THE INFLUENCE OF THE PLYOMETRIC TRAINING ON THE LOWER LIMB EXPLOSIVE POWER OF BASKETBALL PLAYERS

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ABSTRACT

Key words: basketball, plyometric training program, lower limb explosive power.

The plyometric training program currently used almost all kinds of sports. Athletes use them to improve their performance in specific movements, such as throws, jumps, starts, etc. Especially basketball is considered a very explosive, dynamic and fast- paced sport in which plyometric training is widely used. For the highest explosive power, two training methods must be recommended: strength and plyometric training. PT is commonly used method for developing of the lower limb explosive power by natural dynamic movements, such as various jump and jumps with counter movement.

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INTRODUCTION

Basketball is a high-intensity contact and team sport, combination of aerobic and anaerobic capacity (Delextrat and Cohen, 2009; Meckell et al., 2009; Metaxas et al., 2009) requiring a lot of jump, sprint, change of direction abilities (Troijan et al., 2017), dribless, turns, screens (Drinkwater J., 2008), demanding technical and tactical skills. The lower limb joints are constantly subjected to physical stress from the technical movements and intense physical interactions during play (Stojanović et al., 2018; Taylor et al., 2017). In basketball is aerobic capacity positively associated with recovery during repeated high-intensity bouts (Castagna et al., 2008; Tomlin and Wenger, 2001). Moreover, the high intensity movements of basketball players are closely related to the development of strength, speed and agility (Castagna et al., 2007; Meckell et al., 2009). During a basketball game, professional players cover about 3500–5000m. Each player performs about 1000, mainly short, activities lasting around 2 seconds (Boone et al., 2013); time motion analysis has shown that these short activities are performed with a different frequency according to the player's position

(Abdelkrim et al., 2007). Explosive strength, speed, take-off power, and agility are abilities that make an important contribution to efficient movement with and without the ball, thus play an important role in basketball technique and tactics (Erculj et al., 2010).

In a basketball game, lower limb explosive power, which is determined by jump height and acceleration during short sprints (Castagna et al., 2007; Ben Abdelkrim et al., 2007; Alemdaroğlu, 2012).

These abilities are essential because a single basketball game includes 50 jumps per player and 10% of the movements during a game are sprints that cover 10–20 meters (Drinkwater et al., 2008) and only 5% of sprints are longer than 4 seconds (Boone et al., 2013). The ability to move quickly and jump as high as possible (when reaching) determines player's performance and the quality of other technical actions that are important in basketball: fast breaks, rapid transitions from defense to offense, jump shots, fighting for the rebound and defense activities (Arede et al., 2021). Consequently, it is astute that practitioners develop methods of enhancing sprint and repeat sprint ability in team sports athletes, like plyometric training.

Plyometric training

Leg muscle power in general, and vertical jump performance in particular, are considered as critical factors for successful athletic performance (Canavan, et al., 2004; Markovic G., 2007). Jumping is also essential during rebounding, shooting or blocking, with means of 35–46 jumps per game in male players (Cherni et al., 2021); Matthew and Delextrat, 2009) and 19–43 jumps in female players (Ziv and Lidor, 2010). During competition, players have to overtake their opponents by being faster and more powerful. Hence, an improvement of speed and acceleration as well as an increases in strength and power are crucial to maximizing basketball performance (Stojanović et al., 2017).

Exist a lot of training methods used for development of vertical jump performance, like explosive-type resistance training (Adams et al., 1992) heavy-resistance training, vibration training and electrostimulation training (Malatesta, 2003). Several training approaches are used by basketball coaches to improve power, speed, balance, and strength attributes (Simenz CJ., 2005). However, plyometric jump training (PT) seems to be particularly common and equally (Slimani et al., 2016) or even more

effective than other training methods (e.g., traditional resistance training). The common incorporation of PT among training practices in basketball1 may be due to its high translatability to game scenarios. For instance, there is a strong reliance on vertical expressions of power when players are defending, shooting, and rebounding (Stojanović et al., 2018; Taylor et al., 2017; Slimani et al., 2016).

