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Original Article

Study the Impact Force in Boxing

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Abstract:
Boxing is a complex and intermittent sport in which all physical qualities are manifested. The movements are performed at an alternate intensity, and are governed by a character of speed and strength. The objective of the study was to scientifically verify the influence of strength training of the upper limbs, and at the same time, which function performs the movement speed of a general exercise such as the bench press, on mechanical performance in a stroke of boxing. The analysis and conclusions of the results obtained in this study allow us to plan and perform qualitative strength training of the upper limbs with a view to improving strength in a boxing hit.
Key Words*:* - strength, speed, boxing, hit, training

Introduction

The sport

Boxing is a combat sport, complex and intermittent in which all physical qualities are manifested. The constant variation of the intensity in the actions that take place in each assault and during all the combat is divided in a great number of episodes and periods, alternated with small intervals of rest. Boxing belongs to the acyclic sports modalities and of great technical complexity. In it, movements are made with alternating intensity and governed by a character of speed and strength. The intensity of work during combat varies and alternates submaximal actions with maxims, and all the actions of the attack and defense, as well as their intensity, are a function of the behavior of the opponent.

An Olympic boxing match, consisting of 3 assaults of 3 minutes, with 1 minute rest between rounds, the predominant energy systems is glycogen. During a boxing assault, there is an almost complete decrease in muscle phosphoric acid (CP) reserves, which does not allow time to fully recover between breaks in the assaults, since the recovery time is low. There is also a decrease, although to a lesser extent of the glycogen, and a large amount of lactate is produced.

The physical demands during a fight are maximum, due to the complexity of the sport, so it is necessary to reach the competition in a physically optimal state, since being a combat sport, the adversary can take advantage of any symptomatology of fatigue due to a bad physical condition, not only affecting the sports performance, but also the physical integrity of the athlete.

Specific problem. Boxing is a sport little studied scientifically, so that currently translates into a large part of coaches and athletes make mistakes in the planning and design of training, and can sometimes be harmful to sports performance.

One of the variables that we analyze in this study is the bench press, this exercise is basic for the development of the strength of the upper limbs, and it is a forcefully studied exercise scientifically.

Authors such as Gerke, A., Woratschek, H. & Dickson, G. (2019). informs us of the loads where a rugby team obtained higher peaks of power during bench press training, comparing the maximum strength of the upper train (1RM in bench press) and production of power with several loads, in order to determine if there were differences in the production of power, and in this way, if there were differences in the load (percentage of 1RM) that allowed the achievement of the Pmax. As a result, it informs us that the Pmax. occurred at an average load 55 ± 5% of 1RM. Being the optimal load for the Pmax. an optimal load range between 50-60% of 1RM. Also in another study Wylleman, P. (2019) shows that the maximum force has a high correlation with the maximum power. So the maximum force is the physical quality that most seems to "highlight" the maximum power. This article attempts to focus on the strategies and specific techniques that can be implemented to improve the effectiveness of maximum power training for the upper body, talking about various training methods and confirming that potential trained athletes can generate maximum power at greater percentages of 1RM. Also in relation to the speed of execution in a strength exercise Nite, C., Hutchinson, M. & Bouchet, A. (2019). report that there is a high correlation between metabolic stress (lactate, ammonia) and mechanical fatigue (loss of speed of execution), so they validate the use of the loss of speed as a system to objectively quantify neuromuscular fatigue during strength training.

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Regarding the variable of beating, there are few studies supported by science. Authors such as Tshibangu, A. (2009) studied the biomechanics of the head at the time of receiving punches in the jaw, and the risk that exists of head injury by translational and rotational acceleration. Seven Olympic boxers of five different weight categories were studied. Each one gave 18 blows to the device (dummy), and translational and rotational acceleration of the head, neck response and pressure distribution in the jaw were measured. Shocks were recorded with high-speed videos to determine the speed of each hit. The strength of each hit was greater in the higher weight categories mainly due to a greater effective mass of the hit. Olympic boxers strike straight with high impact velocity and high energy transfer. And it was specified that the severity of the blow increases proportionally to the weight category. Also in another study Petronel, M. & Florentina, M. (2013) verified the correlation of the mechanical variables of the blow and the force of the blow in amateur boxers. Two types of blows were analyzed, the hook (curved ascending blow), and the direct one (straight blow). And as a result it was determined that the force of the blow correlates more with the speed of the fist than with the strength of the lower train. And this direct correlation is greater for direct hits than for hooks. But he also informs us that the force of the blow is correlated to a greater extent with the strength of the lower train on the hook, rather than direct hits.

