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The Football Players on Plyometric Exercise: A Systematic Review
Entrenamiento pliométrico en jugadores de fútbol: Una Revisión Sistemática

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Abstract. Achieving peak performance in sports necessitates athletes having a high level of physical fitness. Among the key physical components, both overall fitness and movement fitness play significant roles in competitive sports, particularly those involving muscles. Football, a globally popular sport, demands explosive movements like kicking, tackling, jumping, sprinting, and rapid changes in direction. Training effectiveness is crucial for attaining success in football matches. This paper focuses on investigating studies that utilize plyometric training to enhance football performance. In order to search for articles, using the keywords plyometric training, physical fitness, performance football by using database from Google Scholar, PubMed Central, and Science Direct. 13 articles were obtained and analyzed from 2013 to 2022. Search results were arranged based on the format of P (Population), I (Intervention), C (Comparison), O (Outcome). A review of 13 articles concluded that there was an improved level of agility, speed, strength, explosive power, physical fitness, aerobic endurance, acceleration power, on the physical performance of football players. The goals and demands of each training session must be adapted through plyometric training, and each exercise can then be performed regularly to reduce the possibility of injury. Based on the results of the review, plyometric training has been extensively studied to understand its impact on football players. The training program, lasting 6-10 weeks with 2-3 sessions per week, can enhance physical performance by increasing explosive lower body strength, specific physical abilities, and endurance. Plyometric exercises come in different intensity levels, such as low, moderate, and high, and positively affect leg strength, explosive speed, power, aerobic capacity, body composition, flexibility, and muscle endurance in elite athletes and can be customized to target specific goals like speed or strength enhancement, benefiting football players.
Keywords: Athlete; Performance; Football; Plyometric Training.

Resumen. Para alcanzar el máximo rendimiento en el ámbito deportivo es necesario que los participantes desarrollen un alto nivel de condición física. Entre los aspectos claves de la condición física, se encuentra tanto el nivel físico como la eficacia del movimiento, especialmente en aquellos deportes de alta demanda muscular. En el caso del fútbol, uno de los deportes más practicados, la exigencia de movimientos explosivos es máxima: tiro a puerta, acciones defensivas, saltos, carreras y cambios de dirección a la máxima velocidad. La efectividad del entrenamiento, por tanto, se vuelve crucial para poder alcanzar el éxito en dicho deporte. Este artículo presenta una revision sistemática de estudios que han utilizado el entrenamiento pliométrico para mejorar el rendimiento en el fútbol. Para la búsqueda y selección de artículos, se emplearon las palabras clave entrenamiento pliométrico, aptitud física y fútbol de alto rendimiento utilizando la base de datos de Google Scholar, PubMed Central y Science Direct. Se obtuvieron y analizaron 13 artículos desde 2013 hasta 2022. Los resultados de la búsqueda se ordenaron según el formato de P (Población), I (Intervención), C (Comparación), R (Resultado). La revisión concluyó que hubo una mejora en el nivel de agilidad, velocidad, fuerza, potencia explosiva, aptitud física, resistencia aeróbica y potencia anaeróbica en el rendimiento físico de los jugadores de fútbol. Los objetivos y cargas de cada sesión de entrenamiento deben adaptarse a través del entrenamiento pliométrico, manteniendo dicho trabajo con regularidad para reducir el riesgo de lesiones. Según los resultados analizados en la presente revisión, un programa de entrenamiento pliométrico, con una duración de 6 a 10 semanas con 2 a 3 sesiones por semana, puede mejorar el rendimiento físico al aumentar la fuerza explosiva del tren inferior de los jugadores, sus habilidades físicas específicas y la resistencia. Los ejercicios pliométricos se categorizan según niveles de intensidad, como bajo, moderado y alto, y afectan positivamente la fuerza de tren inferior, la velocidad explosiva, la potencia, la capacidad aeróbica, la composición corporal, la flexibilidad y la resistencia muscular en jugadores de élite y pueden personalizarse para objetivos específicos como la mejora de la velocidad o la fuerza.
Palabras clave: Entrenamiento; Fuerza; Futbolistas; Fútbol; Pliometría.

