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SPINAL AND SHOULDER GIRDLE RANGE OF MOTION IN ELITE FEMALE VOLLEYBALL ATHLETES

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Abstract

Introduction. Doing asymmetric sports when one suffers from body asymmetry may cause body posture disorders. The aim of the study was to assess the spinal and shoulder complex mobility of professionally trained volleyball athletes compared to that of their peers who do not practise any sports. ***Material and methods.*** The study involved 60 participants divided into two groups. Group 1 consisted of 30 girls aged 14 years. The average height in the group was 176.37 ± 6.29 cm, and the average body mass was 64.53 ± 7.12 kg. Group 2 consisted of 30 girls aged 15.6 ± 1.12 years who did not practise any sports. The average body height in this group was 159.37 ± 3.33 cm, and the average body mass was 51.83 ± 4.03 kg. The dominant limb was defined on the basis of lateralization. The spinal range of motion was measured by means of a Saunders digital inclinometer, and the shoulder complex range of motion was examined using the goniometric method. Means and standard deviations were calculated, and Student's t-test was applied in order to determine the differences between the two groups. ***Results.*** The differences in the values obtained in the two groups for the spinal range of motion in the sagittal plane were statistically significant only for the range of lumbar spine bending and extension. It was found that group 1 had a higher range of spine mobility in the frontal and transverse planes, and the differences were statistically significant in all the assessed ranges towards the dominant limb. An analysis of the shoulder girdle range of motion in the groups revealed that the differences were also statistically significant in all of the examined ranges. ***Conclusion.*** Professional volleyball practice can cause an increase in spine flexibility in most of its ranges, and the shoulder girdle range of motion in female volleyball players can exceed population norms, especially for the upper dominant limb.

Key words: spinal range of motion, shoulder girdle range of motion, Saunders inclinometer, volleyball

Introduction

Flexibility is one of the components of physical fitness. It is a predisposition that serves as a foundation for the development of motor skills. Its adequate level enables proper joint flexibility, prevents injuries, influences general agility, and makes it possible for players to master specialised techniques of movement characteristic of a particular sport [1, 2, 3, 4]. Many studies have confirmed that physical activity helps improve joint flexibility [5, 6]. A review of the recent literature shows that the sports which cause it to increase include: volleyball [7], judo [5], and sports acrobatics [8]. On the other hand, however, some reports claim that an above-average involvement of the muscle system and increase in muscle mass and strength resulting from specialised training may lead to a reduced range of motion in the joints [1, 2].

The aim of this article is to examine spine and shoulder complex mobility in the Polish women's national volleyball team compared to that of their peers who do not practise any sports.

Material and methods

The study included sixty girls aged 14-16 years. Both groups had entered puberty. Group 1 consisted of thirty girls (aged 14 years) enrolled in a macro-regional volleyball representation team. They had all participated in a training camp for macro-regional teams at the Olympic Training Centre in Spała in Poland. The average body height of the players was 176.37 ± 6.29 cm, and their average body mass was 64.53 ± 7.12 kg. The girls trained for 1.5-2 hours daily, five times a week, and were in their preparatory training period. The warm-up phase took 8 minutes and contained various exercises, particularly those connected with overall flexibility and static stretching. The control group (group 2) consisted of thirty girls aged 15.6 ± 1.12 years who did not practise any sports. The average body height in the control group was 159.37 ± 3.33 cm, and the average body mass was 51.83 ± 4.03 kg. The mean BMIs of the first and second group were 20.74 ± 1.94 and 20.42 ± 1.72, respectively. Dominant limbs were defined on the basis of lateralization. In order to be classified into group 1, the girls needed to meet the following requirements: at least three years of being a professional volleyball player and no injuries or musculoskeletal surgeries, as ascertained in an interview.

Figure 1. Saunders digital inclinometer (own photograph)

The assessment of spine and shoulder girdle flexibility was carried out for all plane motions. The spinal range of motion was measured using a Baseline Saunders digital inclinometer (Baseline Evaluation Instruments) shown in figure 1. The measurements were conducted in accordance with the recommendations of the producer developed on the basis of the instructions issued by the American Medical Association [9]. The initial posture for thoracic and lumbar spine measurements in the sagittal and frontal planes was standing with the feet spread hip-width apart, while for the transverse plane this posture involved being bent over to the front, with the hip bent up to 90° and upper limbs crossed over the chest. Before the measurements, the mid-point of the sacrum and disk spaces at the TH12-L1 and C7-TH1 levels were marked on the body of the subject. The Saunders digital inclinometer was positioned at those points before and after a maximum front, back, and side bend, as well as rotation movements. The home position for the measurement of the cervical spine motion range in the sagittal and frontal planes was sitting on a chair with the hands holding the seat, the head in the Frankfurt plane position, and the inclinometer placed on top of the head. The assessment of rotation movements was carried out in the supine position, with the head in the Frankfurt plane position and hands holding the edges of a table to ensure stability. The measuring point was located in the middle of the forehead at the height of the frontal eminences.

