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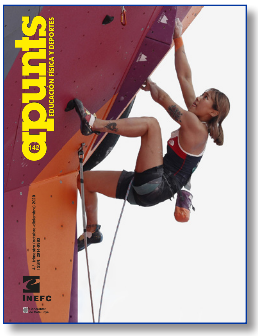

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Effect of Two Periods of Power Training on Performance in the Thrust, Barracuda and Boost Exercises in Synchronised Swimming

Francisco Ramón Escrivá-Sellés [1]* & Juan José González-Badillo [2]

[1] Catholic University of Valencia
[2] Pablo de Olavide University, Seville

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***Corresponding author:**
Francisco Ramón
Escrivá-Sellés
ram_861@msn.com

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Abstract

The objective of this study was to ascertain the effect of two training periods differentiated by the type of power training (with/without added external load-weights) in synchronised swimmers. The variables assessed were performance (height) on the countermovement jump (CMJ) and on specific boost and barracuda tests. The study participants (n = 10) were a group of swimmers from the children's/junior category (14±1 years) with no experience in power training. During the first preparation period, they were trained without added external load, while in the second period they worked with added external load (lift, squat and weighted jumps). The athletes were tested at the end of the preseason (baseline data) and after each intervention period (14 weeks). The statistical analysis showed significant changes in the boost ($p<.05$) and the thrust ($p<.01$) after the second period. No significant changes were found in the barracuda. No significant change was observed in the first period. A significant positive relationship was found between the boost and the barracuda ($p<.05$) and between the CMJ and the boost ($p<.01$) whenever they were measured. The CMJ and the barracuda presented a positive, albeit not significant, correlation. A significant correlation ($r=.643$; $p\leq.05$) was found between the changes in the CMJ and the barracuda and an almost significant correlation with the boost ($r=.602$; $p=.065$). The results show that training with added external load had a greater effect on the swimmers' performance in the CMJ and that there is transfer to specific actions, probably leading to an improvement in competitive performance.

Keyword: RFD training, assessment, synchronised swimming, CMJ, specific test.

Introduction

Synchronised swimming, or water ballet, is an Olympic sport which combines swimming, dance, ballet and gymnastics. The competitors execute (individually, in duets or in groups) a choreography of elaborate movements in water accompanied by music. This sport is famous for the long periods of apnoea and the characteristic jumps in the water (Hernández Mendizábal, 2015; Mountjoy, 1999, 2009; Peric et al., 2012; Ponciano et al., 2017; Sajber et al., 2013; Zamora, 2015).

It is a sport in which the athlete's performance is assessed by judges, and the aspects evaluated include the precision of positions and transitions, control, extension, height, clarity and uniformity of the moves (FINA, 2017; Hernández Mendizábal, 2015).

In recent years, a more athletic profile is emerging through the inclusion of acrobatic elements in the choreographies, increasing speed of movement and in general requiring that the athletes have a higher capacity to generate rate of force development (Zamora, 2015).

Thus, one of the fundamental skills in synchronised swimming are jumps, when the athletes use techniques specific to this sport to elevate their bodies as high as possible above the surface of the water (Peric et al., 2012).

Justification of the study

The classic concept of power, "any cause capable of modifying the state of rest or motion of bodies, or capable of deforming them", adapted to the field of sport, can be defined as "the muscles' capacity to deform a body or modify its acceleration (starting or stopping a movement, increasing or decreasing its speed or changing its direction)" (González-Badillo & Gorostiaga, 2015). Given the demands of sports competitions, power should be regarded as an extremely important factor. More specifically, the rate of force development (RFD) is the main factor of success in almost all sports disciplines (González-Badillo & Gorostiaga, 2015; Kraska et al., 2009; Suchomel, et al., 2016).

When planning the training process, coaches have to consider a series of questions regarding power training: the possible positive and negative effects, the level of power required for the sport, the time needed to achieve the objectives, the time available, the exercises to be performed, training demands on other qualities and specific training (González-Badillo & Gorostiaga, 2015).

Dryland training sessions are usually needed to develop certain factors that condition performance properly, such as power and flexibility (Mountjoy, 2009). The objective of this training is to produce a transfer effect on the specific actions, leading to improved performance. If one training content or method has no effect on specific performance, coaching professionals will most likely dispense with it. Knowing whether this conditioning work outside the specific medium of competition has the desired effects and leads to improved performance is extraordinarily important and an appropriate battery of tests must therefore be developed and systematically applied (González-Badillo & Gorostiaga, 2015; Gorostiaga, 2015; Suchomel et al., 2016; Uljevic, et al., 2013).

Currently, specific tests are gaining in popularity, particularly since assessing aquatic sports in which the data obtained from tests which are not conducted in the natural medium of competition will be likely to have only a limited application in the water (Sajber et al., 2013; Uljevic et al., 2013).