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Introduction

Football holds a prominent position as one of the most universally acclaimed sports worldwide. This is especially true in Indonesia, where football is played on a grass field by two opposing teams, each comprising eleven players. The primary objective is to score goals by placing the ball into the opponent's net while simultaneously defending one's own goal against the opponent's offensive maneuvers (León, Castiblanco, Mosquera, Quecán, & Patiño, 2022). To become an expert in football and achieve optimal results, it is essential to master the fundamental techniques of the sport (Suryadi et al., 2023). These basic techniques encompass effective and efficient movement tasks that every player must excel in. These movements represent specific actions performed by individuals to attain their objectives within the realm of football. The intricacy of football skills, including shooting, dribbling, heading, ball handling, throwing, and catching, necessitates the execution of complex natural human movements (Khasanah & Hariyoko, 2023). These movements demand physical such as strength, speed, power, endurance, flexibility, and coordination (Martinez, Mira, Cuestas, Pérez, & Alcaraz, 2017). The complexity of the movements in carrying out all the basic techniques of football is most dominantly supported by foot movements (Chomani et al., 2021).

Movement in the feet is produced by a combination of active locomotor and passive locomotor, namely muscles and bones (Falces-Prieto et al., 2021). Therefore, in the game of football, physical elements are needed, namely strength and speed or explosive power from the work of muscles and bones, so that running, jumping and kicking movements can be more optimal (Peña-brito, Delgado, Soto, Coronel-rosero, & Andrade, 2023).

The fundamental problem in national football of Indonesia is the lack of attention to coach grassroots level (Ihsan et al., 2022). The coach can select talented players and provide effective coaching, the desired achievements in football can be realized. Additionally, when coupled with other factors such as adequate facilities, infrastructure, sufficient financial support, and sound management, success becomes more attainable. The quality of football at the elite level is significantly influenced by successful coaching, especially when it comes to appropriate training for grassroots and youth players (Reilly et al., 2000). There are various training methods aimed at enhancing speed and power, and coaches from many countries are constantly striving to achieve the best results. One of the widely adopted methods for improving speed and power development in football is plyometric training (Bedoya et al., 2015; Meylan et al., 2009; Sa'ez de Villareal et al., 2015) 11. 16]. Plyometric exercises have received much attention to date by researchers attempting to study their effectiveness in improving various aspects of physical conditioning of players especially in football (Szymanek et al. 2006).

However, until recently, there have been limited reviews attempting to synthesize the results of studies focusing on the impact of plyometric exercises on the physical performance of football players (Imlellizzery et al., 2006). In competitive sports like football, achieving better match results typically hinges on a training process capable of enhancing the athlete's physical, mental, and technical readiness. Preparing athletes physically is essential for them to compete at their peak condition (González-Agüero et al., 2014).

Components of physical conditioning, such as jumping, agility, and speed performance tests, are commonly employed by researchers to assess the outcomes of plyometric training (Chelly, Hermassi, & Shephard, 2015). While plyometric training is believed to be effective in improving athletes' performance, it necessitates coaches to possess sufficient knowledge, including understanding protocols, procedures, and the characteristics of the athletes they are training (Riemann, Hipko, Johnson, Murphy, & Davies, 2019).

Other research mentions that plyometric training is not a new method of exercise, some research literature mentions the benefit of plyometric exercise on the physical demand of athletes (Peitz, Behringer, & Granacher, 2018). However, differences in plyometric training and exercise protocols have various impacts on physical conditions, so it is considered crucial to obtain in-depth information from plyometric exercises based on the findings of previous researchers (Slimani, Chamari, Miarka, Del Vecchio, & Chéour, 2016). Plyometric training has long been used in training programs for athletes who need power in sporting events aimed at increasing explosive force (Padrón-Cabo, Lorenzo-Martínez, Pérez-Ferreirós, Costa, & Rey, 2021).

Furthermore, plyometric training holds significant importance as it constitutes an integral component of a competitive sports training program (Ampillo & Ristian, 2014). However, despite the theoretical foundation outlined above, several studies have suggested that plyometric exercises may have a minimal significant impact on increasing jumping performance. This outcome could be attributed to the relatively short exercise duration (6 weeks), which may not provide sufficient time for athletes to adapt to the plyometric training process (Al Attar, Bakhsh, Khaledi, Ghulam, & Sanders, 2022). Moreover, the lack of prior training experience could contribute to the limited performance improvement following plyometric training, given the demanding nature of physical conditioning requirements (Ling, Cepeda, Marom, Jivanelli, & Marx, 2020). Typically employed to enhance vertical jump ability and overall physical prowess in fundamental categories of football, plyometric training is widely utilized (Fonseca et al., 2023). The implementation of an adequate plyometric training program, such as jump height-focused training, may lead to increased vertical and overall physical performance among football players (Chaabene et al., 2021).

