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# Strength training in youth soccer players: towards an optimal relationship between load magnitude and performance enhancement

# Entrenamiento de fuerza en futbolistas jóvenes: hacia una óptima relación entre la magnitud de la carga y la mejora del rendimiento

**Adrián Magallanes[1], Andrés Parodi[2], Carlos Magallanes[2], Andrés González-Ramírez[2*]**

[1] Instituto Universitario Asociación Cristiana de Jóvenes, Montevideo, Uruguay.

[2] Instituto Superior de Educación Física, Universidad de la República, Montevideo, Uruguay.

* Correspondence: Andrés González-Ramírez; andres.gonz.ramirez@gmail.com

## ABSTRACT

In soccer, sprinting speed and vertical jump are critical skills to achieve high performance. Controversy exists about which type of training is most appropriate to improve these skills in youth players with no previous experience in programmed strength training. The aim of this study was to evaluate the efficacy and efficiency of a 16-week programme of resistance (weight) and plyometric training on sprinting and vertical and horizontal jumping in male youth soccer players. The study involved 18 soccer players, 14.1 ± 0.3 years old, with no previous experience in programmed strength training. They performed a combined cycle of resistance and plyometric training on different days, twice a week, respectively. Before and after the experimental intervention, the athletes were tested in countermovement vertical jump, bipodal horizontal jump, unipodal horizontal jump and 30 m linear sprint. After the intervention, significant improvements were observed in all the variables analyzed ($p \leq 0.05$). Given that the relationship between the improvement in performance and the magnitude of the loads applied was shown to be superior to other similar interventions, it is possible to conclude that this type of training programme is both effective and efficient in the population studied.

## KEYWORDS

Resistance training; Plyometric training; Horizontal jump; Countermovement jump; Sprinting speed.

## RESUMEN

En fútbol, el sprint y el salto vertical son habilidades básicas para alcanzar el alto rendimiento. Existe controversia sobre qué tipo de entrenamiento es el más apropiado para desarrollar estas habilidades en futbolistas jóvenes sin experiencia previa con programas de entrenamiento de fuerza. El objetivo fue evaluar la eficacia y la eficiencia de un programa de 16 semanas de entrenamiento de fuerza con cargas y pliométrico sobre las carreras de velocidad y saltos verticales y horizontales en jugadores de fútbol juveniles masculinos. Participaron 18 futbolistas, de 14,1 ± 0,3 años, sin experiencia previa en entrenamiento de fuerza programado. Realizaron un ciclo combinado de entrenamiento de fuerza y pliométrico en días diferentes, dos veces por semana, respectivamente. Antes y después de la intervención experimental, los atletas fueron evaluados en salto vertical con contramovimiento, salto horizontal bipodal, salto horizontal unipodal y sprint lineal de 30 m. Se observaron mejoras significativas en todas las variables analizadas ($p \leq 0,05$). Dado que la relación entre la mejora en el rendimiento y la magnitud de las cargas aplicadas se mostró superior a otras intervenciones similares, es posible concluir que este tipo de programa de entrenamiento es efectivo y eficiente en la población estudiada.



## PALABRAS CLAVE

Entrenamiento de fuerza; Entrenamiento pliométrico; Salto horizontal; Salto con contramovimiento; Velocidad en sprint.


## 1. INTRODUCTION

For some decades, strength training has been introduced in team sports with two main objectives: to reduce the probability of injury and to optimize the athletic skills of athletes in a playing situation (Suchomel et al., 2018; Verkhoshansky & Siff, 2004). Concerning the latter objective, based on a meta-analysis work, Seitz et al. (2014) determined that there is transfer between lower limb strength increases and sprint performance (average effect size: $d = 0.87$; average performance improvement = 3.1%). This led the authors to conclude that this type of training is of practical relevance for coaches and athletes in sports that require high sprinting speed, such as soccer.

Although there is no longer any doubt that well-designed strength training is necessary to improve the physical performance of soccer players, there is still controversy with respect to the characteristics it should have to enhance this objective. In this regard, there is no consensus on which combinations of the different components of the training load (type of exercise, intensity, volume, frequency, etc.) favour the best results (Raya-González & Sánchez, 2018; Seitz et al., 2014). It is also necessary to take into account the complexity of the relationship established between strength (which is only one of the attributes that determine a soccer player's performance) and the other variables involved, as well as the fact that the time available and the amount of training that an athlete can assimilate are limited resources.

