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## ORIGINAL

# IMPLEMENTATION OF A RESISTENCE TRAINING ON YOUNG FOOTBALL PLAYERS

# APLICACIÓN DE UN PROGRAMA DE ENTRENAMIENTO DE FUERZA EN FUTBOLISTAS JÓVENES

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## ABSTRACT

This study aims to analyze the impact of a specific resistance training program of 20 sessions in young football players. 38 subjects, divided into an experimental group (EG) and a control group (CG), took part in the study. A football training session and a specific resistance training exercise were assigned to the EG whereas the CG only performed football practice. Both groups were assessed at the beginning and at the end of the program in order to determine the maximum dynamic strength of their knee flexors and extensors, the mass of the muscles in their lower limbs, their fat percentage and finally their speed in the 10 or 20-meter sprints. Only the EG significantly improved their maximum dynamic strength ($p$<0,01). Neither the muscle mass nor the speed showed any differences. The EG and the CG increased their body mass percentage.

**KEY WORDS:** Resistance training, football, body composition, maximum strength, speed.

## RESUMEN

El objetivo de este estudio, es comprobar el efecto de un programa de 20 sesiones de entrenamiento específico de fuerza en futbolistas jóvenes. Participaron 38 sujetos en el estudio, divididos en un grupo experimental (GE) y un grupo control (GC). Al GE se le administró un entrenamiento de fútbol y un trabajo específico de fuerza; mientras el GC sólo efectuó práctica de fútbol. Ambos fueron evaluados al inicio y al final del programa, con el objetivo de conocer su fuerza dinámica máxima en los flexores y extensores de la rodilla; su masa muscular en las extremidades inferiores; el porcentaje de grasa; y, por último, la velocidad en las pruebas de 10 y 20 metros. Únicamente el GE mejora de forma muy significativa la fuerza dinámica máxima ($p$<0,01). No se encuentran diferencias en la masa muscular, ni en la velocidad. El GE y el GC incrementan el porcentaje de grasa corporal.

**PALABRAS CLAVE**: entrenamiento de fuerza; fútbol; composición corporal; fuerza máxima; velocidad.

## 1 INTRODUCTION

Muscle strength is a capacity which conditions motricity in general and sport performance in particular (Behringer, Vom Heede, Yue, & Mester, 2010; Cuadrado, Pablos, & Garcia-Manso, 2006; Garcia-Manso, Navarro, & Ruiz, 1996; González, 2010; González-Badillo & Gorostiaga, 2002). Although it is today highly popular in the design of sport programs in order to allow athletes to give their best, the traditional training methods using external load in preparation programs of athletes whose discipline bore no direct link with resistance have proved an unsuccessful strategy.

The insertion of specific resistance training into adult sport has been surrounded by heated controversy. Even so, its appropriateness in the sport training stages has been even more debated over the last decades (Behringer et al., 2010). Resistance training had been for a long time considered unsuitable and thus not advisable for children (Metcalf & Roberts, 1993) since it could increase the risk of injury and seriously undermine growth (Garcia-Manso et al., 1996).

However, it has nowadays been acknowledged that the negative effects of resistance training on growing subjects are either relative or have a reduced presence (Ingle, Sleap, & Tolfrey, 2006). As a matter of fact, the vast majority of injuries linked to this type of operation are not related to the content but to errors in the design of the training: incorrect technical performance, excessive loads, dangerous equipment or lack of qualification among the technicians who supervise the exercise (Faigenbaum et al., 2009). A well-designed program, which considers the particular characteristics of the evolutionary stage at which it is aimed, should not undermine the growth of the participants (Ratel, 2011), and hence becomes a strategy at the disposal of any athlete irrespective of their age (Guy and Micheli, 2001; Matos and Winsley, 2007). Nonetheless, this type of training implies an inherent risk of injury, which on the other hand is not much higher than that likely to be found in other sports and leisure activities in which teenagers commonly engage (Zaricznyj, Shattuck, Mast, Robertson, & D'Elia, 1980).

