THE ASSESSMENT OF SPINAL MOBILITY IN FEMALE HANDBALL PLAYERS

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Abstract:
The aim of the study was to assess shape and mobility of the spine in the sagittal and frontal planes. We assessed shape of the spine in upright position, flexed position, extended position, and right and left lateral flexion. Mobility was expressed as the range of motion from upright to flexion and extension, and from extension to flexion. Percentage analysis showed occurrence of changes. A sample of fourteen U19 female handball players of the ŠŠK SLŠ Bemaco Prešov handball team participated in the study. Spinal mobility was assessed using a modern and noninvasive measuring device Spinal Mouse (SM®). The results showed that engaging in unilateral sports leads to changes in shape and mobility of the spine. The study was conducted within the project KEGA 044PU-4/2016 "Innovation of health-oriented educational tools for future teachers of physical and sports education and experts in sports and health".

INTRODUCTION

Handball is a fast, contact, and team sports game popular all over Europe. The game of handball is dynamic and based on execution of locomotor skills such as running, jumping, changing direction of movement, sudden stops, turns, starts, jumps and throws [Zaťková, Hianik 2006]. Players commonly bump into each other deliberately, as well as accidentally. Handball falls into the category of acyclic sports, that is, sports characterized by nonperiodic movement. During handball matches exercise intensity alternates and varies during the course of the game. Handball players must be able to run quickly in short bursts, and be capable of changing direction quickly in order to wrong-foot opponents. Catching ability is also essential, together with a fast and accurate throw [Stubbs 2011].

Handball, similarly to most other sports, is a unilateral sport. During their careers, handball players who perform specific playing functions are exposed to unilateral loading, which leads to muscle imbalance and also to the origination of postural imbalance.

The most strained muscles during matches are:
primary – m. trapezius, m. deltoideus, m. pectoralis major, minor, mm. antebrachii, m. coxae, m. quadriceps femoris, m. triceps surae, m. gluteus maximus
secondary – m. rectus abdominis, harmstring muscles.
The most strained muscles during shooting and passing:
- m. deltoideus, m. triceps brachii, m. latissimus dorsi.

Figure1

In handball, as well as in other team sports games, laterality, or preference of one side of the body, is predominant. Individual playing functions differ in player tasks and in different degree of weakening and shortening of muscles.

Wing players tend to suffer from muscular shortening of m. quadratus lumborum and hip flexors (HF). This is caused by the fact that wing players operate in the corners of the handball court during offensive phase of the game and have to extend opponent's defense. Shooting at the goal mostly takes place from minimal shooting angles, which forces wing players to open the angle by leaning sideward [Slovík et al. 1974]. Most often, these players show weakened abdominal muscles, which may be caused by incorrect muscle strengthening. Thus the movement is not performed by abdominal muscles but rather by hip flexors. This may consequently lead to shortening of lumbar muscles and pelvic tilt. Shortened muscles may be found especially in the scapular and shoulder girdle regions – m. trapezius, m. levator scapulae, which may be caused by laterality.

Back players move on the court within the distance between 12 and 14 meters from the opposing team's goal. Their primary task is to execute fast shots from a long range and get through opponent's defense using their feinting skills [Slovík et al. 1974]. These actions cause muscle shortening of knee flexors (KF), hip flexors (HF), hip adductors and m. gluteus maximus. Lopata (2012) found that weakened gluteal muscle result in poor muscle recruitment during knee flexion, which consequently causes pain in the lumbar region of the spine. Similarly to wing players, back players also suffer from weakened abdominal muscles and shortened muscles in the scapular and shoulder girdle regions.

Pivots operate and move close to the opponent's goal area by standing sideward or backward to opponent's goal, which means that pivots shoot after turns and most often after being fouled [Slovík et al. 1974]. Similarly to wing players, pivots suffer from shortening of m. quadratus lumborum, hip and knee flexors because pivots often shoot while falling. Shooting after a turning movement may lead to shortening of mm. paravertebrales with less frequent shortening of m. piliformis, which allows rotation in the hip joint. Pivots, similarly to other playing functions, suffer from weakened arm muscles due to laterality.

