Original Article

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The influence of core stability exercises programme on the functional limitations of the musculoskeletal system in girls practising volleyball

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Abstract

Introduction. High physical fitness requirements in young athletes may lead to physical injuries. This study aimed to determine the influence of a core stability exercise program on the functional limitations of the musculoskeletal system in girls practising volleyball. Materials and Methods. 32 female players practising competitive volleyball in the Sport Club SMS Warsaw participated in this study. Group 1 (study group) comprised female volleyball players who, apart from training, performed stabilisation exercises from the developed program. Group 2 (control group) included players who did not perform any additional exercises. The assessment tool was the FMS test, comprising of 7 movement patterns scored on a scale of 0–3. Results. In the studied group of 32 volleyball players, at the first measurement, the average result of the FMS test amounted to 11.38 points. At the second measurement, considerably better results (p<0.001) were observed in the study group. Both the players in the study and control groups obtained the highest possible result of the pectoral girdle mobility test at both measurements. Conclusion. Stabilisation training may have a diminishing influence on functional limitations in women practising volleyball. The use of stabilisation exercises is recommended to prevent traumatic and overload-related bodily injuries.

Keywords: volleyball, FMS, injury prevention, functional assessment

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INTRODUCTION

The main causes of injuries include lack of time for regeneration, overtraining, and inadequate choice of training load [1]. Considering the increasing number of injuries in professional sports, the importance of prevention has increased. Adequate regeneration between training and sports competitions is important. In volleyball players, prevention should include a choice of stabilisers and protection that greatly diminish the risk of injury [2].

An important element in traumatic body injury prevention is pre-training warm-up, as the neuromuscular strategies used during it may diminish the risk of lower limb injuries. The techniques used include stretching, strengthening, and balance augmentation exercises [3-5]. Appropriately conducted training, adjusted to a given sports discipline, and the abilities of the athlete constitute the basis for motor system injury prevention. The aim of altering the training load is to minimise the effects of overtraining and diminish the occurrence of musculoskeletal system damage. To obtain good results in a given discipline, it is indispensable to include its typical forms of activity in the training program to place a load on the appropriate physiological and energetic systems [6].

Core stability exercises, dynamic stability, proprioceptive training, eccentric muscular work, and plyometric exercises should be incorporated into training programmes [7]. According to Stiff et al., plyometric exercises are important in load training programs. The objective is to shape the muscular ability to trigger strong work in a short time because of the transition from the stretching phase to the strain of the muscle [8]. For volleyball players, plyometric training is usually performed using the interval method. The important factor of training is the mode of performing the exercise itself, based on the concentric (during upward jumps) or eccentric strain (during downward jumps) [9].

When designing a suitable training program, it is important to refer to functional diagnostics, assessment of movement patterns, and existing restrictions in the motor system [1,6]. The aim of this study was to assess the influence of a core stability exercise program on the functional limitations of the musculoskeletal system in girls aged 11 to 14 years practising volleyball.

MATERIAL AND METHODS

32 female players practising competitive volleyball in the Sport Club SMS Warsaw participated in this study. The players were aged between 11 and 14 years old. Training was performed three times a week. The players were divided into two groups. Group 1 (the intervention group) comprised female volleyball players who, apart from the training, performed stabilisation exercises from the developed program. Group 2 (control group) included players who performed no additional exercises. No significant differences were observed between the groups (for each element: age, body mass, body height, and BMI). Table 1 shows the biometric characteristics of the volleyball players who participated in the study.

Contracting an injury during the study, pain-related ailments that made it impossible to take part in matches and training as well as the unsystematic performance of exercises contained in the program contributed to disqualification from the study. One player in Group 1 and two players in Group 2 did not complete the intervention because of contracting injuries during the league matches. Four volleyball players in the intervention group and three from the control group were excluded from the intervention because of the unsystematic participation in training and not performing exercises included in the program.

The main intervention tool was the functional movement screen test developed by Gray Cook and Lee Burton [10, 11]. The test was designed for the purpose of an objective analysis of human movement patterns in relation to their functional capacity and to predict and prevent injuries among

Table 1. Characteristics of research groups.