There also is concern over the resistance training during the introduction stage of sport practice with reference to an alleged lack of efficiency (Falk & Tenenbaum, 1996) that is associated with low levels of androgen found in the years prior to puberty (Zakas, Mandroukas, Karamouzis, & Panagiotopoulou, 2007). The American Academy of Pediatrics (1993) (mentioned in Mayorga, 2011) claimed that the best results of using loads in the resistance training would be achieved after puberty. However, some studies show improvements of the strength in prepubertal participants when they were subjected to exercise with external load (Da Fontoura, Schneider, & Meyer, 2004; Ingle et al., 2006; Ramsay et al., 1990; Sadres, Eliakim, Constantini, Lidor, & Falk, 2001). Although it is undeniable that maximum strength is particularly sensitive to certain training stimuli between 20 and 30 years (Garcia- Manso et al., 1996), that ability may be trained in most ages (B. Falk & Tenenbaum, 1996; Bareket Falk & Eliakim, 2003; Malina, 2006). An ability is trainable when it responds to the applied training stimuli. With regards to strength, such a response is a result of various factors which are inherent to the participants' own characteristics as well as the load conditions.

When we refer to young sports beginners in the practice against resistance, the first increases in strength stem from neural adaptations (Häkkikinen & Komi, 1983). The development of strength is affected by recruitment and synchronization of motor units and, on the other hand, from the reduction of the co-activation of the antagonist muscles. The effects of training with external loads on intermuscular and intramuscular coordination factors allow for progress in the development of strength during the prepubertal period. That adaptation to resistance training is what allows to gain strength regardless of whether no muscle has been gained, as a result of the restrictions linked to the structural component inherent to these ages.

Some of the studies which analysed the effects of resistance training in teenagers mention this type of research because of its positive impact on multiple areas. This type of research, as opposed to the negative opinions linked to resistance training in teenagers, has advantages that transcend sport performance and which are put into practice as a way of providing efficient help for growth, maturation and the participant's health. Improvements in the body composition, skeletal and cardiovascular systems have been mentioned (Guy & Micheli, 2001). The American Academy of Pediatrics (2008) recommends including perfectly developed and supervised resistance training within the physical activity programmes of children and adolescents.

A training session specifically aimed at the improvement of strength may be combined with the specific practice of sport (Alvarez-San Emeterio, Antuñano, López-Sobaler, & González-Badillo, 2011; Christou et al., 2006; Gorostiaga, Izquierdo, Iturralde, Ruesta, & Ibañez, 1999). If that composition is correctly carried out, physical and motor abilities of athletes will actually benefit from that (Faigenbaum, 2007). This causes great impact on present and future sport performance, so it should be taken into account during the planning of football teaching and training processes. Resistance training along with the development of a specific football training session is not only compatible, but it also gives better results than a merely and exclusively football-based preparation (Christou et al., 2006). Therefore, it is a mistake to exclude that combination or reduce it to preparation periods of the season. During the competition, 1 or 2 sessions can be organised in every microcycle so that they can keep contributing to the biological and sport development of the young football player without affecting the competition.

## 2 OBJECTIVE OF THE STUDY

Following our analysis so far, this study mainly aims to determine the effect of a training programme involving external load on the maximum dynamic strength, acceleration speed and body composition (expected muscle mass, body mass index and percentage of fat) of football players aged between 14 and 15 years lacking prior experience in this type of research.

# 3 MATERIALS AND METHODS

## 3.1 SAMPLE

The sample of participants consists of 38 male players coming from the Unión Deportiva Salamanca football club's under-18 first and second teams. In the study, the first under-18 team was used as experimental group (EG). These players practise 4 days per week and play official matches on Saturdays or Sundays, which are included within the regional football league under the supervision and management of the football association of Castilla y León regional government. The second under-18 team was used as a control group (CG). The players of that group also train 4 days a week and play official games on Saturdays, which are included in the under-18 first category of the provincial league organised by the provincial football association of Salamanca. Table 1 shows general characteristics of groups taking part in the study.

**Table 1.** Main characteristics of the sample taking part in the study.

| Group: | No | Age ($\bar{x}$) | Age ($S\bar{x}$) | Weight ($\bar{x}$) | Weight ($S\bar{x}$) | Height ($\bar{x}$) | Height ($S\bar{x}$) |
|---|---|---|---|---|---|---|---|
| EG | 20 | 14,80 years | 0,410 | 61,68 Kg | 10,683 | 171,40 cm | 7,479 |
| CG | 18 | 14,06 years | 0,236 | 54,87 Kg | 7,824 | 165,44 cm | 7,048 |

None of the subjects involved in the study had prior experience in resistance training. All the players carried out the training programmes established by the technical staff of each team. The resistance training programme performed by the EG was included within the team's weekly preparation programme. However, the sport management staff as well as the players' parents gave their consent in order for the footballers to participate in the study.