The aim and importance of the study for this research is to investigate the impact of plyometric training on football players, with a focus on improving their physical performance. This study is important because it can provide deeper insight into the benefits and effectiveness of plyometric training in improving football players' abilities, which can be useful for coaches, players and practitioners in the field of sports.

Methods

The preparation of this article was carried out by analysis using the literature review method. A systematic and comprehensive strategy was employed by searching of research result from databases, were searched combining the search terms: "plyometric training", "physical fitness", "performance", "football". The databases used are ScienceDirect, PubMed, and Google Scholar. The inclusion criteria in this study were articles that discussed plyometric training, physical fitness, performance, and football. The exclusion criteria adopted in this review study were articles published in the last ten years (2012-2022). This study consisted of male and female football players. Participants in this study ranged in age from 10 to 50 years. All research subjects actively participated in regular football practice activities. Our participants came from various levels of the game, including beginners, amateurs and semi-professional players.

Table 1.
Inclusion criteria according to the abbreviation PICO

PICO Indicator	Results according to PICO
Design	Clinical trials, RCT
Population	Players Football (Male and Women)
Intervention	Plyometrics (all forms of plyometrics)
Comparisons	The control group received no treatment, the experimental group received plyometric training
Outcome	Effectiveness of plyometric training on the physical performance of football players

Results

The search results for articles through the databases employed in this literature review areas are given in the following Table 2.

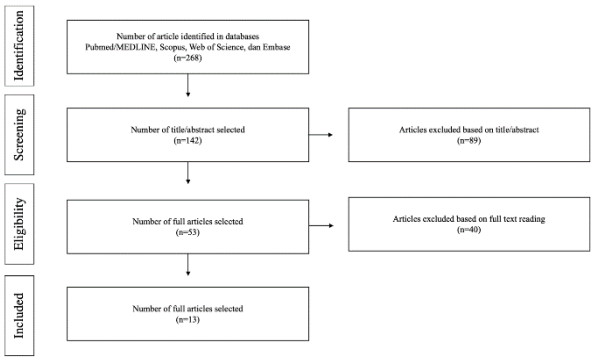

Figure 1. Flow chart of studies included in a systematic review

Table 2.
Literature Search Results

Source	Design	Sample	Types of Plyometric Exercises	Results
(Bal, Singh, Dhesi, & Singh, 2012)	Randomized controled trials	22,02 years old	The workout routine consists of ankle hops with low intensity, a standing jump followed by reaching, hopping over cones in the front and diagonally, moderate-intensity lateral jumps over barriers, hops using both legs, a standing long jump combined with a lateral sprint, as well as high-intensity bounding and lateral jumps performed on a single leg.	Plyometric training significantly improves physical fitness components (aerobic capacity, body composition, flexibility). Plyometric training is recommended to improve and maintain a jumper's physical fitness
(Elsayed, et al. 2012)	Randomized controled trials	17.49 years old	The exercises of moderate intensity consist of ankle hops, standing jump with reaching, hopping over cones, and stair exercises at a height range of 40-50 cm. While the high-intensity exercises include divided box and hurdle exercises, powerful double leg hops with sudden stops, exercises involving falling from different heights, stair exercises at a height range of 50-60 cm, and further divided box and hurdle exercises.	8 weeks of plyometric training improves physical abilities. Plymoteric training is recommended at the end of the preparation stage before the season
(Rodrigo Ramirez at al, 2014)	The experiment study	10 - 16 years old	The measured variables include countermovement jump (CMJ), reactive strength index at 20 milliseconds (RSI20), reactive strength index at 40 milliseconds (RSI40), 5-meter multiple bound (MB5), time taken for the Illinois agility test, modified King-Devick test (MKD), and performance in a 2.4-kilometer time trial.	The control group (CG) did not show any notable improvements. Incorporating a comprehensive vertical plyometric program during regular football training sessions can replace football-specific drills and enhance explosive movements and endurance. However, it is important to include horizontal exercises as well to improve sprinting performance.
(Manescu Claudin, 2014)	Examine scientific literature to analyze experimental studies, mathematical statistical methods, and graphical techniques utilized in the research.	10 – 12 years old	The exercises included in the training regimen were squat jumps, long jumps, isometric holds, triple jumps performed on both legs, abdominal exercises, and squats.	Implementing plyometric exercise programs for strength enhancement in junior players highlights the multifaceted demands placed on the involved muscles. The methods employed to enhance strength capacity through plyometric exercises should be adjusted according to the specific goals and requirements of each training session
(Ramírez Campillo dkk. 2014)	Randomized controled trials	22,1 years old	For high-intensity training, the TG group performed a total of 60 bounce drop jumps (DJs) per session. This included 2 sets of 10 jumps from a 20 cm box, 2 sets of 10 jumps from a 40 cm box, and 2 sets of jumps from a 60 cm box	Following a six-week plyometric training program characterized by high intensity and moderate volume, enhancements were observed in speed, aerobic endurance, and explosive strength. There were notable improvements in both aerobic endurance and explosive strength.
(Chelly et al., 2015)	Randomized controled trials	14 years old	High intensity: Hurdle and depth jumping.	Significant jump performance and running speed
(Ostiak et al,, 2015)	Non- randomized studies	18,07 years old	Intense level: A brief and highly intense plyometric program consisted of exercises such as squat jumps, countermovement jumps, horizontal jumps, standing long jumps, and standing triple jumps.	A brief plymoteric training program significantly improves explosive power performance of the limbs (vertical and horizontal). The increase is higher in vertical jumps than horizontal ones. This plyometric exercise too increase the