At young ages, the need to consider the prospective development of the players is added; this makes the management of the training loads (and the consequent fatigue induced) even more relevant in this population (Peña-González et al., 2019). Although the exact physiological and molecular mechanisms that determine and limit the adaptive processes of training are still under study, there is substantial evidence that, to increase the chances of a young player achieving his or her maximum performance potential when reaching sporting maturity, training loads must be applied cautiously and gradually (Bompa & Buzzichelli, 2016; González-Badillo & Ribas-Serna, 2014). In this regard, when designing and implementing a training programme for young players, it is not only important to take into account that it is effective (resulting in performance improvements) but also efficient (that these improvements are achieved with low-stress loads).

Furthermore, it is important that strength training with the aim of optimizing athletic skills is oriented towards increasing useful strength, understood as the maximum strength that the athlete can apply in sport-specific movements. In the case of team sports, this is manifested in actions such as linear accelerations, changes of direction, and vertical and horizontal jumps (González-Badillo & Gorostiaga, 2002; Raya-González & Sánchez, 2018). This justifies the tests used in this study.

This research aimed to evaluate the efficacy and efficiency of a resistance (weight) and plyometric training programmed on sprinting speed and jumping distance (horizontal and vertical) in male youth soccer players. We hope that the findings will be useful for coaches and athletes, particularly in youth-level team sports, when selecting exercises, volumes, intensities, and forms of progression that, without requiring large training loads, result in persistent improvements in performance over the longest possible time of the athlete´s sporting life.

## 2. METHODS

### 2.1. Design

This research used a pre-experimental design. The sample was chosen on a convenience basis. Pre- and post-intervention, the dependent variables were measured.

### 2.2. Participants

The sample consisted of 18 youth players from the first league of Uruguayan soccer. Although 24 players were initially selected, six were excluded for not having completed at least 80% of the scheduled training sessions.

Inclusion criteria were considered to be: i) having a current health certificate; ii) attending training regularly before the start of the intervention; iii) not presenting previous or current injuries or illnesses that could affect performance during the intervention period; and iv) not be consuming drugs or substances that could alter sporting performance.

During the experimental intervention, the players were in the competition season. The characteristics of the sample (age, weight, height, and body fat percentage) are presented in table 1. Weight, height and body fat percentage were determined by anthropometry, using the procedures described by the International Society for the Advancement of Kinanthropometry (ISAK).

The study obtained the approval of the Ethics Committee of the *Instituto Universitario Asociación Cristiana de Jovenes* of Uruguay (Resolution Nº 10 of November 12th, 2021) and was conducted respecting the ethical principles established in the Declaration of Helsinki (Rev. 2008). All participants and their parents or legal guardians were informed of the objectives and procedures of the study in advance and prior to the start of the intervention, they were asked to sign the respective informed consent forms.

**Table 1.** Sample characteristics (18 subjects)

| | Age (y) | Weight (kg) | Height (cm) | Body fat (%) |
|---|---|---|---|---|
| Mean | 14.1 | 58.8 | 169.3 | 10.1 |
| Standard deviation | 0.3 | 9.7 | 0.1 | 1.3 |

### 2.3. Procedures

During the intervention the players performed their usual training, with a frequency of 5 times per week, 90 to 100 minutes per session. On Sundays, they also participated in official competitions. In addition, they performed resistance training (Tuesday and Thursday) and plyometrics (Wednesday and Friday) at the beginning of each session, and after a standardized warm-up. During the intervention time, none of the participants undertook any other type of training or sport.

All subjects were tested pre- and post-intervention as described below. During the three weeks before the start of the first test session, participants underwent familiarization sessions for the tests and exercises that were subsequently used. The purpose of these sessions was to detect and improve possible technical errors in execution, as well as to avoid learning bias in the testing procedure.

The familiarization sessions were held twice a week (Tuesday and Thursday). During each session, after the standardized warm-up, the subjects performed three sets of six repetitions of lounges with a straight bar and half squat with a hexagonal bar. The load was set using Borg's modified perceived exertion scale (Borg, 1998), so that subjects perceived it as a value of 2 or 3 on a scale of 0 to 10 (mild to moderate exertion). It should be noted that the subjects were already accustomed to using this scale. Subsequently, all participants performed three sets of three countermovement jumps (CMJ), horizontal bipodal jump (HBJ), horizontal unipodal left leg jump (HUJleft), horizontal unipodal right leg jump (HUJright), and three 30 m linear sprints, respectively, under exactly the same conditions that would later be used in the corresponding tests.