After having carried out the bibliographic review cited above, we have been able to draw conclusions related to strength training in bench press or hitting, but none that groups these two variables, and analyze them. For this reason we believe it is necessary to give an answer about the need that coaches have today to control the specific physical condition and training of boxers. So we raised the specific problem of how a strength training in the upper limbs affects through the bench press on the striking force, and what effect does the speed of execution on the bench press have on the striking force.

The purpose of the study

Therefore, the objective of the study that we set was to check the influence of strength training of the upper limbs, and at the same time, which function plays the speed of movement of a general exercise such as the bench press, performance mechanic in a boxing punch

Hypothesis

Based on the fact that strength training is well studied, tested and proven to produce improvements in sports performance, we seek to deepen this statement with real data that support this theory in a quantified way, making it necessary to solve different related uncertainties in the present in the physical training related to boxing.

In some studies cited in the literature, it was observed that the optimum load for the maximum power in the bench press oscillated around 55 ± 5% of 1RM (1). And that the maximum force has been shown to have a high correlation with the maximum power, because the maximum force is the physical quality that most seems to "highlight" the maximum power (3). Regarding the boxing hit, it has also been observed in the literature that the strength of each stroke was greater in the higher weight categories mainly due to a greater effective mass of the hit (6), and that the force of the stroke correlates more with the speed of the fist that with the strength of the lower train. And this direct correlation is greater for direct hits than for hooks. But he also informs us that the force of the blow is correlated to a greater extent with the strength of the lower train on the hook, rather than on direct hits (7).

This background leads us to consider the following *hypothesis*: A strength training through the bench press with loads of 40% 1 RM has a greater effect on the striking force than a load of 60%, and this has an effect greater than a load 80% 1RM.

Material & methods

Given the characteristics of the study and the data collected, we worked with an experimental training methodology in which we defined variables such as the speed of execution in a bench press, the striking force and the MRI.

Design

Three working groups were formed, each group was composed of 5 subjects, subjects were randomly assigned to each of the levels of the independent variable (40, 60 and 80% RM).

The work speed assigned for each work group was:

- Group 1: 1.13 m / s (40% RM)
- Group 2: 0, 79 m / s (60% RM)
- Group 3: 0.47 m / s (80% RM)

The planning and development of the study was carried out in 4 weeks, strength training was performed two days a week on alternate days, being the only strength training performed by the subjects in the four weeks of the study. The rest of the days, the subjects carried out their usual boxing training, from 5 to 6 weekly boxing sessions.

All bench press training sessions were adjusted daily and individually according to the speed assigned during the planning of the study, making the weight variations that were necessary for the adaptations caused or any other circumstance produced.

The maximum range of tolerable velocity loss during the study was 10%. So once the subjects reached that range of speed loss, they were immediately stopped in their work.
Group 1, maximum loss of speed tolerated 1.02 m / s
Group 2, maximum loss of speed tolerated 0.71 m / s
Group 3, maximum loss of speed tolerated 0.42 m / s

Subjects

The study was composed of 15 male subjects, all of them amateur and professional level boxers, ranging from 21 to 32 years old, all with extensive experience in boxing and with a correct and well assimilated pugilistic base. Regarding strength training, there were some participants with more experience than others, but all with a correct execution of technical exercise, and with more than one year of experience in the practice of strength training.

An initial interview was conducted with all the participants in the study, where they were informed that in order to take part in this study, said subjects had to meet several requirements:

To have a federal license in force, since said license requires the appropriate medical controls to be able to compete, and therefore, we understand that the health status of the athlete is optimal for participation in the study.

Have a correct technique, and be familiar with the practice and performance of the bench press and strength exercise.

Do not perform another type of specific physical training of strength in the study time, committing to perform all the planned sessions.

After confirming their commitment to the study and compliance with the requirements, they were informed of the purpose of the research, the experimental procedure, and the risk thereof, by signing the consent for the participation of the study.