Plyometric training refers to performance of stretch-shortening cycle (SSC) movements that involve a high-intensity eccentric contraction immediately after a rapid and powerful concentric contraction (Malisoux et al., 2006). For the lower limb explosive power, PT includes performance of various types of body weight jumping-type exercise, like drop jumps (DJs), countermovement jumps (CMJs), alternate-leg bounding, hopping and other SSC jumping exercises (Fleck et al., 1999). PT is a widely used method to develop explosive strength using natural dynamic movements such as jumping (Zribi et al., 2014; Mackala and Fostiak, 2015; Asade et al., 2017).

Two training methods, strength, and plyometric training are usually recommended in literature to achieve the most powerful explosive strength (Santos and Janeira, 2008).

Strength and plyometric training methods aim to help athletes to jump higher and further, to run faster, throw further and lift heavier weights.

Several studies have indicated that regular participation in strength training and plyometric training programs can improve jumping and sprinting performance and also increase strength, independent of the age and playing level of basketball players (Gonzalo et al., 2016; Asadi et al., 2017).

Plyometric exercises have been shown to be an effective method of improving a number of physical qualities such as strength and jump height (Oxfeldt et al., 2019), running economy (Lum et al., 2019), agility (Villarreal et al., 2008), sprint speed and endurance. The exercises involved in PT are characterised by explosive muscle extension and contraction (Davies et al., 2015). The quick transition from the eccentric to the concentric phase of the movement is known as the stretch–shortening cycle (SSC) (Markovic et al., 2011). In the eccentric pre-activation phase of plyometrics, the Golgi tendon organs are stretched more than in regular strength training which leads to a greater inhibition of their protective function and leads to an

increase in concentric power output (Davies et al., 2015). Thus, PT can improve the mechanical characteristics of the muscle–tendon complex, strengthen the elastic properties of connective tissue and optimise cross-bridge mechanics and motor unit activation (Ramirez et al., 2015). These adaptations are associated with improvements in muscle strength, dynamic stability and neuromuscular control, as well as with an increase in contraction speed and joint stiffness (Markovic et al., 2007; Ramiréz et al., 2022).

TESTING METHODS

Jumping ability is crucial for successful performance of several team sports' fundamental motor skills, in addition to being the most widely used task to improve and indirectly measure lower limb power in multidirectional sports (Dominguéz et al., 2021; Keller et al., 2018; Slimani et al., 2016).

In the literature, there are many protocols to prove or validate the proposed systems. Among the different kind of jumps performed in those protocols, there are jumps with and without countermovement (Rodrigues et al., 2017; Casartelli et al., 2010; Mijailovic et al., 2015; Howard et al., 2014), jumps with and without arm swing (Boukhenous, et al., 2011), drop jumps, single and double leg jump, continuous jumps, squat jumps and loaded squat jumps (García et al., 2015).

With any of these types of jumps, height reached by the user can be analyzed, but the jumps most commonly used in all related work are the countermovement and squat jumps.

Vertical jump (VJ) is one of the most widely used tests to diagnose the explosive force of the lower limbs, which is very important in basketball, is the vertical jump. The vertical jump is one of the most common fundamental motor skills, and in various sports (Suchomel et al., 2016), the capacity to jump higher than an opponent can be advantageous in competition.

Thus, improving the vertical jumping ability of athletes can be an important objective for coaches, as well as strength and conditioning professionals, who often use countermovement jump height to assess athletic performance and physical conditioning.

Given that vertical jumps, as well as other movements in sports, are often performed with time constraints, rapid force production during the propulsion phase of a movement is crucial.

Thus, it is important to regularly assess such characteristics as well as to implement training strategies that may benefit rapid force production (Suchomel et al., 2020).

Picture 1 Vertical jump testing by OptoJump

DISCUSSION

The ability to achieve maximum strength in the shortest period of time is crucial for the performance of several sports, especially basketball. Basketball is an intermittent sport that is characterized by a lot of jumps, changes of speed, and frequent and sudden changes in the intensity of movement at various levels (Abdelkrim et al., 2007). In a basketball game is jumping necessary when players rebounding, shooting or blocking. Average of jumps is 19 - 43 for female basketball players (Ziv and Lidor, 2010). During the competition, players must overtake their opponents by being faster and stronger. Therefore, improving speed and acceleration, as well as increasing power and performance, is key to maximizing basketball performance.

Improving the lower limb explosive power is a widely methods of researchers, coaches and athletes, as the ability to jump higher and be faster than an opponent can be advantageous in team competitions.

