

Functional fitness as criterion for predicting the risk of injury in young men practicing boxing

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Abstract:

Background and Study Aim: The prevention of bodily injuries in sports consists, among others, in using various preventive measures. However, the use of appropriate preventive measures would not be possible without a proper recognition of an athlete's condition. Therefore, the cognitive aim of this study was knowledge about the functional limitations of the musculoskeletal system in male boxers.

Materials and Methods: The study included 122 men, divided into two group (sport vs. non-active). In the sports group there were 55 boxers training in five sports clubs in Warsaw, Poland. The control, non-active, group consisted of 67 male students. For comparative purposes, the athletes were divided into two groups: competitive athletes with more than 4 years of boxing training experience, participating in competitions and holding a competitive license issued by the Polish Boxing Association, and non-competitive athletes – men training boxing from 1 to 4 years, not participating in sports competition. The main research tool was the Functional Movement Screen test, consisting of seven movement activities, while taking into account the previously experienced injuries.

Results: There were no significant differences between sports and non-sports group in potential risk of injuries. Most of athletes in competitive group (73%) obtained a moderate total FMS score. One participant achieved a high score, indicating a low risk of injury, while four participants obtained a low score, indicating a high susceptibility to injury. In non-competitive group, nine participants (28%) achieved a moderate score, whereas 23 (72%) obtained a low score. The differences between groups were statistically significant.

Conclusions: There is a relationship between the level of functional fitness and the occurrence of injuries in boxers. Therefore, the FMS result may be useful from the point of view of preventing bodily injury.

Keywords: combat sports, Olympic boxing, injury prevention, functional assessment

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Dictionary:

Combat sports – group of sports when the competition involves in hand-to-hand struggle of two athletes [33].

Non-apparatus test – that motoric test (exercise endurance test) of the required reliability (accurate and reliable), which use does not require even the simplest instruments [34].

Functional Movement System – the philosophy was introduced in 1995 (by Grey Cook and Lee Burton), at a time when there was no systematic tool to identify movement asymmetries or major limitations in functional movement patterns. The aim of the Functional Movement System is to help people move better and then increase their physical fitness, and decrease number of injuries [16, 17].

Functional Movement Screen (FMS) – is an evaluation tool that helps to assess the fundamental movement patterns of an individual. A screening tool such as this offers a different approach to injury prevention and performance predictability [16, 17].

1. Introduction

Boxing is a high-intensity sport characterized by complex biomechanics involving multiple movement patterns, making it one of the most demanding sports in terms of coordination and physical fitness. Each sport has its own specific movement and physical effort profile. However, regardless of the type of combat sport, the nature of physical effort remains similar [1-4]. In combat sports, physical effort is predominantly intermittent and based largely on anaerobic energy systems. A boxer who can repeatedly execute punches and maintain proper body positioning with optimal frequency and speed is more likely to achieve success. According to Miarka et al. [5], the ratio of high- to low-intensity activity ranges from 1:2 to 1:4 (in judo). A similar study reported similar proportions of 1:3 to 1:4. In championship bouts lasting up to 12 minutes, physical effort is primarily based on anaerobic energy expenditure. In boxing, similar proportions are observed. However, boxing is divided into weight categories; therefore, athletes in lower weight classes are typically able to sustain high-intensity effort for longer periods [5, 2].

A boxer's movement is based on complex, multi-joint actions that require full-body involvement. In boxing, technique is fundamental and must be integrated with adequate coordination and strength. A boxer's starting position requires a wide stance of the lower limbs, with the knees slightly flexed and one leg extended forward. Proper footwork enables the athlete to perform defensive movements, quickly change position, and generate directed punching force. When delivering a punch, not only are the upper limbs involved, but the movement must also be properly coordinated with hip rotation and leg positioning. The upper limbs constantly maintain the guard, both to protect against attack and to allow punches to be thrown. Proper head positioning helps maintain balance through the action of the neck muscles and also reduces the risk of injury. Breathing during punching plays an important role, as it helps regulate heart rate and supports concentration. The coordination of all these components and the integration of the individual elements allow the athlete to attack and defend effectively. An appropriate combination of movements makes it possible to achieve the intended goals [6, 1, 7].