Groups	Number of people	Age [years]	Body mass [kg]	Body heigth [cm]
(1) Experimental	16	13.56 ±1.21	47.56 ± 4.02	164.98 ± 7.07
(2) Control	16	13.63 ±1.03	52 ± 9.14	168.11 ± 7.42

sportspeople. The three-dimensional evaluation of movement brings to light abnormalities in kinematic chains, as well as it allows for a comprehensive assessment revealing the asymmetry and significant functional limitations, resulting from incorrect mobility and stability of musculoskeletal system. The Functional Movement Screen consists of seven exercises that test basic movement patterns:1. Deep squat, 2. Hurdle step, 3. In-line lunge, 4. Shoulder mobility, 5. active straight leg raise (ASLR), and 6. Trunk stability push-up, and 7. Trunk rotation stability [10, 11].

The FMS was conducted before the exercises and prior to the warm-up. The assessment was performed in two planes: sagittal and coronal. The subject performed three repetitions of a specific test, and the person conducting the test assessed the best result. In case of doubts regarding the correctness of the pattern, the score was lower. Each side was assessed separately. The performance of each of the seven exercises mentioned above was graded on a 4-grade scale, in line with the established criteria. Each movement pattern was graded from 0 to 3 points (3 points were awarded to a person who executed a movement pattern in the correct manner, 2 points were awarded to a person who executed a movement pattern with compensation, 1 point was awarded to a person who did not manage to execute a movement pattern, and 0 points were given to persons who experienced pain while executing a movement pattern or during a provocative test). A participant in the study obtained 21 points in total [10-12]. The FMS test was performed by a licenced functional movement-screen instructor.

The intervention was reinforced by a custom-created survey containing biometric identifiers, training details, bodily injuries, and potential pain-related ailments. The survey conducted among players contained 11 multiple-choice questions. The questions addressed the contracted injuries, the reasons and circumstances in which they occurred, their methods of treatment, forms of biological recovery, and chronic pain ailments.

Over two months, the study group performed stabilisation exercises using a custom program. The exercises were performed three times a week (Mondays, Wednesdays, and Fridays) and preceded specialised training. The program consists of three phases. The level of difficulty of the exercises in every phase was adjusted according to the age and abilities of the players. The duration of stabilisation training did not exceed 25 min. After each stage, the exercises were modified to increase difficulty. The first stage of the exercises lasted for two weeks. The primary aim was to learn to activate deep muscles in the lie-down position.

The set of exercises in the first phase was as follows: supine position with flexed knee joints, learning to activate the vertical abdominal muscle, 3 series of 10 s supine position with flexed knee joints, learning to activate the transverse abdominal muscle, interchangeable stretching of the lower limbs, 2 series of 10 repetitions plank on forearms, 3 series of 20 seconds, side plank on the forearms, 3 series of 20 seconds, exercise performed on the right and left side, reverse plank, 3 series of 20 seconds on all fours, interchangeably lifting the right upper limb and left lower limb to level with the core, and the subsequent touch of the knee to the elbow of the upper limb, three series of five repetitions, and exercise on both sides.

The second stage of the exercises lasted for three weeks. An increase in difficulty levels was obtained by increasing the timing of the particular exercises and modifying them. The exercises performed at this stage were as follows: supine position with flexed knee joints, learning to activate the transverse abdominal muscle, 3 series of 20 s supine position with flexed knee joints, learning to activate the transverse abdominal muscle, interchangeable stretching of the lower limbs, 5 series of 10 repetitions plank on forearms, 5 series of 20 seconds, side plank on forearms while maintaining the upper and lower limbs up with no support, three series of 30 seconds, supine position with support on forearms with raising the lower limb straight in the knee joint, 3 series of 30 seconds, on all fours, interchangeably lifting the right upper limb and left lower limb to level with the core, and the subsequent touch of the knee to the elbow of the upper limb, five series of five repetitions, and exercise on both sides.

At the last stage, which lasted three weeks, the above exercises were performed on unstable ground (a balance disc). The study was reinforced by a custom-created survey containing biometric identifiers and details of the injuries and training.

