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Effects of Plyometric Training on Sports Performance in Team Sports: A Literature Review

Efectos del entrenamiento pliométrico en el rendimiento deportivo en deportes de equipo: una revisión de la literatura

Efeitos do Treinamento Pliométrico no Desempenho Esportivo em Esportes Coletivos: Uma Revisão da Literatura

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ABSTRACT

Introduction: Plyometric training is a methodology that has been used for decades, reporting favorable results in different sports disciplines. ***Objective***: Analyze the types of plyometric evaluation and training methodologies most used in the team sports of soccer, basketball and volleyball that are reported in recent literature. ***Methodology***: Seventeen studies met the inclusion criteria; eight in volleyball, six in soccer and three in basketball. ***Results***: Significant effects ($p > 0.05$) were reported in jumping tests Counter Movement Jump, Squat Jump, Abalakov, Drop Jump, as well as speed tests at different distances (15-40 m). The studies report significant effects after 6-8 weeks of training, with two sessions per week. There were no significant differences between men and women. ***Conclusion***: Plyometric training produces improvements in jump height and short-duration speed. It is recommended to carry out studies in which the results obtained can be applied, in addition to being able to combine plyometric training with strength training, or to perform it on different types of floors.

Keywords: plyometric exercise, explosive force, vertical jump, team sports.

RESUMEN

Introducción: El entrenamiento pliométrico es una metodología que se ha utilizado durante décadas, reportando resultados favorables en diferentes disciplinas deportivas. ***Objetivo***: Analizar los tipos de evaluación pliométrica y metodologías de entrenamiento más utilizadas en los deportes colectivos de fútbol, baloncesto y voleibol, reportados en la reciente literatura. ***Metodología***: Diecisiete estudios que cumplieron los criterios de inclusión; ocho en voleibol, seis en fútbol y tres en baloncesto. ***Resultados***: Se reportó efectos significativos ($p > 0.05$) en pruebas de salto Counter Movement Jump (CMJ), Squat Jump, Abalakov, Drop Jump, así como en pruebas de velocidad en diferentes distancias (15-40 m). Los estudios informan de efectos significativos tras 6-8 semanas de entrenamiento, con dos sesiones por semana. No se registraron diferencias significativas entre hombres y mujeres. ***Conclusiones***: El entrenamiento pliométrico produce mejoras en la altura de salto y en la velocidad de corta duración. Se recomienda realizar estudios en los que se puedan aplicar los resultados obtenidos, además de poder combinar el entrenamiento pliométrico con el de fuerza o efectuarlo en diferentes tipos de suelo.

Palabras clave: ejercicio pliométrico, fuerza explosiva, impulso vertical, deportes de equipo.

RESUMO

Introdução: O treinamento pliométrico é uma metodologia utilizada há décadas, com resultados favoráveis em diferentes modalidades esportivas. ***Objetivo***: Analisar os tipos de avaliações e metodologias de treinamento pliométrico mais utilizados nos esportes coletivos de futebol, basquete e vôlei, conforme relatado na literatura recente. ***Metodologia***: Dezessete estudos atenderam aos critérios de inclusão; oito no vôlei, seis no futebol e três no basquete. ***Resultados***: Efeitos significativos ($p > 0.05$) foram relatados nos testes de salto, como o Counter Movement Jump, Squat Jump, Abalakov, Drop Jump, assim como em testes de velocidade em diferentes distâncias (15-40 m). Os estudos reportaram efeitos significativos após 6-8 semanas de treinamento, com duas sessões semanais. Não houve diferenças significativas entre homens e mulheres. ***Conclusão***: O treinamento pliométrico proporciona melhorias na altura do salto e na velocidade de curta duração. Recomenda-se a realização de estudos cujos resultados possam ser aplicados na prática, além da possibilidade de combinar o treinamento pliométrico com o treinamento de força, ou realizá-lo em diferentes tipos de superfícies.

Palavras-chave: exercício pliométrico, força explosiva, salto vertical, esportes coletivos.