Due to its specific nature, boxing is associated with several risks. Direct physical contact with an opponent, repetitive and frequent punches directed mainly at the head and torso, as well as the force of the punches received, carry a high risk of injury; therefore, boxing is considered one of the most injury-prone sports. According to the available literature, a substantial number of injuries in boxing are classified as mild and moderate, as well as those requiring immediate medical attention [8-10].

The most vulnerable body regions include the head, chest, upper limbs, and torso. Blows to the head may significantly affect brain function, which in turn may lead to various traumatic brain injuries, the formation of hematomas, or a concussion. A common condition observed among professional boxers is chronic traumatic encephalopathy, known as boxer's dementia. Based on the study by Kočański et al. [11] and the available literature [12, 13], the condition affects more than 20% of professional boxers. It is worth noting that this dementia progresses with a delay, and symptoms may become apparent even after 12 years of training.

The main causes and factors increasing the risk of injury include improper technique, excessive training intensity combined with insufficient recovery, poorly selected equipment, and human-related factors such as the athlete's health status, referee decisions, or the opponent's behaviour. An important factor influencing the likelihood of injury in an athlete is the level of their physical and functional fitness. In boxing, due to the predominance of unilateral body work, a number of asymmetries occur,

which significantly affect the likelihood of injury. Boxing is a sport that requires a high level of mobility, stability, coordination, and strength; therefore, any deficits in these components may increase the risk of injury. It is also worth noting that previous injuries and bodily damage constitute an additional factor increasing the probability of injury occurrence [11, 10, 14].

Considering the above risks, it is important not only to ensure appropriate physical preparation but also to regularly monitor physical fitness and the functional status of the musculoskeletal system in boxers. This approach helps minimize the risk of injury and protects athletes' health in the long term [15].

To identify potential movement deficits that may increase injury risk, functional tests such as the Thomas test, Thomayer test, Dega test, Y-Balance Test, and the Functional Movement Screen (FMS) can be used. According to their underlying assumptions, improper movement habits may constitute a primary factor in the occurrence of injuries in athletes. Repetition of such faulty patterns may lead to reduced mobility and impaired neuromuscular control, which in turn results in the distortion of fundamental movement patterns. According to the available literature and scientific research, this may lead to an increased risk of injury in athletes. Any movement deficits, such as limited mobility, impaired body stability, or poor motor coordination, pose a threat not only during training but also during a boxing match. A low level of motor coordination slows down reactions to an opponent's actions, thereby increasing the risk of head injury [16-21].

Therefore, the cognitive aim of this study was knowledge about the functional limitations of the musculoskeletal system in male boxers.

The decomposition of the goal into research tasks included three questions:

Were there a correlation between the declared number and location of injuries, and functional fitness among boxers with different sports level and training experience?

What were the most common locations of body injuries?

What were the differences in functional fitness in boxer with different ports level and training experience?

2. Material and Methods

Participants

The study included 122 men, divided into two group (boxers vs. non-active). In the sports group, there were 55 boxers training in five sports clubs in Warsaw, Poland. The control, non-active, group consisted of 67 male students who, apart from obligatory classes at the university, did not participate in any regular, organized physical activity (Table 1).

Table 1. Characteristic of examined participants, boxers vs. non-active

Groups	Age [years]	Body mass [kg]	Body height [cm]	Training experience [years]
Boxers (n = 55)	25.25 ±6.13	76.62 ±15.91	178.79 ±5.10	4.97 ±2.73
Non-active (n = 67)	22.76 ±2.46	76.96 ±8.20	181.57 ±5.54	–

For comparative purposes, the athletes were divided into two groups: competitive athletes with more than 4 years of Olympic boxing training experience, participating in competitions and holding a competitive license issued by the Polish Boxing Association. The group of competitive athletes consisted of medallists of Polish Championships, Polish Cups and international tournaments. The second group (non-competitive athletes) consisted of men training boxing from 1 to 4 years, not participating in sports competition or participating only occasionally (Table 2).

