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Effect of post-activation potentiation on the force, power and rate of power and force development of the upper limbs in mixed martial arts (MMA) fighters, taking into account training experience

Alan Langer
Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland, langermma@gmail.com

Angelina Ignatieva
Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland

Patricia Fischerova
Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland

Magdalena Nitychoruk
Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland, magda.aneta.krawczyk@gmail.com

Artur Gołaś
Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland

See next page for additional authors

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Abstract

Introduction. The aim of the study is to determine the optimal load for generating the highest value of force, power and the rate of power and force development (RFD and RPD) in the upper limb of mixed martial arts (MMA) fighters with the use of activation and explosive exercises. The training period of MMA players was included in the research. Material and Methods: Twenty-nine MMA fighters participated in the study and were divided into two groups depending on the length of their training period (under and over 5 years). The subjects did 2 ballistic push-ups before the study and after-wards they performed 5 repetitions of press dumbbells while lying down with an increasing load: 50% 1RM, 65% 1RM and 80% 1RM. The rest was 4 minutes. All ballistic push-ups were performed on ForceDecks, and the data was analysed using the manufacturer's software. To compare differences between the groups, one-way ANOVA and post-hoc test were used. T-Student test was used to deter-mine the differences within the groups. Results: Amateurs obtained greater force and RPD results after the activation exercise performed at 50% 1RM, while power and RFD at 65% 1RM. For professionals, the highest force was achieved with a load of 80% 1RM, power at 50% 1RM, and RFD and RPD at 80% 1RM. Statistically significant differences between the groups were observed before and after each trial in force and RPD. The power did not statistically differ only after the load of 65% 1RM. In RFD, no statistically significant differences were found between the studied groups. Conclusions: Competitors with longer training experience should use a greater load in an activation exercise than competitors with shorter training experience.

Keywords

MMA, ballistic push-ups, Post Activation Potentiation, press dumbbells

Authors

Alan Langer, Angelina Ignatieva, Patricia Fischerova, Magdalena Nitychoruk, Artur Gołaś, and Adam Maszczyk

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Article

Effect of post-activation potentiation on the force, power and rate of power and force development of the upper limbs in mixed martial arts (MMA) fighters, taking into account training experience

Alan LANGER[1], Angelina IGNATIEVA[2], Patricia FISCHEROVA[3], Magdalena NITYCHORUK[4*], Artur GOŁAŚ[5], Adam MASZCZYK[6]

1 Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education, Katowice, Poland
2 Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland
3 Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland, ORCID 0000-0002-3998-2975
4 Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland, ORCID 0000-0002-1240-6919
5 Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland, ORCID 0000-0002-6656-6993
6 Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Education in Katowice, Poland, ORCID 0000-0001-9139-9747

* Correspondence: Magdalena Nitychoruk, Institute of Sport Sciences, The Jerzy Kukuczka Academy of Physical Eduction in Katowice, Mikolowska 72a, 40-065 Katowice, Poland, e-mail: magda.aneta.krawczyk@gmail.com

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Abstract: Introduction. The aim of the study is to determine the optimal load for generating the highest value of force, power and the rate of power and force development (RFD and RPD) in the upper limb of mixed martial arts (MMA) fighters with the use of activation and explosive exercises. The training period of MMA players was included in the research. Material and Methods: Twenty-nine MMA fighters participated in the study and were divided into two groups depending on the length of their training period (under and over 5 years). The subjects did 2 ballistic push-ups before the study and afterwards they performed 5 repetitions of press dumbbells while lying down with an increasing load: 50% 1RM, 65% 1RM and 80% 1RM. The rest was 4 minutes. All ballistic push-ups were performed on ForceDecks, and the data was analysed using the manufacturer's software. To compare differences between the groups, one-way ANOVA and post-hoc test were used. T-Student test was used to determine the differences within the groups. Results: Amateurs obtained greater force and RPD results after the activation exercise performed at 50% 1RM, while power and RFD at 65% 1RM. For professionals, the highest force was achieved with a load of 80% 1RM, power at 50% 1RM, and RFD and RPD at 80% 1RM. Statistically significant differences between the groups were observed before and after each trial in force and RPD. The power did not statistically differ only after the load of 65% 1RM. In RFD, no statistically significant differences were found between the studied groups. Conclusions: Competitors with longer training experience should use a greater load in an activation exercise than competitors with shorter training experience.