This study focused on ascertaining the effects of two training periods on power, one without external loads (weights) and the other with them. It was conducted with a single group of synchronised swimmers (14 ± 1 years and 57.14 ± 5.75 kg weight) who were assessed at three different points in the season: a) preseason and pre-test; b) first intervention phase (without added external load) and post-test 1; and c) second intervention phase (with added external load) and post-test 2. The effect of the training was assessed with one dryland exercise, the countermovement jump (CMJ), and specifically within the medium of competition via the height achieved through the specific technical moves of the boost and the barracuda.

The lift, squat and weighted jumps were chosen as the exercises for the power training based on the specific technical pattern of the moves to be assessed. Both the boost and the barracuda are somewhat similar to the vertical jump on dryland. On the one hand, the height in the boost depends on a sudden powerful thrust by the arms coordinated with the extension of the hips and trunk. In turn, although the barracuda is a thrust from an inverted position with a push of the arms, it also requires the energetic extension of hips and trunk (Homma, et al., 2014).

Being aware of the technique of the movements in question, assuming that they are two of the most frequently used moves in synchronised swimming, and related to the rate of force development (RFD) (Peric et al., 2012), the hypothesis was posited that the performance of these two moves in competition would be improved through power training targeting improving RFD on the lower body (measured via the CMJ).

Not only are both the lift and the squat similar to the technical patterns of the moves to be assessed, they also generate high power, and their execution enables the load to move at high speed. Similarly, jumps are also obviously a good exercise for improving it. The best results (Adams et al., 1992; Fatouros et al., 2000) are obtained when both kinds of training are used: a combination of Olympic exercises (or partial ones like the squat and the clean lift) and jumps (González-Badillo & Gorostiaga, 2015).

No scholarly research was found in the literature that studies the efficacy of power training with added external load to improve performance on the CMJ and specific competitive performance in synchronised swimming. Similarly, there are few or no procedures for assessing the specific power required in this sport.

Methodology

Participants

The study sample was comprised of 10 synchronised swimmers ($n = 10$) in the children's and junior categories (14 ± 1 years and 57.14 ± 5.75 kg weight) with three to six years of preparation and no previous experience in power training with added external loads.

Ethical aspects

All the participants were informed of the study in which they were participating and gave their informed consent to participate. The experimental protocol was developed in accordance with the principles of the Declaration of Helsinki.