Table 2. Characteristic of examined participants

Group	Age [years]	Body mass [kg]	Body height [cm]	Training experience [years]
Competitive athletes (n = 23)	24.43 ±5.49	77.43 ±18.67	179.82 ±6.78	6.87 ±2.47
Non-competitive athletes (n = 32)	25.83 ±7.05	76.03 ±13.87	178.27 ±5.98	2.51 ±1.25

The inclusion criteria were: age between 18 and 40 years (in accordance with the senior category in boxing), regular boxing training (at least three times per week), absence of serious chronic diseases or congenital conditions affecting physical performance, and informed consent to participate in the study.

The study was conducted during the preparatory period. None of the boxers was undergoing pre-competition weight reduction. Athletes currently undergoing injury treatment or in a period of rehabilitation were excluded.

Research procedure

The Functional Movement Screen (FMS) and an original questionnaire were applied.

Functional assessment was performed using the Functional Movement Screen (FMS). The study was conducted using the standard FMS equipment and protocol. It consists of seven movement tests that require an appropriate combination of mobility, stability, and coordination. The FMS is applicable across various sports as well as in everyday physical activities. Developed by Gray Cook and Lee Burton [16, 17] in 1995 enables the assessment of injury risk through the analysis of the quality of fundamental movement patterns.

In the presence of compensatory movements, including asymmetries, lower scores are obtained, which may indicate an increased risk of injury. The FMS consists of seven scored movement tasks and three clearing tests, which exclude individuals experiencing pain during their performance. Each of the main tasks are assessed on a scale of 0 to 3 points, with a maximum total score of 21 points. If pain occurs during the performance of a movement task, a score of 0 is assigned [22].

Conventionally, a total score of 19–21 indicates a high level of functional fitness and a low risk of injury, a score of 14–18 indicates a moderate risk of injury, while a score below 14 points indicates a high risk of injury [16,17].

The Functional Movement Screen tasks

1. Deep squat: assesses range of motion and motor control in the shoulder and hip girdles, as well as in the knee and ankle joints. The participant stands with feet shoulder-width apart. The upper limbs are flexed at the shoulder joints and extended at the elbow joints while attempting to hold a dowel overhead. Proper performance requires keeping the heels on the ground, maintaining the dowel

overhead, and keeping the chest and cervical spine aligned with the head in a neutral position.

2. Hurdle step: assesses the range of motion and stability of the lower limb. The participant stands with feet hip-width apart. The height of the hurdle is set at the level of the knee joint line. The participant holds a dowel on the shoulders. The feet are positioned under the hurdle. The participant steps over the hurdle with one leg, touching the ground with the heel. The supporting limb should remain extended at the hip joint. The participant then returns to the starting position in the same manner.
3. In-line lunge: assesses range of motion in the lower limb and balance. The participant places the heel at the end of the board. The length of the tibia is measured from the toes, and a marker is placed on the board at that distance. A dowel is held behind the back, touching the sacrum and thoracic spine, and is maintained by the hand opposite to the front foot.
4. Active straight leg raise: assesses mobility and motor control of the lower limb. The participant lies supine with a measuring board placed under the knees. A dowel is positioned vertically at the midpoint between the anterior superior iliac spine and the centre of the patella. The participant raises one leg while keeping it extended at both the hip and knee joints.
5. Shoulder mobility: assesses the mobility of the shoulder girdle. The length of the hand is measured from the wrist joint to the tip of the middle finger. The participant makes fists and attempts to bring the hands together behind the back, combining internal rotation of one shoulder with abduction and external rotation of the other.
6. Trunk stability push-up: assesses trunk stability and upper limb strength. The starting position is prone, with hands placed shoulder-width apart and the lower limbs extended at the knees. The entire body should be lifted as one unit.
7. Rotary stability: assesses trunk stability in a quadruped position. A measuring board is placed between the knees and hands. The participant simultaneously flexes one upper limb at the shoulder and extends the opposite lower limb at the hip, raising both segments parallel to the ground, and then brings the elbow and knee toward each other [16, 17].

