A long-term cohort study of the muscle apparatus of female volleyball players after the application of a compensatory programme

Tamara Čučková, Vladimír Süss, Jan Carboch*

Faculty of Physical Education and Sport, Charles University, Prague, Czech Republic
* Corresponding author: carby@post.cz

ABSTRACT

Volleyball is a sport with great unilateral load that can have a negative impact on a postural system. The aim of the study was to perform a detailed examination of posture and muscle imbalance in elite female volleyball athletes and, according to the results of the examination, to put together compensatory exercises and to assess their effect. A group of elite junior female volleyball players (n = 12) was examined by an experienced physiotherapist using a complex kinesiological analysis especially focused on body posture (from frontal, sagittal and dorsal plane), shortened muscles and performance of basic movement patterns (hip extension, hip abduction, sit-up, cervical flexion, shoulder abduction, push-up). The preliminary examination showed that every tested player had some kind of posture deficiency. The compensatory programme, consisting of breathing techniques, stretching exercises, strengthening exercises with an elastic band, and balance exercises with a Bosu balance trainer, was applied at the end of every training session over the competitive parts of two volleyball seasons. Before the application of the exercise programme we found flat back in 92% subjects, whereas 33% of subjects exhibited it after compensation. Improvement was noted in the intensified lumbar lordosis (from 50% subjects to 42%), and scoliotic body posture (from 50% to 17%). The biggest improvement in shortened muscles in the upper body was observed on the m. levator scapulae (from 83% subjects to 8%) and the m. trapezius (from 42% subjects to 8%); and in the lower body m. triceps surae (from 75% subjects to 33%) and hip abductors (from 83% subjects to 25%). The study suggests that balance exercises with a Bosu balance trainer and exercises with an exercise elastic band seem to be useful for volleyball since we noted improvement in body posture, movement patterns and muscle shortness. We therefore highly recommend this compensatory programme.

KEYWORDS

kinesiological analysis; compensatory exercise; muscle imbalance; Bosu balance trainer

DOI

https://doi.org/10.14712/23366052.2017.10

INTRODUCTION

Volleyball is a physically demanding sport with many rapid changes of bodily direction as well as many rapid reorientations of body segments toward each other. Even though it is a sport in which the players are not in direct contact, there are still many acute and overuse injuries. This is due to repeated jumps, stops and movements that exert great pressure on joints, e.g. the serve and the hit (Manshouri, Rahnama, & Khorzoghi, 2014). The most common injuries include traumas of fingers and especially their joints, the biggest load being on the dominant arm, and mainly on the shoulder joint (McFarland, Muvdi, Jia, Desai, & Petersen, 2010). Čučková and Süss (2014) found the following body parts overused: abdominal and lumbar muscle ligaments, the lower limbs and knee joints. Ankle sprain is the most common acute injury (Vorálek, Palová, & Süss, 2009) and, because of an extensive one-sided load, muscle imbalances in the shoulder, lumbar, pelvic and lower limb regions are also common (Čučková & Süss, 2014).

As shown in previous research (Grabara & Hazdik, 2009; Modi et al., 2008; Oyama, Myers, Wassinger, Ricci, & Lephart, 2008; Větrovcová, 2007; Vařeková, Vařeka, Janura, Svoboda, & Elfmark, 2011; Vorálek, Süss, & Parkanová, 2007), a high number of tested volleyball players have faulty posture, tension of m. trapezius, tension of paravertebral muscles in the lower back region and (owing to a forwarded carriage of the head and shoulder protraction) intensified cervical lordosis. Some muscles or muscle groups of the tested players are weakened, especially the lower section of the abdominal muscles. All these problems affect lower back posture. Muscle groups are impacted which are not usually used in volleyball training, such as the lower abdominal muscles or m. trapezius (lower fibers). Those muscles are weakened, which leads to quite severe muscle imbalance and faulty posture, as well as chronic pain in some segments. Volleyball players also have some overused body parts, such as m. trapezius (upper fibers) or m. pectoralis major, which are often shortened (Čučková & Süss, 2014).