In her research, Kanasová confirmed the occurrence of muscle imbalances, which consequently leads to diminished spinal mobility, functional disorders of the spine in athletes, and to spinal deformities even in young athletes. Complex mobility of the spine is determined by the sum of movements between individual vertebrae. The degree of movement is affected by the height of intervertebral discs, the laxity of joint capsules, ligaments and length of muscles. Almost every human movement relies on the spine. Therefore, spine is considered a flexible body axis [Bínovský 2001].

Fleischmann, Linc (1992) refer to 4 basic spinal movements:

1. forward and backward flexion (in the sagittal plane), leaning forward and backward, anteflexion and retroflexion,
2. flexion to the sides and lateroflexion,
3. rotation and torsion,
4. subtle springlike or pliable movements reliant on the curvature of the spinal column.

Diminished spinal mobility may be attributed to insufficient compensation of training load and early specialization. High-intensity training load places excessive demands on individual body parts. Bones, muscles, tendons, and ligaments are loaded beyond their anatomical and physiological limits. Long-term and uncompensated one-sided loading leads to pain, sports injuries, mental discomfort, and also to deterioration in player performance. Hianik (2001) recommends that every player, including goalkeepers, try each of the playing functions, in order to prevent the origination of health problems specified above.

The aim of the study was to analyze the shape and mobility of the spinal column in female handball players using the Spinal Mouse® (SM®), and to determine deviations in the shape of the spinal column in the sagittal and frontal planes.

THE AIM AND METHODOLOGY OF THE STUDY

The sample consisted of 14 female handball players of the ŠSK SLŠ Bemaco Prešov handball team. The players who participated in the study were 15 to 17 years old. Mean body height and body weight of players was 171 cm and 62.6 kg, respectively. The mean training age of players was 5.8 years. The current standings of the team in the first league of U19 players was fourth place after 20 games played.

To analyze spinal mobility, we used the measuring device Spinal Mouse® (SM®), an innovative device manufactured in Switzerland. This device assesses curvatures of the spinal column without applying harmful radiation. The device is guided manually on the skin along the spine and measures alignment and angles [Mikuľáková, Živčák et al. 2015] (Figure 2).

Figure 2. Spinal mouse SM®

SM®, the shape of which is similar to that of a computer mouse, consists of two rollers The Spinal Mouse ® device includes two rollers included on a mobile support that allows spinous contour tracking. This shape is recorded by three sensors, which, via a Bluetooth connection, transmit clinically relevant data to the computer program. The analysis and assessment of data provide information about the curvature of the spinal column, angles between individual body segments, and spinal mobility in the sagittal and frontal planes. The measurements were conducted in the sagittal and frontal planes in the upright position, from upright to flexion and from upright to extension, and in the upright position, from upright to left lateral flexion, and from upright to right lateral flexion. The SM® software displays and graphically represents data. Consequently, the software displays the true spinal configuration and the examined person has the chance to see it.

RESULTS

Data showed negative changes in the shape and mobility of the spinal column in frontal and sagittal planes. Of the sample consisting of 14 female handball players data about shape and mobility of the spinal column using SM® in both planes are interpreted for one player. The overall study findings are presented in the conclusions of the study in form of percentage analysis of all handball players.

Miriam was a 16-year-old handball player who was 178 cm tall and weighed 64 kg. During SM® measurements in the upright position (standing position), from upright to flexion, and from upright to extension, data are automatically transmitted to the computer program and displayed graphically (Figure 3).

Table 2 shows values in individual positions (Upr - upright position, i.e. standing position, Flex – flexion, Ext – extension, U-F – range of motion from upright to flexion, U-E – range of motion from upright to extension, E-F – range of motion from extension to flexion). The black dot in the middle column for each position represents segments with deviations from reference values. Plus values represent the degree of kyphotic curvature, and minus values represent the degree of lordotic curvature of the spinal column. The values in the upright position showed excessive kyphotic curvature of the thoracic spine in segments of Th_8 and Th_{10}, which is visible in the figure displaying extended analysis, the so-called expert mode (Figure 4). This figure shows all abnormal values, positions and mobility of the spinal column both regionally and locally.

