SPECIAL FITNESS LEVEL OF COMBAT SPORTS ATHLETES: MIXED MARTIAL ARTS (MMA) AND THAI BOXING (MUAY THAI) IN THE ASPECT OF TRAINING EXPERIENCE

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Keywords: combat sports, somatic structure, special fitness, MMA, Thai boxing

Summary:

Introduction: The best test of the technical skills and special physical fitness of the combat sports athlete is his or her response to the specific effort that occurs in a sports fight during tournaments. The aim of the study was to assess the variation in the level of special fitness and technical skills of modern combat sports athletes from the Legion Team Tarnów sports club.

Material and Method: The research was conducted in a group of 30 athletes of two different fighting styles in terms of techniques and tactics: mixed martial arts (MMA, group 1, N=15) and Thai boxing (group 2, N=15). Measurements of basic somatic body build characteristics were performed. The fitness of the participants was measured using the special kickboxing fitness test (SKFT). The strength of the correlation between special fitness level and training experience was also evaluated.

Results: The analyses revealed that the body build of the athletes of different combat sports does not significantly differ between each other. The athletes of both groups (MMA and Thai boxing) presented similar levels of basic somatotype characteristics. The level of special fitness in the MMA and Thai boxing groups significantly differed between the athletes of these sports in terms of the second series of punches (p = 0.030) and the second series of kicks (p = 0.011). A higher level of these elements of special fitness was displayed by Thai boxing athletes. The MMA group showed a very high strength of correlation that was statistically significant between training experience and first series of punches, second series of punches, and final HR. Furthermore, the first series of kicks and the second series of kicks showed high and significant strength of correlation. In the Thai boxing group, statistically significant relationships were found, with very high strength of correlation, in the first series of punches, first series of kicks, second series of punches, second series of kicks, and HR measured after one minute.

Conclusions: The results allow for the initial diagnosis and interpretation of special fitness competencies along with the level of technical skills in the application of basic striking techniques in MMA and Thai boxing, which promotes optimization and enhances the quality of coaching control.
Introduction

As pointed out by Ambroży and Piwowarski, martial arts and combat sports such as karate, ju-jitsu, and kickboxing (all style karate) [1,2] allow practitioners to engage in competitive sports, and to effectively perform self-defense combat in the spirit of security culture [3]. In combat sports, achieving the set goals is closely related to the broadly understood control of the sports training process. Evaluation of training effects at individual stages requires regular supervision and coaching control, including control over special fitness parameters, taking into account the aspect of their possible correlation with the athlete’s training experience [4,5].

Following the general-to-specific path proven by scientific research, here we examine the praxeological, particular aspect of security culture. Piwowarski states that security culture is understood to mean the totality of established tangible and intangible human achievements, constituting at a given time and place a resource of military and non-military components of human resilience and defense capability, performing four functions: (1) identifying threats (active and potential), (2) maintaining a specific level of security, (3) regaining it when it decreases, and (4) increasing the level of security when the need to do so is anticipated. Security culture analysis is conducted in three dimensions: (1) mental and spiritual (individual dimension of social reality), (2) legal and organizational (group dimension of social reality), and (3) material dimension of reality [6].

In this research experiment and the issues it addresses, the first dimension of the phenomenon termed security culture is dominant. The personal aspect of security culture is related here to the special fitness of athletes undertaking the activity involving very difficult challenges, related to direct combat with a non-random opponent who is well-prepared for the fight.

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Special fitness of an athlete means a motor fitness related to motor skills of a sport, which in our case is the ability of a combat sports practitioner to function effectively in his or her sports environment [7,8]. The best test of technical skills and special physical fitness of combat sports athletes is their response to the specific effort that occurs in a fight during tournaments. Several measurement tools developed for Olympic sports have been used in the combat sports community to assess special fitness. Boxing uses the Pawluk test [11]. The analytical set of special physical fitness tests (SPFT) developed by Story [12] and other tests [13,14,15] is used in karate. In judo, the tests were developed by Sterkowicz [16] and other authors [17,18,19,20]. In the hybrid sports [21], which are cross-sectional with respect to the combat plane (a stand-up/ground fighting hybrid), such as sport ju-jitsu, a compilation of the above-mentioned special fitness tests is used [22,23,24].

The issue of special fitness seems to be particularly interesting in the area of less scientifically explored combat sports such as MMA and Thai boxing, which have seen dynamic growth in popularity on all continents.