Owing to the problems mentioned above, the application of an interventional compensatory programme to counterbalance the lateral asymmetries is necessary, as demonstrated in previous research, not only in volleyball but also in other sports, such as softball, football and skiing (Matošková, Süss, & Vorálek, 2009b). For the correct composition of a programme it is necessary to evaluate individual postural stereotypes and perform functional muscle tests accurately.

The compensatory programme should be a set of relaxing, stretching and strengthening exercises, which means the muscles that tend to shorten need to be adequately stretched, and the muscles with a tendency to weaken need to be strengthened (Čermák, Chválová, Botlíková, & Dvořáková, 2008). Every interventional programme must be planned according to the training periodization of the particular sport and must ensure the absence of undesirable effects, such as disproportionate load (Matošková et al., 2009b). The positive effect of exercising with a Bosu balance trainer and elastic exercise bands was demonstrated on tennis players by Sannicandro, Cofano, Rosa and Piccinno (2014), where balance training significantly reduced percent lower-limb asymmetry. Behm and Colado (2012) stated that unstable surfaces are able to enhance intermuscular coordination between agonist and antagonist muscles, permit-

ting improved control of joint position and reduced joint stiffness. Finally, Sannicandro et al. (2014) found that balance training exercises force the subjects to distribute body weight uniformly between the two limbs.

At the present time, many modern devices are being used to examine the state of the body apparatus, such as BIA methods devices (Bedogni et al., 2002), but is still important that classical physical examinations, such as complex kinesiological analysis, are conducted by experienced physiotherapists. The reason for testing the shortness of these particular muscles (m. triceps surae, hip flexors, knee flexors, hip abductors, m. quadratus lumborum, paravertebral muscles, m. pectoralis major, m. trapezius (upper fibers), m. levator scapulae and m. sternocleidomastoideus) was based on previous research performed on volleyball players (Čučková, Znášiková, Vorálek, & Süss, 2013; Vařeková et al., 2011; Vorálek et al., 2007), which showed a shortening of those muscles, since volleyball exerts a very heavy load on both upper and lower extremities and spine, and also involves very many jumps, hits, and overhead passes. The testing of movement patterns and body posture assessment on a regular basis are part of Janda's method (Janda, 1996).

The aim of the study was to assess posture asymmetry and muscle imbalance (muscle shortness or weakness and poorly performed movement patterns) in elite female volleyball players. According to the results of the physical examination performed by an experienced physiotherapist, the aim was to put together compensatory exercises and assess their effect on the muscle apparatus (body posture, muscular system) after their application.

METHODS

Subject

Elite junior volleyball players (n = 12) participated in this study. All of them were members of the team PVK Olymp Praha, from the Czech Republic in the highest national division. The reason for choosing this particular group was simple, they are the best team for their age in the Czech Republic and won the title several years in row. My (the examiner's) attendance was important so only one team out of the whole division could have been chosen. This team was also chosen for the willingness of the team and the whole management to fully participate in the project for two years. At the beginning of the research (the first year out of two) the subjects had mean age 15.5 years, mean height was 178.6 cm, mean weight 68.6 kg. The players practiced intensively for at least 4 years, had 4 training units per week for two hours, plus two matches per week, usually played during the weekends. The second year the players had mean age16.6 years, mean height 179.8 cm, mean weight 66.6 kg. The number of matches and training sessions was the same as in the first year. Informed consent was obtained from all tested subjects. The study was approved by the Ethics Committee of the Faculty of Physical Education and Sport, Charles University on 12/12/2011 (no. 188/2011).

Method

The kinesiological analysis was performed by an experienced physiotherapist. The examination of body posture consisted of visual inspection of the frontal, sagittal,

and dorsal planes. The subjects were dressed only in their underwear, standing upright with their feet pelvis-width apart. The examiner palpated the asymmetrical height of the acromion process, the angles of scapula, and the symmetry of paravertebral muscles. The visual inspection exhibits any faulty posture such as flat back, round shoulders, intensified lumbar lordosis, any kind of scoliotic posture, the position of iliac crests, pelvis in anteversion, retroversion, winged scapula, head carriage, position of shoulders (protraction, elevation), as well as the position of lower limbs (flat feet, pes valgus, knee joint position). We only specified the type of problem with body posture not the seriousness. The reason for testing particular muscle shortness was based on previous research mentioned above (Čučková et al., 2013; Vařeková et al., 2011; Vorálek et al., 2007). The reason for choosing young athletes was simple: the young body usually exhibits only functional changes otherwise the adults can record structural changes in their muscle apparatus and it is difficult to improve it by tailored exercise.

