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Original article

Post-activation performance enhancement with bench press or landmine on straight punch strength

Mejora del rendimiento post-activación con banco plano o *landmine* en la fuerza del golpe recto

Melhoria do desempenho de pós-ativação com banco plano ou landmine na força do golpe reto

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ABSTRACT

The present research focused its efforts on discovering methodological alternatives that benefit the possibility of applying high levels of strength in the straight punch, thus favoring the probability of a victory by knockout. The working hypothesis proposed that, if exercises with a post-activation performance enhancement effect are used, the strength applied to the straight punch can be increased. This quasi-experiment aimed to

determine the acute effects of post activation performance enhancement on the strength applied to the straight punch, using the bench press or the Landmine as the conditioning activity. It was worked with 20 boxers (eight professional and 12 amateur), and the population was divided into two groups, matched according to body weight. The maximum impact strength was evaluated with a load cell model WLCC01, then the maximum dynamic strength was determined for each exercise, and from this data, a load was placed to mobilize 60% of the maximum dynamic strength, performing repetitions until the speed of the movement decreased by more than 10 %. Then, the maximum impact strength was re-evaluated. Records were taken immediately after, at one, two, three, four and five minutes. The results showed an increase of 9.3 % in the bench press group and 12.46 % in the Landmine group. It was concluded that both exercises, when used as conditioning activity, generate a significant increase (p 0.05) of the maximum impact strength in the straight punch.

Keywords: Bench Press; Straight Punch; Landmine; Potentiation.

RESUMEN

La presente investigación centró sus esfuerzos en descubrir alternativas metodológicas que beneficien la posibilidad de aplicar altos niveles de fuerza en el golpe recto, favoreciendo con ello la probabilidad de una victoria por la vía del *knock out*. La hipótesis de trabajo planteó que, si se emplean ejercicios con un efecto de mejora del rendimiento postactivación, se puede incrementar la fuerza aplicada al golpe recto. Este cuasi-experimento tuvo como objetivo determinar los efectos agudos de la mejora del rendimiento postactivación en la fuerza aplicada en el golpe recto, utilizando el *banco plano* o el *Landmine como actividad condicionante*. Se trabajó con 20 boxeadores (ocho profesionales y 12 *amateur*), y dividió la población en dos grupos, emparejados según el peso corporal. Se evaluó la fuerza máxima de impactocon una celda de carga modelo WLCC01, luego se determinó la fuerza máxima dinámica para cada ejercicio, y a partir de estos datos, se colocó una carga a movilizar del 60 % de la fuerza máxima dinámica, ejecutando repeticiones hasta que la velocidad del movimiento disminuyó más del 10 %. Seguidamente, se volvió a evaluar la fuerza máxima de impacto. Se tomaron registros inmediatamente después, al minuto uno, dos, tres, cuatro y cinco. Los resultados expresaron un aumento del 9.3 % en el grupo de banco plano y del 12,46 % en el grupo de *Landmine*. Se concluyó que ambos ejercicios, al ser utilizados como actividad condicionante, generan un incremento significativo (p 0.05) de la fuerza máxima de impacto en el golpe recto.

Palabras clave: Banco plano; Golpe recto; *Landmine*; Potenciación.

RESUMO

A presente investigação centrou os seus esforços na descoberta de alternativas metodológicas que beneficiem a possibilidade de aplicar níveis elevados de força no golpe reto, favorecendo assim a probabilidade de uma vitória por knock-out. A hipótese de trabalho propôs que, se forem utilizados exercícios com um efeito de melhoria do desempenho pós-ativação, a força aplicada ao golpe reto pode ser aumentada. Esta quase-experimentação visava determinar os efeitos agudos do melhoramento do desempenho pós-ativação sobre a força aplicada ao golpe reto, utilizando como atividade condicionadora a bancada plana ou Landmine. Trabalhámos com 20 pugilistas (oito profissionais e 12 amadores). A força máxima de impacto foi avaliada com uma célula de carga modelo WLCC01, depois a força dinâmica máxima foi determinada para cada

exercício, e a partir destes dados, foi colocada uma carga para mobilizar 60 % da força dinâmica máxima, executando repetições até a velocidade do movimento diminuir mais de 10 %. Depois, a força máxima de impacto foi reavaliada. Os registos foram tirados imediatamente após, aos um, dois, três, quatro e cinco minutos. Os resultados mostraram um aumento de 9,3 % no grupo dos bancos planos e de 12,46 % no grupo das minas terrestres. Concluiu-se que ambos os exercícios, quando utilizados como atividade condicionante, geram um aumento significativo (p 0,05) da força máxima de impacto no soco reto.