Introduction

Team sports each require specific training tailored to their unique needs (Herrera & Moreno, 2014). Training in team sports such as soccer, volleyball or basketball has generated discrepancies as to how it should be structured, in order to obtain better results since they require the ability to perform and repeat the explosive muscle contractions necessary to perform sprints, jumps, turns, changes of pace, kicks or throws (Bangsbo *et al*., 2006), therefore speed and strength play a fundamental role in performance that ultimately impacts collective performance (Barquero-Jiménez *et al*., 2020).

All team sports have high functional and physiological demands (Núñez *et al*., 2016). There are phases of acceleration and deceleration, starts, stops or changes of direction, all intermittently (Santiago *et al*., 2015). To achieve this improvement in power, athletes require a combination of strength and speed, and it is difficult to achieve adequate stimuli to obtain maximum power during competition (Bompa, 2004). It is common to perform sprints, during defensive phases, counterattacks, throws and displacements in most offensive plays, which are characterised by high intensity actions. Collective sports require strength, speed, endurance, flexibility, coordination and balance and varieties formed by their combination, therefore, it is necessary to work on these components in training, so that movements can be precise and energetically efficient, which translates into a better performance of athletes during the game (Lloyd *et al*., 2014).

García-López *et al*. (2003) consider that Professor Rodolfo Margaria in the 1960s was the first to address the relevance of the so-called stretch-shortening cycle (SSC), demonstrating that a concentric contraction preceded by an eccentric contraction could generate higher levels of force than an isolated concentric contraction (Faccioni, 2001). Professor Margaria's contributions were used by the National Aeronautics and Space Administration (N.A.S.A.) to develop an efficient way to walk on the moon (Zanon, 1974). However, Professor Margaria's studies went beyond the N.A.S.A., as some Soviet instructors became interested in the stretch-shortening cycle. Thus, in 1966, Zaciorskij used the work developed by Margaria as a basis for creating a training programme that sought to enhance and exploit the stretch reflex in explosive type actions. It was Zaciorskij who introduced the term plyometrics (Zanon, 1974). On the other hand, in the 1960s, the Soviet jumping coach Yuri Verkhoshansky became interested in exploit the elastic energy accumulated in a muscle after stretching by observing the technique of triple jump athletes, and it was then that Verkhoshansky realised that the best results corresponded to those athletes who spent the shortest time in contact with the

ground in each of the supports. Therefore, for many, Verkhoshansky is the father of plyometrics (García-López *et al*., 2003).

The aim of plyometrics is to decrease the time between the end of the eccentric muscle contraction and the beginning of the concentric contraction. This type of training aims to provide the ability to train specific and biomechanically correct movement patterns, strengthening the muscle, tendon, and ligament in a more functional way (Ruivo *et al*., 2018).

In the meta-analysis conducted by Alfaro-Jiménez *et al*. (2018), the results suggest that plyometric training significantly improves jump height; with increases of between 7.55% and 14.35%. According to Markovic (2007) a change of 5-10% (2-6 cm) can be of great importance for athletes trained in sports involving vertical jumping. Therefore, that plyometric training has significant effects on explosive strength in jumping events.

The literature reviewed agrees with the findings of Sáez de Villareal *et al*. (2009), who investigated the effect of plyometric training on vertical jump height. In the same meta-analysis by Alfaro-Jiménez *et al*. (2018), it was found that women obtain greater benefits from plyometric training on explosive strength compared to men. Also, the work of Flores *et al*. (2015) with female volleyball players and the studies of Spurs *et al*. (2003) report significant increases in the biomechanical variables of jumping (jumping power, height, flight time and jumping speed), when performing a 7-week programme, with a frequency of two sessions per week.

The increase in strength and metabolic health, increases performance and jump height (Ingle *et al*., 2016). Chelly *et al*. (2014) comment that the development of high levels of muscular strength and power in youth football players has become a fundamental process for the improvement of explosiveness. Conversely, a decrease in muscle strength, joint mobility and neuromuscular control modifies the functional behavior of a subject, limiting performance and triggering injuries (Ceroni *et al*., 2012). Efficient strength training and its transfer to sport-specific tasks is a key objective for athletes participating in team sports (Teo *et al*., 2016). In the case of soccer players, an increase in muscle power is associated with increases in jumping ability and speed (Hoyo *et al*.,2016).