Several studies have examined the effectiveness of different training methods on jumping ability. One of the effective training methods is the mentioned plyometric training.

In the creation of the plyometric training, the correct dosage is the basic key to success. The authors' opinions on the length of the training program are different. As the most effective period recorded study Krasňanská- Izáková (2017), which concluded from studies that the plyometric training program should not be shorter than 4 weeks, as confirmed

by Tidow (2016), who found that the development of speed and rapid force is required for at least 4 to 6 weeks.

The results of the applied 12-weeks plyometric program, focused on the development of speed by changing the direction of basketball players of the second top senior category showed that the plyometric program resulted improving the level of speed skills with change of direction without dribbling and with dribbling (Krasňanská, Izáková, 2017).

E.g. Fleck, Kraemer (1997) argue that stretching and shortening cycles are appropriate to improve explosive power, or according to Newton et al. (1996) and Chu (1998) explosive exercises with lighter weights (30-60% 1RM). Ziv and Lidor (2010) study of 26 players of both sexes, contributed to the view that the most effective means of developing the explosive power of the lower limbs is the plyometric method, which is already used by a lot of coaches today. Based on these findings, plyometry will be included in our intervention program to a large extent, which is confirmed by other authors. Craig (2004) according, plyometric exercises use starts, stops and changes of direction in an explosive way, which is also part of the development of agility.

Studies of the authors Slunečka (2012), Hyťha (2009), Dorin (2014), Viša (2016, Kosta (2014), Nedoroščíková (2015 and Kovalčíková (2012) have the same opinion like previous studies. Slunečka (2012), Dorin (2014), Nedoroščíková (2015), Kovalčíková (2012) used 12- weeks plyometric training program of group professional basketball players. Slunečka (2012) confirmed his hypotheses, and players improved their vertical jump by an average of 12.75 cm (best 17 cm, worst 10 cm). Dorin (2014) demonstrated the positive impact of the 12-week program on athletes, who improved their vertical jump by 9.3 cm on average. Nedoroščíková (2015) studied the development of the explosive power of the lower limbs of 14-15 years old female basketball players. Author used 12-week plyometric program, the results of which were not statistically significant. Athletes improved vertical jump on average 2,6 cm. Hyťha (2009) used 15-weeks program, and his program was also successful and the research group achieved positive values averaging 18.75 cm (best 21 cm, worst 16 cm) and Kovalčíková (2012) applied a plyometric program to 16-18 years old basketball players. The players improved jumps on average 5.25 cm in the experimental group, the control group

showed an improvement of only 0.66 cm of 3 months in the competition period. Viša (2016) tested 18-19 years old basketball players for 6 weeks. The group consisted of an experimental and control group of 14 basketball players. While in the control group the jump improved by a whole centimetre, the experimental group recorded a larger average size of up to 6.57 cm. Kosta (2014) used similar training program on 28 respondents in the experimental and control groups. The control group, in which the plyometric training program was not applied, did not show any improvement, while the experimental group achieved an average improvement of 13.08 cm (best 18 cm, worst 10 cm) of vertical jump.

We have seen other significant changes in Kotzamanidis (2006), who points to improved running speeds at 10 m, 20 m, 30 m and vertical jumping through a long-term 10-week plyometric training program. Faigenbaum et al. (2007) conducted a study aimed at improving the rate of change of direction, and found that even after a 6-week plyometric training, the rate of change of direction diagnosed by the Pro Agility Test would improve at the 5% level of statistical significance. Bal et al. (2011) through agility tests on a group of young basketball players confirm method, that also 6- weeks plyometric training program is effective.

Arazi - Asadi (2012) confirm the same theory, that a 6-week training program will suffice to significantly improve the level of speed skills through the plyometric method (at the 5% level of statistical significance). They reached this conclusion based on diagnostics using the 4 x 9 m Shuttle Run Test, T-Test, Illinois Agility Test and 20 m Acceleration Straight Run.

CONCLUSION

All of the study results shows the positive influence of the plyometric training program on the lower limb explosive power. PT shows positive effect on several factors: vertical jumps, speed, changes of direction, strength attributes, etc. However, studies show that a greater increase in lower limb explosive power occurs in players over the age of 16. Another finding was that for a more significant effect of the increase of explosive power, the application of the program is at least lasting 6 weeks and performed 3 times a week.