## 3.2 MATERIALS

The experimental part of the study was conducted in the Unión Deportiva Salamanca club's facilities which are dedicated to the lower categories. In the dressing rooms, the weight, body mass index (BMI), estimated muscle mass and percentage of fat were measured using the TANICA BC-418 segmental body composition body analyser. A Holtex aluminium stadiometre was used for height measurement.

The speed evaluation test over 10 or 20 m was carried out on the second generation artificial pitch where the teams perform their training and play their games. A 50 m tape measure and photoelectric cells "Chrono" included in the Globus Ergo System were used in this test.

In order to do the repetition maximum (RM) test and perform the training programme, we used the gym that the club put at the disposal of the first squad and the rest of the lower categories. In the study we used specialised "Reebook" resistance training devices: knee extension (quadriceps), knee flexion (harmstring), ankle extension while sitting (triceps surae), adductor and abductor muscles of the hip while sitting (adductor and abductor of the hip).

An Acer Travel Mate 5720 laptop computer with a Window 7 operative system was used for recording and examining the data collected on each date of the test as well as for designing the different training programmes. In addition, the following software was necessary: Microsoft Office 2007, SPSS 1.8.0 and the RealPower 20.40 Test (2008).

## 3.3 PROCEDURE

Permission was granted was the technical coordinator of the lower categories of the Unión Deportiva Salamanca club in order to put the study into practice. Later on, the study was presented to the coaches of the teams involved who were informed about the suitable and ideal functions and obligations for the performance of the experience. Before the beginning of the test, the players handed in an informed agreement document signed by their parents or tutors, which confirms their willingness to take part in the performance of the training programme.

The variables considered in the study are:

Dependent variable: BMI, muscle mass in right and left legs, percentage of fat, speed capacity in 10 and 20 metres and maximum dynamic strength.

Independent variable: the resistance training programme (20 sessions) and football (46 sessions in total).

The first step before carrying out the experimental stage was getting the participants of the EG and CG familiar with the specific strength tasks. Thus, 4 sessions were designed over 3 weeks during which the footballers practised the tasks included in the training programme. The exercise in these sessions was geared towards strength and resistance.

The pre-evaluation test tasks were carried out during the 1$^{st}$ session of the 4$^{th}$ week: each team was divided into two groups in order to enhance the process. The order of performance of the tasks was as follows: record of height, body mass, calculation of body mass index and body composition (muscle mass of legs and percentage of fat); speed test; and RM test. The final evaluation (Post-test) was realised following the implementation of the training programme. The assessment conditions between the EG and CG as well as the initial and final tests were kept stable for the collection of data.

The protocols chosen for the control of the dependent variables were always performed by the same assessor in order to ensure the accuracy of the measurement. The description of the assessment process is as follows:
BMI variable, muscle mass of lower limbs and percentage of fat. In order to ensure the most accurate measurement, the task was performed the same day (Tuesday) and at the same time. The players observed and repeated the following conditions for the analysis: not to drink anything before the test; to have urinated 30 minutes before the test; not to wear any metallic item

(wristwatch, ring, chain, etc.) during the evaluation and to perform the test in underwear.

Speed variable: the players, from a stationary position, run as fast as possible over a distance of between 10 or 20 metres. Two attempts are allowed for each of the distances with enough recovery time between them. The best time obtained in each task will be selected. This task was preceded by a supervised training session of 12 minutes: a continuous race, stretching exercise, articulatory mobility exercises, and multiple movements changing the intensity. Maximum dynamic strength variable: the RM was calculated during the knee extension and flexion exercises. A maximum repetition test may result in injury when applied on young participants (Faigenbaum, Milliken, & Westcott, 2003), so we decided to use the indirect calculus instead through the formula suggested by Brzycki, 1993. The players were paired up. The test was preceded by a warm-up session, during which the player performed 2 series of 12 repetitions with a load similar to the one used during the adaptation period. Subsequently, the assessor adjusted the load asking the participant to perform as many repetitions as possible. In all the cases, they took as reference a strength with which the player would not perform more than 10 repetitions.