Chelly *et al*. (2014) states that plyometrics is one of the most widely used systems to improve muscle strength with a wide range of exercises that employ jumping (Hoyo *et al*., 2016), and has been identified as a transferable component towards muscle power increases (Loturco *et al*., 2015). Therefore, the following research was developed, with the aim of analysing the different types of plyometrics and their evaluation considering team sports: football, basketball and volleyball.

Materials and methods

Review and research plan, in correspondence with Hernández *et al*. (2010) in terms of an approach that uses the collection of background information without being manipulated, to unveil or refine questions in a research process and build a specific conceptual framework. This inquiry has a bibliographic approach (González *et al*., 2013), to deepen the background study that is part of the analysis. Its value lies in an approach that generates a scientific view of different research and articles (Guirao-Goris, 2015). In the review, the critical evaluation of the research is performed (Machi & McEvoy, 2012), which in this case involved a compilation, discrimination, review, and synthesis of the material, which had the attributes, characteristics and methodological elements in line with the object of study. A bibliographic evaluation of their discussions and conclusions was carried out, elaborating with each of them an independent unit based on the collection, organization, and synthesis of relevant information (Roussos, 2011), considering integrative and selective criteria that are framed as descriptive reviews whose characteristics stand out for being conceptual and critical updates for academic purposes and useful specifically in the field of teaching or research (Vera, 2009).

The collection of articles was carried out from January to February 2022, through the keywords: plyometric training, volleyball, basketball, basketball, soccer, explosive strength, jumping, collective sports, in the following Databases and search engines: Google Scholar© WoS© , Scopus©, Pubmed©, Scielo, Dialnet©, Redalyc©, from 2011 to the present, with the aim of relating the effects of plyometric training on physical performance in the sports of basketball, soccer and volleyball.

Secondly, a selection was made of articles in Spanish and English focused on the effect of plyometric training in team sports and that have developed experimental studies between 2011 and 2022, including the key concepts indicated in the search variables and that additionally present antecedents associated with the physical performance of the athletes. Articles that did not consider pre- and post-training studies were excluded and the age criterion was not considered, incorporating all the works regardless of this variable.

Finally, the articles were tabulated by the research team, who reviewed the titles, results, discussions, and conclusions of the studies to carry out the integrative analysis.

Results

The search yielded the following results: WoS©: five research, Scopus©: two research, Scielo©: three research, Redalyc©: two research, Latindex catalogue: five research. 110 articles were reviewed and only 17 met the inclusion criteria, which contained all the necessary elements to analyse the different evaluation methodologies, plyometric training, and the effects on the physical performance of volleyball, football, and basketball players.

The following tables show the results obtained from the analysis of the studies found on plyometric training in the collective sports of volleyball, football, and basketball.

Table 1 includes studies in volleyball players (Véliz *et al*., 2017; Vilela *et al*., 2017-2021; Sánchez-Moreno *et al*., 2018; Flores *et al*., 2015; Ahmadi *et al*., 2021; Izquierdo *et al*., 2015; Pérez, 2012) from Chile, Brazil, Colombia, Spain, and Iran, between the years 2012 to 2021. There are significant effects on explosive strength performance, this translates into better jumping and speed, this shows the work of Sánchez-Moreno *et al*. (2018), Flores (2015), Izquierdo *et al*. (2015) and Ahmadi *et al*. (2021). There were studies where no significant effects were found or these effects were very slight, for example in Véliz *et al*. (2017) and Vilela *et al*. (2017, 2021).

In terms of methodology, it is observed that measurements of CMJ, Squat Jump and Drop Jump, Abalakov and speed over a short distance of 20 metres are continuously repeated, which demonstrates the reliability of these tests.