Palavras-chave: Banco Plano; Golpe reto; Landmine; Potenciação.

INTRODUCTION

During the process of physical preparation in boxing, the integral development of the fighter is the goal to be achieved, so that in combat he can use these physical capacities to his advantage. When it is talked about integral development, it is referred to the speed in the punches and displacements, to the sufficient endurance to maintain throughout the combat a correct quality and speed in his techniques, to an optimal flexibility that allows to execute a complete range of movement, both in his upper limbs when throwing the punches, and in the lower limbs when executing the displacements on the ring; and finally, to the strength that must be applied to achieve a strong and fast punch that is forceful (Merlo, 2019).

The straight punch, according to statistics of studies previously conducted in boxing, has become the most used technical gesture by fighters (Pic-Aguilar et al., 2016; Balmaseda, 2011), since it has several functions during the fight, for example, to mark distance between both contenders or to initiate a sequence of punches. This technique is very useful because when a fighter throws a straight punch to the face, the opponent will dodge or block the punch and depending on the response, the one who threw the punch may initiate one or another sequence of combinations, which may even end with a knockout in favor of the puncher (Lenetsky, Harris and Brughelli, 2013).

Based on what was mentioned in the previous paragraph, regarding the fact that the straight punch in boxing is widely used by fighters, and also that it could be useful to create a range of possibilities when attacking the opponent (Lenetsky, Harris and Brughelli, 2013); it is believed that it is necessary to identify the methods and means of training that serve to increase the strength applied in the straight punch, and thus, expand the chances of obtaining a victory in the sporting contest (Lenetsky, Harris and Brughelli, 2013).

Derived from the aforementioned, the present research problem arises, from where it is tried to determine some strategic-methodological alternatives that benefit the possibility of applying high levels of strength in the straight punch.

Conceptual framework

Post-activation performance improvement

Regarding post-activation performance enhancement (PAPE), it should be said that it refers to when high intensity voluntary contractions are performed with the intention of improving subsequent muscle contractions (Cuenca-Fernández, *et al.,* 2017).

The mechanisms that affect PAPE are not only referred to the phosphorylation of the regulatory myosin light chain (CLMr), since this process is affected by:

- Elevation of muscle temperature (MacIntosh, Robillard and Tomaras, 2012; McGowanet *al.,* 2015).
- Increased motor unit recruitment (Tillin and Bishop, 2009).
- Increased excitability or synchronization of motor neurons (Güllich and Schmidtbleicher, 1996; Trimble and Harp, 1998).
- The enhancement of plasma catecholamines (Cairns and Borrani, 2015; Decostre, Gillis, and Gailly, 2000). Because brief periods of intense exercise can increase circulating levels of adrenaline and noradrenaline (Botcazou et al., 2006) exposure to these catecholamines improves the strength of fast and slow muscle fibers (Cairns and Dulhunty, 1993).

Effects of PAPE

Analyzing the PAPE from a methodological framework, it can be cited studies such as Dimitrios *et al.,* (2013), who reported an increase in the power achieved by amateur-level martial artists, when performing a bench press exercise, using the bench press as a conditioning activity (530.3 ± 65.9 watts in the pre-test and 556.8 ± 79.4 watts for the post-test, with a difference of 26.44 ± 13.78 watts, representing a 5 % improvement). For their part, Jones *et al.,* (2018) demonstrated that in wrestling athletes, explosive movements such as arm flexion-extensions in prone position (6.8 ± 5.3 % improvement in peak strength) can be improved after performing a series of repetitions on a bench press as a conditioning activity. In 2012, it was possible to increase the power of the straight punch in boxers by 15.85 %, using the Landmine in a four-week training program, mobilizing weights that were within the zone of maximum mechanical efficiency (Merlo, 2012).