Keywords: MMA, ballistic push-ups, Post Activation Potentiation, press dumbbells.

1. Introduction

Mixed Martial Arts (MMA) is one of the most popular and fastest growing sports in the world [1]. Despite its popularity, the form of martial arts in the area of training is still little studied, namely in the optimization of sports training, taking into account different elements of the methodology of strength and muscle power training. Correct selection of external loads, rest breaks, the number of series and repetitions, exercises and the order of their implementation enables the coaches to effectively prepare an athlete to participate in the competition and achieve high sports results. The size of the force and power of skeletal muscles is of concern to coaches, athletes, and scientists in order to achieve training and research goals [2]. During an MMA fight, competitors must demonstrate both static and dynamic force, under no load (punch) and load (takedown) conditions [3]. Competitors must be prepared to perform movements repeatedly without excessive fatigue, such as knocking down the opponent, turning or fleeing a ground fight, defending submissions, and delivering punches with their hands and kicking legs. Training muscle strength and power is the foundation of motor preparation in MMA. Upper limb power output is a key aspect of athletic ability and performance [4]. Maximum pressing force (bench press) is also important for MMA fighters to increase their ability to push or hit opponents [5].

According to researchers, training programs aimed at improving muscle power in MMA should focus on explosive exercises [6]. Post-Activation Potentiation (PAP) improves the explosive capacity of energized muscles through prior maximal or submaximal contractile activity [7]. The possibility of using the post-activation enhancement effect (PAP) in muscle strength training is a modern tool to increase the potential of motor training. In practice, this effect is used in comprehensive training, which consists in combining a series of activation exercises, a few minutes' rest break, and performing a series of explosive exercises [8].

In the literature on the subject, in order to determine the optimal motor profile of an MMA fighter, the athlete's lower limbs have been most often studied [9–12]. However, no in-depth analysis of MMA fighters' upper limbs was performed, especially in the comprehensive training of the upper limbs.

The ballistic push-up (BPU) is a reliable measurement exercise for assessing the muscle power and force of the upper limbs [4, 13, 14]. The effectiveness of plyometric push-ups primarily depends on the rate of power development (RPD) and the rate of force development (RFD). Performing very fast movements (e.g. strikes) takes place in the range of 50–200 ms, so for an MMA fighter it is crucial to have a high rate of power development [15]. Pressing dumbbells lying on a flat bench (activation exercise) and plyometric pump (explosive exercise) are commonly used exercises in training strength and muscle power of the upper limbs [16–18]. The optimal rest break with external loads of 50% 1RM, 65% 1RM, 80% 1RM is 4 minutes [19–20].

The aim of the study is to determine the optimal load for generating the highest value of force, power and the rate of power and force development (RFD and RPD) in upper limbs of mixed martial arts (MMA) fighters with a use of activation and explosive exercises. The training period of MMA players was included in the research.

2. Materials and Methods

2.1. Participants

Twenty-nine (n = 29) MMA fighters participated in the study and were divided into two groups depending on the length of their training period. The first group consisted of amateurs with training experience of less than 5 years (n = 14), and the second group consisted of professionals with training experience of more than 5 years (n = 15). The athletes' classification was developed on the basis of the Ranking of Polish MMA Fighters.