Variables object of study

Maximum dynamic force (1RM), in kg.
Average propulsive speed in m / s. In each test the average speed of the common loads was calculated.
Direct striking force of left and right.

Control of strange variables

In a study of these characteristics, possible extraneous or contaminating variables that could affect the results refer to:

-The validity of measuring instruments

The measurement instruments used measure directly the variables analyzed. The linear encoder, provides us with information about the average speeds of propulsion in the bench press, this device is used as usual for this type of studies, having great use in the scientific world. The beating meter is an adaptation to our study, since its use is not designed specifically for the assigned function, and has not been used for studies of these characteristics, but its functionality is consistent with the interests of our study.

-The technical execution and compliance with the protocols in the exercises that were applied as training or test
All tests and training were done under the supervision of the researcher, ensuring that everything was done as planned and agreed, with a correct technique, and following the bases of the study.

-The environmental situation of each work session
In order to ensure that factors outside the study influenced the performance of the training or the tests, all the subjects performed the training sessions and the tests at the same time of the day, under the same environmental conditions, being prohibited from training combat 48 hours before the training sessions or test.

Tests performed

For the study, two tests were performed.
-Test of strength in bench press, the main objective of the test was to know the strength of the athletes, obtaining data from their RM, and the average speeds of execution with different loads.

In the 1 RM test, a progressive bench press test was performed, where the initial load was 40 kg for all subjects, increasing gradually by 10 kg until the subject was unable to overcome the resistance at a higher average speed. at 0.30 m / s, at which time the weight was constantly increased by 5 or 2.5 kg, in search of MRI.
-Test of hitting, the main objective of the objective test was to know the striking strength of the athletes.
In the hitting test, it was performed with straight blows, where we analyzed intermittently 3 hits to the bag with each hand. Between blows and blows, the athlete is allowed a recovery of 1 minute. At the end of the three strokes made with each hand, they were analyzed and the stroke of each hand was chosen where the athlete obtained the best score.

Research instruments

To measure the mechanical variables in the bench press exercise were measured with the linear encoder EV-PRO ISOCONTROL DYNAMIC, The transducer measures the speed of displacement of the loads and

contains a high accuracy tachogenerator that measures at what speed is stretched or retracted 2 m cable that has built-in. The sensor outputs an electrical voltage proportional to the speed with which the cable moves. Hardware and software are connected through the interface, which consists of an electronic data acquisition card equipped with a 14-bit resolution A / D converter that transforms the analog signal emitted by the transducer into a digital signal that is received by the software. The sampling frequency at which the data is acquired is 1 value / millisecond, with an accuracy of 0.2 millimeters. This speed meter has already been used in several works in journals with a high impact index in our field.

To measure the impact variable, the electronic vest "ADIDAS ELECTRONIC BODY PROTECTOR" was used. These vests are used in international taekwondo competitions (approved by WTF) to mark the hitting areas of the opponent, and verify that the hit has the minimum force required to be considered valid. The vest uses the latest Wireless technology and has an innovative sensor for air channels. It is a material developed by Adidas that offers an intelligent product for competition and training. The EBP Adidas is capable of registering up to four hits per second and includes software to evaluate the technique and forcefulness in a combat. The EBP Adidas is calibrated to mark not only the contact but also the tension in joules (JOULES). It is the only EBP system in the market that uses Wirelessel technology sending the impact information to the computer.

Workplan

A 4-week training was carried out, with a total of 8 sessions (2 per week). Before and after the training period, the pre-test and the post-test, both strength and striking, were performed. All training sessions were planned and carried out on alternate days with a minimum of 48 hours difference.

During the training cycle, the three groups performed the same number of series per day, and the same recovery time between series (3 minutes), but the total volume (total number of repetitions performed) was different, because the percentages strength by group were different, which allowed more repetitions to groups that worked with lower force percentage, allowing athletes to perform the maximum number of repetitions possible until they lost the 10% speed stipulated for each group.

Bank press

In all the training and test sessions, a 20 kg warm-up was performed, performing 10-15 repetitions with progressive speed. The execution technique during the training sessions began when the subject removed the bar from the supports and stabilized the weight. At that moment the eccentric phase is carried out in a continuous and controlled manner, until the bar touches the chest, at which point the concentric phase begins where it was performed at the maximum possible execution speed.