Series for potentiation

When inquiring about the number of sets that are necessary to perform to achieve potentiating effects, it was found that according to Rhea *et al.,* (2003) and Suchomel *et al.,* (2016), it is sufficient to perform only one set of repetitions of the conditioning activity. The above has been verified in previous studies such as that of Jones *et al.,* (2018) who, although they applied two sets of the conditioning activity, in both of them the peak strength of the flexion-extension of arms in prone position was improved. Likewise, in a study by Dimitrios *et al.,* (2013), one set was sufficient to improve the power of the flat bench thrown with an increase of 5 %.

Intensity for potentiation

Regarding the appropriate intensity to mobilize to obtain a potentiation effect, Whelan, *et al.,* (2014) proposed that a load of 60 % of the maximum dynamic strength (FDM in Spanish) can be used, which they demonstrated in their research, where they increased in this way the reactive strength index of the study population by 7.9 %. In turn, Jones *et al.,* (2018) agree with the use of that percentage of FDM as a load to be used for potentiation, and report in their study an improvement of 6.8 ± 5.3 % in the peak force achieved in the flexion-extension of arms in prone position. The evidence provided by Lesinskiet et al. in 2013, share the idea that with 60 % FDM potentiation effects are

achieved, which was demonstrated in reports of sprint time improvements, using the squat as AC and finding a 1.1 % increase in speed using 60 % FDM as AC, 1.8 % with 70 % and 3 % with 85 %.

Some other authors propose that it is necessary to perform the enhancer exercises in percentages of the FDM within the range of 70 to 93 %, especially when trying to empower the lower limbs (Lowery *et al.,* 2012).

Estimation of the FDM

To correctly estimate the FDM, the two-point method created by Garcia-Ramos and Jaric in 2018 can be used, who propose to use two loads corresponding to approximately 40-50 % of the RM and the other to 70-80 %. This proposal represents a reliable alternative for the evaluation of muscle mechanical capacities through the strength/velocity profile ratio that helps to predict the FDM. Besides it can be a fast and safe method to predict this parameter in different exercises.

Recovery time for potentiation

Regarding the time needed to rest between the conditioning activity (CA) and potentiation, Dimitrios *et al.,* (2013) state that this occurs four minutes after CA. On the other hand, Tillin and Bishop (2009), conclude that the necessary post-CA rest time is seven to ten minutes. For their part, Picón-Martínez *et al.,* (2019) consider that the post-CA pause time to obtain potentiation ranges widely, from four to nine minutes for strength exercises, and from one to five minutes for plyometric exercises. In this same line, Whelan *et al.,* (2014) demonstrate a great variability in athletes, reaching their peak power or potentiation after four minutes, some others at six and few at eight minutes after CA.

Exercises for strengthening the straight punch

While the methodology of strength training that provides a potentiation (PAPE) is relatively clear, presenting evidence on the intensity at which the conditioning activity should be stimulated (Whelan, *et al.,* 2014; Jones *et al.,* 2018; Lesinskiet *et al.,* 2013; Lowery *et al.,* 2012), the amount of rest time that should be present before potentiating (Dimitrios *et al.,* 2013; Tillin and Bishop, 2009; Picón-Martínez *et al.,* 2019; Whelan *et al.,* 2014), and the number of sets to use (Rhea *et al.,* 2003; Suchumel *et al.,* 2016; Jones *et al.,* 2018; Dimitrios *et al.,* 2013), the overload exercises that produce the greatest benefits in straight-punch potentiation are not entirely clear.

If exercises with a post-activation performance enhancement effect (PAPE) are used during boxing training, the strength applied to the straight punch will increase.