				speed of running a distance of 20 meters
(Papadakis et al., 2015)	Randomized controled trials	28,7 years old	High intensity: Weighted static jumps (SJ) and countermovement jumps (CMJ) were performed using both heavy and light loads.	To enhance plyometric training effectively, the optimal approach is to elevate the number of sets.
(Chelly et all, 2015)	Experiment study	19 years old	Countermovemnt jump, Squat jump, ,	Incorporating biweekly plyometric training, which included customized hurdle and depth jumps, resulted in notable enhancements in key aspects of athletic performance among junior football players, compared to the standard in-season training
(Shahnaz Hasan et al, 2017)	Randomized controled trials	20,48 years old	Bounding, hurdling, drop jumping	In a brief training period, both Resisted Sprint Training (RST) and Plyometric Training (PT) demonstrated equal effectiveness in improving the neuromechanical capabilities of collegiate football players. No participants reported any negative incidents or complications.
(Agustiyawan et al, 2020)	Experiment study	16 – 18 years old	Cooper Test	The study reveals that engaging in plyometric training for a duration of six weeks yields superior improvements in VO2Max compared to sprint training.
(Muhammad Hazwan, 2020)	Experiments study	19 – 26 years old	Side jump, countermovement jump, double bond leg jump.	This study shows an improvement of 6.12% for speed performance and 2.32% for agility performance after 6 weeks of plyometric training on recreational football player. Coaches and physical trainers can plan 6 weeks with twice a week training session as in this study protocol.
(Thaqi, Berisha, & Hoxha, 2020)	Non- randomized studies.	16 years old	The progressive plyometric training program incorporates a range of bounding drills, repeated box jumps, and depth jumps, gradually increasing in intensity from low to high levels	Participating in plyometric training over a 12-week period results in significant enhancements in strength, acceleration power, and speed.

In this study, the PICO format (Population, Intervention, Comparison, Outcome) was utilized in identifying questions, keywords and searching strategies. The analysis was carried out by grouping the research results, the groupings are shown in the form of a table as depicted below.

In conducting a journal search, the PICO format (Population, Intervention, Comparison, Outcome) was utilized as a strategy in searching journals, and identifying questions, and keywords. The analysis was carried out by grouping the research results, in order to summarize the impact of plyometric training on increasing athletes' physical performance in football.