There were also three elimination tests: Impingement, Press-up, and Posterior Rocking clearing tests. The occurrence of pain during the test resulted in a score of 0 points (accordingly for Shoulder Mobility, Trunk Stability, Push-up, and Rotary Stability).

The FMS test is carried out without a warm-up by certified sports diagnostics specialist (with 15 years of experience in FMS testing). The assessment is done in two planes: sagittal and frontal. If there are doubts about the accuracy of the pattern, the participant receives a lower score. The five exercises are bilateral, with each side assessed separately – the dominant side was tested first. The tests were conducted by athletes after the competition period, before the preparation period, while they were not body weight reduction period.

Additionally, all participants completed an original questionnaire consisting of 12 items. The questionnaire included anthropometric data, training experience, history of injuries, the presence of pain, and the consequences of injuries. Participants were

required to specify the type and location of injuries as well as the duration of recovery. The competitors received the definition of an injury as a health indisposition of the musculoskeletal system lasting longer than 10 days (absence from regular training).

Ethics

The research related to human use has complied with all the relevant national regulations and institutional policies, and has followed the tenets of the Declaration of Helsinki. The study was approved by the Research Ethics Committee of the Józef Pilsudski University of Physical Education in Warsaw (No. SKE 01-38/2023).

Statistical analysis

After analysing the data, they were exported to Statistica 12 software (TIBCO software, Santa Clara, CA, United States). Due to the lack of normal distribution of the data, as verified by the Shapiro–Wilk test, further analyses of differences between groups were conducted using the Mann–Whitney U test. In the case of variables on the ordinal and nominal scales, we are only able to determine the Cohen’s [d] strength of the relationship (effect) and the statistical significance [p] of the relationship in the study. Spearman’s [r] correlation was used as a measure of the explained variability. A scale was adopted for the directly proportional strength of the effect d, values of 0.2, 0.5 and 0.8 indicate a small, medium and large effect. The minimal level of statistical significance was set at $p \leq 0.05$.

3. Results

Functional Movement Screen

There were no significant differences between sports and non-sports group in potential risk of injuries (Table 3). Most of athletes in competitive group (73%) obtained a moderate total FMS score. One participant achieved a high score, indicating a low risk of injury, while four participants obtained a low score, indicating a high susceptibility to injury. In non-competitive group, nine participants (28%) achieved a moderate score, whereas 23 (72%) obtained a low score. The differences between groups were statistically significant (Table 4).

Table 3. Susceptibility to injury according to FMS, boxers vs. non-active

Group	Low risk of injury (19-21)	Average risk of injury (15-18)	High risk of injury (0-14)
Boxers (n = 55)	1	27	27
Non-active (n = 67)	3	34	30
Chi-square = 0.82 Difference p = 0.667			

Table 4. Susceptibility to injury according to FMS, competitive vs. non-competitive athletes

Group	Low risk of injury (19-21)	Average risk of injury (15-18)	High risk of injury (0-14)
Competitive athletes (n=23)	1	18	4
Non-competitive athletes (n=32)	0	9	23
Chi-square = 68.71 Difference p = 0.001			

There were no significant differences in overall results of FMS between athletes and non-athletes groups. The differences were observed in Deep Squat, Shoulder Mobility, Active Straight Leg Raise, Trunk Stability Push-up and Rotary Stability (Table 5).

Table 5. FMS results, boxers vs. non-active

Groups	Deep squat	Hurdle step	In-line lunge	Shoulder mobility	Active straight leg raise	Trunk stability push-up	Rotary stability	Sum
Boxers (n = 55)	2.16 ±0.54	2.13 ±0.47	1.95 ±0.59	1.67 ±0.77	2.09 ±0.73	2.85 ±0.41	1.96 ±0.27	14.76 ±2.22
Non-active (n = 67)	1.87 ±0.63	2.10 ±0.58	1.94 ±1.07	2.43 ±0.98	1.67 ±0.79	2.33 ±0.64	1.79 ±0.52	14.32 ±3.23
p - value	0.005	0.812	0.973	0.000	0.003	0.000	0.035	0.397
d - value	0.15	0.20	0.54	0.21	0.08	0.39	0.67	0.47

The mean total FMS score in professional sportsmen group (16.22) was significantly higher than in control group (13.44). Significant differences, favouring the competitive group, were observed in six out of seven movement tasks included in the FMS. The highest scores (in both groups) were recorded in Task 6: Trunk Stability Push-up, while the lowest scores were observed in Task 4: Shoulder Mobility (Table 6).