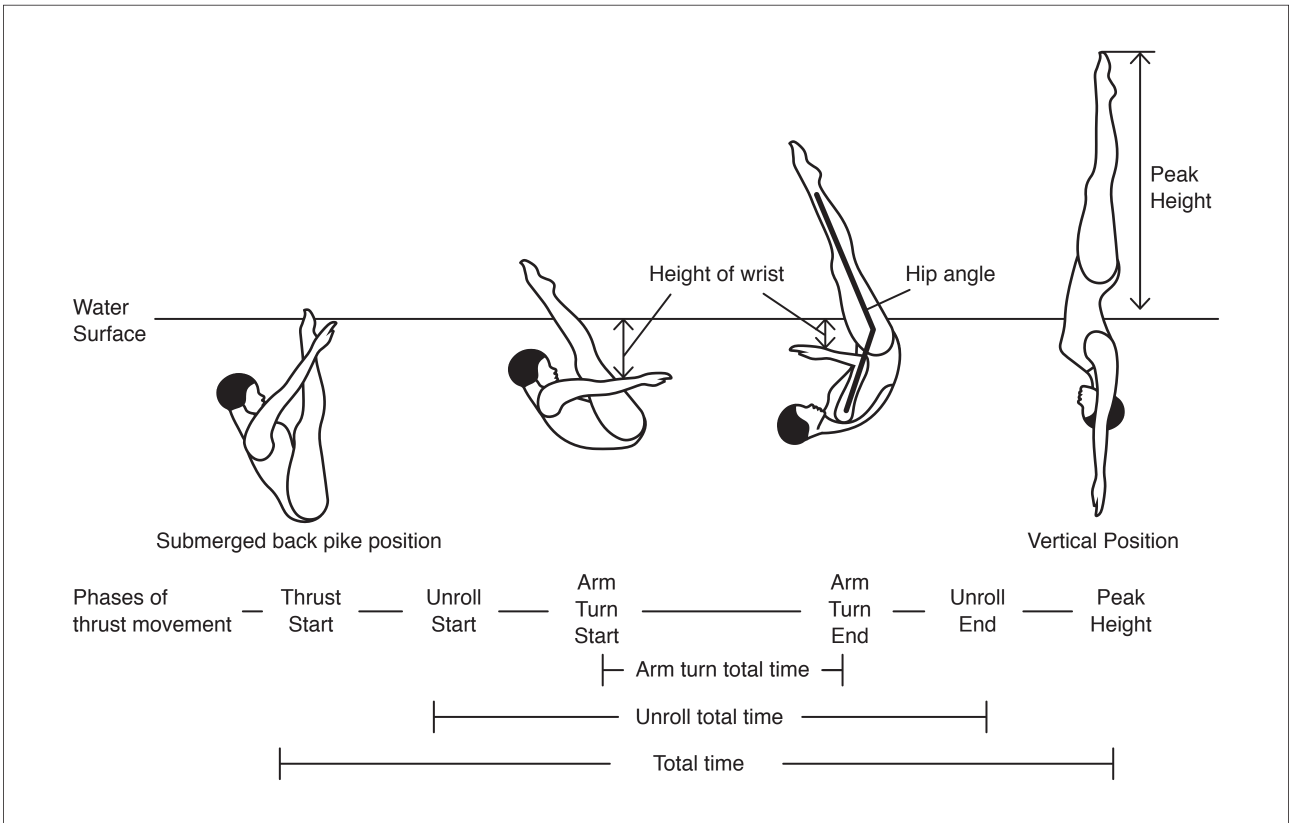
Barracuda and boost

The barracuda and the boost are the two most common jumps in synchronised swimming.

The barracuda is a movement in which the athlete elevates her legs and hips as high as possible from an inverted position.

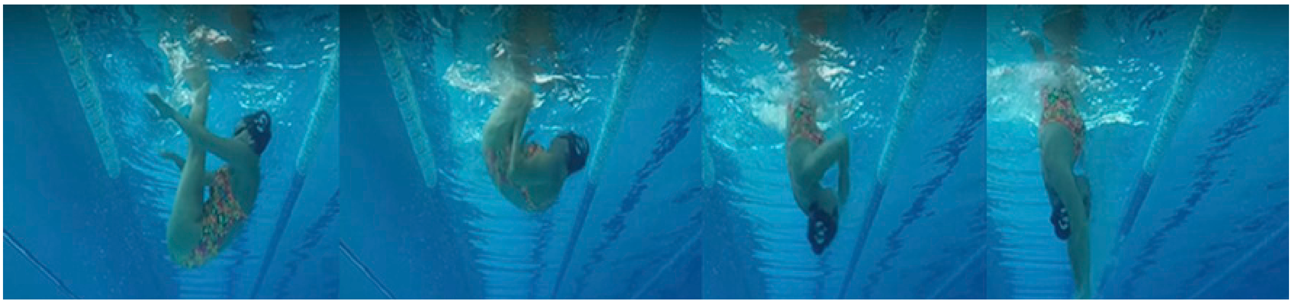
From a frontal extended position (face up, body stretched out with the face, chest, thighs and top of the feet in line on the surface, and with the ears, hips and ankles aligned), the athlete begins to go underwater by moving to a pike position, bringing her legs perpendicular to the surface, and then extending her body (trunk and hips) upward as quickly and as explosively as possible to elevate herself above the surface of the water in an inverted position while also thrusting with her upper limbs (Homma et al., 2014) (Images 1, 2 and 4).

Figure 1
Technical phases of the vertical thrust in the barracuda.



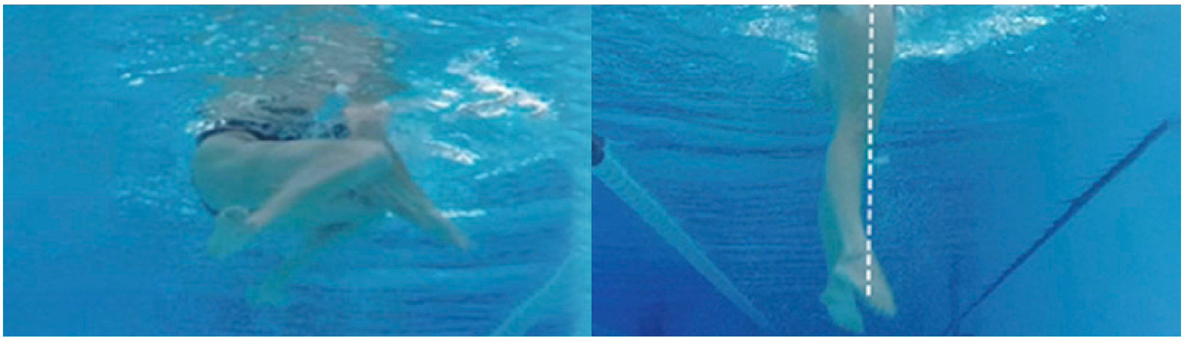
Note: Extracted from Homma et al. (2014).

Figure 2
Underwater view of the vertical thrust in the barracuda.