Discussion

The impact of plyometric training in improving the physical components

Based on the measurement results, it was found that high- volume plyometric training was superior in increasing leg power in elite athletes. In addition, plyometric training with a hard base can increase maximal dynamic strength. In a study conducted by Chelly et al. (2015), it was found that a 10-week high-intensity plyometric training program during the pre-competition phase resulted in enhanced leg power, as evidenced by improvements in squat jump, countermovement jump, drop jump, and multiple 5-bound test. Similarly, Ostiak (2015) conducted a study demonstrating the effectiveness of a brief, high-intensity plyometric training program in increasing explosive leg power of elite athletes through squat jump tests, standing long jumps, standing triple jumps and countermovement jumps. (Thaqi et al., 2020) training by adding plyometric exercises to their training program for 8 weeks is more effective in increasing leg power performance (vertical jump) in young athletes. The increase in speed is caused by an increase in stride frequency due to reduced contact time with the ground. Reported no change in stride length. Intense plyometric training can be recommended in a short time to increase leg power and speed in the race preparation stage (in the study the treatment was given 2 weeks before competition).

Plyometric training designed to increase athletes' speed capacity should include more exercises in the form of vertical rather than horizontal plyometric (Ostiak, 2015). Study (Bal et al., 2012) for 6 weeks, three sessions per week, showed that plyometric training programs can improve physical fitness in the form of aerobic capacity, body composition and flexibility. Aerobic capacity in this study used the 20 meter progressive aerobic cardiovascular endurance run (PACER) test as a measuring tool. While body composition uses skin folds as a measuring tool. To measure flexibility using the trunk lift test. Plyometric training given to elite long jump athletes with an average age of 22 years showed a significant increase in physical fitness parameters. Bal et al. (2012) explained that this significant increase was influenced by the effect of a positive increase in physical and biomechanical functions. This im

provement is the result of an increase in the motor unit,

that polymetric training is the most effective method for increasing physical fitness and power parameters.

The study findings revealed that implementing plyometric exercises with 17-year-old athletes resulted in significant improvements in leg strength and flexibility of the lower back. Furthermore, previous research has indicated that plyometric training can enhance strength endurance. A study conducted by Thaqi et al. (2020), provided plyometric training to athletes aged 16 for 12 weeks consisting of 3 sessions each week. The instrument used to measure endurance is the eurofit test battery which consists of Performing sit-ups for a duration of 30 seconds and push-ups for 30 seconds, plyometric training demonstrated notable improvements in strength endurance, with sit-ups increasing by 40% and push-ups increasing by 45.83%.

The plyometric training protocol for improving jumping performance and speed

Based on the literature review, it was found that most of the plyometric training programs were given for 6 to 8 weeks with a total of 2 to 3 sessions per week. Two studies were given eight weeks of plyometric training (Thaqi et al., 2020). One study administered plyometric training for six weeks (Bal et al., 2012). Two studies administered plyometric training for ten weeks (Chelly et al., 2015) and one study was given plyometric exercises for two weeks (Ostiak, 2015). In plyometric exercises given for 8 and 10 weeks, most of the 6 studies used plyometric exercises with a progressive plyometric training program, i.e. plyometric exercises were given starting from low intensity movements and then increasing to high intensity (Thaqi et al., 2020). Two studies used plyometric exercises with high-intensity plyometric movements (Chelly et al., 2015; Papadakis, Papadakis, & Grandjean, 2015). One study used plyometric exercises with low-medium-high intensity plyometric movements (Bal et al., 2012). The plyometric training program in the study was given 2-3 sessions per week provided that the rest interval between sessions was at least 48 hours. The average training duration ranges from 30-60 minutes. Prior to training, participants warmed up for at least 10-20 minutes. Participants were instructed to perform plyometric movements quickly (minimum contact with the ground) and exert maximum force in each jump.

For high-intensity plyometric exercises, the participants had previous training experience and had experienced regular exercise. Especially in short (2 weeks) high-intensity plyometric training (Ostiak, 2015) athletes are elite athletes who are given plyometric training 2 weeks before competition. In addition, plyometric training was given the day after strength training or speed training. To reduce muscle stiffness and speed up the regeneration process, massage and activities are also given in the swimming pool (Ostiak, 2015). 90 minutes of high- intensity plyometric training consisting of 20 to 30 minutes of warm-up specific jogging, stretching, light jumping, skipping, and sub-maximal acceleration. After that, continued with plyometric exercises for 60 minutes including cooling down (Ostiak, 2015).

