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Twelve-week sensorimotor training as a factor influencing movement patterns of canoe slalom athletes, assessed by the Functional Movement Screen

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Summary

Introduction: The aim of the study was to evaluate whether our own twelve-week Sensorimotor Exercise Programme (SEP) affected FMS results in canoe slalom athletes. The Functional Movement Screen (FMS) is a tool for detecting asymmetries and movement range limitations in order to prevent sport injuries. The screen evaluates mobility and stability in seven fundamental movement patterns.
Material and methods: The study population consisted of 16 athletes from the Canoe Slalom National Team of Poland who competed in three sports categories: kayak single, canoe single, canoe double. The athletes, 13 men and 3 women, undertook the FMS screen twice before the starting season. Between the first and the second screen the athletes undertook a twelve-week long sensorimotor training programme.
Results: The result analysis showed a statistically significant difference in FMS results. The mean FMS screen result after twelve weeks of training increased from 16.6 points to 19.6 points.
Conclusions: An adequately designed SEP can lead to an improvement in athlete movement patterns. The FMS screen allows for assessment of changes in athlete movement patterns after twelve weeks of SEP training.

Key words: Canoe slalom – Functional Movement Screen – Sensorimotor training

Introduction

Canoeing and kayaking are outdoor activities that can be enjoyed by people of all ages and levels of fitness. In this sport injuries can occur, including at the highest level, such as in our study. We examined a group of professional canoe slalom athletes in whom, despite their experience, various hazards and injuries occurred while doing this sport. Among the most frequent problems are shoulder injuries. The force required to push the paddle through the water can cause an injury. A common high-risk position is abduction and external rotation during a high brace. This is a position used by athletes to prevent a capsize by bracing off the water. Other injuries such as wrist, back, and knee injuries or pain can occur, but the mechanisms of injury and treatment outcomes are poorly reported in the literature [14].

The Functional Movement Screen (FMS) is a widely used tool for assessing fundamental movement patterns, for detecting asymmetries and movement range limitations and for assessing vulnerability to sports injury [8]. Applying the FMS to predict sport injuries has often been questioned and numerous studies are being conducted on this matter [5, 6, 7, 9].

The screen can be widely used. It is conducted inter alia in elite athletes, sport amateurs, uniformed service workers (police officers, soldiers or fire fighters), children and adolescents [2, 3, 20, 26].

Numerous studies have discussed using the FMS in athletes of various disciplines, but there has not been a study on canoe slalom athletes yet. The FMS is easy, quick to do and inexpensive to administer as it does not need sophisticated equipment. The person administering the screen needs only adequate training and an easily accessible screening protocol. The accessibility of the

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FMS makes it a popular screening test. There are studies, however, that point to the need of designing more detailed screen protocols that consider the age and the gender of the person being screened [6, 21].

The aim of the study was to determine the impact of the twelve-week Sensorimotor Exercise Program (SEP) on the quality of functional movement patterns as assessed by the FMS in canoe slalom athletes from the Junior and U-23 Polish Canoe Slalom National Teams.

Material and methods

The study group consisted of the 16 best Polish canoe slalomers in the Junior and U-23 category (13 men and 3 women) aged 18.31 ± 1.34 years, mean body height 181.61 ± 9.82 cm and mean body mass 71.52 ± 6.70 kg. The authors decided not to divide the competitors into two groups, control and research, because of the small number of athletes who took part in the research. In our research athletes from the Polish Canoe Junior National Team and the U-23 National Team took part (except the athlete who was not in good health or who was training abroad that time).

The criteria for subject inclusion in the study according to the authors were: good general health, lack of injuries in the preceding year, a declaration to do the training throughout the time of the study.

The criteria for subject exclusion according to the authors were: health that needed a doctor's consultation, an injury in the preceding year, lack of declaration to do the training.

The athletes were assessed with the Functional Movement Screen twice, i.e. before and after a twelve-week long SEP training course.

The author of the FMS described the test as seven fundamental movement patterns. The FMS consists of seven screens (Table 1).