Data collection

The examination of shortened muscles and movement patterns performance were based on Janda's methods (Janda, 1996). The following muscles were tested: m. triceps surae, hip flexors, knee flexors, hip abductors, m. quadratus lumborum, paravertebral muscles, m. pectoralis major, m. trapezius (upper fibers), m. levator scapulae and m. sternocleidomastoideus. The testing was performed in the same room at constant temperature under the same circumstances and also by the same physiotherapist to guarantee the same conditions.

The data was collected every three months for two years. The second year of the study was performed the same way as the first one so again the subjects were examined by the same experienced physiotherapist every three months. The last data collection was made in May 2013, and all data collected were compared. To show the general trend of the state of body apparatus of the subjects and the impact of the compensatory exercise, only the initial testing and then testing at the end of each year were presented in this paper.

Data analysis

The data analysis was done by the assessment of frequency, by means of percentage analysis, the significant quotient being the value of 70% (Matošková, Tietz, & Süss, 2009a). The same data analysis was used in similar research done on downhill skiers. The same significant quotient was used to distinguish the skiers' shortened muscles (Matošková et al., 2009a). The performance of movement patterns was evaluated as performed correctly or not by means of percentage analysis. The significant quotient of these two tests was also the value of 70% (Matošková et al., 2009a). The shortened muscles were evaluated on a two-value scale: S – shortened muscle, N – non-shortened muscle. Another part of the kinesiological analysis was also an interview with each subject about their subjective feeling (pain, injury, headaches) and also their private feelings about the exercise programme. The preliminary data (September 2011) acquired from the kinesiological analysis was compared with the data obtained in the middle of the volleyball season (January 2012) and at the end of the volleyball season (May 2012).

Compensatory exercises

To counterbalance lateral asymmetries, muscle imbalance, poor body posture and shortened muscles, an interventional compensatory programme was applied at the end of each training session over the competitive parts of two volleyball seasons was completed. The compensatory programme was a combination of relaxing exercises (especially breathing techniques) (Bursová, 2005), stretching (put together with the physiotherapist) and strengthening exercises with the elastic exercise band Theraband and the Bosu balance trainer inspired by Jebavý and Zumr (2009), Kubišová (2006) and Muchová and Tomanková (2009). All subjects were taught how to do full set of exercises from the starting position to the end of each movement, were constantly checked by the examiner, coach and the physiotherapist and were corrected when exercising incorrectly. The full compensatory programme took 30 minutes and was applied at the end of every training session and after the match – 5 times per week. The players exercised together which enabled a good opportunity to check that all exercises being completed properly.

When putting together the breathing exercises (thoracic, costal and abdominal breathing and inspiratory waveform), which initiated the whole compensatory programme, we began with the findings of Bursová (2005) that they could improve the position of the chest and pelvis while playing a big role in relaxation, while the secondary breathing muscles (m. pectoralis, abdominal muscles and scapular muscles) are active. The volleyball players preferred the laying down position, as Hošková (2003) perceived it to be the easiest due to the least muscles being active to hold the said position. Each player performed the same relaxation techniques after every training session in preparation for further exercise. The rhythm of breathing was checked by a metronome at a speed of 18 breaths per minute. The first year each breathing technique was repeated 5 times, the second year 7 times (Bursová, 2005). The full breathing exercise took 5 minutes.

After the breathing session all the subjects performed the full set of stretchers on all the muscles that tend to shorten and are being extensively used during volleyball. None of the players exhibited muscle hypermobility they performed the same set of stretching exercises. Minor changes were made in the case of injury to the individual and always followed the advice of the physiotherapist. The particular exercises were chosen together with the physiotherapist, the stretching time of each muscle/muscle group was set for 10 seconds, the time was checked by the metronome again. The stretching focused on these muscles: Achilles tendon and calf muscles, hamstrings, hip flexors, gluteal muscles, quadriceps femoris, lumbar and abdominal muscles, m. pectoralis, m. trapezius and biceps and triceps brachi. The full stretching exercise took 10 minutes.