Mixed martial arts (MMA) is a competitive mode that expresses one of the current trends in martial arts development. Speaking of their hybridity, one should be aware that it is a secondary phenomenon, being an attempt to return to the roots of combat sports, i.e. to the complementarity of a wide range of techniques used in the fight, which originally were used only for combats.

The competition takes place on three levels: stand-up, clinch and ground fighting. A characteristic phenomenon is the use of techniques derived from other combat sports (e.g. boxing, kickboxing, Thai boxing, wrestling, Brazilian jiu-jitsu) [25, 26].

Thai boxing (Muay Thai) is a ring combat sport characterized by stand-up fighting, the attack techniques being upper limb punches and lower limb kicks (boxing punches and kickboxing kicks). The techniques are supplemented by unconventional actions characteristic of the sport (elbow and knee strikes or fighting in a clinch, catching kicks with sweeps and takedowns) [27]. The fighting format is full-contact, where blows are dealt with full power [28]. Thai boxing is a compilation of fitness training, self-defense, and athletic competitions, and training is implemented using training resources and methods similar in its structure to those used in kickboxing [29].

However, it should be added that in terms of human needs viewed from the standpoint of security sciences, there are historically earlier and still applicable non-sports methods to improve movement technique and its effectiveness through the improvement of special physical fitness. This concerns defensive combat systems from which many combat sports and many other sports, from athletics to archery, horseback riding, and javelin throwing have evolved. The idea is to ensure the possibility of transfer of knowledge, skills, and experience from the domain of general sport to defensive fighting in order to include them in a certain part in combat training. In this case, however, it should be remembered that it is important to go beyond the limitations that are the essence of sporting rules, technique, and strategy, as this would distort the knowledge necessary to be applied about the conditions of conducting a fight against individuals who break the rules of law, being the basis of public safety and public order.

Little attention has been devoted in the literature to detailed analysis regarding the special fitness of athletes.
in sports such as MMA and Thai boxing. Few scientific publications have presented a wider range of variables describing this important aspect of the functional profile of athletes in these sports. This may be due to a deficit of expert research tools specifically designed for these sports. In this situation, it is necessary to agree with the necessity of the transfer of tests (trials) of special physical fitness between different sports with similar nature of training and sports competition. This is a natural process if a particular technique is used in both combat sports [30,31]. An example is the MMA group studied by a team of researchers from Warsaw [32], who were assessed using tests known from judo [16], or boxing [11]. Sterkowicz-Przybycienn, who studied ju-jitsu competitors with a high level of skills [22], evaluated their special physical fitness based on tests used in karate [12] and judo [16] as sports where techniques are components, by definition, of a hybrid repertoire of MMA techniques.

The aim of this study was to assess the level of special fitness of athletes in modern forms of combat sports, representing two different sports, in two aspects outlined below:

1) The aspect of technique and tactics used by the combat sports athlete;
2) the aspect of the relation to the training experience of the combat sport athlete

The present analysis will facilitate the determination of the detailed level of special fitness of athletes being practitioners of two selected combat sports, contributing to the improvement of the quality of coaching control over the training process, having an impact on the level of special fitness parameters, being an important factor of the effectiveness of the fight. By presenting specific aims of the study, the following research questions were addressed:

1. What is the level and intergroup and within-group variability, body composition, and special fitness of the observed athletes with respect to their affiliation with different combat sports clubs?
2. Is there any correlation between special fitness and training experience in the examined combat sports athletes, and if so, of what strength?

Material and Methods

Study participants

The material consisted of the results of the examinations of 30 athletes of two different combat sports in the KS LEGION TEAM TARNÓW sports club in Tarnów, Poland.

1) Group 1: mixed martial arts (MMA, N = 15; mean age: 22.86 years ±1.47),
2) Group 2: Thai boxing (N = 15; mean age: 24.24 years ±3.24)

The training experience of the tested athletes ranged from three to six years (MMA – average experience: 4.33 years ± 1.35; Thai boxing – average experience: 4.6 years ± 1.55)

Information on chronological age and training experience was obtained from a diagnostic survey, using the questionnaire technique. All respondents participated in national and local level competitions and achieved good sports results.

Research methods

To evaluate the basic somatic characteristics of the athletes, we used an A213 anthropometer for body height measurement and a certified TANITA TBF-538 electronic scales for body weight and body fat percentage measurements according to the anthropometric recommendations [33].