Only right-handed players took part in the study. Competitors had not participated in muscle strength training 72 hours prior to the study. All were informed verbally and in writing about the objectives of the intended study and the manner in which it was conducted, as well as the possible health risks and benefits. Before starting the study, each participant voluntarily signed consent to participate in the experiment. People who did not agree to cooperate or had been ill during the last 7 days before the study were excluded. The study was approved by the Bioethical Commission at the Academy of Physical Education in Katowice, Poland. Measurements were made at the Laboratory of Muscle Strength and Power at the Academy of Physical Education in Katowice.

Table 1. Anthtopometric data of subjects (±SD).

Variables	Amateurs (n = 14)	Professionals (n = 15)	Summary (n = 29)
Age [yrs]	25.0 ±7.3	26.4 ±4.4	25.7 ±5.9
Training experience [yrs]	1.9 ±1,4	10.3 ±2.9	6.2 ±4.8
Height (cm)	177.8 ±8.3	179.2 ±5.4	178.5 ±6.9
Body mass (kg)	75.6 ±13.8	82.1 ±8.6	78.9 ±11.6
BMI (kg/m²)	23.7 ±2.9	25.5 ±1.9	24.6 ±2.6
Body fat (%)	13.9 ±10.6	10.0 ±4.2	11.9 ±8.1
Muscle mass (kg)	37.1 ±8.2	42.6 ±5.3	39.9 ±7.3
Fat mass (kg)	10.5 ±7.2	8.1 ±3.6	9.3 ±5.7

2.2. Study Protocol

The study was carried out in two sessions at the Muscle Strength and Power Laboratory at the Jerzy Kukuczka Academy of Physical Education in Katowice. One week before the main tests, the fasting mass was measured in the morning on the InBody 370 measuring device, operating on the basis of electrical impedance. The competitors were thoroughly acquainted with the information about the test and how to perform the exercises. A trainer of motor preparation presented a demonstration form. Each participant in the study had previously performed these two exercises regularly during their training. Before proceeding with the determination of the relative load for each competitor, a 20-minute warm-up was performed. The warm-up consisted of the following elements: riding a bicycle ergometer (10 minutes), performing three series of push-ups of 10 repetitions (5 minutes) and dynamic stretching exercises involving the upper and lower body (5 minutes). During the first session, the maximum weight (1 RM) of dumbbell press was determined for each competitor.

In the second (main) session, after the above-mentioned 20-minute warm-up, the subjects did 2 ballistic push-ups. Then, the subjects performed successive attempts to press dumbbells while lying down with increasing load: 5 repetitions with a load of 50% 1RM, 4-minute rest break (50% – 4), performing 2 ballistic push-ups; 5 repetitions at 65% 1RM, 4-min. rest break (65% – 4) – 2 ballistic push-ups; 5 repetitions at 80% 1RM, 4-min. rest break (80% – 4) – 2 ballistic push-ups. All ballistic push-ups were performed on ForceDecks which is dual-force platform sampling at 1000 Hz (Force Decks FD4000, London, UK). Data was analysed using the manufacturer's software (Force Decks Dual Force Platform Hardware and Software Solutions).

During the two sessions, the experiment director and his assistants (motor preparation trainers) watched the proper execution of the exercises (belayed) to ensure that the technique was as effective as possible.

Barbell press lying on a flat bench

The exercise was performed while lying on the back on a flat bench in a stable position, with the feet resting on the ground (starting position). The examined person held dumbbells over him in such a way that after lowering the barbell to the middle of the chest, the angle at the elbow joint was 90 degrees. The arms were shoulder-width apart, perpendicular to the floor. The wrists were turned so that the thumbs were pointing towards each other. The test subject then inhaled, starting to slowly lower the dumbbells to the centre of the chest. After holding the dumbbell for a fraction of a second, the examined person returned to the starting position, breathing out slowly at the end of the movement.

When the arms were extended with dumbbells (elbows should not be hyperextended), the participant's task was to tighten the pectoral muscle strongly and then to start lowering the arms again. When performing the exercise, it was especially taken into account that the bench press should follow the effect of the muscles (pectoral muscle). Additionally, the rate of lowering the dumbbells should be twice as slow as the rate of bench press.