Table 6. FMS results, competitive vs. non-competitive athletes

Groups	Deep squat	Hurdle step	In-line lunge	Shoulder mobility	Active straight leg raise	Trunk stability push-up	Rotary stability	Sum
Competitive athletes (n=23)	2.52 ±0.51	2.35 ±0.49	2.17 ±0.49	1.87 ±0.63	2.30 ±0.63	3.00 ±0.00	2.04 ±0.21	16.22 ±1.54
Non-competitive athletes (n=32)	1.91 ±0.39	1.94 ±0.44	1.75 ±0.67	1.34 ±0.70	1.94 ±0.76	2.72 ±0.52	1.88 ±0.34	13.44 ±2.26
p - value	0.000	0.002	0.009	0.005	0.057	0.005	0.026	0.000
d - value	0.26	0.12	0.43	0.04	0.22	1.91	0.47	0.48

Injuries and correlations

A similar number of injuries (more than two cases per participant) was observed in both groups. However, when adjusted for training experience, injuries occurred significantly more frequently in non-competitive group. The most commonly injured body region was the upper limbs. Significantly more cases were also observed in the amateur group (Table 7).

Table 7. Characteristics of sports injuries

Group	Number of injuries	Number of injuries per year	Injuries of head / spine	Injuries of upper limb	Injuries of lower limb
Competitive athletes (n=23)	2.09 ±1.31	0.33 ±0.22	0.78 ±0.32	1.04 ±0.72	0.26 ±0.19
Non-competitive athletes (n=32)	2.63 ±1.41	1.25 ±0.98	0.72 ±0.43	1.63 ±0.91	0.28 ±0.16
p - value	0.152	0.000	0.706	0.027	0.870
d - value	0.22	1.30	0.38	0.11	0.07

Significant negative correlations were observed between the total FMS score and the occurrence of injuries (both per participant and relative to training experience). These relationships were stronger in the non-competitive group. Negative correlations between FMS scores and upper limb injuries were stronger in the competitive group (Table 8).

Table 8. Correlations between the results of FMS and characteristics of injuries

Group	Age	Training experience	Number of injuries	Number of injuries per year	Injuries of head / spine	Injuries of upper limb	Injuries of lower limb
Competitive athletes (n=23)	0.096	-0.255	-0.382	-0.194	-0.166	-0.442*	0.030
Non-competitive athletes (n=32)	0.143	0.651***	-0.322*	-0.703***	-0.001	-0.238	-0.341*
All athletes (n=55)	0.035	0.280*	-0.465***	-0.562***	-0.031	-0.518***	-0.008

*p<0.05; **p<0.001; ***p<0.001

The number of injuries was primarily negatively correlated with the results of the shoulder mobility test in both groups, and with the deep squat test in the non-competitive group (Table 9). When considering the annual number of injuries, significant negative correlations were found in the non-competitive group in six out of seven movement tasks (Table 10).

Table 9. Correlations between the results of FMS and number of injuries

Group	Deep squat	Hurdle step	In-line lunge	Shoulder mobility	Active straight leg raise	Trunk stability push-up	Rotary stability
Competitive athletes (n=23)	-0.006	-0.257	0.023	-0.560**	-0.187	–	-0.031
Non-competitive athletes (n=32)	-0.393*	0.012	-0.160	-0.519**	-0.106	-0.263	0.160
All athletes (n=55)	-0.270*	-0.150	-0.152	-0.548***	-0.167	-0.255	0.058

*p<0.05; **p<0.001; ***p<0.001

Table 10. Correlations between the results of FMS and number of injuries per year