Plyometric exercise intensity and volume

Plyometric training volume can be calculated based on the amount of training time, the distance of the jump and the number of jumps/foot contact. The ones compiled by the author use the number of jumps/foot contact as the training volume. The volume of plyometric training provided to improve physical conditioning in the studies collected by the authors can be broadly divided into two. First, plyometric training with decreasing volume and increasing training intensity. Then provide 40-100 jumps each week (Chelly et al., 2015) and with 75-135 jumps (Thaqi et al., 2020). The training volume given in the first exercise has something in common, namely the training volume decreases over time. Meanwhile, the intensity of the exercise movement is getting higher and higher. Likewise, the rest time is getting longer as the intensity of plyometric training increases.

Second, plyometric training with increasing volume and intensity each week. For example, (Bal et al., 2012) used volumes of 80-100-110-100-100-100 per week. Then (Ostiak, 2015)180-200-230-215-231-255 jumps every week. Not unlike (Papadakis et al., 2015) used 180-200-230-215-231-255 jumps each week. High-volume, high-intensity training is provided for experienced elite athletes. It is recommended that these athletes possess prior experience in strength, speed, and plyometric training, with a minimum duration of three months that includes both general and specific preparation. (Ostiak, 2015; Papadakis et al., 2015).

Plyometric Training Effect on Increasing Physical Performance in Football

This research field is still developing today, where this research only provides an initial platform to examine the effect of plyometric training on increasing physical performance. The recommendation that researchers can give is to be able to compare plyometric training with exercises that have the same intensity, and compare each intensity in plyometric training itself. Plyometric training has an effect on improving the physical performance of football athletes, because this exercise has an effect on the components that regulate agility and strength (Pardos-Mainer, Lozano, Torrontegui-Duarte, Cartón-Llorente, & Roso-Moliner, 2021). Dynamic movements that are carried out quickly and repeatedly during exercise continuously activate the lower extremity muscles so that they can increase muscle strength (Pardos-Mainer et al., 2021). Apart from the movements being carried out quickly and repeatedly, this exercise also produces eccentric contractions the muscle group undergoes concentric contractions, leading to an increase in muscular strength.

Engaging in explosive and repetitive movements during muscle strength training can contribute to enhanced acceleration, which, in turn, leads to increased agility. This occurs by utilizing the adaptation of shortening stretch cycles through the neuromuscular system to promote greater leg

muscle strength and agility improvements. In addition to its advantages, plyometric training also has disadvantages that some professional athletes do not use this exercise because it has a high potential for injury (Hasan et al., 2022). Plyometric training is carried out in a short time and requires very strong muscle strength so as to increase neural adaptation, muscle hypertrophy, cell adaptation, muscle endurance and cardiovascular adaptation, so it is important to warm up and cool down so that the body is able to adapt before exercising. core and prevent the body from collapsing (Makhlouf et al., 2018).

Plyometric training can be given to trained or untrained children, youth and adults, however, for children, teaching by qualified trainers is required and adapted to the child's age.

Conclusion

Based on a review of existing research, the authors of this study aim to clarify the impact of plyometric training on football players, including its various exercise variations, protocols, volume, and intensity levels. It is evident that a well-structured plyometric training program holds significant potential for enhancing the physical performance of football players, with the most notable improvements seen in explosive lower extremity strength, particularly in terms of leg power and sprinting speed. Therefore, incorporating plyometric training is essential for improving speed performance. Furthermore, plyometric training may also have a positive impact on specific physical attributes and strength endurance. Commonly employed variations of plyometric exercises encompass movements with varying intensity levels, ranging from low to moderate and high.

The effects of plyometric training on elite athletes are particularly noteworthy, with demonstrable improvements in leg strength. High-intensity plyometric exercises further contribute to enhanced explosive speed and power. Additionally, these exercises are effective in increasing aerobic capacity, optimizing body composition, enhancing flexibility, and boosting muscle endurance. Typically, plyometric training programs span a duration of 6-10 weeks, with 2-3 sessions per week. It is crucial to tailor the training to the athlete's experience and ability while ensuring adequate rest intervals. Plyometric exercises can be adapted to target specific objectives, such as increased speed or strength. In football, these drills prove instrumental in enhancing overall physical performance, including speed, strength, and agility. However, it is imperative to note that these exercises carry a heightened risk of injury, therefore a thorough warm-up and cool-down regimen is essential. Plyometric exercises can be modified to suit different age groups with appropriate adjustments.

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