Comparison of functional movement patterns and risk of injuries in amateur athletes practicing symmetric and asymmetric sports

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DOI: https://doi.org/10.5114/phr.2022.114585

Received: 12.05.2021 **Reviewed:** 04.06.2021 **Accepted:** 04.06.2021

Abstract

Background: Participating in amateur sports seeks to improve overall well-being. However, it also carries a high risk of injuries and abnormalities of the musculoskeletal system. One of the factors that predisposes to an increase in injuries in both amateur and professional sports is the asymmetry of movement. Asymmetrical movements in sports can globally affect the athlete's body and precursor to various types of abnormalities.

Aims: The purpose of this study is to compare an asymmetrical sport (tennis) with symmetrical sport (long-distance running) in terms of injury risk and basic movement patterns.

Material and methods: The study group consisted of 30 tennis players and 30 runners of both genders, between 20 and 50 years old, practicing their sports at the amateur level. One of the research methods used was a questionnaire that included questions regarding elementary participant information, training, and health information. In addition, basic movement patterns were assessed using the Functional Movement Screen (FMS) test.

Results: There were more asymmetries found in the FMS test in tennis players than in runners, and better results in terms of the number of points in runners. However, they did not demonstrate a higher occurrence of injuries in those practicing an asymmetric sport than those practicing a symmetric sport.

Conclusion: Based on the results, it was concluded that practicing an asymmetrical sport may increase the risk of asymmetries in basic movement patterns to a greater extent than practicing a symmetrical sport. Practicing asymmetrical sports at the amateur level does not seem to increase the occurrence of injuries any more than practicing symmetrical sports.

Key words

tennis, asymmetry, injury risks, long distance running, asymmetric sports, functional movement screen (FMS)

Introduction

Currently, physical culture has become one of the more common branches of culture in the broader sense. As a result, a growing number of people are choosing physical activity as a form of leisure. This manifests itself not only in increased competitiveness of many sports practiced at the professional level, but also in a growing interest in amateur activity. Practicing sports on an amateur level is meant to improve your overall well-being; however, it also carries a high risk to your musculoskeletal system. However, many people are unaware that amateur sports also involve numerous overloads and require proper motor preparation, subject knowledge, proper equipment, etc. Therefore, it is worth examining the risk of injury aspect of amateur sport [1,2].

One factor that predisposes to an increase in injuries in both amateur and professional sports is the asymmetry of movement characteristic for some sports. However, it can be assumed that this risk tends to manifest itself more often in amateur sports, as there is less attention paid to the ability to use the opposite side of the body than the dominant one when compared to professional sports. For example, fencing, archery, and tennis, among others, are considered to be asymmetrical sports [3].

The aspect of sports asymmetry as a predisposing factor for injury has been the subject of numerous research. Professional groups that deal with locomotion daily very often get questions about whether symmetrical sports are safer sports with less risk of musculoskeletal abnormalities or whether asymmetries found in other sports are not a direct cause of deviations from the norm. Parents who accompany their children in the choice of sports often consider whether, for example, practicing tennis will not cause a greater imbalance between the sides of the body than practicing running [3]. Unfortunately, there is no conclusive research indicating that asymmetry in discipline-specific movements affects asymmetry in an athlete's physique or movements. Alvarez et al. [4] attempted to study this phenomenon by performing statistical structural analysis in adolescents from Madrid. The participants represented sports such as fencing, swimming, and badminton. The researchers observed only sport-specific differences between disciplines. However, no differences were observed in body symmetry abnormalities [4]. The study by Lagan and Sloniewski [3], focused on athletes practicing archery, is also inconclusive. The analysis of the relationship between biomechanical aspects of this sport and overloads leading to pathological changes showed that only in some athletes the cause of abnormalities is asymmetry of movement. In the rest of the subjects, however, they were associated with the type of training methods used [4].

The comparison of two disciplines representing two groups of sports with different movement characteristics, in this case, symmetrical and asymmetrical, provides an opportunity for a more in-depth analysis of whether movement asymmetry has an impact on injury or dysfunction. The analysis will focus on tennis as a sport belonging to the group of asymmetrical sports and running, which comes from the group of symmetrical sports. Asymmetry of movement in tennis is primarily manifested by the use of the dominant limb, regardless of the type of stroke being performed (in both Backhand and Forehand). The large number of regularly repeated, unilateral movements that are performed here with great force may therefore predispose to overload and thus to injuries or degenerative changes in the future [5]. On the other hand, running is a discipline in which the movements are symmetrical, similar to those of walking, but with greater force, angular velocity, etc. Furthermore, all phases of running are performed alternately between the right and left limbs. This includes upper limbs movements [6].