2.3.1. Tests

On Monday of the week before the start of the experimental intervention, and 48 h after the last training session, all subjects performed the CMJ, HBJ, HUJleft, and HUJright tests. The tests were carried out after a standardized warm-up. The CMJ test was performed according to the protocol described by Bosco (2000), using a contact platform (Chronojump®, BoscoSystem). For the HBJ, HUJleft, and HUJright tests, subjects were asked to stand with the toe(s) of the foot at the level of a 2 cm wide tape. For HBJ, they were asked as a starting position to place their feet hip-width apart. In all cases, they were asked to make a maximal effort to reach the longest possible length with a stable landing. A null attempt was considered if the subject fell backwards after landing. The distance of the jump from toe-off to heel projection was determined, using an inextensible metallic tape measure. Each subject made 2 attempts, with a passive rest of at least two minutes between each one. The best result obtained was taken as valid.

On the same day, and after a passive rest of at least 5 min, all participants performed the 30 m linear sprint test. Time was measured with high-speed filming (iPhone 10, Apple) using the application and protocol of Romero-Franco et al. (2017). The test was repeated after a passive rest of at least 5 min, with the best record of both attempts being taken as valid.

Additionally, to set the training weights for the resistance exercises, on Tuesday and Thursday of the same week progressive load (PL) tests were performed on squats with a hexagonal bar and lunges with a straight bar. In the squat test, the subjects started from a sitting position on a bench (adjustable in height), so that the knees were positioned at 90 degrees of flexion. In the lunge test, subjects started from a position with the right lower limb forward and the left lower limb back, with the knee of the latter resting on the floor on a mat. In both cases, three PLs were used: 20, 25, and 30 kg in squats and 14, 19, and 24 kg in lunges.

From this initial position, the subjects were asked to stand up at the maximum possible speed without taking their feet or heels off the ground. The speed was recorded using a linear encoder (Chronojump, Boscosystem). Three consecutive repetitions were performed with each load, with a passive rest of at least 2 min between sets. The speed of the best repetition of each load (fastest repetition) was considered to estimate the load used during the experimental intervention as explained below.

Two days after the end of the experimental intervention, participants repeated all the tests in the same conditions in which they were performed before the intervention.

2.3.2. Experimental intervention

The intervention lasted 16 weeks, during which resistance training sessions (Tuesdays and Thursdays) and plyometrics (Wednesdays and Fridays) were performed. The resistance training consisted of a linear regressive programming, which is recommended for inexperienced subjects starting with programmed strength training (González-Badillo & Ribas-Serna, 2014). In the squat exercises, the negative (descending) phase was performed in a controlled manner, until the knees reached an angle of approximately 90°. The lunges were performed starting from a position of parallel feet; the subjects took a step backwards and descended in a controlled manner until the back knee touched (without unloading weight) a 1 cm thick mat placed on the floor. The aim was that, when reaching this position, both knees had flexion of approximately 90°. In both exercises, they returned from the end position to the starting position as quickly as possible. In the lunges, the series were performed alternating the left and right leg in each repetition.

Following the recommendation of González-Badillo et al. (2017), in both cases the weight of the barbell was adjusted individually so that the subject was able to execute the exercise at a speed of approximately 1 m/s. On the first day of the intervention, each athlete was asked to perform one repetition of both exercises at maximum speed, measured with a linear encoder, with a given load (estimated from the previously performed PL test). If this speed was between 0.95 and 1.05 m/s, the corresponding weight was used as the training load for the following four weeks; otherwise, and after a complete rest, the process was repeated with a load adjustment, until the aforementioned speed range was achieved.

Once the load was established, it was determined how many repetitions the subjects were capable of performing while maintaining above 90% of the maximum speed achieved in that series, according to the methodology described by Sánchez-Medina and González-Badillo (2011). Subsequently, this number of repetitions was used during the training sessions. This procedure was repeated every 4 weeks, adjusting in each case the weight of the barbell and the number of repetitions per set. The sets per week were maintained at one or two per exercise throughout the cycle (table 2), following the methodology proposed by Izquierdo et al. (2006) for this population. The pauses were passive, of 3 min for the resistance exercises and 90 s for the plyometric exercises, in accordance with Willardson (2006).