The active range of motion of the shoulder complex was measured using the goniometric method. The home position for the measurement of flexibility in the sagittal and frontal planes was a seated position with arms along the sides of body. The goniometer axis pointed towards the acromion, the stationary arm was placed parallel to the base, and the movable arm was moved along the big arm of the axis when all the movement measurements were taken. The range of transverse motion was measured while sitting, with the shoulder abducted up to 90°. The goniometer axis was placed over the acromion, the stationary arm was positioned on the line between the acromia, and the movable arm followed the long arm of the axis. The home position for the measurement of rotation movements was the prone position with the shoulder abducted to 90°, the arm bent at the elbow, and the forearm hung down over the edge of a bed. The rotation axis of the goniometer pointed towards the olecranon, the stationary arm was positioned parallel to the base, and the movable arm moved along the long axis of the arm when all the movement measurements were taken [10].

Before the examination started, the participants were informed about its aim, and they gave their written consent to take part in the research. The study was approved by the Senate Research Ethics Committee of the University School of Physical Education in Wrocław. Basic descriptive statistics (the mean and standard deviation) were used to characterise the two groups in terms of the selected variables. After it was confirmed that the data were normally distributed by means of the Shaphiro-Wilk test, Student's parametric t-test was used to evaluate the differences between the two groups. Differences at the level of $p \leq 0.05$ were assumed to be statistically significant [11]. All the calculations were made using Statistica 7.0 software (StatSoft, USA).

Results

Significant differences in body mass and body height between the volleyball players and control group were found. The body build of both groups was similar according to their BMI values.

Table 1. Spinal range of motion in the sagittal plane in the group of volleyball players (group 1) and the control group (group 2) (mean, standard deviation, and t-test results)

Variable	Norm [°]	Group 1	Group 2
Cervical spine forward bending	≥ 60	69.27 ± 3.43	57.87 ± 3.82
Cervical spine extension	≥ 75	78.67 ± 2.25	72.83 ± 3.14
Thoracic spine forward bending	20-30	20.83 ± 3.75	19.20 ± 5.88
Thoracic spine extension	20-35	35.40 ± 3.67	32.07 ± 6.47
Lumbar spine forward bending	≥ 60	63.60 ± 5.83	70.63 ± 4.52*
Lumbar spine extension	25	25.40 ± 3.72*	22.10 ± 5.71

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$.

Table 2. Spinal range of motion in the frontal and transverse planes in the group of volleyball players (group 1) and the control group (group 2) (mean, standard deviation, and t-test results)

Variable	Norm [°]	Group 1	Group 2
Cervical spine bending toward upper dominant limb	≥ 45	47.60 ± 3.05**	46.77 ± 3.36
Cervical spine bending towards upper non-dominant limb	≥ 45	46.10 ± 4.05	45.33 ± 3.59
Cervical spine rotation towards upper dominant limb	≥ 80	87.40 ± 3.09**	82.73 ± 1.91
Cervical spine rotation towards upper non-dominant limb	≥ 80	85.87 ± 4.21	81.33 ± 3.35
Thoracic spine bending towards upper dominant limb	20-30	34.23 ± 3.98***	25.43 ± 4.98
Thoracic spine bending towards upper non-dominant limb	20-30	25.26 ± 4.11	23.20 ± 5.19
Thoracic spine rotation towards upper dominant limb,	5-10	11.57 ± 5.22**	8.33 ± 3.60
Thoracic spine rotation towards upper non-dominant limb	5-10	9.43 ± 3.81	7.03 ± 3.28

* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$ for comparison between groups.

An analysis of the results showed that spinal motion ranges obtained in the tests that were conducted were within normal limits in both of the groups, except those obtained for cervical bending, thoracic bending, and lumbar extension in non-practising girls (group 2). Higher values were achieved for all the examined parameters by the girls who played volleyball (group 1), except for the range of lumbar bending. The widest range of motion compared to the norm in this group was observed for cervical bending, while in the group of non-practising girls it was observed for lumbar bending (tab. 1). The standards for ranges of motion provided in tables 1 and 2 were issued by the American Medical Association [9].