All the exercises are graded on a four-point scale, with points ranging from 0 to 3. Three points are awarded if the movement is done properly; 2 points if there are elements of compensation, 1 point if the subject is unable to perform the movement pattern, and 0 if the subject feels pain when performing the movement. Each trial is performed twice. The test administrator assesses the better performed trial and, in the asymmetrical trials, the weaker side of the body. The maximum score is 21 points. It is accepted that a score of ≤14 denotes an increased susceptibility to sports injury. Therefore, the total score of the test indicates whether a subject's risk of sports injury is increased [1, 15].

The athletes did the SEP training as a warm-up before their main canoe training. Both screens were undertaken in the preparation period for the starting season. All the athletes expressed informed consent to participate in the study.

The athletes were screened by two physiotherapists experienced in the FMS. Both physiotherapists were experienced in this method and had completed the FMS course. One of them administered the screens, and the other had the role of an observer. Both therapists recorded their results in separate standardized FMS mark sheets. The therapists did not consult one another during the screen. Immediately after the screen, the athletes did their training for the period of three months, registering the training sessions done each week. The number of training sessions per week was between two and three. The numbers of sessions depended on the coach's decision. The athletes controlled the number and the time of the sessions with their coach or themselves.

The aim of the sensorimotor exercise is to learn to adapt to the changing external conditions, and to learn, remember and reproduce the practiced movement sequences [22]. This kind of training has several names, inter alia: deep muscle training, proprioception training, sensorimotor training. Despite having run thorough discussions and having organized conferences on the matter, no single, unambiguous terminology was accepted [18]. The training programme, which we modified for the purpose of the study, has been called the Sensorimotor Training Program (SEP) by its author. We modified it so that it better suited the needs of canoe slalom athletes. The positions were mainly long sitting and sitting on knees, so they resembled

Table 1. Fundamental movement patterns of the FMS

Movement pattern	The screen is done and assessed for the right and the left side of the body separately [X]
1 – deep squat	
2 – hurdle step	X
3 – in-line lunge	X
4 – shoulder mobility	X
5 – active straight leg raise	X
6 – trunk stability push up	
7 – rotary stability	X