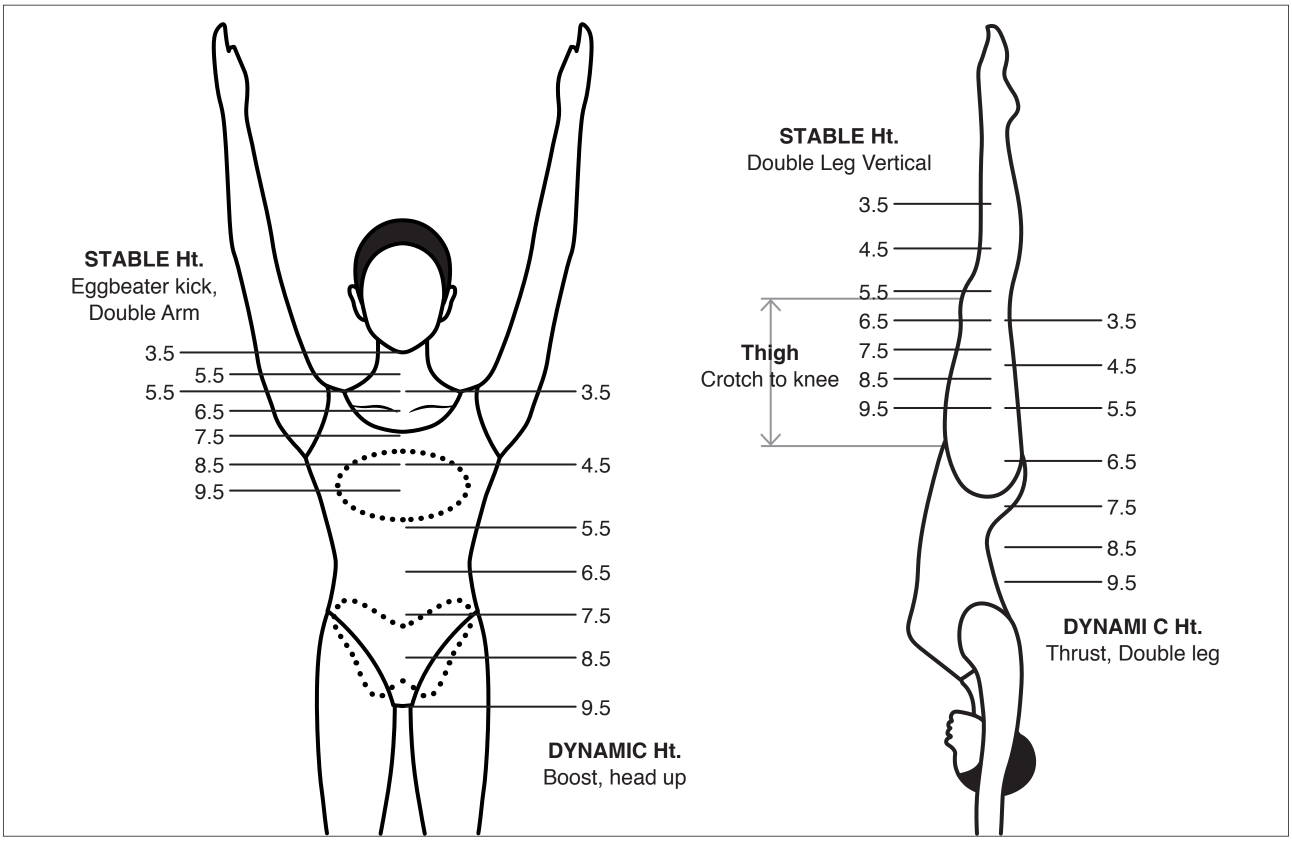
Note. Retrieved from https://synkrolovers.com/ir-mas-alta-hiendo-la-barracuda-la-natacion-sincronizada/?lang=en (07 June 2018).

Figure 3
Underwater view of the vertical thrust, boost.



Note: Fuentes, A. (5 February 2019). Recuperado de https://synkrolovers.com/consejos-natacion-sincronizada-bien-boost-brazos/?lang=en.

Figure 4
Guiding scale for height.



Note: Extracted from FINA manual for judges, coaches and referees (FINA, 2017).

The boost consists of pushing and raising the upper part of the body as high as possible through an energetic arm push and a coordinated, powerful extension of the body with the participation of the arms and elbow extension.

Given their characteristics, both moves are considered to be associated with explosive power (Peric et al., 2012) or with the production of power in the rate of force development (RFD).

Data collection

The objective was to assess and compare the effects of two periods of power training on performance in the thrust, barracuda and boost exercises, while also considering them as a reflection of the athletes' ability to apply rate force of development (RFD).

CMJ

Three jumps per athlete, with a rest time of three minutes between each jump, were recorded on video (Sony α68, 50 fps).

The test corresponding to the CMJ (jump execution) was carried out in accordance with the guidelines described in Bosco, et al. (1983) and Bosco (1994). The move being evaluated was a vertical jump with countermovement, through which they sought to raise their centre of gravity as high as possible through a sudden flexion and extension of their legs and hips, and in this study it was joined by the simultaneous coordinated action of the arms. The athletes were instructed to make contact with the ground after the flight phase in the same way that they lifted off (knees and ankles extended) and to keep their legs and feet totally stretched out during the flight phase. The swimmers' initial position was "standing with the body stretched tall and vertical (without flexing the hips or knees or leaning to the sides or forwards-backwards)" (Bosco et al., 1983; Bosco, 1994; Reyes, et al., 2011).

Based on the filming, the flight time was estimated using the Kinovea (version 0.8.24) software. By ascertaining the time lapse between stills and the number of stills in the flight phase, it was possible to obtain an estimate of the time the athletes were airborne.

