Review Article

Effect of Stretch-shortening Exercise on skill-based physical performance among elite players: A Narrative Review

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Abstract

Background: The Stretch-shortening exercise (SSE), a combination of eccentric and concentric muscle actions, is integral in many sports. Its effect on skill-based physical performance among elite players is of particular interest due to the high demands of their competitive activities. **Objective:** To conduct a thorough literature review on the effect of SSE on elite players' skill-based physical performance. **Methods:** Numerous databases were thoroughly searched, including SPORTDiscus, Web of Science, PubMed, and Scopus. Studies were chosen based on predetermined inclusion and exclusion criteria. **Results:** Out of 50 articles identified, 25 studies met the inclusion criteria. The results indicated that SSE plyometric exercise enhanced shoulder strength, explosive power, throwing accuracy, stability, and power output in sports like rugby, archery, and medicine ball throw, with a positive correlation between arm length and Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) scores. **Conclusions:** Elite athletes can improve their skill-based physical performance with the help of SSE.

Keywords: stretch-shortening exercises, plyometric, explosive training, elite athletes, skill performance, and sports performance.

Introduction

Elite players are athletes who excel at the highest levels of their respective sports, characterized by exceptional skill, athleticism, mental toughness, and consistent performance[(1)]. These players are exposed to various injuries during their performance. Thus, maintaining physical health of these players is important. Research has shown a positive correlation between athletic performance in various sports and upper-body strength and power measures[(2)]. The Stretch-shortening Cycle (SSC) is a spontaneous muscle contraction and extension cycle that uses neuromuscular reflexes and stored elastic energy to contract muscles more forcefully. The biomechanical foundation of many plyometric workouts is this cycle, which is typical of explosive actions and improves force production and power output[(3,4)].

Stretch-shortening Exercises (SSE) are vital for athletic training, particularly in sports requiring stability and explosive movements[(5)]. Skill-based physical performance is an athlete's ability to execute specific motor skills efficiently within their sport, requiring agility, balance, coordination, strength, and speed. It is context-specific and consists of technical skills, tactical skills, coordination, timing, speed, agility, and power. In elite sports, precision, timing, and adaptability are crucial, as they directly influence game outcomes and competition outcomes[(6,7)].

Plyometric activity is a popular method for enhancing sports performance, as it increases the stretch-shorten cycle's efficiency and the muscle-tendon unit's capacity to withstand stretch stresses. Push-ups are popular for building upper body strength and power, as they strengthen important muscles like the pectoralis major, deltoid, supraspinatus, infraspinatus, teres minor, subscapularis, triceps brachii, levator scapulae and rhomboid muscles[(8)].

This narrative review aims to address the gap in existing research on Stretch-shortening Exercises and its impact on skill-based physical performance among elite athletes. The review focused on identifying whether SSE can enhance performance-specific skills more effectively than traditional training methods, the physiological mechanisms underlying these improvements, and any limitations or risks associated with SSE integration into elite players' training regimes. The results have practical implications for coaches, sports scientists, and athletes, providing evidence-based guidelines for SSE implementation in training programs.

Objectives

The objective of the study was to assess the effect of stretch-shortening exercises on power, strength, and stability in elite athletes through literature search.

Materials and Methods

With a focus on keywords like "productiveness", "efficacy, usefulness", "stretch-shortening cycle", "plyometric", "explosive training", "elite athletes", "skill performance", and "athletic activities", this research synthesis sought to find relevant research on the improvement of athletic activities. Time frame, language, demographic, study design, sports

performance indicators, interventions, and outcome measures were among the filters and limits that were used to narrow down the search. Studies assessing the value and efficacy of these training techniques, as well as the productivity, utility, and efficacy of training programs, were included in the review. The search approach made sure that only relevant and specific studies were chosen.

Databases searched included SCOPUS, PubMed, Web of Science, Google Scholar, PEDro, JSTOR, Researchgate, The Journal of Strength and Conditioning Research and Science Direct.