For the strengthening and balance exercises, the individual differences and needs of each player were taken into consideration and were adjusted to the state of their body apparatus (the physiotherapist did an easy muscle test to see the strength of specific muscles). At first, everything was done without the balance utilities, in order to learn the movement precisely and only later did the research subjects start to use the Bosu balance trainer. The players were constantly monitored when exercising, and they were also photographed and corrected when performing incorrectly. The level of

difficulty of the particular exercises was increased as the volleyball player reached the necessary level. The elastic exercise bands were used in a set of exercises to employ the antagonists of the muscles mainly used in hitting and serving and to counterbalance the unilateral load. The specific exercises are shown in Table 1. The full balance and strengthening exercises took 15 minutes.

The first year's compensatory exercise (September 2011 – May 2012) was led by the physiotherapist, who taught the players the correct techniques of exercising and made corrections as necessary. The same physiotherapist was used during the study. She was available the second year but not present at the training sessions. As the second year was completed without the presence of the physiotherapist, the players exercised under the supervision of the examiner, coach, and assistant coach. All subjects exercised together right at the conclusion of each practice at the same location of the gym so further control was possible. All players exercised barefoot and were doing the same type of exercise at the same time.

Table 1 Strengthening and balance exercises

Exercise	Task
Compensatory exercise	position of cat, one arm raised upwards (head height), opposite leg backward, hold
Bosu balance trainer	two-legged squats, arms raised forward, back straight, centre of gravity backward
Bosu balance trainer	toe standing position, arms raised upwards holding 1kg medicine ball, then squat with a side trunk rotation, arms in turns towards one foot
Bosu balance trainer	standing position on the floor, lunge backwards on Bosu balance trainer, legs in turns
Bosu balance trainer	standing on Bosu, bend legs forward in turns keeping the pelvis in a stable position
Bosu balance trainer	sitting position on Bosu, legs bend of the floor, back straight, trunk rotation holding 1kg medicine ball placing it on a side towards the floor
Bosu balance trainer	two-legged jumps from one Bosu balance trainer to other ones in a row (12 together), holding in a squat position after each jump
Elastic exercise band	holding the elastic band, arms raising forward in turns (shoulder height), elastic band kept under feet
Elastic exercise band	elastic band bound to a bar in a height of waist, drawing it diagonally upwards
Elastic exercise band	simulating the hitting movement with the non-dominant arm, elastic band bound to a bar
Elastic exercise band	holding the elastic band bound to a bar, facing it, arms swinging down-wards backwards
Elastic exercise band	two elastic bands bound to a bar approximately 30cm above head, arms winding down keeping the shoulders down and scapulae towards spine

RESULTS

We listed the results of the kinesiological analysis in the tables. The preliminary examination showed that every tested player exhibited some kind of problem with posture (Table 2). In September 2011 (preliminary testing) we observed flat back in 92% subjects, 25% after the first year of testing, and 33% at the end of the second year. Intensified lumbar lordosis appeared in 50% subjects (42% in May 2012, 42% in May

2013) and 50% exhibited scoliotic body posture (75% in May 2012, 17% in May 2013), 11 subjects (92%) exhibited pelvis in anteversion (17% in May 2012, 0% in May 2013). 10 subjects (83%) exhibited elevated shoulders (50% in May 2012, 67% in May 2013), and 58% winged scapula (92% in May 2012, 42% in May 2013). The problems with lower limb posture were demonstrated by knee joint hyperextension (42% September 2011, 42% in May 2012, 50% in May 2013) and flat feet (50% September 2011, 42% May 2012 and 2013). 4 subjects (33%) exhibited forwarded carriage of head during the preliminary testing and 17% in May 2012 and 0% in May 2013.