In relation to training weeks, these vary between six and eight weeks, in some cases during the first week the adaptation to the training and the type of evaluation of the jumps was carried out, in other cases this adaptation was started on the same day of the training. With two-three sessions per week, so as not to overload the athletes, as the studies were carried out as part of the training or in other cases the plyometric training was extra to the daily training.

It was found that plyometric training produced significant effects, combined or not with strength training.

Most of the studies were conducted in the puberty-adolescence period, from 12 to 18 years, and with young adults from 22 to 24 years. No differences were found in this aspect. The number of studies with females was five and with males three.

Table 1

Summary of studies of the effect of plyometric training in volleyball players.

Author (s)	Country	Year	Sex	Age (years)	No. of Participants	Training Combined	N° Sessions per week	N° Weeks	Control Group	Jumps Evaluation	Results
(Sánchez-Moreno *et al*., 2018)	Spain	2018	M	22.9±3	11	Yes, with strength	2	6 – 6	Yes	*Squat jump* *CMJ*	Significant effects on Squat Jump and Countermovement were reported.
(Izquierdo *et al*., 2015)	Brazil	2015	M	16.86±0.74	148	Yes, strength	2	6	Yes	*Squat Jump* *Countermovement* *Abalakov* *Speed test*	Significant effects on maximal strength as well as jumping ability were reported. These improvements in maximal and explosive strength were maintained for several weeks.
(Véliz *et al*., 2017)	Chile	2017	F	13- 16	12	No	1	1 día	Yes	Countermovement	No significant effects were found.
(Ahmadi *et al*., 2021)	Iran	2021	F	23.5± 2.8 22.7± 2.6	17	No	2	8	No	Countermovement Squat Jump Drop Jump 20 mts. speed	Significant effects were found after plyometric training on sandy ground.
(Vilela *et al*., 2021)	Brazil	2021	F	12.18±1.27	78	No	3	8	Yes	*Squat Jump* *Countermovement* *Abalakov* *Drop Jump*	No significant differences were reported, only small changes.
(Vilela *et al*., 2017)	Brazil	2017	F	12.18±1.27	72	No	3	8	Yes	*Squat Jump* *Countermovement* *Drop Jump* *Elasticity index*	No significant effects were reported after training.
(Flores *et al*., 2015)	Chile	2015	F	15±0.7	9	No	1	7	Yes	Squat Jump CMJ Abalakov	Significant effects were reported after the training period. In Squat Jump jumps, Abalakov Countermovement.
(Pérez, 2012)	Colombia	2012	M	14-16		No	3	6	Yes	Countermovement Abalakov Squat Jump	Significant effects on Abalakov and Countermovement were reported.

Table 2 shows studies on football players (Baraona *et al*., 2019; Beato *et al*., 2018; Haro & Cerón, 2019; Hernández & García, 2012; Ramírez-Campillo *et al*., 2015-2018) from Chile, Spain, Cuba, and the United Kingdom. They report results with significant effects like those of Baraona *et al*. (2019); Beato *et al*. (2018); Haro & Cerón, (2019); Hernández & García (2012); Ramírez-Campillo *et al*. (2015) and not statistically significant like Ramírez-Campillo *et al*. (2018).

Training weeks vary between six and eight, number of sessions per week is two. In measurements and pre-post training, measurements of countermovement, Squat jump, and Drop Jump, Abalakov and speed over short distances of 10 to 40 m are performed. In addition, the Sargent test and jumps with load are used.

In football players, studies by Haro & Cerón (2019) and Hernández (2012) combine plyometrics with strength and HIIT, which could have a greater effect on the athlete's performance.

Most studies included adolescents aged 13 to 17 years, with only a study that included adult women aged 21 to 22 years. No major differences were found between males and females in the number of studies (3 and 3), nor in the effects of plyometric training, nor in the jumps performed in the evaluation and during training were similar.

Table 3 presents studies by Fernández *et al*. (2020); Delgado *et al*. (2011) and Sánchez *et al*. (2021) from Chile and Spain. They recorded significant effects, which would confirm the effectiveness of plyometric training in basketball players.