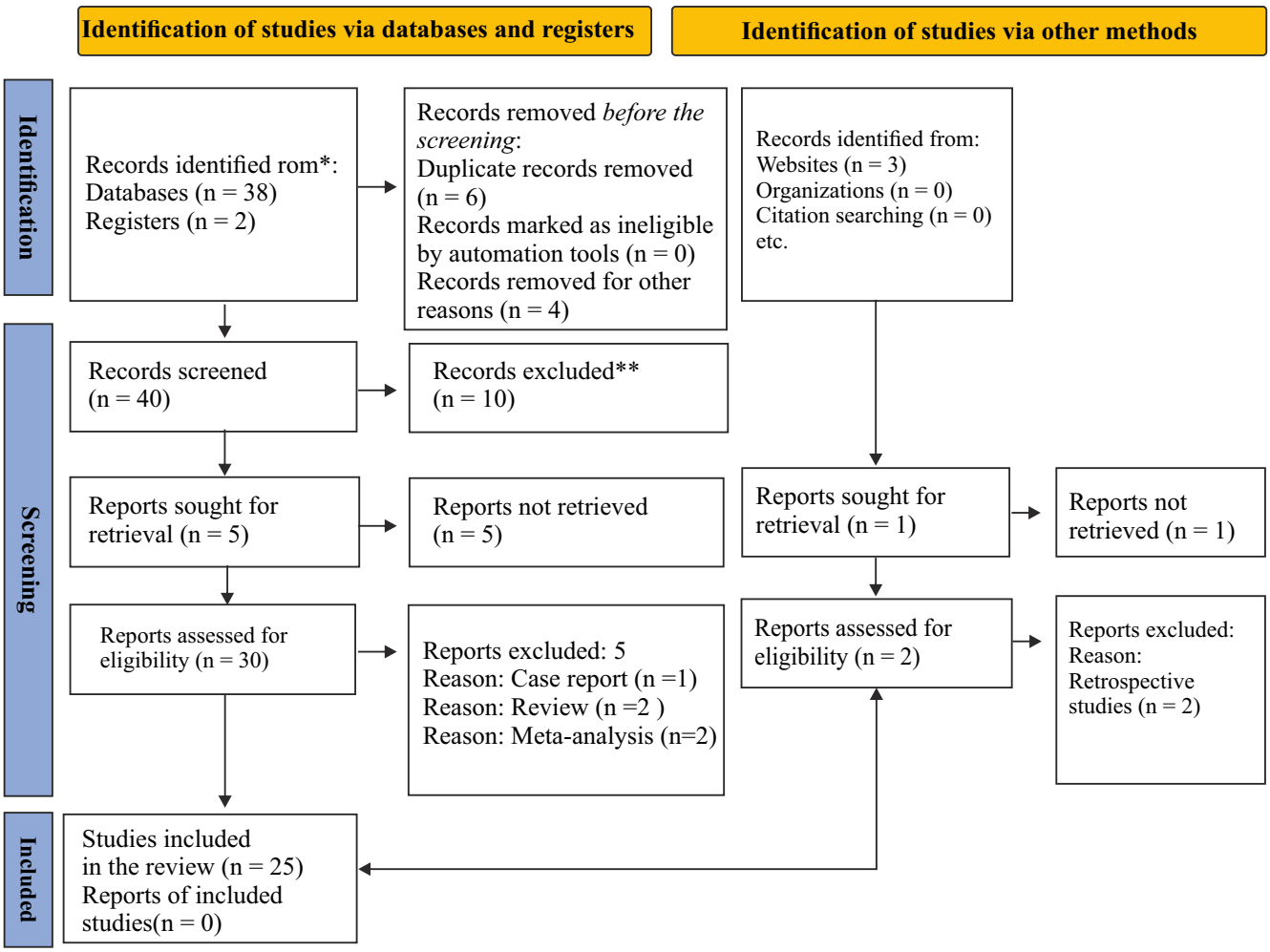

Figure 1: Flowchart showing selection of articles

Eligibility criteria

Studies involving elite athletes who underwent SSC exercises, which included outcome measures related to skill-based physical performance (e.g., strength, power, endurance, etc.) having experimental design as controlled clinical trials- randomized, pre-post intervention studies were included. Articles from the last 15 years were inclued, with one article dating back to 1994.

Research involving non-elite athletes or recreational players, having study design as Non-intervention studies (e.g., reviews, observational studies), studies without measurable outcomes related to skill performance, case reports, correspondence, letters to the editor, errata, over training studies, patents, retrospectives, and articles with only accessible abstracts were excluded.

Study selection and data extraction process

The studies were screened and selected using screening method for narrative review. Title and abstract screening was used to filter out research that didn't fit the requirements, and full-text screening was done to find relevant studies and verify eligibility. Manual extraction of key data points was performed by authors to ensure a human check on all collected data. The final extracted data was compared, and discrepancies were resolved through discussion. In order to ensure impartiality and minimize biases, each record and report was evaluated independently by two authors.