Table 2 Posture examination (September 2011, May 2012, May 2013)

Body part	Type of problem	Prevalence					
		September 2011		May 2012		May 2013	
		n	%	n	%	n	%
Spine	flat back	11	**92**	3	25	4	33
	round shoulders	0	0	2	17	0	0
	L-lordosis intensified	6	50	5	42	5	42
	scoliotic body posture	6	50	9	**75**	2	17
Pelvis	anteversion	11	**92**	2	17	0	0
	retroversion	0	0	0	0	0	0
	inclination	3	25	8	67	2	17
Scapula	winged scapula	7	58	11	**92**	5	42
Shoulders	protraction	3	25	2	17	4	33
	elevation	10	**83**	6	50	8	67
Head	forwarded carriage	4	33	2	17	0	0
Lower limbs	flat feet	6	50	5	42	5	42
	pes valgus	3	25	4	33	4	33
	knee joint hyperextension	5	42	5	42	6	50

Note: Significant frequency of body posture deviation in bold

The results of the movement patterns examination (Table 3) also showed problems. 83% of the tested players performed hip extension (92% in May 2012 and 75% in May 2013) and hip abduction (75% in May 2012 and 50% in May 2013) poorly. While 8 subjects (67%) did not succeed in sit-up and cervical flexion in the preliminary testing, the numbers of sit-ups improved to 42% in May 2012 and 25% in May 2013, and the performance of cervical flexion varied from 75% in May 2012 to 42% in May 2013. There was also a high incidence of poorly performed shoulder abduction (50% in September 2011, 92% in May 2021, and 67% in May 2013) as well as push-up, 9 subjects (75%) exhibited it in September 2011, 6 (50%) in May 2012 and the same percentage in May 2013.

Table 3 Movement patterns (September 2011, May 2012, May 2013)

Type of movement pattern	Poorly performed movement pattern					
	September 2011		May 2012		May 2013	
	n	%	n	%	n	%
Hip extension	10	**83**	11	**92**	9	**75**
Hip abduction	10	**83**	9	**75**	6	50
Sit-up	8	67	5	42	3	25
Cervical flexion	8	67	9	75	5	42
Shoulder abduction	6	50	11	**92**	8	67
Push-up	9	**75**	6	50	6	50

Note: Significant frequency of poorly performed movement pattern in bold

Table 4 Muscular shortening (September 2011, May 2012, May 2013)

Muscle	Prevalence of muscle shortening					
	September 2011		May 2012		May 2013	
	n	%	n	%	n	%
m. triceps surae	9	**75**	6	50	4	33
hip flexors	7	58	8	67	6	50
knee flexors	3	25	7	58	6	50
hip abductors	10	**83**	6	50	3	25
m. quadratus lumborum	8	67	9	**75**	4	33
paravertebral muscles	8	67	7	58	10	**83**
m. pectoralis major	1	8	3	25	3	25
m. trapezius	5	42	4	33	1	8
m. levator scapulae	10	**83**	3	25	1	8
m. sternocleidomastoideus	1	8	2	17	2	17

Note: Significant frequency of muscular shortening in bold

Table 4 represents the results of the shortened muscles examination. The table includes the subjects whose muscles were shortened only on one side. As significant shortening we noted the m. levator scapulae in 83% of cases in the preliminary examination in September 2011. This muscle exhibited the biggest improvement in May 2012 (25% incidence of muscle shortness) and 8% in May 2013. The prevalence of muscle shortness of hip abductors was significant in preliminary examination and exhibited 10 subjects (83%) then 50% in May 2012 and 25% in May 2013. M. triceps surae, another typical muscle shortening for volleyball players, was exhibited in 9 subjects (75%) in September 2011, 50% in May 2012, and 33% in May 2013. M. quadratus lumborum and paravertebral muscles shortenings were present in 8 subjects

(67%) in preliminary examination and varied throughout the two years the shortened m. quadrates lumborum appeared in 75% cases in May 2012 and 33% in May 2013, otherwise the paravertebral muscles got to 58% of prevalence in May 2012 and then to 83% in May 2013. The incidence of muscle shortness of m. sternocleidomastoideus as well as knee flexors and m. pectoralis major worsen over the two volleyball seasons. Particularly from 8% prevalence in September 2011 in sternocleidomastoideus to 17% in both other examinations. The knee flexors from 25% in September 2011 to 58% in May 2012, respectively 50% in May 2013 and m. pectoralis had one subject (8%) shortened in September 2011, and 25% in May 2012 as well as May 2013. The upper fibers of m. trapezius noted an improvement in the shortness over the period of time from 42% in September to 33% in May 2012 and 8% in May 2013.