Asymmetrical movements in sports can globally affect the athlete's body and precursor to various types of abnormalities. This assumption implies the need for risk assessment of these abnormalities, which can be used both to prevent injuries or dysfunctions of the musculoskeletal system and give guidance on the reorganization of training units. This paper was written in relation to the expansion of the recreational sports groups and the great paucity of research conducted on this very group when compared to the professionals. Comparison of basic movement patterns and muscle activity in tennis and long-distance running athletes would give amateurs of these sports a chance to minimize mistakes in planning their training routine.

Aims

The aim of this study was to evaluate basic movement patterns in amateur athletes practicing a symmetrical sport such as long-distance running and an asymmetrical sport such as tennis and to investigate asymmetries resulting from the practiced sport.

Material and methods

Study group

Subjects between 20 and 50 years of age practicing long-distance running or tennis at a recreational level with regular training and no history of injuries in the past six months were enrolled in the study. Written informed consent was also required for inclusion in the study. The following criteria were adopted for exclusion from the study: training at the professional level (players affiliated with Polish sports associations, licensed), age below 20 and above 50 years old, break in running or practicing tennis for more than 1-month, current injury preventing sports activity, practicing sports disciplines other than long-distance running or tennis, and lack of consent to participate in the study.

Sixty subjects, consisting of 13 women and 47 men between 20 and 50 years old, participated in the study. The study group was divided into two 30-member subgroups, the first of which were individuals practicing long-distance running and the second, those practicing tennis. Tennis players trained 1 to 5 times per week, while runners trained 1 to 7 times per week. The years of training in tennis players were two years, the shortest and the longest was 23 years, while in runners the shortest was one year and the longest was 16 years. The characteristics of the study group are presented in **Table 1**.

Subjects were informed about the process and purpose of the study and gave written informed consent for participation. Prior to the study, approval was obtained from the Bioethics Committee of the Cracow Regional Medical Chamber (No. 40/KBL/OIL/2015). The procedures were conducted in accordance with the Declaration of Helsinki.

Questionnaire

The study group completed a questionnaire containing basic information about the participant, i.e., age, gender, body mass, body height, information about training, i.e., length of training, frequency, training duration, activities preparing for training and post-training regeneration, and other sports practiced, as well as about health status, i.e., lateralization, past and current injuries, and the course of treatment.

Functional Movement Screen

The Functional Movement Screen (FMS) test consists of 7 movement tasks. Each of them is supposed to represent a specific category of functional movement patterns. The tasks performed during the test are intended, according to its creators, to form the basis for more complex movements that are used in everyday life and sports activities, and their positions are based on natural development and growth [7]. The test is designed to catch any asymmetries, compensations, or imbalances. The seven functional tests include Deep Squat (**Fig. 1**), Hurdle Step (**Fig. 2**), In-Line Lunge (**Fig. 3**), Shoulder Mobility assessment (**Fig. 4**), Active Straight Leg Raise (ASLR, **Fig. 5**), Trunk Stability Push Up (**Fig. 6**), and Trunk Rotational Stability test (**Fig. 7**). A participant can earn between 0 and 3 points for each task. Three points are granted for correct execution of the movement with no visible compensations. 2 points are given to the athlete if the movement is performed with an element of compensation. One point is granted if the athlete is unable to perform the movement task, and 0 points if pain occurs during the test. The original FMS setup was used to conduct the test, which consisted of a 5 cm x 5 cm x 150 cm base, a bar, two crossbars, and a resistance band.

Table 1. Characteristics of the study group.

Variable	**Group 1** (n=30) $\bar{x} \pm$ SD	**Group 2** (n=30) $\bar{x} \pm$ SD
Women	6	7
Men	24	23
Age [years]	32.67 ± 7.81	31.37 ± 7.23
Body weight [kg]	70.67 ± 10.32	73.60 ± 13.10
Body height [cm]	177.73 ± 8.58	178.08 ± 8.52
Length of training experience [years]	5.06 ± 6.82	9.97 ± 5.68
Training frequency [number of workouts per week]	3.60 ± 2.54	2.20 ± 1.11

Abbreviations: *$\bar{x}$ – mean; SD – standard deviation.*

Figure 1. Deep Squat for 3 points.

Figure 2. Hurdle Step for 3 points.

Figure 3. In-Line Lunge for 3 points.

Figure 4. Shoulder Mobility for 3 points.

Figure 5. Active Straight Leg Raise (ASLR) for 3 points.

Figure 6. Trunk Stability Push Up for 3 points.

Figure 6. Trunk Rotational Stability for 3 points.

Statistical analysis

Statistical analysis was performed using STATISTICA 12.0 Pl. The obtained data were presented as mean ($\bar{x}$) and standard deviation (SD). The Shapiro-Wilk test was used to assess the normality of the distribution of the variables. The student's t-test or, if its assumptions were not met, the Mann-Whitney U test were used to analyze the significance of differences between groups. Differences between variables were considered statistically significant if the test probability level was less than the accepted level of α=0.05 ($p<0.05$).