The first still was the time when the athletes' feet left the ground and the last image was taken the instant the swimmer made contact with the ground again. To calibrate the time, we input the time lapse between images into the program. This particular camera recorded the jumps at 50 stills or images per second (50 fps). Or in other words, 1/50 of a second elapsed between one image and the next, meaning that there were .02 s between stills. Based on this, we were able to estimate the height reached by applying the following formula (Bosco et al., 1983):

Height reached (h) = $1/2g*(Tv/2)2 = g*(\mathrm{Tv})2/8$, in which g is the gravitational acceleration (9.81 m/s) and Tv is the flight time.

The jumps were filmed in an indoor carpeted area and the jumps were executed barefoot. Camera placement was standardised to ensure that subsequent filming took place in the same conditions as the previous recordings.

Prior to the test, all the swimmers did a standard warm-up: 10 minutes of easy running and joint movement, sprints (4 x 10 m approx.), 3 easy jumps in which they tried to coordinate with their arms, 3 submaximal jumps and the 3 final maximal jumps.

Boost and barracuda

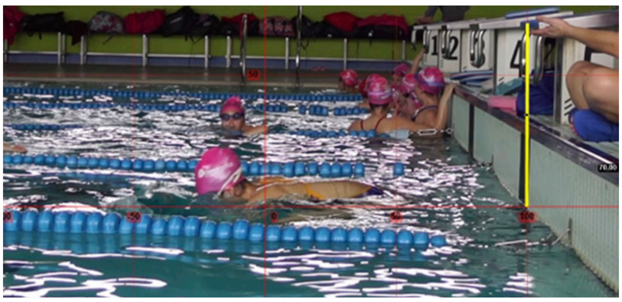
The test was conducted in a 1.8-metre-deep swimming pool. Each athlete did three boosts and three barracudas, with an approximate 3-minute rest time between each move. All the attempts at both moves were recorded on video (Sony α68, 50fps) and subsequently analysed using the Kinovea software (version 0.8.24).

Before the test, the swimmers did a standard warm-up consisting of 100 metres of each style (crawl, backstroke, breaststroke and butterfly) and three practice attempts at the moves being assessed.

Performance in each move was determined by estimating the distance (height) from the surface of the water to the tip of the big toe for the barracuda, and from the surface to the highest part of the frontal bone of the swimmer's cranium for the boost.

Images 5, 6, 7 and 8 show the initial and final positions of the moves assessed.

Figure 5
Initial position of the boost.



Note: Authors' photo.

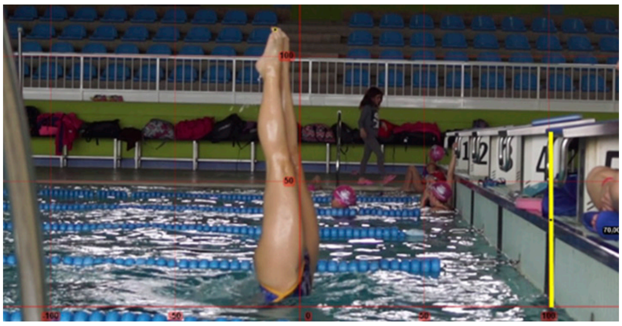
Figure 6
Final position of the boost.

Note: Authors' photo.

Figure 7
Initial position of the barracuda.

Note: Authors' photo.

Figure 8
Final position of the barracuda.



Note: Authors' photo.

For the program to be able to quantify this measurement, the space was parametrised with the height of the starting block with respect to the surface of the water.

The water level was established by the blue marks on the sides of the swimming pool. Therefore, we simply measured from that mark to the near upper edge of the starting block.

Power training
Without added external load.
The exercises used in the power work are presented in Table 1.

With added external load
Before the training, a teaching-learning process was

Table 1
Exercises used during the first intervention period. Without added external load.

Exercises without added external load (without weights)		Series	Repetitions
Bodyweight	Flexions	3-4	8-12
	Pull-ups	3-4	6-10
	Multi-jumps	3-5	5-10
	Plyometrics	0	90-150 jumps
	Isometrics	3-4	30”
	TRX	3-4	10-15
Technical exercises, strokes and propulsive moves with elastic bands	Support scull	3-4	15-20
	Scull stroke	3-4	15-20
	Barracuda propulsion	3-4	10-15
Multiple handball throws	Above the head (throw-in)	3-5	10
	Frontal (chest throw)	3-5	10
	Lateral two hands	3-5	10/side
	Overhead smash	3-5	20”- 30”
	Overhead smash with jump	3-5	20”- 30”
Technical exercises with lower body and breadth of movement (hip)	Dynamic stretches, low-medium speed (flexion, extension, abduction, hip).	2-3	10-15
	Controlled hip flex./ext./abd. up to maximum active breadth (without counter-movement)	2-3	10-15
	Rotation and ext. of hip from 90º abduction	2-3	10-12
	Same exercises as above with load on the ankles or elastic bands	2-3	10
Acrobatic elements	Tiptoes (vertical balance 3 points of supports)		
	Handstand		
	Handstand bridge		
	Bridge with vertical leg		
	Back walkover from bridge		

Table 2
Progression of weights for the squats.