For a correct technical execution in bench press, it was emphasized that the buttocks, hips and shoulders were supported on the bench, in order to have the back properly supported on the entire surface of the bench. The feet correctly supported on the ground, separated a little beyond the width of the shoulders. The hands hold the bar so that the palms face forward and apart, slightly beyond the width of the shoulders. The hands should grip the bar tightly, closing the grip with the thumb.

The hit of boxing evaluated and studied were the direct ones, both direct from the right, as the direct from left. For the evaluation and realization of the live, it was started from a position in which the weight of the body was balanced and the hands on the sides of the face. For the realization of the left direct, the weight of the body is changed to the delayed leg, raising the heel of the foot of the forward leg and turning it to the outside with a hip blow, while extending the left arm towards the objective. For the realization of the right forehand, it is equal to the reverse, the heel of the delayed leg is raised, changing the weight of the body to the forward leg, turning the foot to the outside, turning hips, in such a way that the shoulders and hips are aligned, and at the same time extends the right arm towards the target.

In the evaluation of the beating, both in the pre-study, as in the post-study, is done with the same glove (competition glove of 8oz charlie mark), and the Adidas Body Protector vest is hit on the same sack (heavy sack) everlast).

Below we detail the calendar followed during the 4 weeks of study.

Date	Homework
Performance evaluation (21-25 November)	Test The 1RM (Press Banking) Hit Test (Direct from left and right)
1 Training day (28 November)	Bench press training 6 series with 3 minutes of recovery
2 Training day (30 November)	Bench press training 6 series with 3 minutes of recovery
3 Training day (5 December)	Bench press training 8 series with 3 minutes of recovery
4 Training day (7 December)	Bench press training 8 series with 3 minutes of recovery
5 Training day (12 December)	Bench press training 10 series with 3 minutes of

	recovery
6 Training day (14 December)	Bench press training 10 series with 3 minutes of recovery
7 Training day (19 December)	Bench press training 6 series with 3 minutes of recovery
8 Training day (21 December)	Bench press training 4 series with 3 minutes of recovery
Performance evaluation (23 December)	Test The 1RM (Press Banking) Hit Test (Direct from left and right)

Statistical treatment

For the presentation of the results, the arithmetic mean and the standard deviation were used. An analysis of variance of 2x3 repeated measures was applied to jointly analyze intra-group and inter-group differences. Later, an analysis of covariance was applied to compare the differences between the groups in test 2, taking as a covariate the test 1. Correlations were calculated between the changes of the different variables applying the Pearson bivariate correlation. The effect size (TE) was calculated through the "g" of Hedges in each of the groups. The results were considered significant for $p \leq 0.05$. The statistical program SPSS-15 was used for calculations.

Results

The analysis was performed with ANOVA of repeated measures 2x3. Table 1 shows the values of the different variables before and after the training period.

The results indicate that there were no significant differences between groups in any of the variables.
All the groups obtained significant improvements in speed with different loads in the bench press exercise with respect to themselves ($p < 0.001$ in all cases).

In the variable left beating, groups 2 and 3 improved significantly with respect to themselves ($p < 0.001$), and group 1 improved but not significantly ($p = 0.087$).
In the variable hitting right all groups improved significantly with respect to themselves ($p < 0.001$).
In the RM variable of the bench press all the groups improve significantly with respect to themselves.

Table 1. Results applying ANOVA of repeated measures 2x3.

	Speed test 1	Speed test 2	hit left T1	hit left T2	hit direct T1	hit direct T2	RM Test 1	RM Test 2
Group 1	0.66±0.18	0.73± 0.17***	219.20± 34.65	225± 35.93	240.40± 31.96	250± 34.52***	69± 9.62	72.50±10.46***
Group 2	0.79±0.05	0.86± 0.06***	227.60± 28.90	238± 29.48***	251.20± 27.32	261.60± 24.86***	75.50± 8.29	83.50±9.12***
Group 3	0.70±0.18	0.76± 0.17***	200.20± 17.87	222.20± 17.87***	215.20± 5.07	237.60± 5.03***	74± 11.83	81.50±12.87***

*** $p < 0.001$: Intra-group differences.

Applying an ANCOVA considering the values of the pre-test as a covariate, in the variables of beating and RM in the bench press exercise, significant differences were observed in the left stroke in favor of group 3 with respect to group 1 ($p < 0.001$) and group 2 ($p < 0.01$). Likewise, significant differences were observed in favor of group 3 in the forehand with respect to group 1 ($p < 0.01$) and group 2 ($p < 0.05$). In MRI, only significant differences were observed in favor of group 3 with respect to group 1 ($p < 0.01$) (Table 2).