DISCUSSION

The aim of the study was to perform a detailed examination of posture and muscle imbalance in elite female volleyball athletes and according to the results of the examination put together compensatory exercises and assess their effect. The compensatory programme was a combination of relaxing exercises, stretching and strengthening exercises with the elastic exercise band Thera-band and the Bosu balance trainer (Table 1). The positive effect of exercising with a Bosu balance trainer and elastic exercise bands was demonstrated on tennis players by Sannicandro et al. (2014), where balance training significantly reduced percent lower-limb asymmetry. Behm and Colado (2012) stated that the incidence of ankle sprains in a group of volleyball players was reduced with balance training. While the effect of our exercise programme was not as effective as others mentioned, we noted some improvement.

Scoliotic body posture (50% incidence in September 2011 to 17% in May 2013) or position of the pelvis showed the biggest improvement (pelvis in anteversion improved from 92% to 0% of incidence). The most successful effect of our interventional compensatory programme was recorded on the basic movement patterns; except for the shoulder abduction (worsen from 50% to 67%), every movement improved (Table 2) compared to the beginning of the whole programme.

The lack of improvement of shoulder abduction may be explained by the disproportion between the extreme load on this region caused by constant hitting and serving actions, as well as the extreme load on m. trapezius when performing the overhead pass, as the upper extremities are constantly raised upward and the amount of compensation, as found in the studies of Vorálek et al. (2007) and McFarland et al. (2010). The results suggest that the presence of the physiotherapist in the training sessions seemed to have a slightly higher efficiency of the exercising programme compared than the second year, when the physiotherapist was not present at the training sessions.

The study shows a typical posture pattern for overhead athletes, volleyball players especially. The scoliotic spinal curve was found in 6 subjects (50%) in preliminary examination and was usually combined with the shoulder elevation of the dominant upper extremity and the winged scapula. The clinical findings were evident during the visual inspection. As for body posture, our findings correspond to the findings of other authors, such as Modi et al. (2008), who tested young volleyball players on

the prevalence of scoliosis. The number of players with scoliotic body posture in our study was as high as in Modi's study (47%). Our findings correspond to the statement that volleyball players had a statistically significant increase in the incidence of scoliotic spinal curves, and that hand dominance was related to the curve direction. Grabara (2015) used the Moiré method to examine the spine curve and the whole body posture of young male volleyball players from frontal and transverse planes. Right-handed volleyball players were usually characterized by a slight, left-sided curvature of the spine, left-sided inclination of the torso, left-sided lowering and right-sided torsion of the pelvis. The right shoulder was higher than the left, the right scapula was more protruding than the left one and was further away from the spine (Grabara, 2015).

Similar inclinations were found in our tested group. Contrary to our findings, Vařeková et al. (2011) exhibited the presence of a depressed shoulder on the preferred side combined with the elevation of the contra-lateral iliac crest. The examination of body posture exhibited lumbar lordosis intensified in 6 subjects (50%) together with the pelvis in anteversion. The reason for markedly bad posture of lower back area in our tested group could be an inadequate training load due to high amount of jumps and falls as well as bending the trunk backwards during hitting the ball. Muscle imbalance in the pelvic region, which was also shown in this research, can intensify the lumbodorsal lordosis that leads to appearance of lower back pain or some functional blocks. These findings correspond to Vorálek et al. (2007), who reported scoliosis in 43% of young elite volleyball players aged 15–19 as well as faulty posture in lower back area in 70% of subjects.