Group	Deep squat	Hurdle step	In-line lunge	Shoulder mobility	Active straight leg raise	Trunk stability push-up	Rotary stability
Competitive athletes (n=23)	-0.563***	-0.424**	-0.526***	-0.498***	-0.435***	-0.471***	-0.179
Non-competitive athletes (n=32)	0.046	-0.255	-0.016	-0.335	0.031	–	0.149
All athletes (n=55)	-0.601***	-0.345*	-0.524**	-0.452**	-0.462**	-0.379*	-0.068

*p<0.05; **p<0.001; ***p<0.001

4. Discussion

The assessment of movement pattern quality using the Functional Movement Screen (FMS) constitutes an important element of functional diagnostics in many sports. It is a diagnostic tool used to identify limitations in mobility, asymmetries, and deficits in core stability, all of which may affect movement efficiency. FMS results are widely used to predict injury risk and to plan corrective interventions. The test has been

successfully applied both in injury prevention and in monitoring athletes' training progress. Early detection of functional deficits allows for the implementation of appropriate corrective strategies, which may consequently improve training safety and quality, as well as reduce the risk of injury [18, 22-24].

Proper execution of fundamental movement patterns not only enhances functional fitness but also significantly reduces the likelihood of injury. The use of the FMS test, even in younger populations, may allow for early detection of potential movement dysfunctions and body asymmetries. A timely response to the obtained results and targeted work on identified deficits may improve movement quality and help prevent postural problems or limitations in mobility. The primary purpose of the FMS is to estimate the level of injury risk in athletes. It may therefore serve as an important reference point for coaches in identifying movement dysfunctions in their athletes [24, 25].

Kiesel et al. [26] examined the relationship between FMS scores in professional football players and their likelihood of injury. Among 46 players, a substantial proportion obtained scores below 14 points in the preseason FMS test, and many of them sustained serious injuries during the competitive season. This suggests that the Functional Movement Screen may be useful in determining the likelihood of injury occurrence. A score below 14 points places individuals in a high-risk group, in which the likelihood of injury is approximately doubled. Similarly, in the study by Kocharński et al. [25], the examined group also achieved a mean FMS score below 14 points, which increased the probability of injury from 15% to 51%. Nearly half of the boxers assessed in the present study also obtained low FMS scores. This is particularly concerning given the nature of boxing as a contact and injury-prone sport [26, 27].

Some authors suggest that individual components of the FMS test may have greater predictive value than the total score. The results reported by Mokha et al. [28] indicate that qualitative analysis of individual movement patterns and the identification of asymmetries may be more useful than the overall composite FMS score. This suggests that, in injury prevention, particular attention should be paid to asymmetries and low scores in individual tasks requiring mobility and stability. Such an approach allows for more effective identification of athletes at risk of injury and enables more precise injury prediction.

Functional test results may also serve as an indicator of sport-specific fitness, particularly in combat sports, where training aims to optimize the development of motor abilities. A study conducted on judokas in 2026 demonstrated that athletes achieving higher sport performance also obtained better FMS scores. The authors emphasized the relationship between the quality of movement patterns, performance level, and injury risk. They also highlighted, that limitations in mobility and stability may negatively affect both technical performance and overall physical capacity in sport. These findings support the use of the FMS in other combat sports, such as boxing, as a tool for functional assessment and injury prevention [25].

Based on the present study, it was found that competitive boxers demonstrate a significantly higher level of functional fitness compared to non-competitive practitioners. The FMS test revealed statistically significant differences between the mean scores of the competitive and non-competitive groups ($p = 0.000$). Only four individuals in the competitive group scored below 14 points. Therefore, the majority were not classified as being at increased risk of injury. In contrast, the non-competitive group achieved a mean score of 13.44 points, with as many as 23 out of 32

participants scoring below 14 points. This result indicates a higher likelihood of injury occurrence in this group. However, it is also important to consider the individual components of the FMS. Statistically significant differences between the competitive and non-competitive groups were observed in most of the tasks performed. This indicates a markedly higher level of mobility in the hip, knee, and ankle joints, as well as better core stability, in the competitive group [29, 27, 30].