REFERENCES

1. Abdelkrim N, El Fazaa S, El Ati J. Time-motion analysis and physiological data of elite under-19-year-old basketball players during competition. Br J Sports Med. february 2007;41(2):69–75; discussion 75.
2. Alemdaroğlu U. The relationship between muscle strength, anaerobic performance, agility, sprint ability and vertical jump performance in professional basketball players. J Hum Kinet. march 2012;31:149–58.
3. Arazi H, Asadi A. Effects of high-intensity plyometric training on dynamic balance, agility, vertical jump and sprint performance in young male basketball players. In: Journal of Sport and Health Research; 2012 (1), 35-44.
4. Arede J, Poureghbali S, Freitas T, Fernandes J, Schöllhorn WI, Leite N. The Effect of Differential Repeated Sprint Training on Physical Performance in Female Basketball Players: A Pilot Study. Int J Environ Res Public Health. 30. november 2021;18(23):12616.
5. Asadi A, Ramirez-Campillo R, Meylan C, Nakamura FY, Cañas-Jamett R, Izquierdo M. Effects of volume-based overload plyometric training on maximal-intensity exercise adaptations in young basketball players. J Sports Med Phys Fitness. december 2017;57(12):1557–63.
6. Boone J, Bourgois J. Morphological and physiological profile of elite basketball players in Belgian. Int J Sports Physiol Perform. november 2013;8(6):630–8.
7. Boukhenous S, Attari M. A vertical jumping performance with and without arms swing by using a dynamometric platform. Int Workshop Syst Signal Processing Appl. 2011:17–20. doi: 10.1109/wosspa.2011.5931450.
8. Canavan PK, Vescovi JD. Evaluation of power prediction equations: peak vertical jumping power in women. Med Sci Sports Exerc. september 2004;36(9):1589–93.
9. Casartelli N, Müller R, Maffiuletti NA. Validity and reliability of the Myotest accelerometric system for the assessment of vertical jump height. J Strength Cond Res. november 2010;24(11):3186–93.
10. Castagna C, Manzi V, D'Ottavio S, Annino G, Padua E, Bishop D. Relation between maximal aerobic power and the ability to repeat sprints in young basketball players. J Strength Cond Res. november 2007;21(4):1172–6.

11. Castagna C, Abt G, Manzi V, Annino G, Padua E, D'Ottavio S. Effect of recovery mode on repeated sprint ability in young basketball players. J Strength Cond Res. may 2008;22(3):923–9.
12. Craig, B. W. What is the scientific basis of speed and agility? Strength and Conditioning Journal. 2004. 26(3), 13-14.
13. Delextrat A, Cohen D. Strength, power, speed, and agility of women basketball players according to playing position. J Strength Cond Res. october 2009;23(7):1974–81.
14. Domínguez-Díez M, Castillo D, Raya-González J, Sánchez-Díaz S, Soto-Célix M, Rendo-Urteaga T, et al. Comparison of multidirectional jump performance and lower limb passive range of motion profile between soccer and basketball young players. PLoS One. 07. january 2021;16(1):e0245277.
15. Dorin, T. Vplyv plyometrického tréningu na explozívnu silu dolných končatín futbalistov. Prešovská univerzita. Fakulta športu. Katedra športovej kinantropológie. Prešov. 2014.
16. Drinkwater EJ, Pyne DB, McKenna MJ. Design and interpretation of anthropometric and fitness testing of basketball players. Sports Med. 2008;38(7):565–78.
17. Erčulj F, Blas M, Bračič M. Physical demands on young elite European female basketball players with special reference to speed, agility, explosive strength, and take-off power. J Strength Cond Res. november 2010;24(11):2970–8.
18. Faigenbaum D, Hoffman R,Kang J,Keiper B, Farland E, Ratamess A, Telvin W. Effects of a Short-Term Plyometric and Resistance Training Program on Fitness Performance in Boys Age 12 to 15 Years. In: Journal of Sports Science and Medicine. 2007; 6 (4), 519–525.
19. Fleck, J. S. & Kraemer, J. W. Designing resistance training program. 4th ed. USA: Human Kinetics. 520 p.; 2014. ISBN: 978-0736081702.
20. Fleck SJ. Periodized Strength Training: A Critical Review. The Journal of Strength & Conditioning Research. február 1999;13(1):82–9.
21. García-Ramos A, Štirn I, Padial P, Argüelles-Cienfuegos J, De la Fuente B, Strojnik V, et al. Predicting vertical jump height from bar velocity. J Sports Sci Med. jun 2015;14(2):256–62.
22. Gonzalo-Skok O, Tous-Fajardo J, Arjol-Serrano JL, Suarez-Arrones L, Casajús JA, Mendez-Villanueva A. Improvement of Repeated-Sprint Ability and Horizontal-Jumping Performance in Elite Young Basketball Players With Low-Volume

Repeated-Maximal-Power Training. Int J Sports Physiol Perform. may 2016;11(4):464–73.