The movement patterns examination (Table 3) is widely used in clinical practice. Our subjects exhibited poor performance of the majority of the movement patterns. These results could be expected due to chronic overloading that cause muscle imbalance, lateral asymmetry that go hand in hand with poor muscle coordination. The most common cause of incorrect extension in our case was insufficient activity of the gluteus muscle. The abduction was mainly performed together with flexion and hip rotation. Another incorrect movement pattern was the push-up, which was performed by 75% of players with a poor scapula stabilization, significant weakening of m. serratus anterior and overload of the m. trapezius. We can state that over the time these movement patterns improved. 83% of the tested players performed hip extension (92% in May 2012 and 75% in May 2013) and hip abduction poorly. While 8 subjects (67%) did not succeed in sit-up and cervical flexion in the preliminary testing, the numbers of sit-ups improved. The improvement could be due to the learning process as well as the effect of the compensatory exercise programme. In contrast, shoulder abduction worsened, as well as push-ups. The shoulder abduction was mainly performed with the superiority of m. trapezius (upper fibers). This can be explained by the negative effect of very heavy load on this muscle during all volleyball movements, especially the overhead pass, hit and serve. Our findings correspond to the findings of Kanásová (2005) who tested young volleyball players aged 15 to 18 for the movement patterns performance according to Janda (1997). The results were not as significant: 90% of the subjects exhibited poorly performed hip extension, 30% sit-up test and 15% shoulder abduction performed poorly. It is again explained by the dominant one-sided muscle usage of the sport.

The muscle shortness test is also widely used in practice. When looking at the impact of volleyball on muscle apparatus, our findings were not surprising. Preliminary examination show that a very high percentage of the players had a shortened m. levator scapulae, m. trapezius (upper fibers), paravertebral muscles, hip abductors, m. triceps surae and m. quadratus lumborum. Some of the players had other additional problems with shortened muscles, e.g. hip and knee flexors. These results correspond to Vorálek et al. (2007) whose volleyball players aged 15–19 years exhibited extremely high incidence of muscle tightness and muscle shortness on lower extremities and upper fibers of m. trapezius as well (90%). This is explained by the chronic overload because of a multitude of jumps and stretching methods performed incorrectly. Vařeková et al. (2011) explain the muscle shortness on lower extremities by chronic overloading and a bad stretching method, which is omitted in most cases. The poor results of the kinesiological analysis can be linked to uneven and extreme load on the athletes and little or no compensation.

CONCLUSION

Our findings exhibit a typical posture pattern for volleyball players, since volleyball imposes an extensive load on the dominant upper extremity. A scoliotic spinal curve was found in 6 subjects (50%) in preliminary examination and was usually combined with shoulder elevation of the dominant upper extremity and the winged scapula. Notable muscle shortness was found (m. trapezius upper fibers, calf muscles, hip abductors and lower back muscles were shortened the most), and also poor performance of basic movement patterns (e.g. hip extension and hip abduction, as well as shoulder abduction).

An improvement in body posture of tested players and also in movement patterns and muscle shortness could have been achieved owing to the interventional programme consisted of relaxing (breathing techniques), stretching and strengthening (exercise elastic band) and balance exercises (Bosu balance trainer). We noticed a slightly lower efficiency of the exercising programme in the second year, which can be explained by the absence of the physiotherapist at the training sessions. Due to this we highly recommend that the physiotherapist should be in full control of the exercises. Balance exercises with a Bosu balance trainer and exercises with an exercise elastic band were found suitable, and so we can recommend them for the complete programme to improve the unilateral muscle load.

REFERENCES

Bedogni, G., Malavolti, M., Severi, S., Poli, M., Mussi, C., Fantuzzi, A., & Battistini, N. (2002). Accuracy of an eight-point tactile-electrode impedance method in the assessment of total body water. *European Journal of Clinical Nutrition*, *56*, 1143–1148.

Behm, D. G., & Colado, J. C. (2012). The effectiveness of resistance training using unstable surfaces and devices for rehabilitation. *International Journal of Sports Physical Therapy*, *7*(2), 226–241.

Bursová, M. (2005). *Kompenzační cvičení*. Prague: Grada Publishing.

Čermák, J., Chválová, O., Botlíková, V., & Dvořáková, H. (2008). *Záda už mě nebolí*. Prague: Vašut.