The aim of this study is to determine the acute effects of post-activation performance enhancement on the strength applied to the straight punch, using the bench press or the Landmine as a conditioning activity, as well as to provide evidence showing improvements in potentiation, using two different exercises that respect the dynamic correspondence (Siff and Verkhoshansky, 2000) of the straight punch.

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MATERIALS AND METHODS

The research design was quasi-experimental. The type of research was applied, with documentary and field sources of information, with a longitudinal approach (data were collected in a pretest, and after the conditioning activity in a post-test).

The research method used for this study was hypothetical-deductive, since it started from assertions as working hypotheses and sought to refute such hypotheses, deducing from them conclusions that had to be confronted with the facts.

The scope of the research was explanatory, where an attempt was made to establish some of the causes of the phenomena studied. The present research was approved by the Ethics Committee of the National School of Sports Coaches of Mexico.

The study was conducted with 20 boxers (eight professional and 12 amateur), divided into two experimental groups, where one of them performed the bench press exercise and the other the landmine as conditioning activity, being matched according to body weight (height 1.72±0.09 m, age 21.6±3.75 years, weight 73.1±24.13 kg). These athletes had more than 2 years of boxing training.

To determine the effects of PAPE on the strength applied in the boxing straight punch, it was necessary to measure it before and after the conditioning activity. For this purpose, a winlaborat load cell was used to measure the isometric strength unilaterally or bilaterally. Its data acquisition interval is 1 millisecond and the resolution it offers is 12 bits. The cell used in this study was the WLCC01, which was used with a WLIT04 interface, together with an amplifier, and cables to communicate the cell to the computer. This measuring element was used with Winlaboratâ software which is used to convert the strength applied to the device, from a muscle or muscle groups into an electrical signal, which is then captured and transmitted to the computer in force values in Newton or Kgf. The load cell measures traction (attempting to pull the poles apart) or compression (pressing the poles together), and the applied force values are captured by the software. This cell was placed inside a metallic structure, which has a surface that allows it to receive blows without injuring the boxers' fist (Figure 1).

Fig. **1**. - Metal structure for measurement of the maximum strength of the straight blow

To find out how much impact strength is absorbed by the metal device with its damping elements (cushion and spring), the load cell inside the damping device was calibrated before the test by placing a steel disc of about 20 kilograms on top of it. The kilograms recorded by the load cell software were subsequently recorded in an Excel document. The loads placed on the cell were 20, 40, 50 and 60 kilograms; the data obtained by the software were: 0.88, 20.5, 35.2 and 45.5 kilograms respectively. A record of the kilograms added to the cell and the kilograms reflected in the software was obtained, a scatter plot was inserted in the Excel document and, finally, a linear regression was performed to determine the relationship coefficient of the data, which resulted in a high relationship of 0.9938. To estimate the maximum dynamic strength applied on the bench press and landmine, a Winlaboratâ WLEN01 encoder was used, which has a data acquisition interval of 1 millisecond. This technological element also allowed estimating the values of strength, acceleration, power and speed in the execution of these two exercises. In order to know the load-velocity profile of the boxers when performing the bench press or the landmine, the two-point method was used, taking advantage of the data provided by the encoder (this method was selected due to the immediacy with which it yields the results).

With the velocity parameters associated with each of the two loads used to estimate the FDM, a trend line was obtained from the values obtained by each of the subjects.

For the conditioning activity, a load of 60 % of the FDM was used in a series, seeking the maximum number of repetitions until reaching a speed loss of 10 %.

To check that the speed of execution of the conditioning activity does not fall below 10 %, the Winlaboratâ WLEN01 encoder was used, which provides data on the acceleration at which the bar is moved during each repetition.

Finally, the strength of the straight punch was measured after the conditioning activity (bench press or landmine) with the load cell to obtain this data. The record of the basal state and the potentiated state were contrasted, data that was taken at the end of the conditioning activity, where the strength of the straight punch was measured immediately, as well as at one, two, three, four and five minutes.

One of the limitations of the present study, and which marks a future line of research, is that a strength training program was not carried out using PAPE as a strategy. Here it was only verified the acute effects of this training strategy with different biomechanics and its incidence on the strength levels applied in the straight punch.