The number of weeks of training was six to eight, with two sessions. Coinciding with the other sports studied. The evaluation and training tests are Squat Jump, Counter movement Jump and Abalakov. And only the study by Sánchez *et al*. (2021) combined strength.

One study with women, one with men and one mixed study were reported. Similar assessment jumps were used in all of them. The age of these athletes ranged from 15 to 25 years.

Table 2

Summary of the study of the effect of plyometric training on football players.

Author(s)	Country	Year	Sex	Age	No. of Participants Training	Combined	N° Sessions per week	Weeks	Control Group	Evaluation Jumps	Results
(Beato *et al*., 2018)	United Kingdom	2017	M	17.6±0.8	21	No	2	6	No	Horizontal jump Speed	Significant post plyometric training improvements in jumping speed and power were reported.
(Haro& Cerón, 2019)	Cuba	2019	F	No indica	18	Yes, strength	2	8	Yes	Squat Jump Speed 40 metres. Jump over box.	Significant post plyometric training improvements in jumping speed and power were reported.
(Hernández & García 2012)	Spain	2021	M	17.29±0.791	40	Yes, strength	2	8	Yes	Loaded jumps Jumps to the bench 40 and 50 cm.	Significant effects were reported in the experimental group post plyometric training.
(Barahona *et al*., 2019)	Chile	2019	F	14.3±0.7	24	Yes, Hiit	2	8	Yes	Sargent Test	Significant effects were reported following plyometric training combined with Hiit.
(Ramírez-Campillo *et al*.,2015)	Chile	2015	F	13.06±2.3	24	No	2	6	Yes	*Countermovement Drop Jump Speed 10 mts.*	Significant effects on jumping were reported.
(Ramirez-Campillo *et al*., 2018)	Chile	2018	M	21.4±3.2	23	No	2	8	Yes	Countermovement Drop Jump 20 Speed	No significant post plyometric training effects were reported.

Table 3

Summary of the study of the effect of plyometric training in basketball players.

Author(s)	Country	Year	Sex	Age	No. of Participants Training	Combined	N° Sessions Per week	Weeks	Control Group	Evaluation Jumps	Results
(Fernández *et al*., 2020)	Brazil	2020	M and F	15.83 ±0.75 14.45 ±0.69	39	No	2	6	Yes	Squat jump Countermovement	Significant improvements were reported post plyometric training. In both CMJ and SJ.
(Sánchez *et al*., 2021)	Spain	2021	F	23.00 ±2.94	36	Combined with strength	2	6	Yes	Countermovement	Significant effects on post plyometric performance combined with strength training were reported.
(Delgado *et al*., 2011)	Chile	2011	M	22.7 ± 2.9	14	No	2	8	Yes	Squat Jump Countermovement Abalakov	Significant post plyometric training effects were reported only in Jumping vs. movement.

Discussion

With respect to the effects of plyometrics, both significant and non-significant effects were found. In volleyball significant effects were recorded in; Ahmadi *et al*. (2021); Flores *et al*. (2015); Izquierdo *et al*. (2015); Pérez, 2012; Sánchez-Moreno *et al*. (2018) and non-significant, such as Vilela *et al*., (2017-2021) and Véliz *et al*. (2017). In the case of football, we find significant effects in Beato *et al*. (2018); Barahona *et al*. (2019); Haro & Cerón (2019); Hernández & García (2012) and Ramírez-Campillo *et al*., (2015) and non-significant such as Ramírez-Campillo *et al*. (2018). In the case of basketball, only studies with significant post plyometric training effects were found (Delgado *et al*. 2011; Fernández *et al*. 2020 and Sánchez *et al*. (2021).

Markovic (2010) points out that plyometrics is a method that has solid scientific support that uses jumping exercises in the muscle action of the stretch-shortening cycle (SSC) and represents an improvement in the ability of the neural and musculotendinous systems to produce force in a limited time frame (Wang and Zhang, 2016).

Exercises with rebounding show neuromuscular activation, greater strength and power (double the increase in eccentric muscle activity) than exercises without rebounding (Jarvis *et al*., 2016). According to Markovic (2010) eccentric muscle activations are paramount during SSC, and this mechanism is a key component during football specific actions such as changes of direction, sprints and sprinting activities.