Results

Questionnaire

The subjects in both groups of tennis players and runners indicated the right side of the body as dominant, considering both upper and lower limbs. There were 28 left-handed tennis players and 26 left-handed runners (one two-handed person in the runners' group). The remaining participants, i.e., two tennis players and three runners, indicated the left upper limb as the dominant. Left lower limb dominance was indicated by seven runners and four tennis players (one two-legged person in the runners' group). However, the vast majority indicated right limb dominance. It was found that 26 out of 30 runners practiced other sports activities besides their leading discipline. The situation was identical in the case of tennis players (only four persons did not engage in other sports activities). Additionally, 19 runners and 18 tennis players reported at least one sport-related injury during their training experience. The percentages are shown in Figure 1. Seven out of all the runners reported to have abandoned the pre-workout warm-up, but each of them used post-workout relaxation exercises. In the group of tennis players, as many as 28 performed a warm-up before training, but half of them did not perform post-workout muscle relaxation.

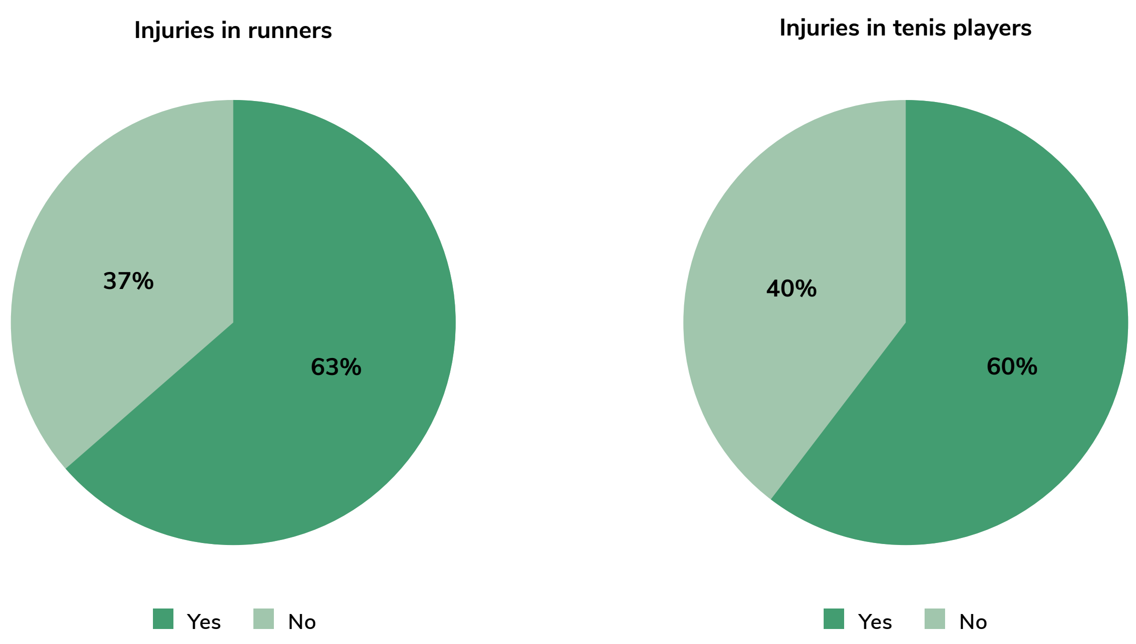

Figure 8. Prevalence of sport-related injuries in runners and tennis players.

Functional Movement Screen Test

In the Functional Movement Screen test, subjects performed 7 functional trials, 5 of which were trials performed bilaterally. Results were presented as median and half of the quartile range. Individual motor task scores and total scores were analyzed to determine differences between Group 1 and Group 2. Comparing the results, statistically significant differences were observed between the groups ($p<0.05$) within two variables. These were going over the hurdle with the left lower limb and the final score, which was higher in Group 1 (runners). Specific data were reported in Table 2. The total score distribution in two groups was presented graphically in **Figure 9**.

Table 2. Between-group comparison of individual movement task values and results.