Table 2. Comparison between groups applying an ANCOVA with the initial Tests of each variable as covariables.

	hit left T1	hit left T2	hit direct T1	hit direct T2	RM Test 1	RM Test 2
Group 1	219.20±34.65	225±35.93	240.40±31.96	250±34.52***	69±9.62	72.50±10.46***
Group 2	227.60±28.90	238±29.48***	251.20±27.32	261.60±24.86***	75.50±8.29	83.50±9.12***
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a: significant differences with respect to group1; b: significant differences with respect to group 2.
aa: $p < 0.01$; aaa: $p < 0.001$; b: $p < 0.05$; bb: $p < 0.01$

Correlation between force changes and hitting

Significant correlations were observed between MR changes and changes in left beat ($r = 0.6$, $p < 0.05$) and changes in right-hand beating ($r = 0.59$, $p < 0.05$). Correlations were also observed between the changes of both beats ($r = 0.76$, $p < 0.001$).

Table 3 shows intra-group TE in the different variables. Group 1 tends to have the highest effect size values in the beats, while group 2 is slightly higher in the estimation of the MRI.

Table 3. Effect on groups

	hit left	hit direct	RM Test
Group 1	0.11	0.29	0.34
Group 2	0.35	0.39	0.91
Group 3	1.4	4.43	0.61

The analysis was performed with ANOVA of repeated measures 2x3. Table 4 shows the values of the different variables before and after the training period.

The results indicate that there were no significant differences between groups in any of the variables.

All the groups obtained significant improvements in speed with different loads in the bench press exercise with respect to themselves ($p < 0.001$ in all cases).

In the variable left beating, groups 2 and 3 improved significantly with respect to themselves ($p < 0.001$), and group 1 improved but not significantly ($p = 0.087$).

In the variable hitting right all groups improved significantly with respect to themselves ($p < 0.001$).

In the RM variable of the bench press all the groups improve significantly with respect to themselves.

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Table 5. Comparison between groups applying an ANCOVA with the initial Tests of each variable as covariables.

	hit left T1	hit left T2	hit direct T1	hit direct T2	RM Test 1	RM Test 2
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Correlation between force changes and hitting

Significant correlations were observed between MR changes and changes in left beat ($r = 0.6$, $p < 0.05$) and changes in right-hand beating ($r = 0.59$, $p < 0.05$). Correlations were also observed between the changes of both beats ($r = 0.76$, $p < 0.001$).

Table 6 shows intra-group TE in the different variables. Group 1 tends to have the highest effect size values in the beats, while group 2 is slightly higher in the estimation of the MRI.

Table 6. Effect on groups

	hit left	hit direct	RM Test
Group 1	0.11	0.29	0.34
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Group 3	1.4	4.43	0.61

Dicussion

The objective of the present study was to verify the effect of strength training of the upper limbs through the bench press on the hitting force in boxing, using loads equivalent to 40%, 60% and 80% of the MRI, with losses of 10% speed in the series in all cases.

All groups significantly improved their performance with respect to themselves in all dependent variables (left and right hits, average speed with all the loads in the bench press exercise and the estimation of the MRI). This means that for subjects who are specialists in boxing, with an average experience in strength training, any load between 40 and 80% is sufficient, provided that the fatigue in each series is very small (maximum loss of 10% of the speed in the series), to significantly improve their performance not only in strength but in specific exercises such as beating. From these results it can be deduced that the improvement of the "maximum force" should not be identified with the need to use very high loads (90-100% of the RM) generally proposed as necessary for it, and to realize a character of the maximum effort (until muscle failure) or almost maximum.