The special fitness of the participants was measured using the special kickboxing fitness test (SKFT) developed by Ambroży et al. [30]. It is a reliable, valid, and simple research tool and its implementation takes place at the level of a specific effort reflecting the structure of the fight and its energy demands [10].

Testing procedure

The examinations were conducted at the KS Legion Team Tarnów combat sports club in Tarnów, Poland, in June 2021. The measurements took place in the training room (where everyday sports training sessions are conducted for the groups studied) using specially prepared stations. Participants were carefully instructed how to perform all steps of the examination process.

Somatic measurements were taken in underwear alone. Body height was determined as a distance between vertex (v) and basis (B) points in an upright position and with upper limbs placed along the torso [34]. Body weight, along with the body fat percentage, was read from the display on the scales. BMI index was then calculated.

To evaluate special fitness levels and technical skills, all participants underwent the special kickboxing fitness test (SKFT) [30].

Description of the procedure for special kickboxing physical fitness test:

Prior to performing the test, participants performed a warm-up that included 5 minutes of an easy run and 10 minutes of general warm-up and stretching (flexibility) exercises. The following tools were prepared to perform the test: adhesive tape to mark distances on the mat, a stopwatch to measure time, kick shields and punch shields, a protocol for recording the results, and a sport tester (heart rate monitor). In the first station, the athlete performs from a fighting stance a combination
of punches to the shield held by the partner: left and right straight punches to the head, without stopping, for 30 seconds. After completing this part of the test, the athlete runs in a straight line 10 meters to the next station (No. 2), where, from the fighting position, he or she performs for 30 seconds roundhouse kicks to the shield held by the partner: left high kick (high roundhouse kick) and right high kick to the head. Next, the athlete runs back to the first station with shields and performs the combination of left straight-right hook combination for another 30 seconds to the head. After completion of this part of the test, the athlete runs 10 meters to the partner holding the shield in station 2 and performs middle roundhouse kicks for 30 seconds alternately with the right and left leg to the body trunk. The total special work time of the test is 2 minutes (4x30 s). Correctly performed kicks and punches are counted in each of the four parts. Heart rate (HR, bpm) is measured directly after completion of the test and after 1-minute rest. The proposed special fitness test allows for the evaluation of the technical level of athletes in terms of the most effective and most frequently used hand techniques (punches) and leg techniques (kicks), speed (number of punches and kicks performed per time unit), special endurance (response of the circulatory system and number of punches and kicks), coordination (combination of kicks and punches), and flexibility (kicking range). The 10m running distance used to move between stations corresponds to the diagonal of the largest ring found in ring combat sports. The technical skills used further ensure the selectivity of the test, making it inaccessible to those who do not perform special training and do not have the appropriate level of technical proficiency. Figures 1 and 2 present a graphical visualization of the technical skills (combinations of punches and kicks) included in the kickboxing test and the location and order in which they are performed. Figure 3 illustrates the global diagram of individual test tasks and the direction of the athlete’s movements.

Furthermore, after the test, based on the results obtained, the index of special fitness was calculated using a specialized formula:

\[
\text{Index of Special Fitness} = \frac{\text{Final HR(bpm)} + \text{HR1 min. (bpm)}}{\text{Kicks} + \text{Punches (N)} (\text{suma})}
\]

Where:
- Final HR – heart rate recorded immediately after completion of the test
- HR1 min. – heart rate recorded 1 min after completion of the test
- Kicks – the number of kicks performed in the test
- Punches – the number of punches performed in the test

The special fitness index reflects the level of a fighter’s special fitness, which means the effective interaction of the body’s exercise capacity, general fitness, and the
Special fitness level of combat sports...

**Fig. 2.** Diagram of kicking combinations in the kickboxing test

*Source:* author’s own elaboration

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**Fig. 3.** Graphical diagram of the special kickboxing physical fitness test

*Source:* author’s own elaboration based on Ambroży et al. 2016
athlete’s technical skills. The interpretation of the score is inversely proportional: the higher the level of special fitness the lower the value of the kickboxing test index.

**Statistical analysis**

Statistical analysis of the collected material was conducted in Statsoft Statistica software (version 13.3). Basic descriptive statistics (arithmetic mean, median, standard deviation, minimum and maximum value, range of variation, and coefficient of variation) were calculated.