Parameter		**Group 1** (n=30) Me ± ½ IQR	**Group 2** (n=30) Me ± ½ IQR	p
Deep Squat		2.00 ± 0.50	2.00 ± 0.00	0.146
Hurdle Step	LL L	2.00 ± 0.50	2.00 ± 0.00	0.016
	KD R	2.00 ± 0.50	2.00 ± 0.00	0.123
In-Line Lunge	LL L in front	2.00 ± 0.50	2.00 ± 0.00	0.323
	LL R in front	2.00 ± 0.00	2.00 ± 0.00	0.113
Shoulder Mobility	UL L at the top	3.00 ± 0.00	3.00 ± 0.00	0.496
	UL R at the top	3.00 ± 0.00	3.00 ± 0.00	0.356
Active Straight Leg Raise	LL L	3.00 ± 0.50	3.00 ± 0.50	0.281
	LL R	3.00 ± 0.50	3.00 ± 0.50	0.126
Trunk Stability Push Up		2.00 ± 1.00	2.00 ± 1.00	0.912
Trunk Rotational Stability	UL L at the top	2.00 ± 0.00	2.00 ± 0.00	1.000
	UL P at the top	2.00 ± 0.00	2.00 ± 0.00	1.000
Total score		16.00 ± 1.00	15.00 ± 0.50	0.036

Abbreviations: *LL – lower limb; UL – upper limb; L – left; R – right; Me –median; ½ IQR – half of the interquartile range; p – level of statistical significance*

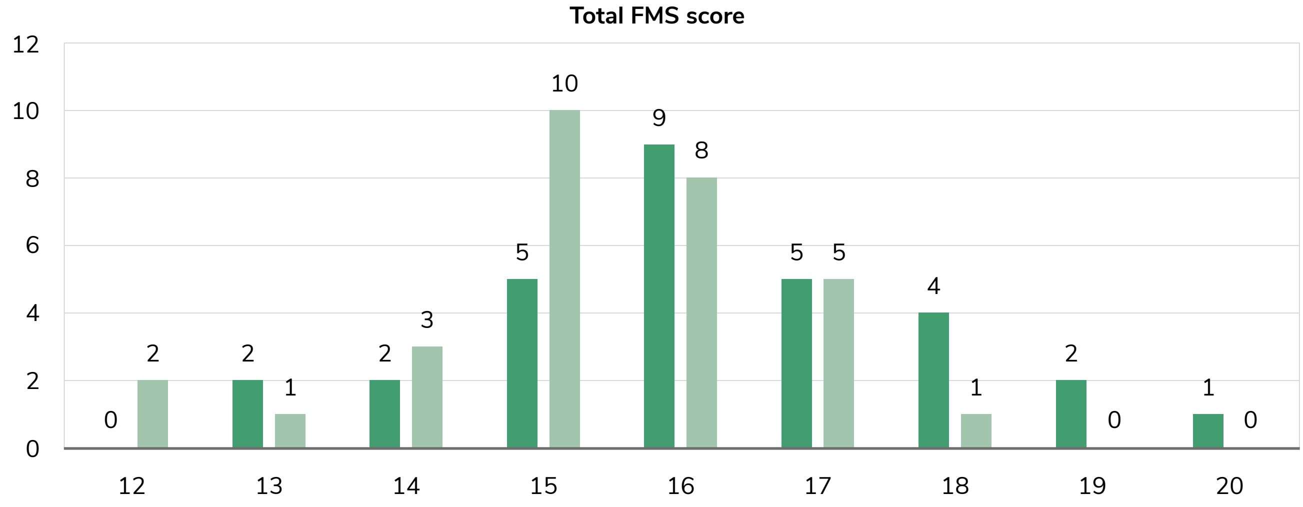

Figure 9. The FMS scores in Groups 1 and 2.

In order to illustrate more clearly the differences between the groups, the mean values of the results of each motor task of the FMS test were calculated in addition to the median. These values were higher in the runners' group across most motor tasks. The exception was trunk stability push up, where a higher mean value was observed in Group 2. A graphical representation of the results was presented in **Figures 10** to **13**, where statistically significant differences were highlighted.

An analysis of the occurrence of asymmetry based on the number of points obtained in each motor task was also performed. The results were compared between groups. Asymmetries were present in four out of the five trials performed bilaterally. They were observed in the hurdle step test, in-line lunge, upper limb shoulder mobility, and active straight leg raise. Only in the first of the above-mentioned trials a greater number of asymmetries occurred in Group 1. In the remaining trials, a greater number of asymmetries were reported in Group 2. There was no asymmetry present only in the trunk rotational stability test. The total number of asymmetries was also higher in the tennis players group than in the runner's group. The data can be found in **Figure 14**.