23. Hyťha, D. Vliv tréninku Air Alert IV na vertikální výskok streetballera. Masarykova univerzita. Fakulta športovních studií; Katedra univerzitního športu. Brno. CZ. 2009.
24. Chu, D. A. Jumping into plyometrics. 2nd ed. USA: Human Kinetics. 177 p. 1998. ISBN 0-88011-846-6.
25. Keller S, Koob A, Corak D, von Schöning V, Born DP. How to Improve Change-of-Direction Speed in Junior Team Sport Athletes-Horizontal, Vertical, Maximal, or Explosive Strength Training? J Strength Cond Res. February 2020;34(2):473–82.
26. Kotzamanidis C. Effect of Plyometric Training on Running Performance and Vertical Jumping in Prepubertal Boys. In: The Journal of Strength and Conditioning Research. 2006; 20 (2), 441–445.
27. Kosta, V. Efektivita tréninkového programu Air Alert IV v tréninku mládeže ve volejbalu. Masarykova univerzita. Fakulta športovních studií; Katedra univerzitního športu. Brno. CZ. 2014.
28. Kovalčíková, I. Vplyv plyometrickej metódy na výbušnú silu dolných končatín 16-18 ročných basketbalistiek. Prešovská univerzita. Fakulta športu. Katedra športovej edukológie. Prešov. 2012.
29. Krasňanská Ľ., Izáková A. Vplyv plyometrického tréningu na rozvoj rýchlosti so zmenou smeru v basketbale žien. In Kondičný tréning v roku 2017 : recenzovaný zborník z medzinárodnej vedeckej konferencie, 23.-24.11.2017 v Banskej Bystrici 1. vyd. - Banská Bystrica : Slovenská asociácia kondičných trénerov, 2017. - ISBN 978-80-8141-165-6. - S. 92-102.
30. Lum D, Tan F, Pang J, Barbosa TM. Effects of intermittent sprint and plyometric training on endurance running performance. J Sport Health Sci. september 2019;8(5):471–7.
31. Maćkała K, Fostiak M. Acute Effects of Plyometric Intervention—Performance Improvement and Related Changes in Sprinting Gait Variability. J Strength Cond Res. jun 2015;29(7):1956–65.
32. Malatesta D, Cattaneo F, Dugnani S, Maffiuletti NA. Effects of electromyostimulation training and volleyball practice on jumping ability. J Strength Cond Res. august 2003;17(3):573–9.

33. Malisoux L, Francaux M, Nielens H, Theisen D. Stretch-shortening cycle exercises: an effective training paradigm to enhance power output of human single muscle fibers. J Appl Physiol (1985). march2006;100(3):771–9.
34. Markovic G. Does plyometric training improve vertical jump height? A meta-analytical review. Br J Sports Med. jún 2007;41(6):349–55.
35. Markovic G, Vuk S, Jaric S. Effects of jump training with negative versus positive loading on jumping mechanics. Int J Sports Med. may 2011;32(5):365–72.
36. Meckel Y, Gottlieb R, Eliakim A. Repeated sprint tests in young basketball players at different game stages. Eur J Appl Physiol. october 2009;107(3):273–9.
37. Metaxas TI, Koutlianos N, Sendelides T, Mandroukas A. Preseason physiological profile of soccer and basketball players in different divisions. J Strength Cond Res. september 2009;23(6):1704–13.
38. Mijailovic N, Radakovic R, Peulic A, Milankovic I, Filipovic N. Using force plate, computer simulation and image alignment in jumping analysis. 2015 IEEE 15th International Conference on Bioinformatics and Bioengineering (BIBE); 2015; Belgrade. 2015. pp.1–4.
39. Nedoroščíková, P. Rozvoj výbušnej sily dolných končatín U 14-15. Prešovská univerzita. Fakulta športu. Katedra športovej edukológie. Prešov. 2015.
40. Newton, R. U., Kraemer, W. J., Häkkinen, K., Humphries, B. J. & Murphy, A. J. (Kinematics, kinetics, and muscle activationduring explosive upper body movements: implications for power development. Journal of Applied Biomechanics. 1996. 12: 31-43.
41. Oxfeldt M, Overgaard K, Hvid LG, Dalgas U. Effects of plyometric training on jumping, sprint performance, and lower body muscle strength in healthy adults: A systematic review and meta-analyses. Scand J Med Sci Sports. október 2019;29(10):1453–65.
42. Ramírez-delaCruz M, Bravo-Sánchez A, Esteban-García P, Jiménez F, Abián-Vicén J. Effects of Plyometric Training on Lower Body Muscle Architecture, Tendon Structure, Stiffness and Physical Performance: A Systematic Review and Meta-analysis. Sports Med Open. 21. march 2022;8:40.
43. Santos EJAM, Janeira MAAS. Effects of complex training on explosive strength in adolescent male basketball players. J Strength Cond Res. máj 2008;22(3):903–9.