### 3.4 TRAINING PROGRAMME

The EG consisting of players from the under-18 team of the Unión Deportiva Salamanca club performed during 10 weeks a football training session and specific resistance exercise at the gym. A training session according to these parameters would represent the 1st stage within the development of strength (González, 2010). In this initial stage, the main goal will be the preparation of the musculoskeletal system so it can withstand highly demanding workloads. The strength enhancement programme consisted of 20 training sessions performed with a frequency of 2 sessions per week (Mondays and Wednesdays). As regards the design of the programme, we relied on the repetition method III (González-Badillo & Gorostiaga, 2002) since the training sessions based on non-maximum loads, not repeated during over maximum number of times, are the most suitable and recommendable for those people who are not specialized in muscular exercise (Pradet, 1999). The repetition method III may be very useful for youngsters and beginners. It reveals the following load components: intensities between 60-75% 1RM; 6-12 repetitions; 3-5 series; recovery between series of 3-5 minutes and average performance speed.

The training exercise consisted of 5 tasks geared towards 5 specific muscle groups: calves, quadriceps, hamstrings, adductors and abductors. The team was organised in two groups of 10 players each for the performance of the session. Each session was supervised by an expert technician who was in charge of running the warm-up session, supervising the performance of the exercises, the performance speed and the use of appropriate weights and of controlling the final part which consisted of exercises aimed at enhancing the abdominal muscles and active muscle elasticity exercises.

On Monday the players who had played the most minutes the previous weekend only carried out the resistance training session. But the non-selected footballers as well as the substitutes carried out the resistance training session and 30 minutes of football practice. On Wednesdays, each group was called at a specific time, during the first 30 minutes of which the players performed the resistance training exercise at the gym followed by 45 minutes of football practice. On Thursdays and Fridays, the training session was carried out on the pitch. That training session was based on general highly tactical activities. The coaches were not allowed to perform specific speed and strength contents.
The CG performed 46 specific football training sessions of 90-120 minutes. This workload is the same as that achieved by the EG. With regards to the design of the training sessions, the tactical contents performed by the EG were taken into account and all the tasks linked to the specific development of speed and strength were left out.

### 3.5 STATISTICAL ANALYSIS

The descriptive statistics (median and standard deviation) of the different varaibles analysed were calculated. With connection to the intragroup analysis, the results obtained from the pre-test and the post-test were contrasted through the T-Student test for related samples. In all the cases, we considered 95% as the confidence interval for the interpretation and analysis. The difference between the findings were highly significant when $p<0,01$ and significant when $p<0,05$.

## 4 RESULTS

The results reveal that the players from the EG, who perform specific resistance exercise at the gym and football practice, have proved successful at significantly improving ($p<0,01$) the maximum dynamic strength of the knee flexors and extensors. That significant improvement in strength is not found in the CG, which consists of players who only carried out the football training session. Although there is a slight improvement in the strength of footballers from the second under-18 team, the comparison between the results obtained from the pre and post-tests in the RM test cannot be considered statistically significant. Table 2 shows the descriptive statistics gathered during the assessment tests for each of the analysed muscle groups. We can also see the p-value found after the comparison of the RM test values through the t-Student test for related samples.

**Table 2.** Descriptive statistics and comparison of medians for the RM values in the EG and CG at the beginning and at the end of the training session.

| Group: | Dependent variable | Pre-Test ($\bar{x}$) | Post-Test ($\bar{x}$) | Sig. |
|---|---|---|---|---|
| EG | RM (Kg) Knee extensor | 112,50 ± 20,40 | 121,67 ± 24,80 | 0,008** |
| | RM (Kg) Knee flexor | 70,26 ± 14,42 | 78,28 ± 17,66 | 0,000** |
| CG | RM (Kg) Knee extensor | 72,18 ± 15,36 | 74,51 ± 15,60 | 0,074 |
| | RM (Kg) Knee flexor | 53,97 ± 53,97 | 54,18 ± 10,48 | 0,783 |

Highly statistically significant difference, $p<0,01$.