The effect of the training does not appear as significantly different between the groups when an ANOVA of 2x3 repeated measures is applied (2 measures x 3 groups), but it is when an ANCOVA is applied taking the initial test as a covariate. In this case the results indicate that the load of 80% of the MRI with losses of 10% of the speed in the series with respect to the speed of the first repetition tends to offer the best results. When comparing the effects of training between the groups, it is observed that group 3 is greater than 1 and 2 in the beating exercises, and even superior to group 1 in the effect on MRI.

The differences between group 3 and group 1 suggest that an intensity equivalent to 80% with a loss of speed in the series of only 10% tends to produce improvements greater than an intensity of 40%. Given that the speed of execution is higher with loads of 40%, the improvement in the strike can not be related to the higher speed of execution of the training loads, but with the greater improvement of the maximum strength (RM). These results are reinforced by TE, which are clearly superior in group 3 with respect to group 1. Therefore, it can be deduced that the greater neuromuscular activation caused by the 80% load, represented by the improvement of synchronization, greater Recruitment of motor units and type II fibers, decreasing the participation of type I muscle fibers (8) may be the basis of these improvements. These neuromuscular effects are favored by the low fatigue caused in each series, and therefore with a very small loss of speed in the series, which explains the greater effect on the maximum force and the force applied to small loads (boxing gloves). that the execution of the highest number of repetitions per series performed at a higher speed when training with 40% of the MRI (since the initial speed is higher, it is necessary to perform more repetitions to lose the same percentage of this speed, in this case the 10 %).

The differences between group 3 and 2 are also favorable to group 3, but these are of lesser magnitude. This trend is consistent, since the results seem to indicate that as the training load increases, comprised between 40% and 80% of the MRI, the effects of training in subjects moderately trained in strength and experts in the dependent variables , it tends to be higher. Therefore, the possible explanations indicated above would also be applicable in this case. The TE in group 2 in the RM variable is slightly higher than in group 3, but this is clearly due to the greater variability of group 3 (CV = 16%) compared to that of group 2 (CV = 10%), for practically the same percentage of improvement in the variable, 10.1 and 10.5%, respectively.

The importance of improving the MRI for the improvement of the beating is reinforced by the significant positive correlations between the changes in the MR and the changes in the left beating ($r = 0.6$) and in the right one ($r = 0$). , 59). These relationships indicate that the subjects who improve the most in MRI tend to also improve more in the beating. It must be taken into account that it is not a relationship between variables (MRI and beating) before and after training, but between the changes of these variables after the training period with respect to the initial values, which is a different type of correlation and that allows us to suggest that the improvement of the maximum force (RM) produces (is cause) of an improvement in the speed of striking or striking force.

The results suggest that the training effect occurs in parallel in both types of beating, since the correlation between the changes of the beating is 0.79 ($p < 0.001$), which indicates that the participants who improve more in One type of beating also tend to improve more in the other type. These changes can be considered as a replication of the study, since the strength improvement can be considered equivalent for both arms and therefore also the training effect can be interpreted as mutually confirmed by the effect on both types of beating.

The results of our study also suggest that the effect of training has been due to the improvement of the speed before the same load, or in other words, by the improvement of the force applied to the same load: the weight of the gloves more the weight of the arm itself, and not an increase in muscle mass or body weight, which could have produced greater impact force for the same speed, since no significant changes were observed in the subjects' body weight after the period of training.

Conclusions

We can confirm that at an intensity of work of 80% with respect to 60% and 40% of RM in bench press, and always maintaining a maximum loss of execution speed of 10% allows us to:

Obtain greater improvements in maximum strength (1 RM) than with 40%.
Obtain greater propulsive average speed improvements in all workloads.

Achieve greater positive effect on a specific exercise (hitting), both with the left direct and the right direct.

So we confirm that strength training has a positive application to sports performance in boxing. Therefore, the design carried out in this study constitutes an advance in the methodology of training programming, since for the first time several independent variables have been used, such as the load (% RM determined by the speed of execution) and the loss of speed in the series as indicators of the magnitude of the stimulus. Therefore this study allows, for the first time, to associate in a reasonable way the improvements obtained by the development of strength training in the upper limbs through the bench press and the striking force. But for this you must control the speed of execution in each of the training sessions.

Conflict of interest

The authors state no conflict of interest.

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