The research technique used was of measurement, applying a pre-test and post-test to the maximum impact strength of the straight punch, reflected through the Kgf yielded by the impacted load cell. The data were analyzed through Excel 2021 software, where the significant differences between the two data samples of both experimental groups were evaluated.

RESULTS AND DISCUSSION

Statistically significant differences in the variable impact strength of the straight punch between the pre-test and post-test of the two experimental groups were established with the statistical analysis through the Student's t-test for the comparison of means of two related samples.

To determine whether the data of both populations conformed to the normal curve, taking p≤0.05 as the value, the Shapiro-Wilks test was applied, which yielded the following results:

- P-values Shapiro-Wilks Flat bench group (GBP) = 0.190256.
- P-values Shapiro-Wilks Landmine group (GL)= 0.546870.

It was verified that the data of the impact strength of the straight punch of both tests came from a normal distribution with 95 % confidence. Student's t-test was applied to the data obtained from the pre- and post-test, both in the bench press (GBP) and landmine (GL) experimental groups, where it could be demonstrated that the differences achieved after performing the conditioning activity with both exercises were statistically significant (p≤0.05) (P-value = 0.001560 for GBP and 0.002214 for GL) (Table 1) and (Table 2), (Table 3), (Figure 2) and (Figure 3).

Table 1. - Pre-test and post-test data of the CA of the bench press experimental group

Prueba t para medias de dos muestras emparejadas	*Pre-Test*	*Post-Test*
Datos de la AC Bench Press	Variable 1	Variable 2
Media	111.6540	121.8950
Varianza	319.2994	389.45461
Observaciones	10	10
Coeficiente de correlación de Pearson	0.9304324	
Diferencia hipotética de las medias	0	
Grados de libertad	9	
Estadístico t	-4.4676317	
P(T<=t) una cola	0.00078	
Valor crítico de t (una cola)	1.8331129	
P(T<=t) dos colas	0.001560	
Valor crítico de t (dos colas)	2.2621572	

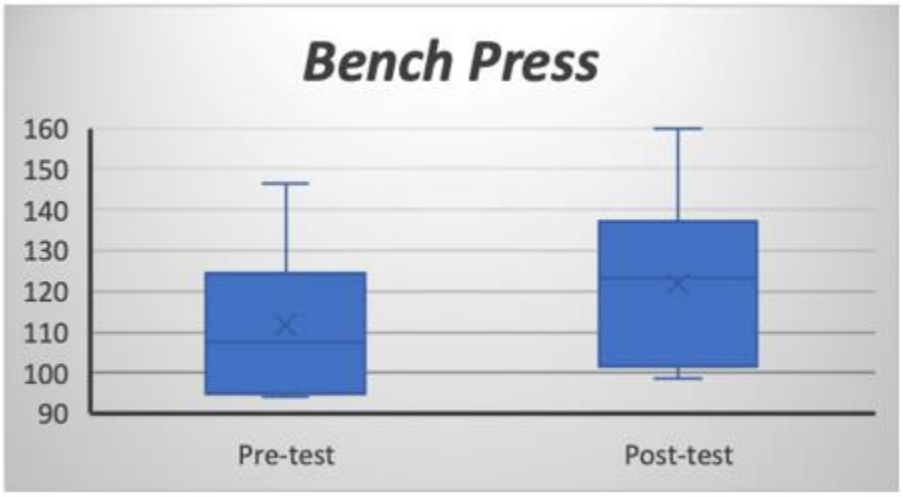

Fig. 2. - Means with their standard error bars for the pre- and post-test of the bench press before a CA

Table 2. - Pre-test and post-test data for the CA of the landmine experimental group

Prueba t para medias de dos muestras emparejadas	*Pre-Test*	*Post-Test*
Datos de la AC Landmine	Variable 1	Variable 2
Media	114.3650	128.4930
Varianza	106.43578	207.68542
Observaciones	10	10
Coeficiente de correlación de Pearson	0.680832	
Diferencia hipotética de las medias	0	
Grados de libertad	9	
Estadístico t	-4.227749	
P(T<=t) una cola	0.001107	
Valor crítico de t (una cola)	1.8331129	
P(T<=t) dos colas	0.002214	
Valor crítico de t (dos colas)	2.2621572	