Ballistic push-up

The starting position on the ground (as for a classic push-up) consisted of resting the hands with the fingers pointing forward at shoulder height. The body of the examined person in an upright position formed a straight line and rested on the toes. When starting to bend the elbows, the tested person lowered the chest until it was just above the ground. The participant then "exploded" with muscle power to push himself high up and lift his hands off the ground.

2.3. Statistical analysis

The obtained results were analysed statistically. In order to determine the differences between fighters depending on the training experience in terms of the generated force, power and rate of power and force development of the upper limbs, one-way ANOVA and post-hoc tests were used [21–23]. T-Student test was used to determine the differences within the groups. Statistical significance was set at $p < 0.05$. The calculations were made using the STATISTICA 10 statistical package by StatSoft.

3. Results

As can be observed from Table 1, professionals are characterized by smaller body fat, fat mass and bigger muscle mass than amateurs. Averaged values for the variables of interest and their percent change across external load progression are reported in Table 2 for the amateur group and in Table 3 for the professional group.

Table 2. Average measurements of force, power, RFD and RPD for amateurs group.

Amateurs								
	Force [N]	%difference to 0% 1RM	Power [W]	%difference to 0% 1RM	RFD [N/s]	%difference to 0% 1RM	RPD [W/s]	%difference to 0% 1RM
0% 1RM	556		479		6518		6726	
50% RM	606	8,24%	513	6,59%	7264	10,26%	8016	16,09%
65% RM	596	6,67%	549	12,68%	7923	17,73%	7807	13,84%
80% RM	578	3,74%	548	12,52%	7281	10,47%	7365	8,68%

Table 3. Average measurements of force, power, RFD and RPD for professionals group.

Professionals								
	Force [N]	%difference to 0% 1RM	Power [W]	%difference to 0% 1RM	RFD [N/s]	%difference to 0% 1RM	RPD [W/s]	%difference to 0% 1RM
0% 1RM	705		654		6962		9675	
50% RM	769	8,24%	729	10,34%	8204	15,14%	11675	17,14%
65% RM	773	8,69%	633	-3,34%	8040	13,41%	11637	16,86%
80% RM	799	11,76%	707	7,53%	8884	21,64%	12608	23,26%

Analysing the results obtained by amateurs, the greatest force and RPD were obtained at 50% of 1RM, while power and RFD were obtained at 65% of 1RM. The obtained differences were not statistically significant, but one should pay attention to the high values of the percentage difference in the results before and after activation exercises in power (12.68% after 65%RM and 12.52% after 80%RM), RFD (17.73 % after 65%RM) and RPD (16.09% after 50%RM and 13.84% after 65%RM).

The results in the professional group were also statistically insignificant; however, the greatest percentage change was observed for force at 80% 1RM (11.76%) and power at

50% 1RM (10.34%). The greatest changes occurred at the RFD, where the fighters achieved better results by 15.14% (50% 1RM), 13.41% (65% 1RM) and 21.64% (80% 1RM). In the case of RPD, the subjects from this group obtained better results by 17.14% (50% 1RM), 16.86% (65% 1RM) and 23.26% (80% 1RM).

Comparing the results obtained by amateurs and professionals, statistically significant differences were observed between the groups before and after each external load in force and RPD. The power did not differ statistically only after the activation exercise performed on an external load of 65% 1RM. In the case of RFD, no statistically significant differences were found between the studied groups. The obtained results are presented in Figures 1–4.