The analysis was carried out on logarithmic data, as a result of which the assumption of conformity with normal distribution was fulfilled and verified by the Shapiro-Wilk test. The differences occurring between groups were evaluated using the Student’s t-test for independent samples. Pearson correlation was used to determine the relationships between the measured parameters. The level of statistical significance was set at \( p < 0.05 \) \[35\].

**Results**

In terms of the assessment of basic somatic body characteristics (Table 1), it was found that the athletes of both clubs did not differ significantly and presented a similar body build. The athletes from the MMA club presented non-significantly higher body height and body weight. Thai boxers were characterized by slightly higher values in terms of body fat percentage and BMI indices.

The results obtained for the coefficient of variation indicate that the within-group variability in the characteristics studied was relatively low in both groups of players. The exceptions were body weight and BMI in the MMA group (above 10%) and a variable describing body fat percentage in both study groups.

Table 2 and Figures 4 and 5 present the statistical characterization of individual parameters diagnosing the dynamics of the development of sport-specific special fitness (special kickboxing fitness test - SKFT). Based on the analysis of the mean values, it can be noticed that the groups of athletes studied were least differentiated by the first series of punches (punches), the first series of kicks, the final HR and HR measured one minute after the end of the special kickboxing fitness test. Higher values of these variables were observed in the Thai boxing group. However, it should be noted that these differences were not statistically significant. The greatest differences in mean values were observed for the second series of punches and the second series of kicks in favor of Thai boxers. The groups of combat sports athletes differed in this respect, as evidenced by the statistical significance of the differences.

The representatives of Thai boxing obtained more favorable results compared to the calculated special kickboxing fitness index and thus showing a higher level of special fitness than MMA athletes (Tab. 2, Fig. 6).

The values of the coefficient of variation illustrate that the MMA group was highly heterogeneous for the 1st series of punches (V%=20.77), 1st series of kicks (V%=19.28), 2nd series of punches (V%=16.23), and 2nd series of kicks (V%=17.87). In the Thai boxing group, a similar trend was observed only for the 1st series of punches (V%=21.98) and the 1st series of kicks (V%=15.9). The least dispersion of results (less than 5%) in the MMA group was found for final HR (V%=3.72) and HR measured one minute after the completion of the test (V%=4.22). The Thai boxing group was characterized by higher homogeneity. A low level of within-group variability was observed for heart rate

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Group</th>
<th>( \bar{x} )</th>
<th>Me</th>
<th>sd</th>
<th>min</th>
<th>max</th>
<th>R</th>
<th>V</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>body height [cm]</td>
<td>MMA</td>
<td>175.83</td>
<td>174.8</td>
<td>6.59</td>
<td>161.6</td>
<td>188.3</td>
<td>26.7</td>
<td>3.75</td>
<td>0.674</td>
</tr>
<tr>
<td></td>
<td>Thai boxing</td>
<td>174.91</td>
<td>175</td>
<td>5.19</td>
<td>164.5</td>
<td>183.7</td>
<td>19.2</td>
<td>2.97</td>
<td></td>
</tr>
<tr>
<td>body mass [kg]</td>
<td>MMA</td>
<td>77.8</td>
<td>76.3</td>
<td>11.26</td>
<td>60.7</td>
<td>95.5</td>
<td>34.8</td>
<td>14.47</td>
<td>0.945</td>
</tr>
<tr>
<td></td>
<td>Thai boxing</td>
<td>77.56</td>
<td>78.7</td>
<td>7.3</td>
<td>61.2</td>
<td>89.7</td>
<td>28.5</td>
<td>9.41</td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>MMA</td>
<td>25.1</td>
<td>24.28</td>
<td>2.87</td>
<td>20.29</td>
<td>31.99</td>
<td>11.7</td>
<td>11.42</td>
<td>0.496</td>
</tr>
<tr>
<td></td>
<td>Thai boxing</td>
<td>25.36</td>
<td>25.99</td>
<td>2.27</td>
<td>20.98</td>
<td>27.7</td>
<td>6.73</td>
<td>8.93</td>
<td></td>
</tr>
<tr>
<td>fat percentage [%]</td>
<td>MMA</td>
<td>19.73</td>
<td>20.3</td>
<td>5.15</td>
<td>12</td>
<td>32.5</td>
<td>20.5</td>
<td>26.08</td>
<td>0.852</td>
</tr>
<tr>
<td></td>
<td>Thai boxing</td>
<td>20.05</td>
<td>20.5</td>
<td>3.92</td>
<td>12.8</td>
<td>25.2</td>
<td>12.4</td>
<td>19.53</td>
<td></td>
</tr>
</tbody>
</table>