The average complementary training time was 21.2 ± 2.1 and 4.6 ± 1.0 min per session, for plyometric and resistance training, respectively, comprising an average of 51.6 ± 3.1 min per week.

A dynamic of 5-1, 4-1, 4-1, 4-1 load-unload microcycles was established. In the unloading week, the volume was halved, with only one resistance training session and one plyometric session. The training programme used is shown in table 2.

**Table 2.** Strength training programme

| Week | Plyometric exercises | Series per week Plyometrics | Repetitions Plyometrics | Series per week Squats | Series per week Lounges |
|---|---|---|---|---|---|
| 1 | Box jumps: Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 2 | Box jumps: Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 3 | Box jumps: Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 4 | Box jumps: Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 5 | Box jumps: Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 6 | HJ acyclic: Bipo, Hlin y lat, Blin y lat | 2 | 5 | 1 | 1 |
| 7 | HJ acyclic: Bip, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 8 | HJ acyclic: Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 9 | HJ acyclic: Bip, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |

| | | | | | |
|---|---|---|---|---|---|
| 10 | HJ acyclic:<br>Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 11 | HJ acyclic:<br>Bipo, Hlin y lat, Blin y lat | 2 | 5 | 1 | 1 |
| 12 | HJ cyclic:<br>Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 13 | HJ cyclic:<br>Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 14 | HJ cyclic:<br>Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 15 | HJ cyclic:<br>Bipo, Hlin y lat, Blin y lat | 4 | 5 | 2 | 2 |
| 16 | HJ cyclic:<br>Bipo, Hlin y lat, Blin y lat | 2 | 5 | 1 | 1 |

*Abbreviations: HJ: horizontal jumps; Bipo: bipodal; Hlin: linear hops; Lat: lateral; Blin: linear bounds. Note: for the squats and lunges the intensity and repetitions were adjusted at weeks 4, 8, and 12; and the repetition limit was set by a 10% decrease in speed.*

### 2.4. Statistical analysis

Data are presented as Mean ± Standard Deviation (SD). Normality was checked by the Kolmogorov-Smirnov test. Homoscedasticity was assessed by Levene's test. Comparison of test results, post vs. pre-intervention, was performed using Student's t-test for paired two-tailed data.

The magnitude of differences between groups was quantified by applying the standardized difference (effect size, ES) using Cohen's d with 95% confidence interval (CI). Values equal to or less than 0.20 were considered as no effect, values between 0.21 and 0.49 as a small effect, values between 0.50 and 0.79 as a moderate effect, and values equal to or greater than 0.80 as a large effect (Caycho et al., 2016).

The significance level chosen for all statistical tests was $p < 0.05$. Calculations were performed using the free software JASP 0.14.1 (University of Amsterdam)

## 3. RESULTS

### 3.1. Squat power

In relation to performance in the post vs. pre-intervention tests, all variables significantly improved. At 20 kg, a large ES was observed ($d = 0.945$, $p < 0.001$); whereas at 25 kg and 30 kg the ES observed was moderate ($d = 0.769$, $p = 0.005$ and $d = 0.777$, $p = 0.004$ respectively).

### 3.2. Lunge power

In relation to post vs. pre-intervention performance, a significant increase was observed, with a large ES, for all loads used (14 kg: d = 1.033, p < 0.001; 19 kg: d = 1.042, p < 0.001; 24 kg: d = 1.027, p < 0.001).

### 3.3. Performance in CMJ and horizontal jumps

All jumping exercises analyzed significantly increased performance post vs. pre-intervention (p ≤ 0.05). In CMJ, a large SE was observed (d = 2.122, p < 0.001), while in the other jumping exercises a moderate SE was observed (HJB: d = 0.679, p = 0.01; HJUright: d = 0.796, p = 0.004; HJUleft: d = 0.786, p = 0.004).

### 3.4. Linear sprinting over 30 meters

A significant improvement in 30 m linear sprint performance was observed post vs. pre-intervention (p < 0.001), with a large ES (d = 1.329).