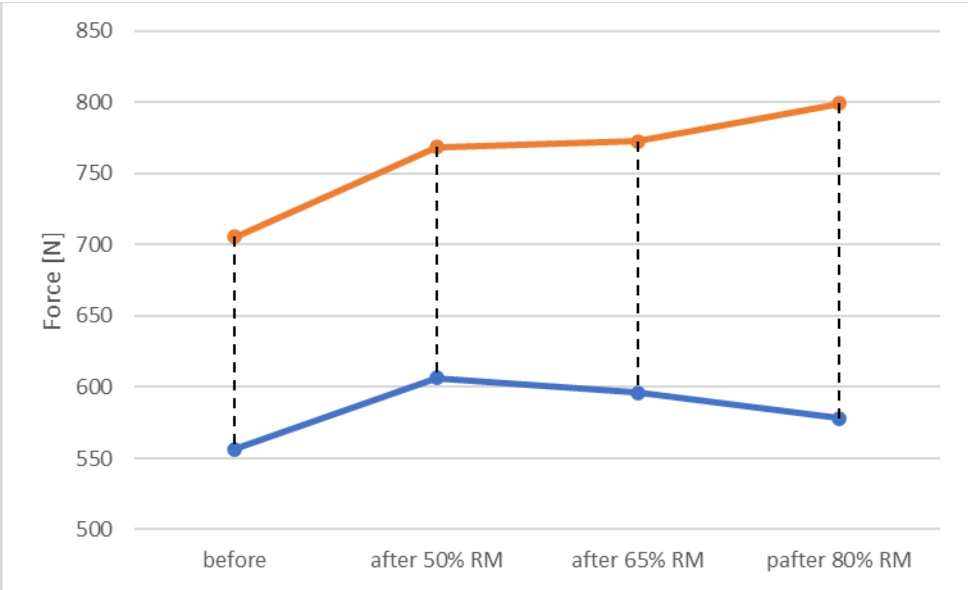

Fig. 1. Comparison of force results obtained by amateurs and professionals.

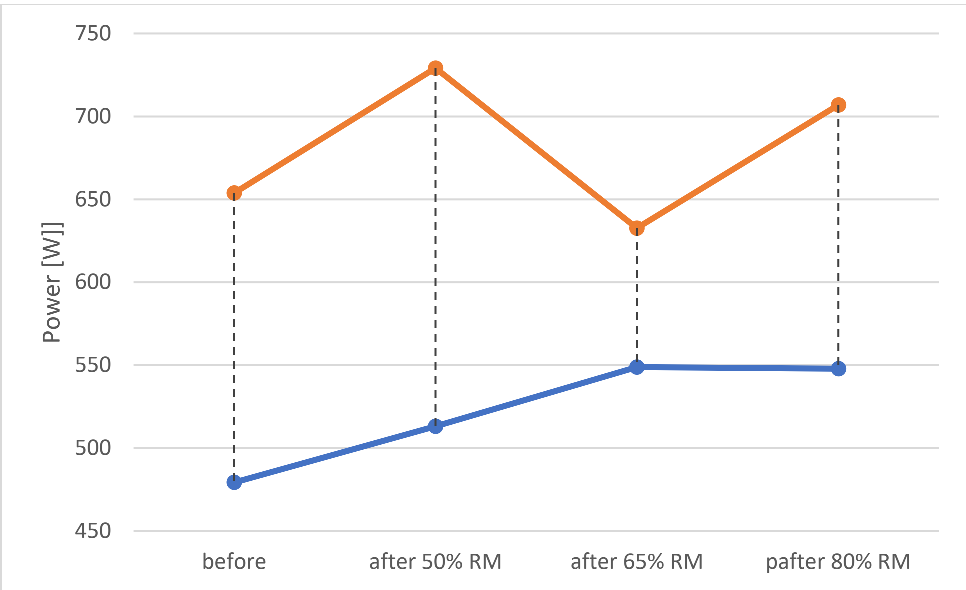

Fig. 2. Comparison of RFD results obtained by amateurs and professional.