In table 3, we can notice the effects of training on the variables associated with the players' body composition. Resistance training paired up with football sessions has not managed to significantly increase ($p<0,05$) the muscle mass of the lower limbs of the footballers from the EG. The lean body tissue mass evolves in the same way in the CG since the improvement of this variable is irrelevant from a statistical perspective.

On the other hand, there is an increase of the BMI in the EG as well as the CG at the end of the training programme. This difference in the comparison of the values obtained in the pre and post-tests is significant in the players who carried out the resistance training and football practice ($p<0,05$) and highly significant in those who only trained by playing football ($p<0,01$). As regards the body fat determined through the TANITA scale, we notice a significant increase ($p<0,01$) in the percentage of the overall body mass which corresponds to the fat tissue in both analysed groups. The increase of the percentage of fat in the EG players is higher than in the CG players who only practised football.

**Table 3.** Descriptive statistics and comparison of medians for the muscle mass values expected in the right and left legs, BMI and % of body fat at the beginning and at the end of the training programme.

| Group: | Dependent variable | Pre-Test ($\bar{x}$) | Post-Test ($\bar{x}$) | Sig. |
|---|---|---|---|---|
| EG | Right leg muscle mass (Kg) | 8,95 ± 1,54 | 8,95 ± 1,52 | 1,000 |
| | Left leg muscle mass (Kg) | 8,63 ± 1,57 | 8,60 ± 1,51 | 0,700 |
| | BMI | 20,93 ± 2,25 | 21,29 ± 2,21 | 0,018* |
| | % Body fat | 15,84 ± 2,70 | 17,10 ± 2,89 | 0,000** |
| CG | Right leg muscle mass (Kg) | 8,10 ± 1,40 | 8,20 ± 1,40 | 0,111 |
| | Left leg muscle mass (Kg) | 7,70 ± 1,30 | 7,74 ± 1,31 | 0,115 |
| | BMI | 19,55 ± 2,32 | 20,00 ± 2,42 | 0,000** |
| | % Body fat | 15,60 ± 2,79 | 16,52 ± 2,58 | 0,000** |

*Statistically significant difference, $p<0,05$. Highly statistically significant difference, $p<0,01$*

The results in the speed tests over 10 and 20 metres show how the resistance training programme slightly succeeds in improving the speed capacity. Neither do the participants who only practised football through highly tactical general activities sufficiently improve in that physical ability. The comparison between the results obtained from the pre and post-tests in each performed test reveals no significant difference ($p<0,05$) in the EG and CG. All these findings can be verified in table 4.

**Table 4.** Descriptive statistics and comparison of medians for the speed values in the 10-20 m tests at the beginning and end of the training programme.

| Group: | Dependent variable | Pre-Test ($\bar{x}$) | Post-Test ($\bar{x}$) | Sig. |
|---|---|---|---|---|
| EG | Speed 10 metres (seconds) | 1,864 ± 0,105 | 1,835 ± 0,113 | 0,434 |
| | Speed 20 metres (seconds) | 3,248 ± 0,203 | 3,170 ± 0,292 | 0,336 |
| CG | Speed 10 metres (seconds) | 1,965 ± 0,086 | 1,951 ± 0,085 | 0,324 |
| | Speed 20 metres (seconds) | 3,433 ± 0,196 | 3,370 ± 0,152 | 0,087 |

## 5 DISCUSSION

Any well-designed training programme involving the use of external loads should be considered as an efficient and safe strategy for the enhancement of the player's strength (Faigenbaum, 2000). A reasonable intensity and load volume combined with a minimum number of training sessions will produce a positive effect on strength values (García- Manso et al., 1996). In our study, the use of intensities of 60% and 70% on the RM recorded in the pre-test, which combined 6-12 repetitions for 3-5 series, has generated some positive impact on the maximum dynamic strength. The same fact was noticed in other studies which used similar load parameters (Faigenbaum et al., 2002; Faigenbaum, Westcott, Loud & Long, 1999; Ingle et al., 2006; Ozmun, Mikesky & Surburg, 1994). Therefore, using average loads with young football players may be sufficient in order to achieve interesting results on resistance (García et al., 2005).