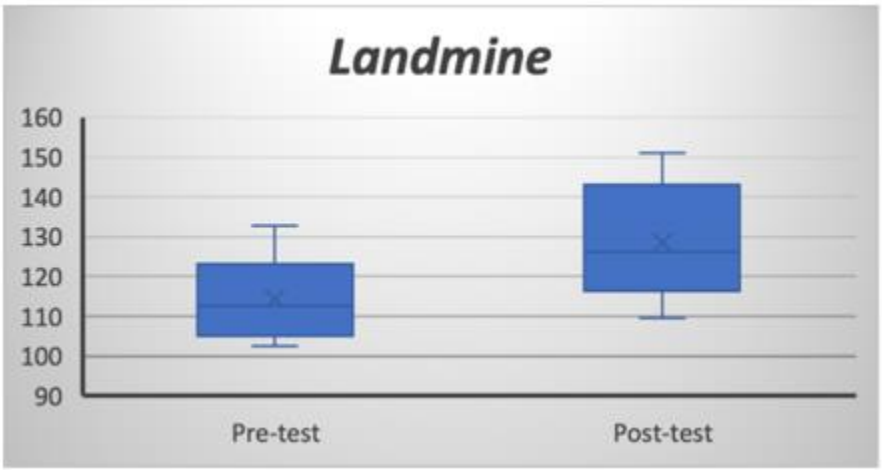

Fig. 3. - Arithmetic means with their standard error bars for the pre- and post-test of the landmine before a CA

Table 3. - Comparison between the magnitude of improvement of the straight punch strength between the GBP and the GL

Prueba t para dos muestras independientes suponiendo varianzas iguales

	GBP	GL
Media	9.3035424	12.45674918
Varianza	46.61216384	84.90448083
Observaciones	10	10
Varianza agrupada	65.75832234	
Diferencia hipotética de las medias	0	
Grados de libertad	18	
Estadístico t	-0.869484995	
P(T<=t) una cola	0.198014294	
Valor crítico de t (una cola)	1.734063607	
P(T<=t) dos colas	0.396028589	
Valor crítico de t (dos colas)	2.10092204	

The Student's t-test applied to the data yielded in the magnitude of straight punch strength enhancement between the GBP and the GL showed that there are no statistically significant differences between them ($p \leq 0.05$) (P-value = 0.396028589).

The results express a statistically significant difference with a p≤0.05 between the straight punch impact strength indicator between pre-test and post-test in both conditioning activities (bench press and landmine) with improvements in the corresponding marks in the post-test.

Boxers significantly improved (p≤0.05) the impact strength of their straight punch (Table 4) and (Table 5).

Table 4. - Time of the PAPE of the strength (Kgf) of the straight punch with bench press as conditioning activity (GBP)

Sujeto	Basal	0 min	1 min	2 min	3 min	4 min	5 min
1	94.56	85.13	96.61	91.74	97.61	95.85	**98.55**
2	94	82.71	94.36	97.42	**98.81**	96.92	95.36
3	102.27	111.16	**122.78**	110.96	102.4	114.42	114.06
4	98.89	101.06	98.21	97.7	100.17	**102.55**	99.72
5	130.25	131.33	121.64	**136.06**	118.44	124.46	125.21
6	112.65	120.02	118.68	122.57	123.13	122.96	**124.43**
7	94.91	89.97	94.97	109.54	**112.6**	111.13	100.48
8	120.44	129.93	134.93	116.4	125.16	**140.02**	119.15
9	146.33	156.19	112.74	150.87	118.98	**159.68**	110.66
10	122.24	**123.47**	118.73	119.63	114.65	120.44	119.86

Table 5. - PAPE time of the strength (Kgf) of the straight punch with landmine as conditioning activity (GL)