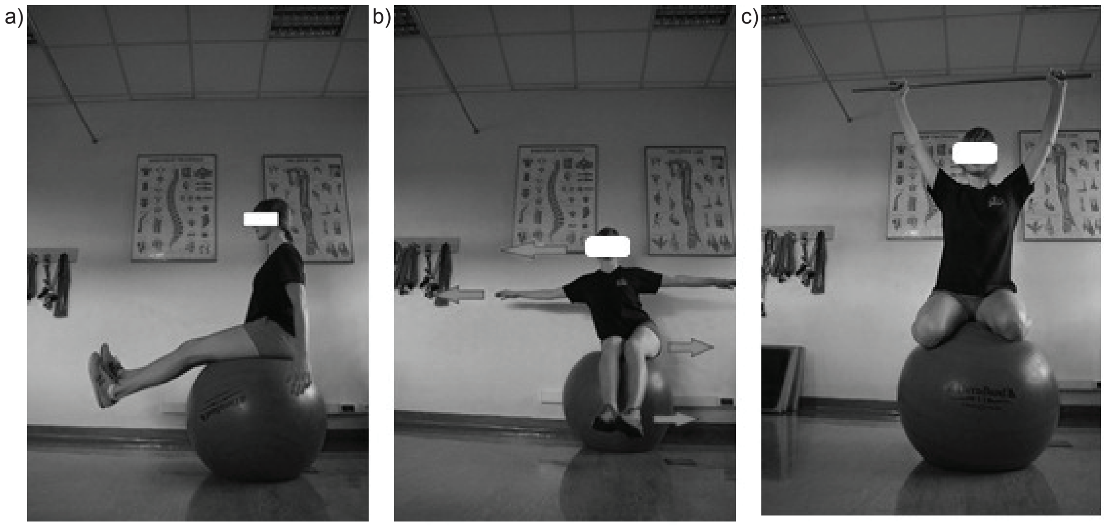

Fig. 1. Stability ball exercises

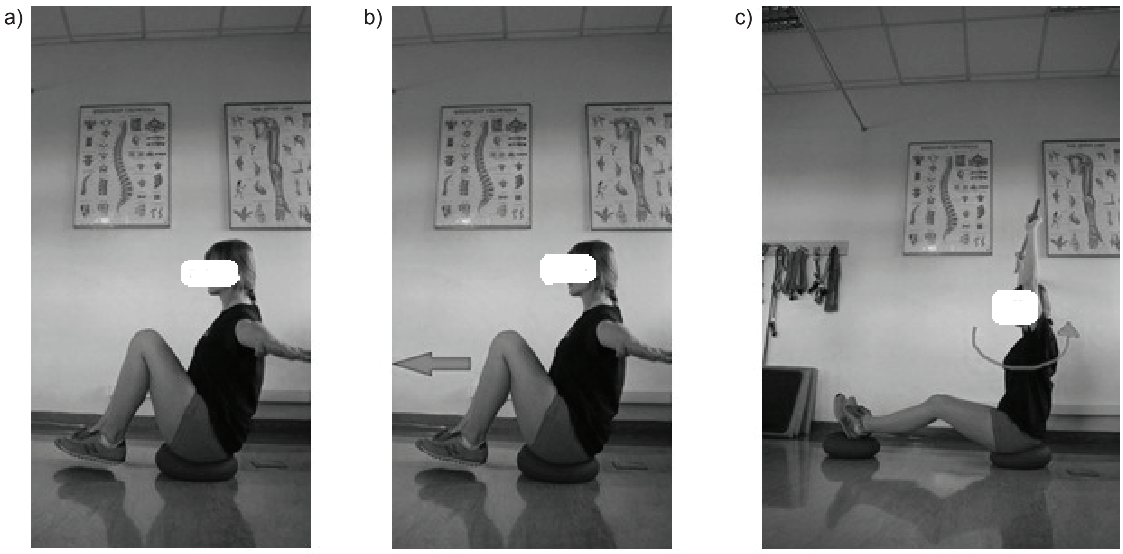

Fig. 2. Exercises in sitting positions

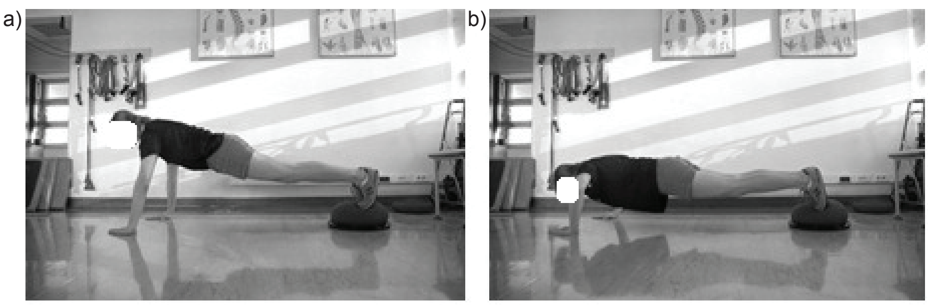

Fig. 3. Push up exercises

athlete posture in the canoe. The time units were the following: a single exercise lasted 30 to 60 seconds, and the total time of SEP training was 10 to 15 minutes. We considered the fact that canoe slalom athletes need to work on several motor skills: power, speed, endurance, supplene ss and motor coordination. As a result, we designed a training programme that was in line with the athletes' core training programme (Figures 1–3) with descriptions in the tables (Tables 2–4). The designed training was discussed with the coach and adapted to training assumptions.

Table 2. Stability ball exercises

	The exercise	The aim	Time
Picture 1a	Long sitting on stability ball.	To maintain balance while sitting on the ball.	60 seconds.
Picture 1b	Sitting on the ball, legs together, arms out to the sides, extended.	Moving the pelvis and the trunk in opposite directions, stopping and holding the position of the maximum inclination for about 2 seconds, then moving in the opposite direction and holding in the maximum inclination.	60 seconds.
Picture 1c	Kneel sit on the balancing boat, holding the paddle over the head or in front of the chest and making paddling movements in various positions.	To maintain balance on the ball.	3 series of paddling, 40 seconds each, then 20 seconds breaks. Total time 3 minutes.