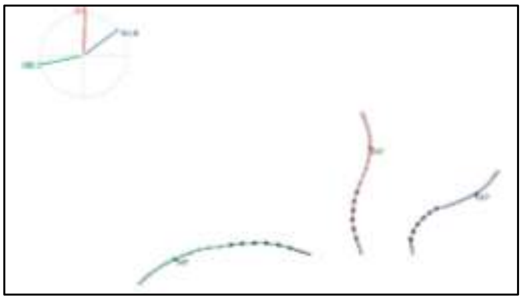

Figure 3. Graphically displayed data in the sagittal plane

Measurements in the flexed position showed no kyphotic deviations in the thoracic spine with exception of Th_{11}/Th_{12} segment with lordotic curvature. Values in the extended position showed diminished kyphotic curvature in $Th_{1/2}$ and $Th_{4/5}$. On the contrary, $Th_{6/7}$ showed excessive kyphotic curvature. Segments Th8/9 also showed lordotic instead of kyphotic curvature. The thoracolumbar spine showed excessive lordotic curvature, especially in the segments of Th_{12}/L_1-L_3.

When measuring range of motion of the spine, that is, the mobility of the spinal column, diminished mobility was found in the thoracic spine from upright position to flexion for segments Th_4-, Th_6 and $Th_8/_9$. Data collected for other spinal regions did not exceed reference values. Excessive mobility in the lumbar region of the spine was found for upright to extension and for extension to flexion. Diminished mobility was found in the thoracic region of the spine from extension to flexion. On the contrary, excessive mobility was found in the lumbar and sacral spine.

Table 2. Values in the sagittal plane

Segment	Upr			Flex			Ext			U-F			U-E			E-F		
Th1/2	1	1	9	-1	0	5	3	1	♦10	-7	-2	1	-4	0	6	-8	-1	0
Th2/3	4	5	8	3	3	8	3	6	9	-4	-1	2	-3	1	3	-4	-2	2
Th3/4	3	6	7	3	5	7	4	6	9	-3	-1	3	-2	0	4	-4	-1	2
Th4/5	2	4	6	3	2	♦ 7	3	2	♦ 7	-1	-2	♦ 3	-2	-2	4	-3	-1	3
Th5/6	3	7	7	3	2	♦ 7	3	4	7	-3	-5	♦ 3	-3	-3	♦ 3	-3	-1	3
Th6/7	3	7	7	3	6	7	2	10	♦ 6	-3	-2	3	-4	3	2	-2	-4	♦ 4
Th7/8	2	3	6	4	4	8	2	7	8	-1	1	5	-2	4	4	-2	-3	♦ 4
Th8/9	1	7	♦ 5	4	2	♦ 8	1	-4	♦ 7	0	-5	♦ 6	-2	-11	♦ 4	-1	6	♦ 5
Th9/10	0	5	♦ 4	5	8	9	-2	5	♦ 4	3	3	7	-3	0	1	3	3	9
Th10/11	-1	0	3	3	5	8	-3	0	1	1	5	7	-5	0	1	4	5	9
Th11/12	-4	-3	2	2	-2	♦ 6	-7	6	♦ 1	2	1	8	-6	9	♦ 2	4	-8	♦11
Th12/L1	-5	-5	1	2	1	♦ 8	-9	-17	♦-1	4	6	11	-7	-12	♦ 1	6	18	♦14
L1/2	-7	-5	-2	3	3	7	-9	-11	♦-3	6	8	12	-5	-6	♦ 1	8	14	15
L2/3	-10	-7	-2	5	5	10	-13	-4	♦-5	10	11	16	-8	3	♦ 2	12	8	♦20
L3/4	-13	-11	-5	3	9	9	-17	-13	-9	10	19	20	-8	-3	0	14	22	24
L4/5	-11	-6	-3	3	7	9	-18	-13	-9	9	14	17	-10	-7	-2	14	20	24
L5/S1	-11	-5	-1	-3	2	5	-18	-25	♦-4	3	6	11	-10	-21	♦ 0	6	27	♦19
Sac/Hip J.	11	19	29	58	72	84	7	8	25	39	54	63	-12	-11	4	45	64	65
Thoracic spine	31	42	47	45	33	♦ 65	24	42	52	5	-8	♦ 27	-16	0	14	2	-8	♦ 32
Lumbar spine	-44	-37	-24	22	26	38	-67	-83	-47	54	63	74	-35	-46	♦-11	77	109	♦ 97
Incl.	4	-3	♦12	104	103	♦128	-24	-52	-6	98	105	120	-32	-49	♦-14	117	155	♦145
Length		419			505			367			86			-52			138	