The differences in spinal range of motion values between the examined groups in the sagittal plane are statistically significant only for the range of lumbar spine bending and extension (tab. 1). When it comes to the spinal range of motion in the frontal and transverse planes obtained for the groups (tab. 2), the differences are significant and highly significant in all of the assessed ranges but only towards the dominant limb (group 1).

Table 3. Shoulder complex range of motion in the group of volleyball players (group 1) and the control group (group 2) (mean, standard deviation, and t-test results)

Variable	Norm [°]	Group 1	Group 2
Upper dominant limb forward bending	170	182.60 ± 9.76*	170.53 ± 9.73
Upper non-dominant limb forward bending	170	180.07 ± 8.84*	170.93 ± 8.39
Upper dominant limb extension	50	65.67 ± 6.12*	52.13 ± 8.66
Upper non-dominant limb extension	50	61.83 ± 9.78*	49.63 ± 7.45
Upper dominant limb abduction	170	193.57 ± 11.79***	170.37 ± 6.73
Upper non-dominant limb abduction	170	183.23 ± 14.70***	170.17 ± 8.56
Upper dominant limb horizontal flexion	135	135.67 ± 11.88*	125.47 ± 7.57
Upper non-dominant limb horizontal flexion	135	130.33 ± 9.17**	125.53 ± 6.83
Upper dominant limb horizontal extension	30	41.33 ± 6.48	45.17 ± 6.44***
Upper non-dominant limb horizontal extension	30	38.00 ± 5.15	44.40 ± 6.03*
Upper dominant limb external rotation	90	103.67 ± 10.90***	85.70 ± 3.95
Upper non-dominant limb external rotation	90	99.00 ± 11.09***	85.23 ± 4.38
Upper dominant limb internal rotation	80	59.33 ± 14.84	77.77 ± 4.16***
Upper non-dominant limb internal rotation	80	60.67 ± 17.36	77.60 ± 4.46***

* p ≤ 0.05, **p ≤ 0.01, ***p ≤ 0.001 for comparison between groups.

It was established that the shoulder complex range of motion in the volleyball players (group 1) was much wider than the norm, except for the range of internal rotation and horizontal extension of both arms. In both groups, the range of horizontal flexion and internal rotation did not reach the levels of physiological parameters, and poorer flexibility was observed in the group of girls practising volleyball. The differences between the shoulder girdle ranges of motion of the groups (tab. 3) were found to be statistically significant and highly statistically significant in all of the examined ranges.

Discussion

One of the methods commonly used for musculoskeletal system diagnosis is the assessment of the spinal range of motion. This is due to the significant role of flexibility in maintaining good posture and its influence on kinematic parameters [11, 12]. New methods which allow for a non-invasive and objective assessment of the musculoskeletal system have always been sought, and one such method involves using the Saunders inclinometer. Thanks to this device, a reliable examination can be performed, and the results achieved are the basis for an effective and safe clinical practice which provides a foundation for evidence-based medicine [13].

In light of the reports of many authors, the type of structured physical activity which is being performed and its intensity can influence spinal mobility and the range of motion of peripheral joints [14, 15, 16]. According to Sławińska et al., practising asymmetric sports with high training and psychological loads may lead to musculoskeletal function disorders, especially in very young people [17]. An asymmetric sport combined with existing body asymmetry may cause a player to develop body posture disorders. That is why it is important to monitor all the changes in the player's posture, spine mobility, and joint mobility, as well as making monitoring an important element of training and selection [15]. According to the American Medical Society for Sports Medicine, musculoskeletal function disorders should be promptly identified, as they can cause future problems or a decrease in a player's fitness level [18]. This is particularly important since a higher intensity of practice and stronger competition can be observed particularly in young people attending high school, and the greatest number of sports injuries are recorded for this age group [19].