Competitive boxers achieved the highest scores in the trunk stability push-up test, with all participants scoring 3 points. This reflects a very high level of trunk stability, well-developed core musculature, and excellent body control. These attributes are crucial for delivering punches, executing defensive techniques, and maintaining trunk balance during boxing training.

The lowest scores were observed in the shoulder mobility test. This finding is somewhat surprising, as the mean score in this task was only 1.87 points. Similar results were reported among boxers examined by Kochański et al. in 2015 [27]. This may indicate overload in the shoulder girdle region, likely resulting from prolonged and repetitive use of the upper limbs. The posture adopted by boxers promotes anterior shoulder positioning, which may lead to shortening of the pectoral muscles. A lack of stretching of this muscle group may result in reduced shoulder girdle mobility and increase the risk of upper limb injuries. The level demonstrated by the competitive group may directly influence the range and force of punches, as well as their execution speed [27].

In the non-competitive group, the highest score was also recorded in the trunk stability push-up test. Although it was clearly lower than in competitive athletes, it can still be considered satisfactory. This result may indicate insufficient strength of the trunk muscles responsible for body stabilization, as well as a lack of strength and conditioning programs that contribute to the development of abilities essential for boxing.

Limitations of the study

Despite the results indicating the usefulness of the FMS in the functional assessment of boxers, several important limitations of the study should be emphasized. First, the sample size was relatively small (55 athletes, 67 non-athletes). The examined competitors trained in clubs in Warsaw (Poland), which limits the generalizability of the findings to the broader population of boxers. Second, the lack of a longitudinal analysis should be noted. The test was conducted only once, without subsequent verification of its relationship with injury occurrence. Furthermore, the study did not take into account the number of training sessions, the type of physical conditioning program applied, or potential asymmetries resulting from limb dominance, which is particularly relevant in boxing. Although the Functional Movement Screen is a widely used and easily accessible tool, it does not diagnose specific musculoskeletal dysfunctions but rather identifies general limitations in the movement system. The literature emphasizes that a single FMS score should not be considered an independent indicator of injury risk. Therefore, the interpretation of FMS results should be supported by additional functional and clinical assessment tools, including technical and motor performance indicators, to enable a more comprehensive analysis.

Directions for further research

It is therefore advisable to continue Functional Movement Screen testing in athletes especially in sport disciplines where there is a large number of injuries. It will enable

the coaches to prepare the training schemes to avoid injuries, which often bring the careers to a close. Low cost and the ability to assess the multiple dimensions of the movement, and not just particular fitness indicators may be considered advantages of the test.

Practical recommendations

The Functional Movement Screen constitutes a useful diagnostic component. It is worth applying it to assess fundamental movement patterns and potential asymmetries not only in athletes but also in individuals beginning any form of physical activity. It is a helpful tool that may assist coaches in identifying potential movement dysfunctions, estimating injury risk, and designing targeted training programs aimed at improving functional fitness [29-32]. However, it is not possible to rely primarily on this single test, as the assessment and the obtained results are subjective and not always fully accurate. This test is not capable of determining the level of physical fitness. It only contributes to the assessment of joint mobility, range of motion, and body stability, which have a significant impact on the development of selected motor abilities. The obtained results also do not demonstrate that a high level of functional fitness is capable of eliminating the risk of in-jury, particularly in combat sports, where the opponent and their behaviour also play an important role.

5. Conclusions

1. There were no significant differences between overall FMS results in boxers and non-active groups. However significant differences were observed in five tasks (Deep Squat, Shoulder Mobility, Active Straight Leg Raise, Trunk Stability Push-up and Rotary Stability). This may indicate a specific effect of boxing training.
2. There is a relationship between the level of functional fitness and the occurrence of injuries in boxers. Therefore, the FMS result may be useful from the point of view of preventing bodily injury.
3. The body regions most exposed to injury among boxers include the upper limbs as well as the head and spine, which is characteristic of the sport of boxing.
4. Professional boxers are characterized by a higher level of functional fitness and physical fitness based on the results obtained from the FMS test. Boxing training aims to achieve a high level of sports performance. However, a high level of functional fitness reflects the comprehensive nature of the training process.

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