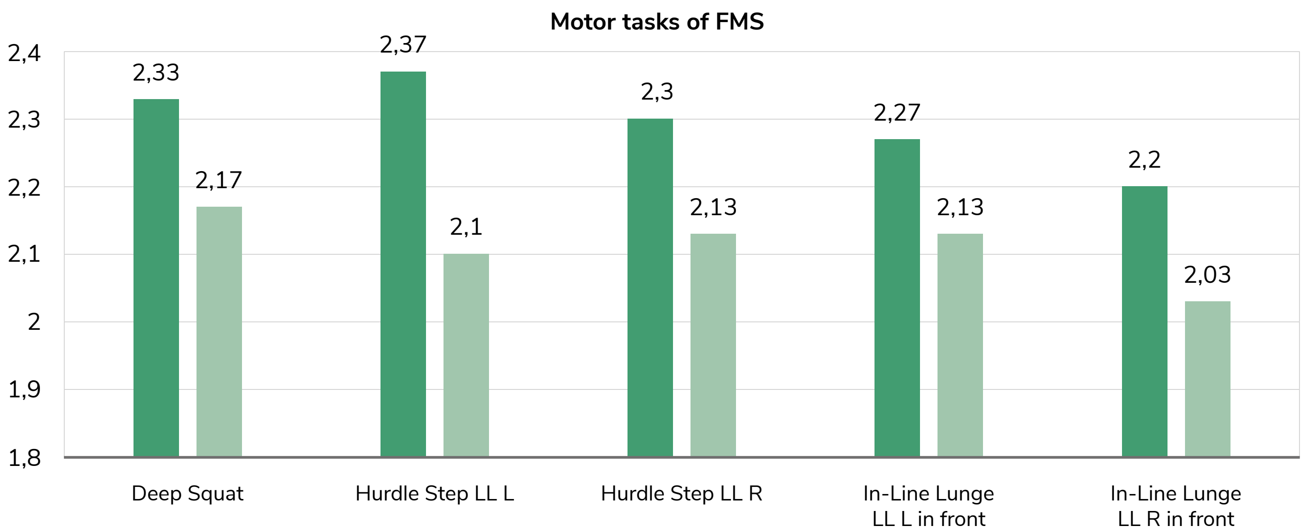

Figure 10. Between-group comparison of the mean values of the individual motor tasks of the FMS.

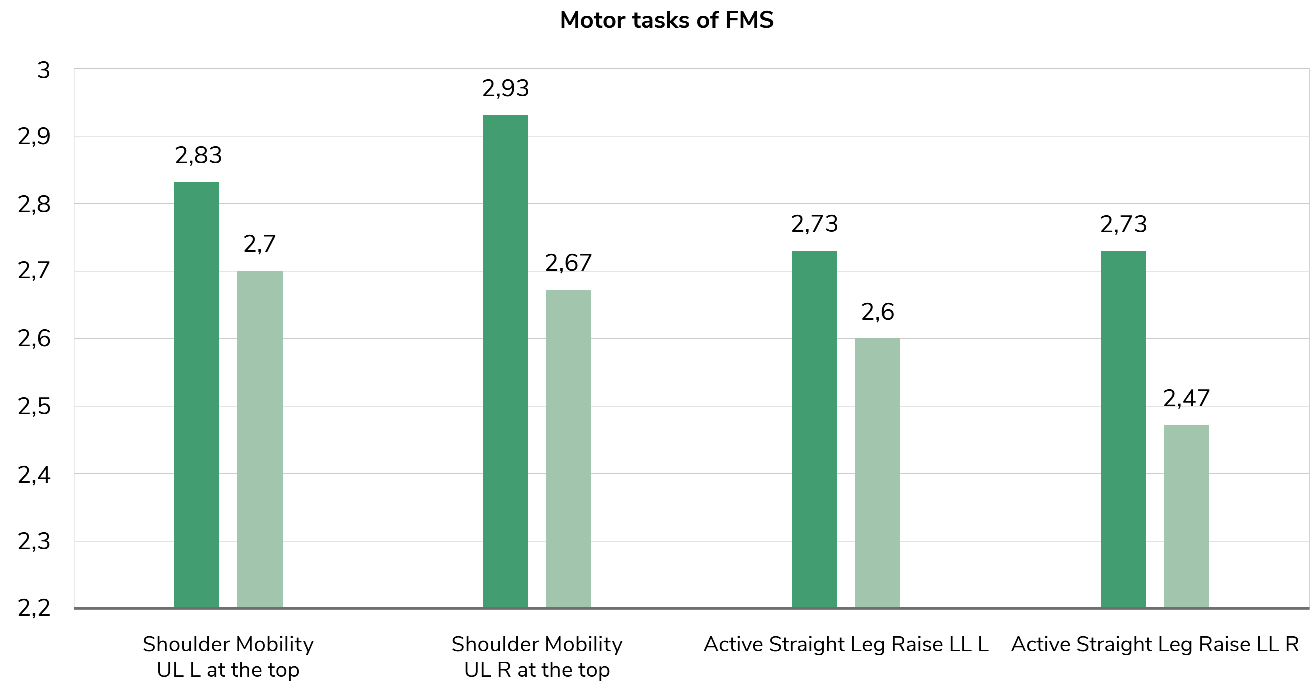

Figure 11. Between-group comparison of the mean values of the individual motor tasks of the FMS.