This study sought to examine the spine and shoulder girdle ranges of motion in girls training volleyball and their non-practising peers. Higher values of the examined parameters were obtained for practising girls, except for lumbar flexion. The poorer mobility of this part of the spine in the group of volleyball players proven in the current study was also confirmed in Grabara's research, which showed that the lumbar spine of most volleyball players is flattened, and thus its flexibility can be limited [14]. The specific nature of volleyball can affect the shape of the spine. During the game, the volleyball player stands in a flexed position, with the arms and shoulders at the front, usually ready to react to the ball [20]. The players can also suffer from a reduction in the range of motion of the lower spine as a result of excessive muscle contraction which may be caused by injury to the muscle. Muscle contraction can also occur due to the use of local anti-inflammatory mediators during an attempt to stabilise the injured part of the spine [21, 22]. According to many authors, this part of the spine is particularly exposed to severe strain, which stems from two-legged locomotion and the great amount of movement performed in standing position, especially in a bent position with straight legs. The closer the flexion is to 90°, the higher the risk of developing spinal overload syndrome. From the biochemical point of view, deviatoric stress which counterbalances the load put on a particular segment is responsible for pathological changes in spinal tissue. In many studies, the value of the deviatoric component differed among others based on the position of the body (the angle of body incline to a vertical line). It was also proven that the higher the person examined was, the higher the deviatoric component values of particular angles were [23, 24, 25]. Pain in the lower part of the spine occurs in 1-30% of athletes, and it is one of the most common reasons for the inability to practise sports [26, 27]. The most spectacular element of a game of volleyball which is worth the most points is grounding a ball. When preparing to hit the ball, a player must make a rapid spine extension movement, hence the high flexibility of this part of the spine found in the current study. During this movement, a player extends her hitting arm backwards and then rotates to the opposite direction with a deep bend. During landing, the body must absorb the ground reaction forces, which are much higher than the body mass, so the movement imposes high loads on the lower part of spine [28].

It is stated that improving the flexibility of the player's lumbar spine may increase its resistance to significant forces and protect the player from pain episodes. Poor flexibility, on the other hand, causes a risk of post-workout injuries in this part of the spine. The duration of the warm-up plays an important role in the process; the aim of the warm-up activities is to increase deep body temperature and improve blood circulation and flexibility. It was proven that the flexibility achieved in the lumbar spine after a warm-up decreases after a 30-minute period of rest before the game. Thus being active before the game and during the break decreases the risk of post-workout injuries [29]. It was observed that in players with chronic post-workout injury to a muscle-tendon unit, back pain usually results from tiredness and increases at the end of a week of intensive practice or a practice cycle [21, 22].

The wide range of motion in the cervical spines of the players found in the current study is essential from the point of view of volleyball skills; however, such extreme flexibility of this part of the spine may result in serious consequences. According to Stodolna-Tukendorf, with age, the muscle control of facet joint motion decreases. Having a range of movement that constantly exceeds the physiological range of motion may cause permanent joint strain. In a later period, degenerative changes may develop and osteophytes may appear on joint surface edges or vertebral bodies as a defensive stabilising factor, which may lead to the instability of particular spinal segments or disc herniation [4].

An analysis of the results of this study showed that the female volleyball players had higher flexibility of the shoulder complex, and their ranges of movement significantly exceeded population norms, except for inner arm rotation. Higher than average flexibility values were observed in dominant limbs, which may result from practising a sport that causes the shoulder complex range of motion to be irregular and influences the muscle strength responsible for its mobility. In the case of volleyball players, multiple repetitions of specific motion sequences, done mainly for the upper dominant limb, with a high speed and strength of the movement being practised, may lead to changes in the resting position of the scapula. The research conducted by Ribeiro and Pascal showed that this characteristic asymmetric scapular position results from excessive arm involvement in maximum bending position, outer rotation, and abduction, as well as in extension and inner rotation performed from above the head with high speed and strength [30]. This may result in shoulder complex function disorders and predispose a player to injury [31].

Since the shoulder girdle is complex from a biomechanical point of view, it is necessary to condition such elements and mechanisms which will assure its stability during spatial movements. Among the rotator cuff muscles, the subscapularis muscle is definitely the most important stabiliser of this joint [32]. It protects the player from front, back, and upper displacement of the head of the humerus when raising the arm. The research carried out by Martelli et al. showed that a decrease in the strength of the subscapularis muscle of the upper dominant limb precedes the first pain symptoms in volleyball players and may be an important diagnostic element in rotator cuff function disorders [33]. The study of Tonin et al. which involved volleyball players also showed that there is muscular imbalance between the rotating muscles in the dominant upper limb [31]. Forthomme et al. emphasise the necessity of performing isokinetic assessment of the maximal eccentric strength of muscles responsible for arm rotation in volleyball players in order to assess the shoulder damage risk factor [34].

As many as about 15-20% of all the injuries sustained by volleyball players are shoulder injuries, and they affect mainly women [35, 36]. The available research indicates that 90% of shoulder injuries in volleyball players are of an overload type [35, 36, 37, 38, 39]. It is important to make sure that the training process does not have an adverse effect on flexibility and the balance of strength in the muscles influencing the spine and shoulder girdle.

Conclusion

The research showed that professional volleyball practice can cause a significant increase in spine flexibility in most of its ranges. The shoulder complex range of motion in the female volleyball players who participated in the study exceeded population standards, especially in the upper dominant limb.

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