Furthermore, we realise in our study that 2 days of training per week are sufficient to develop the introductory unit to strength, which has been supported by other studies that also achieved improvements on this physical ability using that weekly training frequency with a similar sample (Faigenbaum, Milliken, Moulton & Westcott, 2005; Sadres et al., 2001). It seems that 2 specific sessions per week is the appropriate amount. Increasing the weekly frequency would result in similar consequencies for the development of strength (Mayorga, 2011), and reducing the exercise to one session would minimise the load effect on the strength gain (Faigenbaum et al., 2002).

During puberty, the physiological factors involved in growth are constantly changing so that these structural changes influence growth and physical abilities (Faigenbaum et al., 2009). The training programme needs to have the sufficient length in order for the improvements to be able to combine with the performed exercise. The training programme should last at least 6-8 weeks in order to get the desired effect from the load (Faigenbaum et al., 2002, 1999; Ozmun et al., 1994). Thus, we believe that the improvements of strength achieved by the footballers in our study stem from the 10 weeks' training effect and not only from an evolutionary type of reasons. Moreover, the CG did not achieve any improvement in strength, so we may well claim that the evolution of that ability is not linked to other variables but training.

The EG achieved improvements in the maximum dynamic strength of the knee extensors and flexors as it is described in other studies conducted with athletes in the pubertal (Alvarez-San Emeterio et al., 2011; Gorostiaga et al., 1999; Lillegard, Brown, Wilson, Henderson, & Lewis, 1997) and pre-pubertal (Da Fontoura et al., 2004; Ingle et al., 2006; Sadres et al., 2001) stages. However, football practice alone did not manage to make footballers improve that variable. Therefore, in order to achieve the development of such an interesting ability as strength, training programmes have to be combined with specific stimuli. This type of training is likely to be effective from 14 to 15 years according to the results obtained after the implementation of our programme. Like previous studies (Ozmun et al., 1994; Ramsay et al., 1990), strength gain does not seem to involve a clear enhancement of the muscle mass. This proves that the improvement of maximum strength does not only depend on factors linked to the muscle development, but there are qualitative factors associated with neural function, which are highly responsible for the improvement of that ability when we deal with beginners in the counter-resistance training (Falk & Eliakim, 2003; Häkkinen & Komi, 1983).

The development of a physical ability may lead to the enhancement of others (Pradet, 1999). In this sense some studies have revealed, in samples with similar ages as ours, a good transfer of training with external load to the speed exercise over 30 metres (Christou et al., 2006; Lillegard et al., 1997). However, the results in this study show that there is no correspondence between strength improvement and the time performance in the 10 and 20-metre races. Although intramuscular coordination may be improved with the performance of the suggested exercises, the findings reveal that the interaction between the different muscle groups involved in a sport activity has not been optimised. Hence, we believe that resistance training in the gym need to be accompanied by other strategies that may subsequently improve physical and coordinative conditions of sport. Some studies suggest that the inclusion of plyometric exercises may enable the transfer of strength gains to the race (Faigenbaum et al., 2007). Furthermore, in disciplines like football, physical abilities and technical moves need to be combined with the defining tactical context.

The negative response of the EG with regards to speed may also be caused by the increased percentage of fat mass found in the players who took part in the resistance training. In our study the players participating in the resistance training programme have increased the percentage of fat mass. We think that this response to the training programme undermines the mechanical efficiency and, as such, will negatively influence the movement speed.

This increase of the percentage of fat has not been described in other studies (Westcott, Tolken, & Wessner, 1995). The higher increase in the EG's adiposity with regards to the CG, may be due to the fact that the resistance training and football reduce the aerobic training load since the Monday session and part of the Wednesday training session are dedicated to resistance exercise. As a result of this factor, we are compelled to pay particular attention to diet of our athletes.

## 6 CONCLUSION

According to the findings in our study, we may think that a training programme with external load applied to inexperienced footballers of 14 and 15 years produces an increase in the maximum dynamic strength of the knee extension and flexion muscles. This increase is produced without involving an increase of the muscle mass of the lower limbs. Our resistance training programme does not produce an improvement of acceleration speed over 10 and 20-metre distances. On the other hand, this intervention has increased the percentage of body mass in the participants of the study.

The characteristics of our sample keep us somewhat cautious. We, therefore, do not intend to reach universal conclusions but to shed light on a specific issue and particular context.

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