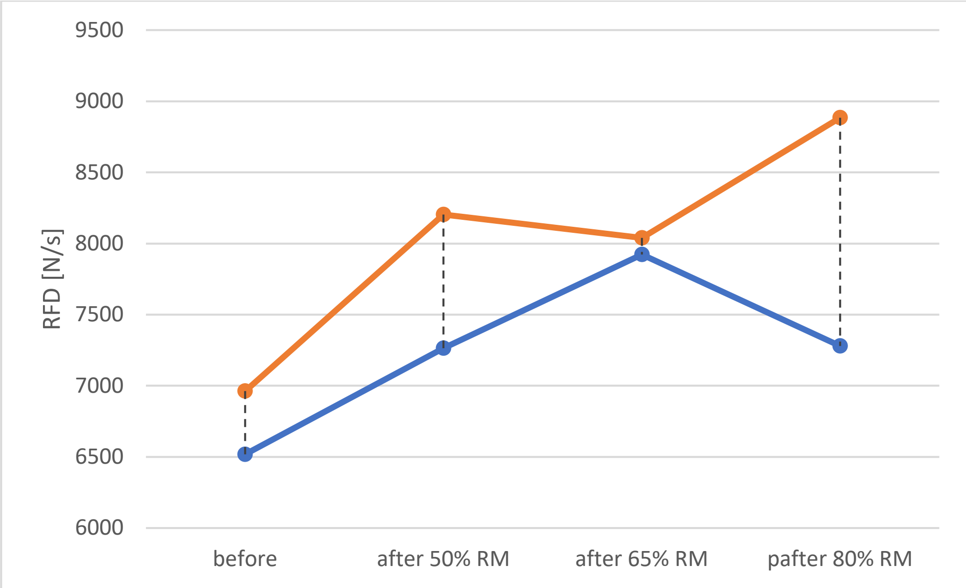

Fig. 3. Comparison of power results obtained by amateurs and professional.

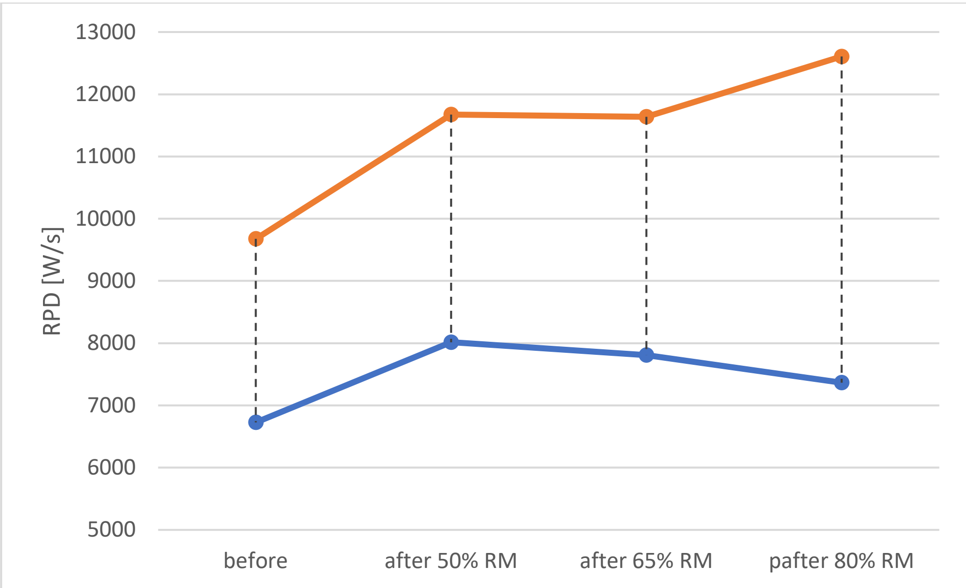

Fig. 4. Comparison of RPD results obtained by amateurs and professionals.