Data were analysed using standard methods of statistical analysis and arithmetic means, including standard deviations. The significance of the differences between the results of the first and second measurements was determined using the Wilcoxon signed-rank test. The relationships between the variables were determined using Pearson correlation. The minimal level of significance was set at $p \leq 0.05$. The calculations were conducted using MS Excel and Statistica 10 software.

RESULTS

In the studied group of 32 volleyball players, at first measurement, the average result of the FMS test amounted to 11.38 points (11.5 – Group 1, 11.25 – Group 2). In the second measurement, significantly better results ($p<0.001$) were observed in the intervention group (Table 2). The highest score was obtained by one player in group 1, with 16 in the first measurement and 19 at the second. The lowest score of 9 at the first measurement was obtained by two volleyball players in the intervention group and one in the control group. The lowest score obtained on the second measurement was 11.

Both the players in the study and control groups obtained the highest possible result of the pectoral girdle mobility test at both measurements. The lowest scores on the first measurement were observed in the in-line lunge and rotary stability tests.

The players in group 1 augmented their scores on the six movement tasks. At the second measurement, the players in the intervention group scored considerably higher on the deep squat, hurdle step, in-line lunge, active straight leg raise, trunk stability push-up, and rotary stability tests. The greatest differences were observed in active straight leg raise and rotary stability ($p < 0.001$). Among the players in the control group, no significant change was observed in the results (of all tasks) in the second measurement (Table 3).

As many as 59% of the players who participated in the study (n = 19) had contracted bodily injuries. Players in the intervention group had a higher number of injuries (n = 18) than those in the control group (n = 11). The most contracted bodily injuries in the two groups were joint sprains and dislocations, as well as soft tissue contusions. The prevailing number of injuries is related to the talocrural joints. In the intervention group, as many as 25% (n = 8) reported sprains or dislocations while practising volleyball. In the control group, talocrural joint injuries occurred in 15% of volleyball players (n = 5).

Table 2. Overall FMS results.

Groups	Pre-test [points]			Post-test [points]			p
	max	min	mean	max	min	mean	
(1) Experimental	16	9	11.50	19	11	14.56	p<0.001
(2) Control	13	9	11.25	13	9	11.00	0.333

p - statistically insignificant

Table 3. Results of FMS tasks in points.

Test	(1) Experimental			(2) Control		
	pre-test	post-test	p	pre-test	post-test	p
Deep squat	1.38 ±0.62	1.69 ±0.61	0.019	1.38 ±0.51	1.31 ±0.48	0.581
Hurdle step	1.50 ±0.52	2.00 ±0.00	0.002	1.25 ±0.44	1.31 ±0.48	0.333
In-line lunge	1.25 ±0.44	1.94 ±0.57	0.001	1.25 ±0.44	1.19 ±0.40	0.581
Shoulder mobility	2.88 ±0.34	3.00 ±0.00	0.164	2.94 ±0.25	3.00 ±0.00	0.114
Active straight leg raise	2.06 ±0.57	2.44 ±0.51	0.001	1.88 ±0.62	1.75 ±0.58	0.333
Trunk stability push-up	1.31 ±0.48	1.94 ±0.57	0.014	1.56 ±0.63	1.44 ±0.51	0.164
Rotary stability	1.13 ±0.34	1.56 ±0.63	0.001	1.00 ±0.00	1.00 ±0.00	–

p - statistically insignificant

DISCUSSION

Volleyball is a team sport that, despite the lack of direct contact between players, has a high degree of trauma [13]. The progressing commercialisation of sports requires a continuous increase in training loads from the players so that better results can be obtained. An inappropriate choice of training load and incorrect movement techniques could lead to asymmetry in the motor system and the occurrence of functional limitations that predispose the athlete to contracting an injury [9].

According to one study, bodily injuries among female volleyball players most often concern the talocrural joint, which has been confirmed by other authors [14-16]. According to Chorba et al., the injuries are due to incorrect movement patterns related to mobility limitations, lesser body stability of the players, and coordination dysfunctions [17]. The most frequent results of traumatic bodily injuries include training activities, which have increased in recent years, as well as the number of competitions run. According to Reeser et al., the risk of contracting injuries in volleyball is similar to that in contact sports [13].