\( \bar{x} \) - arithmetic mean, Me - median, sd - standard deviation, min- minimum value, max- maximum value, R- range, V- variance
Table 2. Descriptive results of special kickboxing fitness test (X ±SD) in the study groups

<table>
<thead>
<tr>
<th>Parameter</th>
<th>MMA</th>
<th>Thai boxing</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st series of punches</td>
<td>97.73 ± 20.3</td>
<td>105.53 ± 23.19</td>
<td>0.335</td>
</tr>
<tr>
<td>1st series of kicks</td>
<td>27.8 ± 5.36</td>
<td>29.73 ± 4.73</td>
<td>0.304</td>
</tr>
<tr>
<td>2nd series of punches</td>
<td>69.2 ± 11.23</td>
<td>78.47 ± 6.05</td>
<td>0.030</td>
</tr>
<tr>
<td>2nd series of kicks</td>
<td>34.07 ± 6.09</td>
<td>40.53 ± 2.64</td>
<td>0.011</td>
</tr>
<tr>
<td>Total of Punches or Kicks</td>
<td>228.8</td>
<td>254.26</td>
<td></td>
</tr>
<tr>
<td>Final HR</td>
<td>188.6 ± 7.01</td>
<td>183.33 ± 6.84</td>
<td>0.060</td>
</tr>
<tr>
<td>HR after one minute</td>
<td>148.67 ± 6.28</td>
<td>146.27 ± 6.52</td>
<td>0.433</td>
</tr>
<tr>
<td>Total HR</td>
<td>337.27</td>
<td>329.6</td>
<td></td>
</tr>
<tr>
<td>Index</td>
<td>1.47</td>
<td>1.30</td>
<td>0.024</td>
</tr>
</tbody>
</table>

Fig. 4. Comparison of indices of technical combinations of punches and kicks in combat sports athletes studied

Source: author’s own elaboration

measurement components (final HR: V%=3.73; HR after 1 min: V%=4.46), 2nd series of punches (V%=7.7), and 2nd series of kicks (V%=6.52). Furthermore, a statistically significant difference in Index was also shown (Tab. 2, Fig. 4, Fig. 5).

Table 3 presents the characteristics of the relationship between the variables of special fitness (individual SKFT tasks) and training experience of the combat sports athletes studied, in the form of Pearson correlation coefficient results. There was a statistically significant relationship with a very high correlation strength, between the 1st series of punches and training experience in both groups of athletes. A statistically significant correlation was found for the 1st series of kicks in the MMA group, with high strength of correlation with training experience, and in the Thai boxing group with very high strength of correlation with training experience. Statistically distinct relationships in both groups were noted sequentially in the 2nd series of punches, with a very high correlation. In the 2nd series of kicks, a statistically significant relationship with the training experience became apparent again in both groups studied, with high values of the
correlation coefficients. The strength of correlation between variables was high for the MMA group and very high for the Thai boxing group. The results of the correlation coefficients between training experience and cardiovascular fitness indicate a varied correlation between the variables in the study groups. Very high (statistically significant) strength of correlations was found in the MMA group for final HR. The Thai boxing group showed a very high (statistically significant) negative correlation between training experience and HR measured 1 minute after the completion of the test (SKFT).

Discussion

The main aim of this study was to evaluate the level of special fitness in athletes of modern forms of combat sports (MMA, Thai boxing) and its relationships with training experience.

Somatic characterization reveals that the observed groups had a similar level of basic characteristics of the somatic build. The observed lack of significant intergroup differences in the level of analyzed variables is probably due to similar recruitment and selection carried
out in both forms of sports, where athletes with such somatic parameters are preferred.

In our research on special fitness, a discrepancy was noted between the diagnosed groups of combat sports athletes. Clear contrast between the MMA and Thai boxing groups studied was found for the 2nd series of punches and 2nd series of kicks, with a higher level of effect presented by the Thai boxers. These differences were statistically significant, which may suggest that sport specialization appears to determine significant disparities in the level of performance of individual test tasks (total number of correctly executed techniques per unit time).