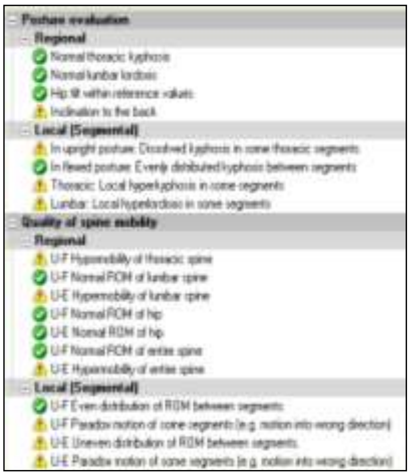

Figure 4. Expert mode in the sagittal plane

As in measurements using SM® in the sagittal plane, we also measured spinal mobility in three positions: upright position (i.e. standing positon), left lateral flexion, and right lateral flexion. The results were transmitted to the computer program (Figure 5).

Figure 5. Graphically displayed data in the frontal plane

Table 3 shows data for individual positions (Left – left lateral flexion, Upright – upright position, Right – right lateral flexion, S-L – range of motion from upright to right lateral flexion, S-R – range of motion from upright to right lateral flexion). Unlike sagittal plane, the table showing data for the frontal plane does not present reference values, which are not necessary because curvature is not considered nonphysiological unless it exceeds the value of 7. Individual table columns show only values with parentheses or without parentheses either on the left or right side.

A parenthesis is shown for values in the upright position and lateral flexions. As shown in Table 3, we may state that scoliotic curvature in left lateral flexion was found in the thoracic region of $Th_{11}/_{12}$. Other regions showed normal values. However, there were no signs of scoliotic curvature in the upright position in any of the spine regions. In the laterally flexed position, scoliotic curvature was found for Th_{12}/L_1 of the thoracolumbar spine and also in the sacral region of the spine. When measuring spinal mobility, the direction of curvature is labelled with red and purple flags. In the position from upright to left lateral flexion, scoliotic curvature was found for $Th_{11}/_{12}$in the thoracic region of the spine, and also for Th_{12}/L_1 of the thoracolumbar spine. The curvature exceeds the norm also in the lumbar region of L_3/L_4 and L_4/L_5.

Table 3. Values in the frontal plane

Segment	Left	Upright	Right	S-L	S-R
Th1/2	) 2	) 1	2 (	◄ 2	3 ►
Th2/3	2 (	0	1 (	2 ►	1 ►
Th3/4	) 1	0	1 (	0	2 ►
Th4/5	) 3	1 (	2 (	◄ 4	2 ►
Th5/6	) 2	1 (	1 (	◄ 2	0
Th6/7	0	0	) 1	0	◄ 2
Th7/8	0	3 (	0	◄ 4	◄ 3
Th8/9	0	2 (	0	◄ 2	◄ 2
Th9/10	) 3	0	4 (	◄ 3	4 ►
Th10/11	) 7	) 2	5 (	◄ 5	7 ►
Th11/12	) 12	) 1	9 (	◄ 11	10 ►
Th12/L1	) 5	3 (	10 (	◄ 8	8 ►
L1/2	) 4	2 (	2 (	◄ 6	0
L2/3	) 6	0	5 (	◄ 6	4 ►
L3/4	) 7	) 5	6 (	◄ 1	12 ►
L4/5	) 8	) 5	4 (	◄ 3	9 ►
L5/S1	) 6	) 3	3 (	◄ 3	6 ►
Sac/Hip J.	4 (	3 (	8 (	0	5 ►
Thoracic spine	) 28	3 (	24 (	◄ 30	22 ►
Lumbar spine	) 36	) 9	30 (	◄ 28	39 ►
Incl.	) 38	) 5	41 (	◄ 33	46 ►
Length	497	469	452	28	-16

Study findings about the shape of the spinal column of Miriam showed that thoracic region of the spine was hyperkyphotic, that is, she suffered from flat back syndrome, which is most frequently caused by the imbalance of the thoracic muscle groups. The curvature of the lumbar region was lordotic, and this curvature is most frequently caused by the shortening of back extensors. Measurements in the frontal plane showed scoliotic curvature of the spine in the thoracic region. The data about spinal mobility from the upright position to flexion showed that spinal mobility was diminished in the thoracic region but normal in other regions of the spine. We found excessive spinal mobility in the lumbar and sacral regions in the position from upright to flexion and from extension to flexion.