The risk of contracting an injury is the highest during the attack and block, which share the presence of upward jump and landing and is considered the most chargeable for the talocrural and knee joints [15, 16]. Launay lists the lack of time for recovery, overstraining, and improper choice of loads during training as the main reasons for injuries [18]. Research has also shown that fatigue is one of the main reasons for contracting bodily injuries.

The FMS may be a useful tool for defining risk factors and functional shortages because it is a simple screening test that highlights functional deficits as well as asymmetries in studied subjects. It is currently employed not only in professional sports but also in young sportsmen [19-24]. According to its creators, Grey and Cook, FMS makes it possible to determine fundamental movement patterns, quality of functional mobility, and stability of the motor system, with simultaneous insight into neuromuscular coordination [10, 11]. The link between the history of bodily injuries and FMS test results is described in this paper.

Studies by Chorba et al. [17] on female players from different disciplines (football, volleyball, and basketball) have demonstrated that for athletes scoring lower than 14 on the FMS, the risk of contracting an injury was four-fold. According to the author, compensation in the musculoskeletal system increases the risk of injury. Conducting the FMS test enables the prediction of potential injuries without a detailed history of prior bodily injuries [17].

The above correlation was not observed by Mokha et al. [25], who, while studying volleyball and football players of both sexes, defined asymmetry as the main cause of injuries. According to them, asymmetries and lower scores in individual FMS tests influence the risk of contracting a bodily injury, rather than the tallied score of the test [25].

The relationship between the FMS test results and the number of bodily injuries contracted was obtained for, among others, women practising combat and team sports. The persons who obtained more points in the functional assessment had fewer injuries [26]. The results obtained in the FMS test may also be influenced by training experience and sports class. Adamczyk et al. [27] and Boguszewski et al. [26] have confirmed the relationship between the average FMS score and the training experience for weightlifters. The authors demonstrated a correlation between sports level and functional assessment. The higher the level of sports, the higher the functional level of the athletes. A positive effect of exercises employed in specialised weightlifters training on the functionality of athletes was observed, which justifies the need to introduce them in general fitness training as a means to prevent bodily injuries [26,27].

Apart from training experience, the age of the athletes may have a strong impact on the FMS test results. Mitchell et al. [28] considered the FMS a test suitable for screening school-aged children, as the physical tasks that form the test have proven to be possible for study participants [28]. This has been proven in previous studies. School-aged female volleyball players (11-14 years of age) completed each task included in the FMS test, making it possible to functionally assess the players.

The increasing number of injuries among best volleyball players in recent years has influenced the growing importance of preventive actions. Our research confirms the appropriateness of stability training in traumatic bodily injury prevention because of the increased quality of the movement pattern. Hupperets et al. [3] tried to determine the appropriateness of neuromuscular training. His studies have confirmed a reduced risk of repeated talocrural joint injury by 34% compared to the control group [3]. Studies conducted in Great Britain under Herman's supervision confirmed that using neuromuscular strategies during warm-up may reduce the risk of lower-limb injuries. Such strategies include stretching, strengthening, balance, and agility exercises as well as landing techniques [29].

The results demonstrate the need to conduct further research on a larger number of players. Studies on the influence of stabilisation training on the occurrence of traumatic bodily injuries should be conducted on a wider scale.

CONCLUSIONS

Stabilisation training may have a diminishing influence on functional limitations in women practising volleyball. It may be an element for preventing trauma and overload-related bodily injuries. The appearance of functional limitations may be related to traumatic bodily injuries contracted in the past, which may lead to further injuries to the motor system. The bodily injury that occurs most often among female volleyball players is the talocrural joint sprain, which may be related to the specifics of the discipline itself as well as insufficient prevention. It is recommended that particular attention be paid to the prevention of lower-limb injuries. Studies on stabilisation training for functional limitations of the motor system should be continued, especially among athletes, because of the increased risk of bodily injuries.

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