Weeks	Squat													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series x repetitions	4x12	3x10	2x10 1x10	1x10 2x10	3x10	2x10 1x10	1x10 2x10	3x10	2x10 1x10	2x10 1x10	1x10 2x10	1x10 2x10	3x10	3x10
Load: bar + weight (Kg)	n/l	10	10 15	10 15	15	15 20	15 20	20	20 25	20 25	20 25	20 25	25	25

*n/l: No external load.

Table 3
Progression of weights for the clean lift.

Weeks Semanas	Lift													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series x repetitions	A.P.	3x10	2x10 1x8	1x10 2x8	3x8	2x8 1x6	1x8 2x6	3x6	3x6	3x8	3x8	2x8 1x4	2x8 1x4	1x8 2x4
Load: bar + weight (Kg)	8	8	8 13	8 13	13	13 18	13 18	18	18	18	18	18 23	18 23	18 23

*A.P.: Analytical practice of the exercise (technical).

Table 4
Progression in the weighted jumps.

Weeks	Weighted jumps													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Series x repetitions	Multi-jumps							4x10	4x10	5x10	5x10	5x10	5x10	5x10
Load	Without added external load							Progression from a minimum of 3-5 to a maximum up to 5-7 kg (increases of .5-1.5 kg/week)						

conducted in which the athletes learned the technical foundations, thus allowing them to do the exercises safely. The 14 weeks of power training with added external load consisted of one weekly session lasting one hour. The exercises chosen were the squat, the clean lift and weighted jumps.

Tables 2, 3 and 4 present the progression and weights planned for the clean lift, squat and weighted jump exercises.

Before starting the weights (kg) indicated for each training session, the subject did two or three series of warm-ups with lighter weights and the same number of repetitions per series, or several more than the number proposed for the maximum weights of each day.

Each repetition had to be performed at the highest possible speed. The recovery time between series was approximately three minutes.

The weighted jumps began in the eighth week, after the athletes had been prepared with multi-jump exercises (plyometrics with cones and benches of different heights, horizontal jumps, long jumps, vertical jumps, bench jumps, etc.).

The weights and progressions for each exercise shown in Tables 2 and 3 were proposed for the subjects who were developing favourably, with the appropriate technical changes in the execution of the exercises. According to the subjective assessment of the ease with which the athletes were capable of moving the weight and the technical quality with which they did it, the weights were increased according to the planned progression, while absolute weight increases were delayed if necessary, as well as the number of series for each weight magnitude.

All the athletes started practising with the same initial weight (weight of the bar) in the squat and lift exercises (bar weight: 10 and 8 kg, respectively). The progressions were in 5-kg increments. In the squat, all subjects worked with the maximum weight of 25 kg. In the lift, the mean maximum weight used was 20 kg (between 18 and 23 kg). The variation between the subjects in both exercises depended on the number of series they did with each absolute maximum weight (between 1 and 3) and the number of weeks in which the maximum weight lasted for each subject.

The athletes' score on the vertical jump test was taken as a reference for selecting the weight for the jumps (their ability to jump higher meant that a higher weight was proposed for the exercise and a higher magnitude of progression, when they were ready). The progression over the weeks was incremented based on the observation of how they executed the exercise (technique-ease of movement).

Experimental procedure

The study was conducted throughout the season in three phases: a) preseason and pre-test; b) first intervention phase and post-test 1; and c) second intervention phase and post-test 2.

The athletes were assessed through the battery of tests chosen once the season was over (pre-test: baseline or point of departure).

There were five hours of weekly dryland training in the course of the season (28 weeks): one hour of flexibility, one hour of ballet, one hour of specific training for the tests to move up a level (according to the RFEN 2018: "aptitude tests whose purpose is to establish initiation and progression criteria in the speciality"; they provide access to the different national competitions), one hour of power (with and without added external load in the first and second interventions, respectively) and one hour used for core control and specific power (technical exercises, strokes and propulsive moves, acrobatic elements, active breadth of motion, etc.). In addition to the dryland work, the athletes also did their usual pool training.

The first intervention was conducted during the first 14 weeks of the season. At this point, the swimmers did their usual water and dryland training, the latter characterised by power work with body weight and elastic bands. No added external loads were used. The athletes were assessed again at the end of this first period.

In the course of the next 14 weeks of training (second intervention phase), the preparation process consisted of the same type of training that they had already done, albeit replacing the usual power training with the work with added external load (one hour of the five available).

Once the second training period was over, the athletes did the tests for the third and last time.

Statistical analysis

The data are presented as mean ± standard deviation. A repeated measures ANOVA was applied to compare the changes in the different tests. The reliability of the measures was analysed by applying the intraclass correlation coefficient (ICC), the standard error of the mean and its expression in relative terms through the coefficient of variation (CV). The bivariate Pearson correlation coefficient was used to analyse the correlation between the variables and the changes in them. In all cases, a result was considered statistically significant if the probability of error was equal to or lower than 5% ($p \leq .05$).