In the review conducted, most of the studies with football players recorded an amount of 8 weeks of training with two sessions per week, which agrees with Sáez de Villareal *et al*. (2009) who mentions that if a moderate frequency and volume of plyometric training is used (two days per week), a similar stimulus is generated as training with a high volume and frequency (four days per week). Moderate training has been found to be slightly more efficient than high volume and frequency training (Yiannis, 2014).

In volleyball players, football players and basketball players, there was a history of studies that reported studies with and without significant effects, both in plyometric training combined with strength, as well as in plyometric training without combining plyometric training. This coincides with the studies by Sáez de Villareal *et al*. (2009) and the meta-analysis conducted by Alfaro *et al*. (2018) both of which show that there are no differences between applying plyometric training in isolation or combining it with other training (strength, sprint, HIIT) to improve jump height. According to Markovic (2010)) improvements in jumping performance can be attributed to factors such as

improved motor unit recruitment, increased intermuscular coordination or improved neural drive to agonist muscles.

Four studies were reported with significant post-training effects and three studies with no significant effects, these results are compared by Izquierdo *et al*. (2015) in his research with team sports, specifically volleyball. The quantitative results are those that have the greatest impact with respect to other sports since work with overloads and plyometrics is a constant in regular training to preserve and improve jumping ability (Stanganelli *et al*., 2008). Another study, with the combination of plyometrics and speed training reported significant results in CMJ and Abalakov (Idrizovic *et al*., 2018). In terms of the number of weeks of training the studies reported varying numbers of weeks, with six or eight being the most recurrent with two sessions per week. This is in line with studies that have reported positive effects on both jumping and explosive strength following the application of plyometric training with varying numbers of weeks (Berton *et al*., 2018). Another work that conducted six weeks of plyometric training in water with female volleyball players, reported significant improvements in jumping (Mckay *et al*., 2005), where it was observed that training in water can help in injury prevention and adaptation of young players (Mckay *et al*., 2005).

Regarding the jumps evaluated, specifically Countermovement, Abalakov and Squat Jump, pre and post measurements were performed, and no significant effects were reported, which coincides with García-López *et al*. (2005) where no important results were reported after four weeks of training. This could be due to the short duration of the programme applied, in comparison with the programmes cited in the literature, which did produce significant increases in the assessments. In the case of the Drop Jump, the results are also varied as in the case of Wilson *et al*. (1993), who compared the results of a traditional training programme with high loads (80-90% of maximum), a power programme with low loads (30% of maximum) and high execution speed, the latter being the one that induced the greatest improvements. It should be noted that in this research, the plyometric training group, within the jumping test, only obtained a significant increase in the CMJ. The authors attribute this to the effect of plyometric training in improving the use of elastic and neurological factors. Unlike the studies reviewed that did obtain significant effects, such as those of Sánchez-Moreno *et al*. (2018); Izquierdo *et al*. (2015); Ahmadi *et al*. (2021) and Flores *et al*., 2015, which showed improvements in CMJ, DJ and SJ post plyometric training. This implies that for plyometric training to be significant, a more varied training methodology is required, involving adequate volume, frequency, intensity, and recovery.

In soccer, training exercises should be like what happens on the playing field (Zamparo *et al*.,2014). According to Bangsbo *et al*. (2006) soccer players perform several changes of direction, sprints and power activities during a match involving decelerations, re-accelerations and constant adjustments of step distance, which is one of the most important skills to be considered in this sport (Beato *et al*., 2018).

Regarding the studies in football, five investigations were reported with significant effects, and only one without significant effects, the protocols proposed in most of the studies presented used a training frequency of eight weeks with two training sessions per week. This seems to be a sufficient stimulus to improve power parameters in young players (Beato *et al*., 2018).