This also reveals the significantly higher ability of the Thai boxing group in terms of anaerobic metabolic efficiency relative to the test tasks (SKFT). Similar to kickboxing, the specificity of Thai boxing training includes regular development of special movement skills in a standing position (stand-up fighting) which are based on a high level of general and special fitness. Boxing punches (straight, hook, undercut) and leg kicks (low, middle, and high) delivered in different planes are the basic and most popular techniques used in this sport. They are the basic technical foundation underlying the proper sports fighting [36].

The training of a combat sports athlete specializing in stand-up fighting is particularly directed at general fitness, especially speed, leg strength, and flexibility, and has a more beneficial effect on these elements than exercises in a group of fighters combining the stand-up and ground fighting in their technical and tactical actions [37]. Training objectives, the synergy of general fitness, special fitness, and motor skills may explain the superiority of Thai boxers over MMA practitioners in test tasks (SKFT).

The training process of MMA fighters is much more cross-sectional in terms of utilizing the possibilities of human movement, where the priority is the need to develop a comprehensive range of technical stand-up and ground fighting actions.

With the simplified approach, the following three spheres of activity need to be developed for effectively conducted training and sporting activities in this sport: 1) sphere of stand-up striking sports (upper and lower limb punches), 2) sphere of wrestling (clinch, takedowns), 3) BJJ (Brazilian jiu-jitsu) sphere (joint locks, chokes, guard sweeps, ground control).

Unlike a Thai boxer, an MMA practitioner ultimately focuses on the harmonious development of all three of the above-mentioned spheres. The higher level of effect of applying combinations of boxing techniques and kicks in Thai boxers compared to MMA fighters observed in our study indicates that Thai boxing is a sport with higher demands on striking techniques. The results of the test (SKFT) indicate that effective Thai boxing requires a high level of efficiency in the execution of these techniques for two minutes. In contrast, in MMA, a high level of striking techniques seems to be extremely important in the first part of the fight (SKFT). Based on empirical observation it was found that in MMA fights, after the intensive exchange of punches in the stand-up, one of the fighters (depending on fighting style preferences) often changes the plane of the fight (clinch fighting or transition to ground fighting) feeling less effective in punches [38].

It is worth noting an interesting phenomenon: in our study, the analysis of mean values of standard deviations and coefficients of variation in the groups studied revealed that the group of Thai boxers was characterized by greater intra-group homogeneity in terms of the results obtained. Again, the effect of targeted and specialized training of Thai boxers on the lower dispersion of intra-group results seems highly likely. MMA fighters often come from different combat sports (grappling sports or

Table 3. Correlation coefficient for special kickboxing fitness test results (SKFT) and training experience

<table>
<thead>
<tr>
<th>Special fitness parameter</th>
<th>MMA athletes (group 1)</th>
<th>Thai boxing athletes (group 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st series of punches</td>
<td>0.85</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>p&lt;0.01</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>1st series of kicks</td>
<td>0.64</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>p&lt;0.05</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>2nd series of punches</td>
<td>0.86</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>p&lt;0.01</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>2nd series of kicks</td>
<td>0.64</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>p&lt;0.05</td>
<td>p&lt;0.01</td>
</tr>
<tr>
<td>Final HR</td>
<td>0.73</td>
<td>-0.16</td>
</tr>
<tr>
<td></td>
<td>p&lt;0.01</td>
<td>p&gt;0.05</td>
</tr>
<tr>
<td>HR after one minute</td>
<td>-0.13</td>
<td>-0.87</td>
</tr>
<tr>
<td></td>
<td>p&gt;0.05</td>
<td>p&lt;0.01</td>
</tr>
</tbody>
</table>
stand-up/striking sports) and therefore are based on the source style (e.g. kickboxing, wrestling, BJJ), which they use more strongly in their sporting activities [32]. It also happens that they choose the priority (specialization) as one of the planes in which the sports competition takes place (stand-up or ground fighting). This is dictated by the preferences of conducting a sports fight.

Studies have found similar effectiveness (50%) between the use of grappling techniques (stand-up and ground fighting) and stand-up striking techniques [39]. These considerations seem to explain the degree of disparity in the competence to apply striking techniques and thus also the variation in performance in the intra-group context of the population studied.

In other test criteria (SKFT) such as the 1st series of punches, 1st series of kicks, final HR, and HR measured after one minute, there were no statistically significant differences between the groups studied. However, it should be noted that Thai boxers dominated in all these indices and had better results.

Evaluation of the level of special fitness, which is a hybrid of physiological properties, general fitness, and technical skills, in the form of calculated special kickboxing fitness indices, showed more favorable results in Thai boxers. This type of verification is performed in judo using throwing techniques. Using the calculated values of TSSR index, the special endurance profile of the practitioner of this sport was diagnosed [16].