Results

The assessment procedures showed that reliability was stable. The results were: intraclass correlation and confidence intervals of 95% with .95 (.91-.98), .98 (.96-.99) and .89 (.78-.96) for the barracuda, boost and thrust tests on dryland, respectively, and coefficients of variation of 3.26, 1.76 and 6.43 for the same tests, respectively.

Significant differences were found between the initial test or pre-test and the final test or post-test 2 in the boost in favour of the final test (Table 5). In the CMJ, there are significant differences between post-test 2 and the pre-test and post-test 1, always in favour of the final test (Table 6).

Table 5
Descriptive statistics of the boost test.

Boost	
Assessment	Mean ± DT
Boost pre-test	70.07 ± 9.23
Boost post-test 1	71.69 ± 9.06
Boost post-test 2	72.52 ± 8.60*

** Significant changes compared to pre-test values.*

Boost post-2>boost pre (p<.05).

Table 6
Descriptive statistics of the CMJ tests.

CMJ	
Assessment	Mean ± DT
CMJ pre-test	24.52 ± .043
CMJ post-test 1	24.65 ± .031
CMJ post-test 2	26.57 ± .041** &&

* Significant changes compared to pre-test values.
CMJpost-2>CMJpre (p<.01).
&& Significant changes compared to post-test 1.
CMJpost-2>CMJpost-1(p<.01).

No significant changes were found in the barracuda in any of the tests (Table 7).

Table 7
Descriptive statistics of the barracuda tests.

Barracuda	
Assessment	Mean ± DT
Barracuda pre-test	96.45 ± 11.69
Barracuda post-test 1	93.39 ± 10.67
Barracuda post-test 2	93.89 ± 11.95

Table 8
Correlations between CMJ, barracuda and boost.

	Boost_pre	CMJ_pre	Boost_post1	CMJ_post1	Boost_post2	CMJ_post2
Barracuda	.871*	.561	.638*	.412	.643*	.314
Boost		.784**		.768**		.839**

* *p*<.05; ** *p*<.01.

A significant positive relationship was found between the boost and the barracuda ($p < .05$) and between the CMJ and the boost ($p < .01$) every time they were measured. The CMJ and the barracuda presented a positive correlation, although it never reached statistical significance (Table 8).

With regard to the correlation between the changes, we found a significant positive correlation ($r = .643$; $p < .05$) between the changes in the CMJ and the changes in the barracuda between the post-test 2 and the pre-test, and an almost significant correlation with the boost ($r = .602$; $p = .065$) (Table 9).

Table 9
Correlations between pre-test and post-test 2 changes in the CMJ, barracuda and boost variables.

	Barracuda	Boost
CMJ	.643*	.602
Barracuda		.416

* (*p*<.05)
CMJ-Boost: p=.06.

Discussion

The main finding was that the power training led to a significant improvement in the athletes' performance in the tests compared to the absence of changes in performance with the usual training (CMJpost-2 > CMJpre ($p < .01$) and CMJpost-2 > CMJpost-1($p < .01$); boost post-2 > boost pre ($p < .05$)). Although no significant changes were observed for the barracuda, a small change was found compared to the period without external load (Table 7). This improved performance in the CMJ, boost and barracuda tests reflects an increase in the swimmers' capacity to apply the rate of force development (RFD) in these moves.

The minor effect of the intervention on the barracuda may be explained by the absence of a stimulus with external load for the upper limbs. According to Homma et al. (2014), the height of the barracuda depends on the technique of two distinct steps: the one that the authors call "unrolling", meaning the extension of the body from the initial pike position until the complete barracuda extension is reached (which could be improved with this intervention), and the stroke, traction or push, as well as the final thrust, all of which depend on the upper limbs.

We could consider including exercises for the upper body muscle groups in combination with the ones already proposed to gain a favourable effect in barracuda performance.

We also found significant correlations between the scores in the CMJ and the boost, as well as between performance on the latter and the barracuda. The correlation between the direct scores of these variables (CMJ-boost and boost-barracuda) enables us to posit the existence of common features that mutually explain their variances, which could be relevant when power training is programmed (improvement of maximum power and RFD). **

The ICC and CV values showed that the means of the variables studied are stable enough to be valid. Furthermore, the absence of effects after the first intervention period suggests that the changes found after the second preparation series must be related to the power work, thus justifying the positive effects of the training.

No literature outlining procedures to assess specific power in synchronised swimming nor information on training RFD in this sport was found, the sole exception being the study by Peric et al. (2012). These authors suggest the same moves (CMJ, boost and barracuda) as actions that require the swimmers' capacities to express high values of rate of force development (RFD) and they assess the reliability of the same tests used in this study, albeit using different measurement systems, while also seeking to identify relationships between performance in these moves and performance in competition. Their methodology is not the same as ours, since theirs is a descriptive study with a single test with no intervention. Consequently, the results are not directly comparable with the findings of this study. On the other hand, these authors used Cronbach's alpha as a reliability index of the data obtained in the tests. This index is not appropriate in this study, although the intraclass correlation coefficient and the coefficient of variation are, since they are continuous quantitative variables.