No differences were found between men and women. This could show a possible potential of the selected method to improve capacities such as speed and specific strength in female sex, an aspect evidenced by Meylan & Malalesta (2009), where eight weeks of plyometric training in girls improved performance parameters, an aspect also demonstrated by Diallo *et al*. (2001) where strength-speed trained by plyometry, showed improvements in children. Besides, in strength and motor agility capacity in adolescents with short-term plyometric training, the study of Thomas *et al*. (2009) showed improvements in vertical jump and agility time. In women, the results are also significant, demonstrating that plyometrics is useful in both sexes to improve physical performance. Sáez (2004) explains that muscular strength is one of the relevant variables in relation to jumping ability, and that it is directly related to speed and power.

Regarding plyometric training combined with HIIT performed by Barahona *et al*. (2019), effects were reported in the Sargent test after eight weeks of training, two sessions each. This compares with the study by Chelly *et al*. (2010) who after eight weeks of plyometric training, showed significant increase in jump height in Squat Jump and Countermovement jump tests. Other studies, such as that of Chelly *et al*. (2014), where the plyometric method has been used to obtain a significant increase in sprinters, soccer players, basketball players, handball players and gymnasts, plyometrics contributed to improving jump height and peak power However, these investigations did not use HIIT-based training to increase muscle power. This may explain the paucity of scientific evidence on the combination of plyometric training with HIIT. Thanks to the results obtained by Barahona *et al*. (2019), HIIT-based plyometric training has been demonstrated to be an effective tool to increase jump height and peak power in U-17 adolescent soccer players. A correct use of this training would allow to obtain higher levels of sports performance, mainly because HIIT added to explosive exercises could improve power

and some factors related to fatigue It is not clear why HIIT adding factors related to fatigue could explain the lack of evidence of that matter (Brocherie *et al*., 2015).

The review recorded the efficacy of plyometric training in improving the physical and athletic performance of basketball players, more specifically in the SJ, CMJ and AJ. In Sanchez *et al*. (2021) combined plyometrics with strength training, effects on CMJ and SJ were recorded, as well as in previous research increases in vertical jump performance have been observed. However, information on the mechanism impacting this increase is required (Perez-Gomez & Calbert, 2013). In the study by Sanchez *et al*. (2021) the increase in jumping performance after plyometric training were accompanied by decreases in applied force values. The results suggest that training without resistance can generate improvements in vertical speed. In the studies analysed, both the groups that only performed plyometric training and those that combined plyometric training with strength training experienced an increase in their performance (Perez-Gomez & Calbert, 2013).

McCormick *et al*. (2016) tested plyometric training efficacy for CMJ among female basketball athletes. The athletes were divided into two groups. One received plyometric training in frontal plane and the other in sagittal plane. Both groups improved their performance, but the sagittal plane group showed significant improvement in CMJ. In men, the effects of a six-week plyometric training on vertical jump in basketball athletes were investigated. These were divided into two groups, with the experimental group obtaining improvements over the control group (Asadi & Arazi, 2012).

In Delgado *et al*. (2011), it was observed that the experimental group improved jump height in the three tests, and in reactivity, although these improvements did not reach statistical significance for SJ, AJ and reactivity. The CMJ presented significant values. García-López *et al*. (2003) suggest that the test most sensitive to the adaptations induced by plyometric training is the countermovement.

In basketball, Abdelkrim *et al*. (2007) comment that, due to its specificity, it can contribute to improve vertical jump performance. It is believed that the improvement of the stretch-shortening cycle is a factor that can explain the significant improvements in vertical jump performance. According to Markovic & Mikulic (2010), the development of this cycle involves better utilization of the elastic components of the muscles and proprioceptive reflex stimuli, resulting in several neuromuscular adaptations directly associated with vertical jumping.

Conclusions

The results suggest that plyometric training, as shown in many of the studies analysed, is beneficial in improving the athletic performance of basketball, volleyball and soccer players with respect to jumping, strength, speed and explosive strength variables. 13 studies reported significant effects v/s four studies that showed an improvement in performance, but without reaching statistical significance. It can be concluded that an organized and planned plyometric training can improve the sports performance of basketball players. Soccer players and volleyball players.

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