Table 3. Exercises in sitting positions

	The exercise	The aim	Time
Picture 2a	Long sitting on wobble cushion, arms stretched out to the sides.	To bend and extend legs while maintaining balance.	3 series of 40 seconds.
Picture 2b	Long sitting on wobble cushion, arms stretched out to the sides.	To bend and extend legs while maintaining balance.	3 series of 40 seconds.
Picture 2c	Long sitting on wobble cushions, arms lifted over the head, holding a paddle.	To rotate the trunk left and right while maintaining balance.	3 series of 40 seconds.

Table 4. Push up exercises

	The exercise	The aim	Time
Picture 3a, 3b	Push up exercises. Variations of the starting position, depending on how well trained the athlete is: feet on wobble cushion/ hands on wobble cushion/ both hands and legs on wobble cushions.	To do 3 series of 10 push-ups in one of the positions.	3 series of 40 seconds.

Statistical analysis

The test revealed that in the second screen, i.e. the screen after the training, or the FMS (TEST 2), the distribution was not normal. Therefore, for the subsequent analysis we used the non-parametric Wilcoxon signed-rank test. Statistical significance was set at $p \leq 0.05$.

Results

The analysis of results showed a statistically significant difference in FMS results. The results showed a significant ($p = 0.018$) increase in the FMS of the study population from mean 16.6 ± 1.7 points to 19.6 ± 1.1 points. Only one athlete (number 2) had the same result in the pre- and post-test. The line chart shows the points the athletes scored in both screens (Fig. 4). The blue columns illustrate the results in the first screen, FMS 1, while the red ones illustrates the results in the post-training screen, FMS 2. The bar chart illustrates the statistically significant improvement in post-training screen results.

Differences in FMS prior to and after the training were statistically significant for most tests (Table 5).

The study on canoe slalom athletes showed that the experience of test administrators did not affect their FMS assessments. The concordance of their marks was 100%. These conclusions were drawn after analyzing the cards the administrators filled out during screens.

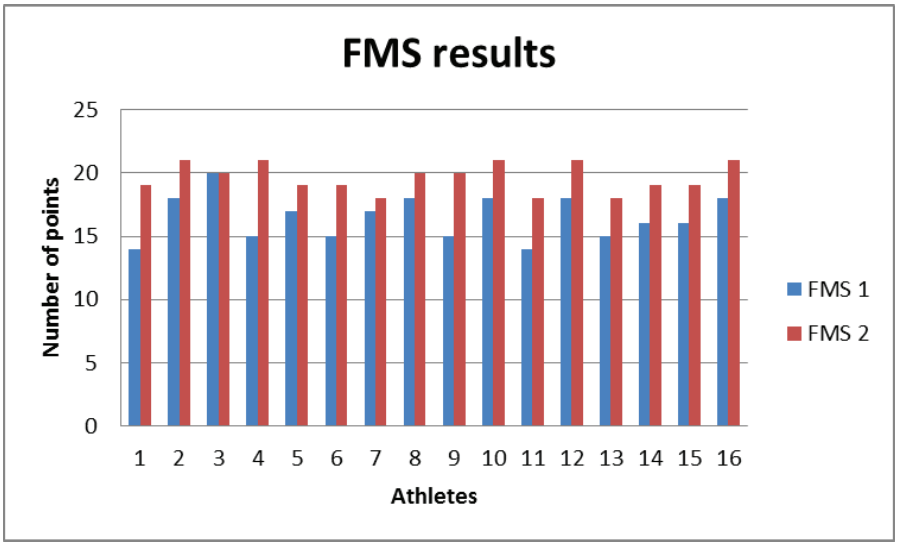

Fig. 4. Comparison of FMS results from 16 canoe slalom athletes

Table 5. Differences in FMS prior to and after the training

	Statistics of the non-parametric test							
	FMS 1 – FMS 2	TEST1 – TEST1	TEST2 – TEST2	TEST3 – TEST3	TEST4 – TEST4	TEST5 – TEST5	TEST6 – TEST6	TEST7 – TEST7
Asymptotic significance (two-sided)	p = 0.0005	p = 0.083	p = 0.025	p = 0.0008	p = 0.008	p = 0.025	p = 0.083	p = 0.0003

Discussion

The FMS is a screening test and it meets the criteria of test reliability and accuracy. In their reviews of available literature Kraus et al. [16], as well as Li et al. [20], showed that the total FMS result is a reliable result. Simultaneously, they noted that the result from each of the individual test parts is more significant than the total result.