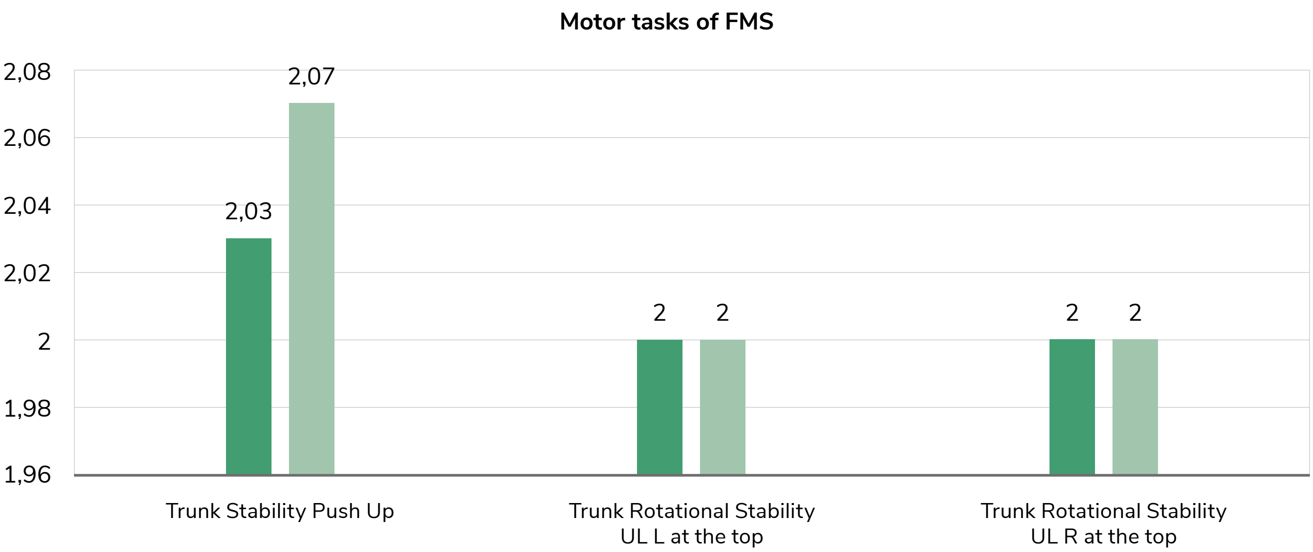

Figure 12. Between-group comparison of the mean values of the individual motor tasks of the FMS.

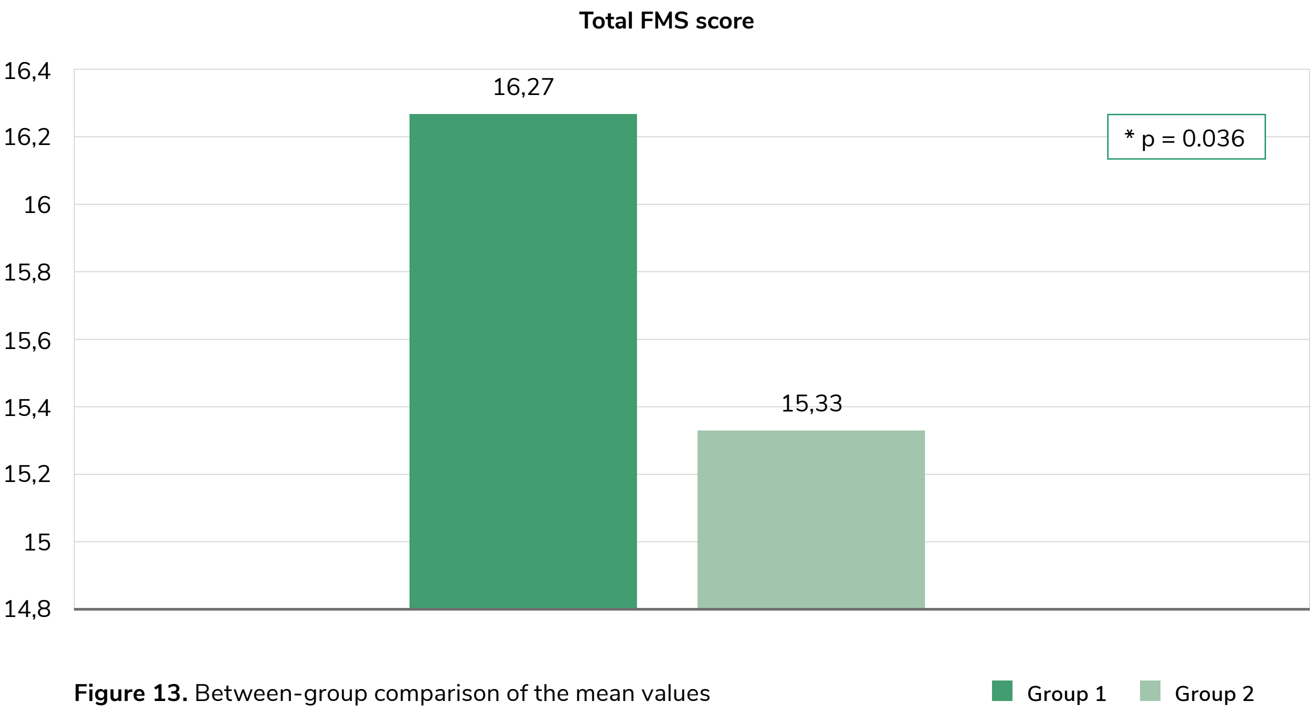

Figure 13. Between-group comparison of the mean values of the total score of the FMS.