The results obtained in the aforementioned tests, comparing post vs. pre-intervention performance, can be seen in table 3.

**Table 3.** Performance in squats, lunges, CMJ, HJB, HJUright, HJUleft, and 30m linear sprint

| Test (exercise) | Pre (mean ± SD) | Post (mean ± SD) | p-value | Cohen's d |
|---|---|---|---|---|
| Squat 20 kg (w) | 1064.5 ± 237.8 | 1297.6 ± 318.2 | < 0.001 | 0.945 |
| Squat 25 kg (w) | 1063.0 ± 270.3 | 1248.3 ± 322.0 | 0.005 | 0.769 |
| Squat 30 kg (w) | 1049.1 ± 251.0 | 1213.1 ± 287.8 | 0.004 | 0.777 |
| Squat 14 kg (w) | 572.5 ± 134.1 | 826.8 ± 229.2 | < 0.001 | 1.033 |
| Lounge 19 kg (w) | 601.5 ± 142.0 | 838.2 ± 245.1 | < 0.001 | 1.042 |
| Lounge 24 kg (w) | 589.7 ± 135.2 | 785.4 ± 180.3 | < 0.001 | 1.027 |
| CMJ (cm) | 30.02 ± 3.4 | 32.3 ± 3.0 | < 0.001 | 2.122 |
| HJB (cm) | 159.5 ± 12.9 | 193.7 ± 49.4 | 0.01 | 0.679 |
| HJUright (cm) | 170.7 ± 15.4 | 182.6 ± 13.8 | 0.004 | 0.796 |
| HJUleft (cm) | 177.1 ± 17.0 | 185.9 ± 13.0 | 0.004 | 0.786 |
| Linear sprint 30 m (s) | 4.561 ± 0.176 | 4.396 ± 0.142 | < 0.001 | 1.329 |

*Abbreviations: SD = standard deviation; CMJ: countermovement jump height; HJB: bipodal horizontal jump length; HJUright: right leg jump length; HJUleft: left leg jump length; Pre = pre-intervention results; Post = post-intervention results.*

## 4. DISCUSSION

In the present study, after 16 weeks of combined resistance and plyometric training in youth first league soccer players, a significant performance improvement was observed in all the variables analyzed (sprint, horizontal and vertical jumps, and lower limb power). Given that several scientific papers (Franco-Márquez et al., 2015; Hammami et al., 2019; Hammami et al., 2017; Rodríguez-Rosell et al., 2017; Rodríguez-Rosell et al., 2016; Wong et al., 2010) show that, when elite youth soccer players perform only specific training, they do not manifest significant improvements in CMJ and sprinting speed, at least after 6 to 12 weeks of training, it is plausible to conclude that the observed performance improvement was due to the experimental intervention and not merely to the soccer-specific training or the on-going maturational development of the young athletes.

Although it was not the purpose of the present study to elucidate the mechanisms underlying this performance improvement, it is possible to speculate that it would be associated with neuromuscular adaptations (improved inter- and intra-muscular coordination, increased nerve conduction velocity, modifications in MHC isoforms, among others) specific to the type of exercises and methodology used (Aagaard et al., 2002; Cormie et al., 2010; Škarabot et al., 2021).

It is noteworthy that the intervention was shown to be not only effective but also efficient, in that the performance improvement was obtained by applying relatively low training loads in volume and intensity when compared to studies that have been conducted with similar populations in terms of age, sport and previous experience in strength training [see point (ii) below]. Numerous factors could explain, at least partially, these results; among others: (i) the training methodology used, (ii) the dosage of the training loads, (iii) the duration of the intervention, and (iv) the focus on speed for the execution and monitoring of the exercises.

(i) Concerning the strength training methodology, it combined resistance and plyometric exercises, a strategy that has been shown to be effective in this population. In this regard, Brearley and Bishop (2019) and Loturco et al. (2016), after implementing combined coordinative and traditional resistance training, reported significant improvements ($p \leq 0.05$) in vertical and horizontal jumping, and displacements with changes of direction abilities. Along the same lines, Rumpf et al. (2012) suggest that mixed or combined methods are superior to methods using only conventional resistance exercises, applied in pre-, intra- and post- adolescence when the aim is to transfer to linear speed. This could be the reason why, in an intervention of much longer duration (two years) with a matched population in terms of age and level of performance, but involving only traditional resistance training (Sander et al., 2013), similar results to our work, of 16 weeks' duration, were reported.