No studies were found on the relationships between the CMJ and the moves in the water; therefore, we cannot compare the information obtained in this study with synchronised swimming values. However, the relationships between dryland jump capacity and vertical jump in the water have been studied in water polo (Platanou, 2005), a move quite similar to the boost in synchronised swimming in terms of technique. Thus, a very minor correlation was found between the dryland jump and the vertical jump in water ($r = .25$) (Platanou, 2005), while in this case, the correlational values between the CMJ and the boost are much higher and more significant (Table 8). The assessment methodology used by Platanou (2005) in the tests is reminiscent of Sargent's test for the dryland jump and assessment in the water. Platanou's (2005) study only provides reliability data on the vertical jump in the water (boost), without mentioning the reliability of the dryland jump. The reliability index for repeated measures used by the author is expressed with "*r*" ($r = .92$-.94), which seems to refer to the Pearson correlation coefficient. Once again, this coefficient is in no way valid for expressing the reliability of repeated measures. Therefore, it is also impossible to compare the reliability of the assessment system.

The differences in the assessment methodology used can explain the discrepancies between the results in terms of the correlations between the CMJ and the boost. In this study, the starting angle of the athletes' trunk is as small as possible, as the back is virtually parallel to the surface of the water (Image 5) (the starting position of the centre of gravity is higher, helping the lift) (Sanders, 1999), which enables them to engage the intense participation of the hip extensor muscles, as in the CMJ during the move (Dávila et al., 2012; Luhtanen & Komi, 1978; Vanrenterghem, et al., 2008), while the initial positions of the jump into the water with the trunk location closer to the barracuda, as in Platanou (2005), lower the engagement of these muscle groups, in addition to lowering the centre of gravity. This variation may account for the lack of relationship between performance in the tests in Platonou's study and therefore the discrepancy with the results of this study.

On the other hand, the absence of details in the description of the procedure used to assess the dryland vertical jump prevents us from asserting that the move used is the same as in our study (CMJ, with countermovement), hence the possible variations in the protocol (without countermovement of SJ) may have altered the performance in the test, as well as any possible similarity between the dryland move and the jump into the water, affecting the correlation between scores.

Finally, the concordance of these data with the position of several studies (Peric et al. 2012; Platanou, 2005; Zamora, 2015) is worth mentioning. These studies assert that jumps in water in general, and in synchronised swimming in particular (both the barracuda and the boost), meet the requirements to be moves that are representative of the rate of force development. These results seem to match this approach, given that a positive significant correlation was found ($r = .643$; $p < .05$) between the changes in the CMJ and the changes in the barracuda between the post-test 2 and pre-test, and an almost significant correlation was found with the boost ($r = .602$; $p = .065$). If we consider the CMJ to be a reflection of the athlete's ability to apply rate force of development (Bosco et al., 1983; Kraska et al., 2009; Reyes et al., 2011; Suchomel et al., 2016; Vanrenterghem et al., 2008), and positive relationships were found between this performance and an improvement in the barracuda and boost, this may suggest that both actions are representative of the specific RFD in synchronised swimmers, and that, as found with the data presented in this study, the RFD in synchronised swimming can be improved through an appropriate power training programme.

It could be asserted that a minimum stimulus frequency used for the power work (1 hour a week) is sufficient to improve performance in the CMJ, with a possible transfer effect to the boost and barracuda, most likely leading to improved performance in competition (Peric et al., 2012).

In terms of load dose, particularly in relation to the nature or intensity of the power, we chose a subjective observational methodology to determine both the working weight and the number of repetitions, primarily because there were no other means, although there are reasons supporting this decision. First, estimating the RM, especially in young athletes with no experience in power training, encounters certain limitations and contradictions, including the imprecision of the estimates as a consequence of the inhibition caused by fear or insecurity (which may lead to erroneous conclusions) and the ensuing risk of injury. Secondly, the repetitions assigned to each athlete were determined according to a subjective evaluation of the ease with which they were able to move the load and the technical quality with which they did so throughout the series, giving an idea of the nature of the effort it entailed (González-Badillo & Gorostiaga, 2015).

It should be borne in mind that the effects of this study were observed in athletes with scant experience in power training, which may have led the training to have a greater effect, given that the potential of genetic adaptation had hardly been developed (González-Badillo, 2015). Therefore, the results should only be mainstreamed to a population with similar characteristics, although this does not mean that the positive effects of this kind of training for more highly-trained athletes should be ruled out.

Conclusions

The results suggest that it would be recommendable to include power training with added external load in the synchronised swimming preparation process. More specifically, the clean lift, squat and weighted jump exercises were effective in improving the RFD and the specific RFD of synchronised swimmers (estimated by means of the tests performed).

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