** Statistically significant differences*

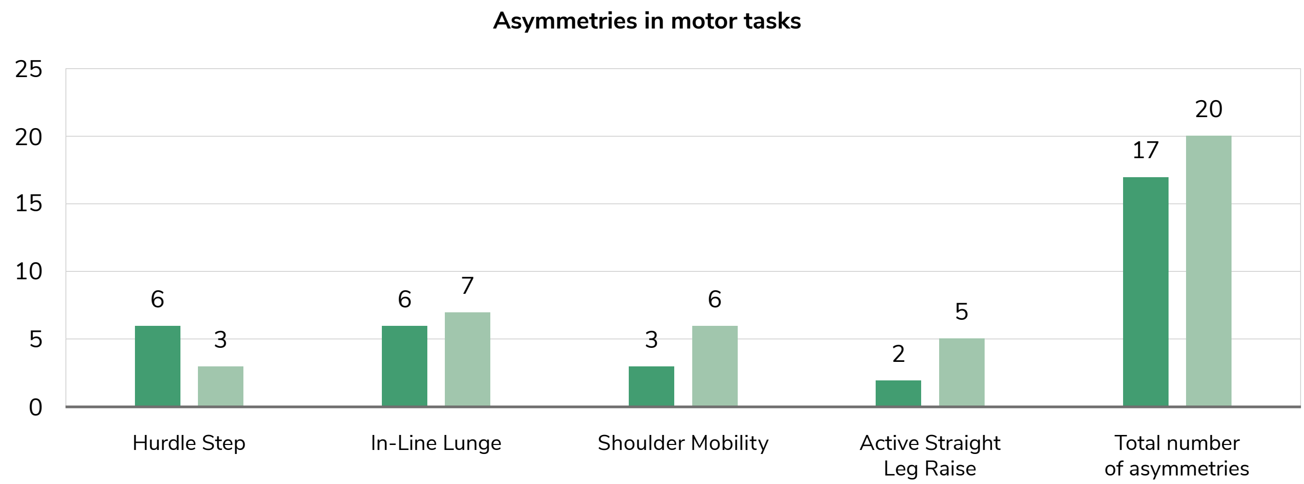

Figure 14. The number of asymmetries in each motor task in Group 1 and 2.

Discussion

The aim of this study was to assess the formation of asymmetries in basic movement patterns in subjects practicing asymmetric and symmetric sports and to verify whether these asymmetries are more evident in athletes practicing a sport considered asymmetric than in those who practice a symmetric sport.

Examination of basic movement patterns using the FMS test revealed a higher fitness level in Group 1 (runners) than in Group 2 (tennis players), as demonstrated by the test results. However, a statistically significant difference in the advantage of Group 1 over Group 2 was evident in only one of the movement tasks. This score contributed to a higher final score in the runners' group. This was a statistically significant difference. The only test in which the tennis players scored more points was the trunk stability push up test. This was most likely due to greater use of the upper limb muscles in tennis players than in runners. Therefore, from the above observations, it can be concluded that runners have increased quality of basic functional patterns, which may contribute to fewer compensations in everyday activities or more complex movements associated with athletic activities.

An important observation related to the purpose of the study is the observation of asymmetry of movements in individual movement tasks in Groups 1 and 2. Out of the five locomotor tasks performed bilaterally, in four of them, asymmetry was more common in Group 2. Furthermore, the total number of asymmetries in the FMS test was higher in tennis players. Practicing an asymmetrical sport such as tennis can affect movement asymmetry, which becomes apparent in basic movement patterns.

Asymmetry in the FMS tests was considered by the creators to indicate an increased risk of injury. However, it does not correlate with the reported number of injuries in both groups in this study. Instead, it was nearly equal, with 18 tennis players and 19 runners reporting the occurrence of an injury during their training experience. The aspect of performing warm-up or relaxation exercises also did not affect this difference, demonstrating more sport-related injuries in either group.

In the literature, it is not easy to find research that aimed at comparing two sports: one being considered symmetrical and the other asymmetrical, and studying the effect of their practice on specific parameters in athletes. Many publications describe the causes of abnormalities in the athletes' bodies; however, few have addressed the issues involved in investigating the causes of these dysfunctions. The present study evaluated whether practicing an asymmetrical sport can cause variability in the performance of basic movement patterns between sides.