Another important matter is the concordance of screen administrators. Kraus et al. [16] found that the FMS is reliable if the administrators are adequately educated and experienced in screen assessment. A review of the literature by Cuchna et al. confirmed the concordance of the test administrators [10]. Additionally, Minick et al. [25] and Bonazza et al. [1] proved that only some of the trials, such as deep squat, can be assessed by test administrators who have different levels of expertise. Gulgin and Hoogenboom had similar results, yet they drew different conclusion. In their study, the difference in total number of points between the test administrators was 1.9 points and it was not statistically significant (p=0.136). They concluded that experienced test administrators are more critical in their assessments. In our study on the canoe slalom athletes, the experience of test administrators did not have a significant impact on the assessment of individual trials or on the total result of the test [13].

Sensorimotor training. So far the literature has not discussed the effect of sensorimotor training in canoe slalom athletes. Similarly, there are no studies on the impact of this kind of training on other water sport disciplines. This is why we contrasted the methodology of SEP training we used with the training assigned to athletes of other disciplines. We found that the name of the training, its duration, the number of training sessions, and results achieved are different depending on the author and on the study group [12, 19, 23, 24, 28].

The literature confirms the effectiveness of exercise done on an unstable surface, for example TRX, wobble cushions or stability balls [11]. Still, it is impossible to explicitly state that distortions to stability in exercise are always beneficial. Both stable and unstable surfaces have their beneficial effects. For example, TRX equipment in push-ups increased activation of the deep muscles of the abdomen, triceps brachii muscle, posterior head of the deltoid muscle and the descending part of the trapezius muscle. Similarly, a stable surface activates the following muscles more: the pectoralis major muscle, anterior head of the deltoid muscle and the serratus anterior muscle [4]. In electromyography (EMG) tests, Snarr and Esco found increased activity of the pectoralis major muscle, triceps brachii muscle and the anterior head of the deltoid muscle when push-ups were performed in unstable conditions [27].

According to Kümmel et al. [2016], doing specific sensorimotor exercises tailored for a particular sports discipline or a particular sports activity is more beneficial than doing general sensorimotor exercises [17]. Consequently, the sensorimotor training that our study population of canoe slalom athletes did was practised in the sitting positions they take while in a canoe or a kayak (Figs 1 and 2).

In summary, the Sensorimotor Exercise Program influences the proprioception and balance of athletes. We noted improvement in FMS test results in our study, which was our strategy.

The value of the study

This is the first study of its kind on canoe slalom athletes. Additionally, the study population consisted of highly trained sports professionals. It seems interesting that until now, there have not been any studies on the effect of sensorimotor training on movement patterns of water sports athletes. Therefore, our results provide an opportunity to use our conclusions in other water sports disciplines with similar characteristics (e.g. sailing, rowing, windsurfing, wakeboarding, canoe polo). Another value of the study is that the training aims were 100% met. All participating athletes did the training programme for 12 weeks and completed it within projected deadlines.

Limitations of the study

The study population was limited in number – it consisted of 16 athletes. The reason for this size of the group was our decision to focus on the Canoe Slalom National Team of Poland, i.e. to study the phenomenon in the group of best trained athletes. A second limitation is the lack of FMS test results after a longer observation period. It could be helpful to assess whether the results stay at the same level or decrease. Another limitation is the lack of information on the correlation between FMS results and the athlete vulnerability to injury during the starting season. Also, it is not known whether a better FMS result leads to improved results in sports competition during the starting season. The two latter aspects are going to be studied and presented in follow-up papers.

Conclusions

1. SEP had a positive effect on the improvement of functional movement patterns in canoe slalom athletes assessed with the FMS screen.
2. SEP provides an opportunity to improve the quality of movement, which is important for kayakers and canoers.
3. Follow-up studies should focus on how FMS results correlate with athletes' vulnerability to injury.

Conflict of interest: Authors state no conflict of interest.

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