The results indicate that the test represents a very high intensity exercise test in both study groups, as the heart rate immediately after exercise averaged 188.6 bpm for the MMA group and 183.33 bpm for the Thai boxing group. The results are consistent with literature data indicating that in trained athletes, two minutes of intensive exercise based on the performance of combat sports techniques leads to an increase in heart rate ranging from 165 to 185 bpm.

The lack of significant differences between the studied groups indicates similar competencies in the use of striking techniques in the first part of punches and kicks (SKFT), the response (adaptation) of the cardiovascular system to physical exercise, and the efficiency of post-exercise recovery.

There are studies in the literature containing reports on the level of special fitness examined based on the kickboxing test (SKFT) in athletes of various combat sports. To compare the results we used our research and the scientific output of other authors [10,30] who have explored the combat sports environment. Comparison of groups of athletes of combat sports from our study with the kickboxers studied by Ambroży et al. [30] reveals that the MMA fighters were characterized by higher scores in the 1st series of punches and a more favorable final HR. They had significantly lower values than the kickboxing group for the 1st series of kicks, 2nd series of punches, 2nd series of kicks, and total punches. In terms of HR measured after 1 minute and total HR, the groups were similar, with a slight advantage for kickboxing athletes. Compared to kickboxers, the Thai boxing group had more favorable results in the 1st and 2nd series of punches, total punches, final HR, total HR, and slightly more favorable in the 2nd series of kicks. They scored lower in the 1st series of kicks and had a less favorable HR measured after 1 minute than kickboxers.

Comparison of kickboxing, karate, and ju-jitsu athletes studied by Ambroży et al. [10] with the athletes participating in the present study indicates that the former were characterized by higher special fitness, performing better in most of the tasks of the kickboxer test (SKFT). The MMA group obtained more favorable values only for final HR compared to the kickboxing group and HR measured after 1 minute compared to ju-jitsu athletes. The Thai boxing group had a more effective 1st series of punches, more favorable final HR, HR measured after 1 minute, and total HR measurements compared to the ju-jitsu group. They outperformed the kickboxing group in terms of final HR and total HR.

The comparative analysis of the research results published by other authors and those obtained in our study indicates that the difference or its lack between the level of special fitness and special endurance between the athletes may result from environmental conditions such as a targeted sports training process characterized by different program contents due to the sport-specific technical and tactical requirements and similar energy demands. In the context of MMA fighters, the comparison confirms previous discussions regarding the advantage of stand-up combat sports fighters (kickboxing, karate, Thai boxing) in the use of striking techniques.

Analysis of the results of the research conducted by a team of scientists from Kraków and Rzeszów [10] reveals a certain analogy, namely, the fighters of stand-up combat sports outnumbered to a greater or lesser extent (for most of the test tasks) the ju-jitsu competitors who, similarly to MMA fighters, need to combine the stand-up and ground fighting in their technical and tactical actions. These differences also occurred in the Thai boxing group but to a lesser extent. Again, this can be explained by specific training closely related to the prevailing formula of sports competition. The nature of the process of developing and mastering the technical skills of a Thai boxer, in addition to boxing combinations and kicks, includes to a large extent a number of unconventional striking techniques such as clinch fighting, and knee or elbow strikes. These elements may have a significant effect on the performance during the kickboxing test compared to the athletes from the control group. Furthermore, the results of the cardiovascular response to
intense exercise (final HR, HR after 1 minute, and total HR) in the combat sports groups indicate a similar level of this parameter developed through sports training.

Based on the correlation coefficients of the parameters studied, the greatest correlation with training experience for the MMA group occurred for the 1st and 2nd series of punches and final HR (positive statistically significant correlations with very high strength of correlation).

In the Thai boxing group, the effect of training experience was strongest in the 1st and 2nd series of punches (positive correlations), 2nd series of kicks (positive correlation), and HR measured after one minute (negative correlation). The nature of statistical significance and a relationship with very high strength of correlation was demonstrated. The strength of correlation for HR measured after one minute shows a negative direction, indicating that longer training experience may determine more effective—post-exercise recovery. Furthermore, a highly significant positive correlation was found in the MMA group for the 1st and 2nd series of kicks, and in the Thai boxing group for the 1st series of kicks.