Results

Study selection

The initial search yielded 50 articles. Ten duplicates were removed, titles and abstracts were screened for relevant literature, and 25 studies were eligible for narrative review after meeting inclusion and exclusion criteria (Figure 1).

Study characteristics

Supplementary Table 1 provides a summary of 25 selected articles[9-33]. The included studies varied in design, with most being Randomized Controlled Trials (RCTs) or quasi-experimental. The sample sizes ranged from 5 to 60 participants, elite athletes from sports such as soccer, basketball, volleyball, baseball, Canoe/Kayak Slalom, handball, cricket, rugby, wrestling, archery, tennis, and track and field.

Interventions

SSC interventions included plyometric training. The duration of interventions ranged from 4 to 12 weeks, with frequencies of 2 to 4 sessions per week.

Effect of SSE

The majority of the articles studied the effectiveness of stretch-shortening exercises whose outcomes suggested stretch-shortening exercises being effective in improving skill-based physical performance in athletes, including significant improvements in upper-body strength and power, skill-specific enhancements, shoulder stability and endurance. The review revealed that plyometric training was equally or more effective in enhancing specific physical attributes compared to traditional resistance training. A positive outcome of SSE on a number of physical performance measures was reported.

Improvements in skill-based physical performance

Strength, power, endurance, coordination, and other skill-based performance metrics were consistently found to be improved by SSE. The improvements were particularly noticeable in upper-body movements, which are important for throwing accuracy in handball, serving and spiking in volleyball and handball, throwing velocity in basketball and rugby, serve speed in tennis, and improved accuracy in archery[15-21]. Plyometric workouts improved muscle strength, shoulder stability, and explosive power dramatically. Examples of these exercises included medicine ball throws, push-ups, and dynamic explosive movements.

Upper body power and strength gains

Exercises like plyometric push-ups, medicine ball chest passes, and depth push-ups demonstrated a significant increase in upper-body power and strength when plyometric exercises were incorporated into training regimens for elite athletes. Throwing velocity increased by 4.1% in a study on baseball players, and spike speed improved by 3.8% in a study on volleyball players[22-24].

Plyometric training versus traditional resistance training

The narrative review's comparative advantage of plyometric training over conventional Resistance Training (RT) was among its most important findings. Plyometric exercises have been found to be more effective in enhancing explosive strength and sports-specific skills, even though both forms of training increase strength and power. Plyometric training, as opposed to conventional resistance exercises, produced increased shoulder stability and power, as evidenced by a study conducted on handball players[25,26].

Faster muscle activation was another benefit of plyometric training, which is important for sports involving quick, explosive movements. Superior results were obtained in terms of muscle activation, agility, and power when upper-limb plyometrics were incorporated.

Specificity and customization of training

Baseball and basketball players demonstrated increased throwing velocity through medicine ball training, while volleyball players benefited from spike-specific plyometric drills. Tennis players showed significant improvement in service velocity and recreationally trained men improved the body strength. Also significant change in throwing velocity was seen among rugby players. This finding further supports the necessity for sport-specific SSE programs that complement the particular skill requirements of each discipline.

Moreover, plyometric drills that replicate in-game movements, like forceful throws and dynamic push-ups, assist players in translating their physical improvements into enhanced performance in competition[27-32].

Shoulder stability and injury prevention

Additionally, it has been demonstrated that plyometric exercises improve shoulder stability, especially in sports like volleyball, baseball, and tennis that require repeated overhead motions. Enhancing shoulder stability lowers the risk of overuse injuries and improves performance for athletes. A study conducted on rugby players demonstrated that shoulder stability, as assessed by the Closed Kinetic Chain Upper Extremity Stability Test (CKCUEST) and the Y-Balance test, improved significantly as a result of plyometric-based shoulder training[33].

Discussion

The study aimed to evaluate the effectiveness of Stretch-Shortening Exercise (SSE) workouts in enhancing power, strength, accuracy, and stability in elite athletes. This

narrative review includes 25 studies that explored the effects of stretch-shortening exercise or Plyometric Training (PT) on skill-based physical performance measurements. The strength, power, endurance, shoulder stability, and explosive strength are main outcomes, whereas muscle activation and specific skill performance (throwing velocity, spike speed, serving skill and accuracy) calculations.