Čučková, T., & Süss, V. (2014). Muscle imbalance and body composition of elite junior female volleyball players. *Paripex – Indian Journal of Research*, *3*(4), 1–2.
Čučková, T., Znášiková, I., Vorálek, R., & Süss, V. (2013). Pohybový aparát mladých volejbalistek. *Rehabilitácia*, *50*(4), 235–240.
Grabara, M. (2015). Comparison of posture among adolescent male volleyball players and non-athletes. *Biology of Sport*, *32*(1), 79–85.
Grabara, M., & Hazdik, A. (2009). Postural variables in girls practicing volleyball. *Biomedical Human Kinetics*, *1*(1), 67–71.
Hošková, B. (2003). *ABC kompenzace pohybem.* Prague: Olympia.
Janda, V. (1996). *Funkční svalový test.* Prague: Grada Publishing.
Jebavý, R., & Zumr, T. (2009). *Cvičení s balančními pomůckami.* Prague: Grada Publishing.
Kanásová, J. (2005). Funkčné svalové poruchy u atlétov, tenistov, plavcov, hokejistov, volejbalistiek a moderných gymnastiek OŠG v Nitre. In: J. Vindušková (Ed.), *Atletika 2005: sborník mezinárodní vědecké konference 24.–25. 11. 2005* (pp. 1–7). Prague: KA FTVS UK.
Kubišová, H. (2006). *Kompenzační cvičení v odbíjené.* Brno: Masarykova Univerzita, Fakulta sociálních studií.
Máhrová, A., & Bunc, V. (2008). Význam kompenzačních cvičení v prevenci a terapii svalových dysbalancí v tréninku badmintonistů. *Studia Kinantropologica*, *2*, 266–269.
Manshouri, M., Rahnama, N., & Khorzoghi, M. B. (2014). Effects of pilates exercises on flexibility and volleyball serve skill in female college students. *Sport SPA*, *11*(2), 19–25.
Matošková, P., Süss, V., & Vorálek, R. (2009a). Kompenzační programy ve sportu. In: P. Matošková & D. Jonášová (Eds.), *Intervenční pohybové programy*. Svatoňova stráž 2009 (pp. 97–118). Prague: UK FTVS.
Matošková, P., Tietz, J., & Süss, V. (2009b). Vyšetřeni postury a stav pohybového aparátu u dětí – lyžařů sjezdařů. *Rehabilitácia*, *46*(4), 207–215.
McFarland, E. G., Muvdi, J. G., Jia, X., Desai, P., & Petersen, S. A. (2010). Clinical and diagnostic tests for shoulder disorders: a critical review. *British Journal of Sports Medicine, 44*(5), 328–332.
Modi, H., Srinivasalu, S., Mehta, S., Yang, J. H., Song, H. R., & Woo Suh, S. (2008). Muscle imbalance in volleyball players initiates scoliosis in immature spines: A screening Analysis. *Asian Spine Journal*, *2*(1), 38–43.
Muchová, M., & Tománková, K. (2009). *Cvičení na balanční plošině.* Prague: Grada Publishing.
Oyama, S., Myers, J. B., Wassinger, C. A., Ricci, D., & Lephart, S. M. (2008). Asymmetric resting scapula posture in healthy overhead athletes. *Journal of Athletic Training*, *43(*6), 565–570.
Sannicandro, I., Cofano, G., Rosa, R. A., & Piccinno, A. (2014). Balance training exercise decrease lower-limb strength asymmetry in young tennis players. *Journal of Sport Science and Medicine, 13*(2), 397–402.
Stodolová, L. (2009). *Kompenzační cvičení v odbíjené žen*. Brno: Masarykova Univerzita, Fakulta sociálních studií.
Vařeková, R., Vařeka, I., Janura, M., Svoboda, Z., & Elfmark, M. (2011). Evaluation of postural asymmetry and gross joint mobility in elite female volleyball athletes. *Journal of Human Kinetics*, *29*, 5–13.
Větrovcová, M. (2007). *Nervosvalová kontrola kolenního kloubu u mladých hráček volejbalu*. Prague: UK FTVS.
Vorálek, R., Palová, H., & Süss, V. (2009). Nejčastější zraněni ve volejbale a rehabilitace. *Rehabilitácia*, *46*(2), 70–75.
Vorálek, R., Süss, V., & Parkanová, M. (2007). Poruchy pohybového aparátu a svalové dysbalance u hráček volejbalu ve věku 15–19 let. *Rehabilitácia*, *44*(1), 14–20.