4. Discussion

The aim of the study was to determine the optimal load for generating the highest value of power, force, RPD and RFD in mixed martial arts (MMA) competitors, taking into account their training experience. In the study, external load progression (50% 1RM, 65% 1RM, 80% 1RM) was performed with a constant 4-minute rest break using an activation exercise (pressing dumbbells lying on a flat bench) and an explosive one (plyometric pump).

Most sports training consists of multi-joint exercises that involve more muscles (more than one joint) than isolated exercises [24]. It seems obvious to choose two multi-joint exercises in order to shape the players' strength and overall power. Pressing dumbbells lying on a flat bench and plyometric pump are exercises used in specialist training for athletes who practice sports that require rapid explosive movements to improve speed and strength parameters and increase the level of generated muscle power [25].

In the literature on the subject, the reliability of research tools for determining the optimal load in generating force and muscle power of the lower and upper limbs has been thoroughly analysed. To determine the optimal load in generating force and muscle power of the lower limbs by means of multi-joint exercises, the following tests were used: squat jump [26], squat jump and vertical jump [27], half squat [28], barbell squat using a Smith machine [29], using a Keizer Leg Press A 420 machine [30–31]. The elbow flexion test [32] was used to determine the optimal load in generating strength and muscle power of the upper limbs with the use of isolated exercises, while for multi-joint (activation) exercises, the following tests were most often performed: bench press [33], throwing the barbell from a supine position [34] and bench press on a flat bench and throwing the barbell from a lying position [35].

Studies with the use of plyometric (explosive) exercises for the upper limbs most often focused on the open kinetic chain in power generation and on the build-up of muscle power using such tests as: vertical throws with a medicine ball up [36], ballistic bench press [34,37], the upper limb stability test of a closed kinetic chain [38], training – a test consisting of six plyometric exercises, i.e. "ballistic six" [39], and different pump variations [40]. Therefore, there are few studies that have tested athletes with a comprehensive upper limb training combining activation and explosive exercises. Thanks to the use of comprehensive training of the upper limbs, MMA fighters can improve the technique of performing, in particular, punches (e.g. Pimp Slap, Hammer Fist, Backfist, Mongolian Chop), takedowns and throws (e.g. Piledriver, Slam), as well as faster prepare for situations resulting from direct duels with the opponent.

In the literature on the subject, the highest values of the rate of muscle power growth for the lower and upper limbs are extensive and are within a range of 10–85% 1RM [28, 29, 41]. The extent of the results depends on the research area: lower or upper limbs, polyarticular or isolated exercises, traditional or explosive ones, player's experience, and training experience [26, 32, 42]. A review of studies by Kawamori et al. [43] showed that external loads for upper limbs, using isolated exercises and for untrained people, tend to be less than 30–45% 1RM, while for lower limbs, using multi-joint exercises and for trained people, external loads are usually greater 30–70 % 1RM. Also, the studies of other authors [44, 45] conducted with the participation of competitive athletes show the effectiveness of using higher external loads in conditioning exercises, ranging from 70% to 93% 1RM.

Results of own research show that athletes with longer training experience achieve the highest values of force, RFD and RPD at 80% 1RM; only in the case of power, they achieve the highest values at 50% 1RM. Athletes with shorter training experience achieve the highest values of force and RPD at 50% and power and RFD at 65% 1RM. As in most external loading reviews, it has been shown that weights of 60–84% 1RM may be the most effective in producing PAP [46, 47].

5. Conclusions

1. Competitors with longer training experience achieve the highest value of upper limb force at 80% 1RM, while competitors with shorter training experience at 50% 1RM.
2. Competitors with longer training experience achieve the highest value of RFD at 80% 1RM, while competitors with shorter training experience at 65% 1RM.
3. Competitors with longer training experience achieve the highest value of upper limb RPD at 80% 1RM, while competitors with shorter training experience at 50% 1RM.

Practical applications

Competitors with longer training experience and at a higher sport level should use a greater load in an activation exercise than competitors with shorter training experience.

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