of the body in the sagittal plane indicate somewhat more inappropriate postural alignment in the table tennis players than in the controls (Table 5). The parameters for head position and the trunk (shoulder) position point to the somewhat hunched position of table tennis players in the cervical and thoracic spine when compared to the control group – the general population of boys of the same age. Few kinanthropometry studies have been performed on table tennis players and even fewer for the ages considered in this study. However, the authors have found some research that has been carried out on people of similar age but for other racket sports (Centeno, Naranjo, & Guerra, 1999; Tomkinson, Popovic, & Martin, 2003; Torres Luque et al., 2007; De Hoyo, Sanudo, & Paris, 2009) where the results are almost identical (head position, trunk (shoulder) position, hunched position in the cervical and thoracic spine) to those established in our research.

The main reason for such a condition can probably be found in the fact that table tennis players constantly stand in a hunched basic position while playing; this is highly characteristic in table tennis and, if maintained for a long time, is likely to increase the probability of an improper postural alignment in the sagittal plane.

CONCLUSION

The results of the present study reveal: (a) no significant difference between the TTP and the C regarding their clustering into groups by different types of postural alignment; and (b) significant differences in several indicators of posture status.

Although a considerable incidence of improper postural alignment was found, it should obviously be stressed that this is a general problem among young people, one not directly related to regular table tennis training. Long-term table tennis training can have some specific implications for improper postural alignment problems, e.g. a lowered shoulder of the dominant hand, and a mildly hunched basic position in the sagittal plane, all mainly linked to the biomechanical and structural characteristics of the sport.

The results of this study point to the particular importance of general preparation of the locomotor system in table tennis athletes, mainly because of the asymmetrical nature of table tennis as a sport. Since the muscles are not developed evenly and symmetrically, muscle imbalance can negatively affect posture and compromise player health and competitive efficacy.

There is no doubt that multi-faceted fitness training, adjusted to an athlete's age, can positively influence proper and symmetrical development in young table tennis players. It should thereby be possible to reduce some of the negative consequences that frequent and intensive table tennis training can have on the posture status of young athletes.

Since this study was conducted at a single point in time it has its limitations. So it is necessary to conduct more future researches whereby young players, with no initial postural deviations, would be monitored over a longer time period with the aim to establish beyond doubt whether regular table tennis training can influence the development of an improper body posture and, if so, in what amount of time (training hours).

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