Research topics similar to those described in this paper were addressed by Ramos-Álvarez et al. [4]. A total of 102 subjects between 12 and 19 years old, comprising of 66 males and 36 females practicing swimming, which is a symmetrical sport, were investigated. The second group included athletes who trained an asymmetrical sports such as badminton and fencing. This study aimed to describe the structural changes occurring in adolescent athletes from Madrid and investigate their possible association with the use of exercises related to asymmetric sports. The participants were assessed with the "toe-to-floor" test. Foot projection was also examined to investigate the presence of flat feet or excessive hollowing of the foot using a podoscope, measurement of patellofemoral angle using a goniometer, the distance between medial ankles, femoral condyles, knee extension angle, and measurement of lower limb length.

Based on the research results, conclusions were drawn confirming the fact that there are numerous structural differences between adolescents practicing a given sport at a high level. However, in our study, there was no influence observed of the type of sport practiced on the occurrence of asymmetry. Furthermore, there is no evidence of a relationship in the occurrence of scoliosis or other musculoskeletal changes between people training asymmetrical sports and athletes training symmetrical sports [4].

Korcz et al. [8] investigated the influence of target shooting sport on the formation of a specific body posture. This research compared ten athletes who practiced fencing to a 13-person from the control group who did not practice the sport. The moiré method (mora4G device) was used to assess posture. Based on the obtained scores, the subjects were assigned to one of three posture classifications: kyphotic type, balanced type, and lordotic type. This study indicated that each of the curvatures of the spine is deepened in people who practice target shooting, especially in women [8].

Research of this type was also described by Barczyk-Pawelec et al. [9]. This study aimed to evaluate the body posture of table tennis players and compare it to the posture of non-athletes and determine if there is a correlation between practicing asymmetrical sport and the formation of deformities and asymmetries in the players' bodies. The study group consisted of 40 table tennis players aged between 11 and 26 years old with training experience ranging from one to 20 years. The control group consisted of 43 subjects of similar age. Posture in natural position was assessed using photogrammetric methods in the sagittal, transverse, and frontal planes. Results of the study showed a frequent occurrence of kyphotic posture in examined table tennis players. Moreover, it was observed that the athletes had greater asymmetries in the frontal and transverse planes than the subjects in the control group. The researchers concluded that this resulted from intense unilateral muscle work in the trunk, characteristic of table tennis players. These studies also reported correlations between the length of training experience and the occurrence of shoulder line angle asymmetry, which may also be the reason for unilateral play and skipping exercises of the opposite limb [9]. In contrast to the results obtained in the article cited above, in our study, no significant asymmetries were observed in most of the assessed parameters in the group practicing tennis. Perhaps the results differing from the hypothesis assuming increased asymmetry in this group of athletes are due to the fact that the players occasionally use the non-dominant upper limb during play in this sport. In addition, our study did not focus on the assessment of the upper limb and shoulder girdle.

Our study results indicate a relationship between practicing a symmetrical or asymmetrical sport and the symmetry of basic motor activity in athletes. According to the creators of the FMS test, this, in turn, may affect the quality of movement in activities of daily living and influence the formation of compensatory mechanisms that may contribute to numerous abnormalities. However, the study also found that the aspect of differences in FMS test scores alone did not correlate with the number of reported injuries.

There are many difficulties in drawing clear conclusions from our current study. The first difficulty is related to selecting the sample, more specifically, the large discrepancy in aspects such as training experience, frequency of training, age of the subjects, and the moment of starting sports activities. In the latter aspect, it is important to answer whether athletic activity began before or after the completion of bone growth, which may also translate into the formation of asymmetries due to training overload. In addition, a significant number of subjects declared to practice sport other than the main disciplines considered in this study, which may distort the final picture of this research.

To further investigate the injury risk aspect, more research methods and follow-up study after several years would be needed to determine the progression of changes along with increased training experience.

The obtained results confirmed the author's assumption that it is necessary to carry out further research based on other research tools and the evaluation of parameters in the context of their influence on disorders in the athletes' musculoskeletal system. An extension of this research problem would be to select players representing symmetrical and asymmetrical disciplines other than tennis and running. The need for continued research in this area is therefore recognized.

Conclusions

Practicing asymmetrical sports such as tennis may increase the risk of asymmetry in basic movement patterns and, consequently, the occurrence of compensation during the performance of more complex functional patterns to a greater extent than practicing long-distance running, which is a symmetrical sport. However, the results suggest that amateur long-distance runners have a higher fitness level in basic functional patterns than tennis players. Nevertheless, practicing asymmetrical sports at the amateur level does not increase the incidence of injury more than in the case of symmetrical sports.

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