The effectiveness of combined strength training could be associated with a synergistic effect of the different adaptations determined by both methods: while traditional resistance training would have a significant impact on strength development as a function of time, the coordinative training would produce better levels of transfer to the sporting actions (Brearley & Bishop, 2019).

(ii) Regarding the dosage of the training loads, it is possible that the magnitude and dynamics of the loads used in the present study would have been particularly appropriate for the age, level, and experience of the target population, as opposed to the higher (and perhaps excessive) loads used in other interventions. Numerous studies (Franco-Márquez et al., 2015; García-Pinillos et al., 2014; González-Badillo et al., 2015; Hammami et al., 2019; Hammami et al., 2017; Rodríguez-Rosell et al., 2017; Rodríguez-Rosell et al., 2016; Wong et al., 2010) that employed similar population samples and interventions to those in the present study, despite having applied considerably higher loads (including intensities of up to 90% of 1RM, volumes of 3 or more sets per exercise and rapid progression in increasing loads) showed smaller improvements in performance for CMJ and sprint speed than those obtained in the present work. Regarding the duration of supplemental strength training, the time used in our study was 51.6 ± 3.1 min per week (42.4 ± 4.2 min and 9.2 ± 2.0 for plyometric and resistance training, respectively), much lower than those used by Hammami et al. (2017) and Rodriguez-Rosell et al. (2017), who averaged 90 min and 75 min per week of supplemental training, respectively.

(iii) The duration (16 weeks) of the present experimental intervention could be another factor contributing to explaining the aforementioned difference between studies. The research studies reviewed in the scientific literature that have employed samples of similar subjects and included combined training (traditional resistance training and plyometrics) mostly had a duration of between 6 to 12 weeks (Franco-Márquez et al., 2015; García-Pinillos et al., 2014; Hammami et al., 2019; Hammami et al., 2017; Raya-González et al., 2017; Rodríguez-Rosell et al., 2017; Rodríguez-Rosell et al., 2016; Wong et al., 2010), except for the study by Gonzalez-Badillo et al. (2015), which lasted 26 weeks. Silva et al. (2015) in a meta-analysis work on strength training and its transfer to sprinting suggest, for youth players, programmed (cycles) of longer duration, compared to what is recommended for more experienced athletes. Specifically, González-Badillo and Ribas-Serna (2014) recommend strength training cycles of more than 12 weeks for populations similar to the present study.

(iv) Finally, and without claiming to be exhaustive, one more factor that could help to explain the considerable performance improvement observed is the (maximal) execution speed used during all strength training sessions. This is in agreement with several studies (Comfort et al., 2012; González-Badillo et al., 2015; Fernández-Ortega et al., 2020; Moore et al., 2005) that report higher transfers to sprint and jump when the execution of strength exercises is performed at the highest possible speed.

The present study had some limitations. Among them, the age and relatively little experience of the young athletes with the tests used could have implied a learning bias. Also, as this is a research study on a real-world scenario, it was impossible to control all the possible interfering variables. Finally, and related to the previous point, the lack of a control group. In any case, this last limitation was compensated in two ways: by contrasting the CMJ and sprinting speed data reported by other authors for youth soccer players who did not undergo complementary strength training, and by comparing with studies that included subjects and treatments similar to those in the present study.

## 5. CONCLUSIONS

In youth soccer players with no previous experience in systematic strength training, a 16-week intervention combining resistance training and plyometrics, with low volume and intensity and slow progression in the applied loads, showed to be effective and efficient in improving sprinting speed and vertical and horizontal jumps. The conservative application of training loads administered throughout the intervention allows us to hypothesize that these players still have considerable room for improvement, an aspect that we intend to investigate in subsequent training cycles.

To sum up, the results of this study suggest that, in youth soccer players with no experience in strength training, it is possible to achieve consistent improvements in sprinting speed and jumping ability through combined resistance and plyometric training programmed, of low intensity and relatively undemanding in terms of their dosage. For future studies, it is suggested to use force platforms and electromyographic recordings, in order to identify the neuromuscular mechanisms by which different strength training protocols produce their particular effects.

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**CONFLICTS OF INTEREST**

The authors declare no conflict of interest.

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