Sujeto	Basal	0 min	1 min	2 min	3 min	4 min	5 min
1	123.13	112.34	124.35	**126.2**	112.62	119.88	124.17
2	108.2	118.41	116.85	119.67	116.58	**135.9**	118.37
3	102.5	95.86	104.72	**109.55**	108.87	108.79	97.31
4	117.11	138.04	**151.17**	136.03	127.4	109.06	130.72
5	123.36	125.34	113.95	122.44	122.27	113.82	**126.3**
6	132.72	129.06	**144.76**	130.44	125.93	132.99	132.89
7	105.43	91.53	94.29	96.18	112.29	109.33	**113.47**
8	103.86	80.01	106.91	106.64	**117.82**	110.87	111.85
9	107.12	86.32	104.64	**117.17**	102.12	106.51	100.25
10	120.22	124.19	126.17	131.44	118.9	**142.59**	135.1

From the findings found, it is proposed (p≤0.05) that, if exercises such as the bench press or landmine are used as conditioning activities, an effect of post-activation performance enhancement (PAPE) in the strength applied in the straight punch can be generated.

The results presented in this research are related to what Dimitrios *et al.*, (2013), who demonstrated in a study with mixed martial arts athletes of amateur level, an increase in performance in the bench press exercise thrown, using the bench press as a conditioning activity in the PAP. In turn, they also agree with the data provided by Jones *et al.,* (2018) who demonstrated that in wrestling athletes, explosive movements such as arm flexion-extensions in prone position after performing a series of repetitions on

the bench press as a conditioning activity can be improved. Regarding the number of sets used in this research, it is shared the idea expressed by Rhea *et al.,* (2003) and Suchomel *et al.,* (2016) who mention that, in order to achieve a performance enhancing effect, it is sufficient to perform only one set of repetitions of the conditioning activity.

The above could be verified in the present study, as well as in previous research such as Jones *et al.,* (2018). Similarly, in a study by Dimitrios *et al.,* (2013), one set was sufficient to improve power on the flat bench thrown.

Regarding the appropriate intensity to use for obtaining an enhancing effect, the present research agrees with what was proposed by Whelan, *et al.,* (2014) who demonstrated that using a load of 60 % of the FDM, increases the reactive strength index. In turn, Jones *et al.,* (2018) agree with the use of that percentage of the FDM as a load to be used for potentiation.

On the other hand, the evidence provided by Lesinski *et al.,* (2013), also shares the idea that with 60 % of the WDF, potentiating effects are achieved.

In this study, there are discrepancies with the proposal offered by Lowery *et al.,* (2012), who conclude that it is necessary to perform the potentiating exercises in percentages of the FDM within the range of 70 to 93 %, although it could be believed that this difference is due to the fact that in the present study PAPE was stimulated for the upper limbs in the straight punch, and in the study by Lowery *et al.,* (2012) they refer to the lower limbs.

The results of the present research do not coincide with Dimitrios *et al.,* (2013), who conclude that performance potentiation occurs four minutes after the conditioning activity, nor do they agree with Tillin and Bishop (2009), who state the need for a post-conditioning rest of seven to ten minutes to obtain potentiation.

This study shares the idea expressed by Picón-Martínez *et al.,* (2019), who consider that potentiation oscillates in wide ranges, ranging from four to nine minutes for strength exercises and one to five minutes for plyometric exercises. In this same line, Whelan *et al.,* (2014) show that there is a great variability among athletes, reaching their peak power or potentiation after four minutes, some others at six and few at eight minutes after the conditioning activity.

CONCLUSSIONS

Finally, because in this research there was a wide variability between the time in which boxers reflected a potentiation in straight punch strength after CA, it can be said that PAPE is a response of individual character, which depends on multiple intrinsic and extrinsic factors.

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Authors' contribution:
Rodrigo Damián Merlo: Conception of the idea, literature search and review, instrument making, instrument application, compilation of information resulting from the instruments applied, statistic análisis, preparation of tables, graphs, and images, database preparation, general advice on the topic addressed, drafting of the original (first version), review and final version of the article, article correction, authorship coordinator, translation of terms or information obtained, review of the application of the applied bibliographic standard

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