The direction and strength of the correlation coefficients showed that in both examined groups of players there was a significant correlation between special fitness and the training experience of the practitioners. This in turn suggests that the increase in the level of special fitness is directly proportional to the increase in training experience.

In conclusion, the results of the individual tasks of the special kickboxing fitness test (SKFT) showed significant differences in relation to the sport practiced in terms of special anaerobic capacity and the ability to perform technical actions per unit time (2nd series of punches and 2nd series of kicks) in favor of the Thai boxing group. In the remaining elements of the test (SKFT), the groups studied presented a similar level of development. There were statistically significant correlations between training experience and the scores of special fitness tests in the groups. Better results were observed in athletes with longer training experience.

In conclusion, it should be emphasized that the proposed test (SKFT) allows a reliable evaluation of the degree of preparation in terms of special fitness and technical competencies in the use of basic striking techniques without the need for using specialized apparatus. The upper and lower limb techniques used in the test are very important techniques of attack used during sports competitions in both sports.

It should be noted that the kickboxing test has some technical distinctiveness from the two sports analyzed in this study. In MMA fighters, the results illustrate the high skills in activities performed during stand-up fighting without the diagnosis of ground fighting. With respect to Thai boxing, some sport-specific techniques (elbow strikes, knee kicks, clinch fighting) are not performed in the test. This fact indicates a new horizon for insightful research concerning the MMA and Thai boxing populations. In our opinion, the scientific exploration of special fitness in these sports may be very valuable in future research, as evidenced by the conclusions and recommendations presented below. Therefore, the next aim should be to develop sport-specific special fitness tests for MMA and Thai boxing to allow for the development of application recommendations for training process optimization in these sports.

Conclusions and recommendations

The observations, measurements, and their analysis and evaluation conducted in this study lead to the following conclusions:

1. Body build of the athletes in the combat sports studied does not significantly differ between each other. The athletes of both groups (MMA and Thai boxing) presented similar levels of basic somatotype characteristics.

2. Special fitness of MMA and Thai boxing fighters shows significant differences between the sports for such parameters as anaerobic capacity and application of specific technical skills in the tasks of the kickboxing test, i.e. second series of punches and second series of kicks. Compared to MMA fighters, Thai boxers showed a significantly higher level of performance in terms of the technical aspects of the special fitness test.

3. Different specialization of athletes of different combat sports has a clear effect on the internal homogeneity in the level of development of special fitness in the members of their respective sports clubs. The Thai boxing club members showed less internal variation in special fitness for the second series of punches and second series of kicks than the MMA group.

4. Special fitness of MMA fighters examined using the kickboxing test expressed by such indices as the first series of punches, second series of punches, and final HR showed very strong and statistically significant correlation with training experience, while the first and second series of kicks showed strong and statistically significant correlation with training experience.

5. The special fitness of Thai boxing athletes examined using the kickboxing test expressed by such indices as the first series of punches, first series of kicks, second series of punches, second series of kicks, and HR measured after 1 minute showed a very strong and statistically significant correlation with training experience.
6. Practical implications for sport, with indices determined in our research, allowed for a preliminary diagnosis and interpretation of special fitness along with the level of technical skills by using basic striking techniques in MMA and Thai boxing, thus improving the quality of coaching control. Based on the results obtained by the best players it is possible to set directions of training for less successful athletes to improve individual elements of broadly understood special fitness.

7. Non-sports application of methods allowing to improve the level of manual technical skills and special physical fitness concern defensive combat and therefore it is recommended to adopt the knowledge, experience, and skills of combat sports coaches, so that in some part they can be included in combat training; in this case, the reservation is the need to go beyond the framework of purely sport rules, technique, and sport strategy, because it would distort the picture of circumstances that accompany the fight, for example, with people breaking the rules of law that provide the basis of security in the era of postmodern conflicts, the quantitative and qualitative emergence of new threats arising today in risk societies [41], which bring about increased uncertainty [42].

8. This implies the need to take into account the correlations between the level of manual skills and special physical fitness with the duration of training experience; this recommendation points out that it contradicts the custom of “fixing” this problem in uniformed services by merely completing a training course and generating appropriate documentation in this regard. It seems indisputable that the dignity of state institutions and security of citizens requires such preparation of each member of uniformed services that he or she can have a substantial advantage over an opponent who is often experienced in hand-to-hand combat (e.g. a criminal), to prevent the reverse situation at all costs.

References:

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