We also present the analysis of spinal mobility in female handball players in form of percentage analysis based on data about individual players.

SAGITTAL PLANE:

The results about the shape of the spine in the upright position showed that seven players suffered from excessive curvature of the thoracic spine, the so-called rounded back. The other players showed normal thoracic curvature. Five players showed diminished, six players normal and three players excessive degree of lumbar curvature, respectively. None of the players showed excessive curvature of the sacral spine. Ten players showed normal curvature of the spine and four of them had diminished spine curvature.

The results about the shape of the spine in the flexed position showed that seven players had excessive, six players normal, and only one player diminished thoracic spine curvature, respectively. None of handball players showed excessive curvature of the lumbar spine. Nine players showed normal curvature and five of them diminished curvature in the lumbar region. None of handball players showed excessive curvature in the sacral region. Half of players had normal spine curvature and the other half showed diminished curvature.

The results about the shape of the spine in the extended position showed that six players had excessive, six players normal and only one player had diminished curvature in the thoracic region. None of the players showed excessive curvature, 10 players had normal curvature, and four had diminished curvature of the lumbar spine. None of the players showed excessive curvature in the sacral region. One player had normal curvature and 13 players diminished curvature of the spine.

The results about the shape of the spine from upright position to flexion showed that three players had excessive curvature of the thoracic spine. Nine players showed normal curvature and two players diminished curvature of the spine. None of the players showed excessive curvature, 10 players had normal curvature, and four players showed diminished curvature of the lumbar spine. One player showed excessive curvature of the sacral spine, eight players had normal curvature, and five players diminished curvature, respectively.

The results about the shape of the spine from upright position to extension showed that one player showed excessive curvature in the thoracic region. Ten players had normal and three players had diminished curvature of the spine. Five players showed excessive, seven players had normal, and two players showed diminished curvature of the lumbar spine, respectively. Two players had excessive curvature of the sacral spine. One player showed normal and 11 players diminished curvature in this region of the spine.

The results about the shape of the spine from extension to flexion showed that one player suffered from excessive curvature of the thoracic spine. Eleven players showed normal, and two players diminished curvature of the thoracic spine. None of the players had excessive curvature, one player showed normal and 13 players diminished curvature of the lumbar spine, respectively. Six players showed excessive curvature, six players normal curvature, and two players diminished curvature of the sacral spine.

FRONTAL PLANE

The results about the shape of the spine in the upright position in the thoracic region showed that none of the players suffered from scoliotic curvature of the spine. All players showed normal curvature of the spine, and scoliotic curvature in the lumbar region was found for one player only. Thirteen players had normal values of lumbar curvature. The curvature of the sacral spine, similar to that of the thoracic spine, was normal in all players because none of the players suffered from scoliotic curvature.

The results about the shape of the spine in left lateral flexion showed that two players suffered from scoliotic curvature of the thoracic spine. Twelve players had normal curvature of the thoracic spine. Ten players suffered from scoliotic curvature of the lumbar spine, and 10 players showed normal lumbar curvature. Half of the players showed scoliotic curvature of the sacral spine, and the other half showed normal curvature.

The results about the shape of the spine in right lateral flexion showed that two players suffered from scoliotic curvature, and 12 players showed normal curvature in the thoracic region of the spine. Twelve players showed normal curvature of the thoracic spine. Scoliotic curvature in the lumbar region was found for three players and 11 players showed normal curvature of the lumbar spine. Half of players suffered from scoliotic curvature in the sacral region of the spine while the other half showed normal curvature.

CONCLUSIONS

The conclusions of the study and generalization of the findings refer only to the players of the ŠŠK SLŠ Bemaco Prešov handball club.

The results of this study have shown that the use of handball-specific movements may have negative effect on the shape and mobility of the spine. This may also affect body posture and lead to the occurrence of muscle imbalance. Majority of players showed changes in the shape and mobility of the spine, especially in the sagittal plane. There were considerable changes in the frontal plane. In future, these changes may pose certain health risks including spine pain.

We may conclude that coaches should have detailed knowledge about training demands with respect to all age categories. Respecting these demands may prevent origination of muscle imbalance, overloading and consequent injuries.

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