44. Simenz CJ, Dugan CA, Ebben WP. Strength and conditioning practices of National Basketball Association strength and conditioning coaches. J Strength Cond Res. august 2005;19(3):495–504.
45. Slimani M, Chamari K, Miarka B, Del Vecchio FB, Chéour F. Effects of Plyometric Training on Physical Fitness in Team Sport Athletes: A Systematic Review. J Hum Kinet. 01. december 2016;53:231–47.7.
46. Slunečko, M. Rozvoj explozivní síly dolních končetin u basketbalistů 20 – 25 let. Univerzita J.E.Purkyně, Ústí nad Labem, CZ. 2012.
47. Stojanović E, Ristić V, McMaster DT, Milanović Z. Effect of Plyometric Training on Vertical Jump Performance in Female Athletes: A Systematic Review and Meta-Analysis. Sports Med. 01. may 2017;47(5):975–86.
48. Stojanović E, Stojiljković N, Scanlan AT, Dalbo VJ, Berkelmans DM, Milanović Z. The Activity Demands and Physiological Responses Encountered During Basketball Match-Play: A Systematic Review. Sports Med. january 2018;48(1):111–35.
49. Suchomel TJ, McKeever SM, McMahon JJ, Comfort P. The Effect of Training with Weightlifting Catching or Pulling Derivatives on Squat Jump and Countermovement Jump Force–Time Adaptations. J Funct Morphol Kinesiol. 01. may 2020;5(2):28.
50. Suchomel TJ, Nimphius S, Stone MH. The Importance of Muscular Strength in Athletic Performance. Sports Med. october 2016;46(10):1419–49.
51. Taylor JB, Wright AA, Dischiavi SL, Townsend MA, Marmon AR. Activity Demands During Multi-Directional Team Sports: A Systematic Review. Sports Med. 01. december 2017;47(12):2533–51.
52. TIDOW. Training for Speed Strength. Dostupné z: http://www.coachr.org/spst.htm.2016.
53. Tomlin DL, Wenger HA. The relationship between aerobic fitness and recovery from high intensity intermittent exercise. Sports Med. 2001;31(1):1–11.
54. Villarreal ESS, González-Badillo JJ, Izquierdo M. Low and moderate plyometric training frequency produces greater jumping and sprinting gains compared with high frequency. J Strength Cond Res. may 2008;22(3):715–25.
55. Viša, P. Vplyv 6- týždňového kondičného programu na zmeny úrovne vybraných kondičných schopností mladých basketbalistov. Univerzita Komenského. Fakulta telesnej výchovy a športu. Katedra atletiky. Bratislava. 2016.

56. Ziv G, Lidor R. Physical attributes, physiological characteristics, on-court performances and nutritional strategies of female and male basketball players. Sports Med. 2009;39(7):547–68.
57. Zribi A, Zouch M, Chaari H, Bouajina E, Ben Nasr H, Zaouali M, et al. Short-term lower-body plyometric training improves whole body BMC, bone metabolic markers, and physical fitness in early pubertal male basketball players. Pediatr Exerc Sci. february 2014;26(1):22–32.

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