Most articles included in our review assessed the efficacy of SSE to develop improvements in upper body strength and power, sport-specific performance increases, enhancements in shoulder stability and endurance, as well as plyometric training more or equally effective in developing specific physical qualities compared to literal resistance training. This research demonstrates gains in sports-specific abilities like serving accuracy, spike speed, and throwing velocity, highlighting the direct relationship between SSE and sports performance. These improvements can be attributed to the neuromuscular benefits of the stretch-shortening cycle, which maximizes the efficiency of musculo-tendinous units to improve muscle elasticity and force production. Due to their ability to induce a stretch-shortening cycle in the muscles, plyometric exercises are suggested for improving muscular power output. The results of this study indicated that adding stretch-shortening exercises for skill-based physical performance to elite players may be beneficial for improving their explosive power, strength, stability, accuracy, and endurance.

Our results were in line with the earlier studies, which were conducted across a range of demographic data and age groups in different sports. A study conducted on healthy individuals analyzed the effect of upper body training on physical fitness and found that plyometric training improved various aspects of physical fitness, with resistance training improving muscle strength and plyometric training enhancing power and explosiveness. No significant gender differences were found in resistance training outcomes, with boys showing larger improvements in plyometric performance around peak height velocity. Resistance training was effective for untrained youth, and training benefits were seen across different age groups, showing an increase in medicine ball throw distance, which also improved sport-specific throwing performance. An increase in muscle mass was noted post Plyometric intervention in the experimental group, suggesting the importance of plyometric training for upper body[34-36].

Similarly, a study on the effect of plyometric training on physical fitness and technical skill performance was conducted on athletes, where authors found small to moderate improvements in skill-based performance and significant improvement in physical fitness with enhancement in athletic performance. Noticed improvement in throwing distance and velocity in baseball, tennis, cricket, basketball, and water polo players was noted. Studies also found improvement in the strength of shoulder and upper back muscles post-intervention, which resulted in improved stability and helped exert maximum force. These findings were seen similar in both male and female athletes, stating clear improvement in athletic performance and physical fitness of the athlete[37,38].

A study was conducted to see the effect of plyometric training on volleyball players and overhead athletes and found gains in overhead throwing performance post plyometric training, resulting in effective throws and better performance, stating plyometric training was more effective than other resistance training programs. Peak changes were observed in strength performance following medicine ball training, which improved muscle mass, resulting in more power generation. They also found that there was improvement seen in the flexibility of the athletes following the plyometric training protocol; changes were seen in the values of the sit and reach test. Improvement was seen in other components, such as sprint and jumping performances. All these lead to improved skill-based performance in volleyball athletes, improving spike speed and throwing distance and velocity, and gains in skill-based performance among overhead athletes. Although significant changes were seen, the authors suggested that an increased duration of training protocol, i.e., more than eight weeks, would benefit the athletes more in comparison to four or six week protocols[39,40].

However, a study on the effects of plyometric training on tennis players' physical performance and skills found mixed results. Some findings included a moderate positive effect on maximal serve velocity, a small to moderate improvement in sprint speed, a small but significant positive effect on lower extremity power, and a moderate effect on agility, while some findings included inconclusive results on upper extremity muscle strength, serve accuracy, aerobic endurance, and upper extremity power. It's possible that different training protocols are the cause of the inconsistent results. The certainty of the evidence across studies remains low to moderate, raising concerns about the efficacy of plyometric training in enhancing overall strength and power[41].

Limitations

We reviewed that plyometric training or stretch-shortening exercises are effective in improving strength, stability, accuracy, and power across all sports. Yet, the review has several limitations. It primarily focuses on sports with significant upper-body explosive movements, such as soccer, volleyball, and baseball, leaving gaps in understanding for less-represented sports like swimming, cycling, and fencing.

The study also highlights the variability in study designs, making it difficult to generalize results across different sports and athlete populations. The majority of studies investigated the short-term effects of SSE, typically between 4 to 12 weeks, but the long-term benefits remain unclear. The review also places a significant emphasis on shoulder plyometrics, such as push-ups and medicine ball throws, but underrepresents lower-body plyometrics. The review also lacks sufficient data on potential injury risks posed by plyometric exercises, especially when integrated into training programs without adequate load management. More research is needed on injury surveillance related to SSE to ensure safety guidelines are appropriately established.

Practical Applications

Tailored plyometric exercise programs

Coaches and sports trainers ought to place a high priority on tailoring plyometric workouts to the unique needs of every athlete and sport. To optimize effectiveness and reduce injury risks, SSE programs should be customized not only for the sports but also for the athlete's position, performance objectives, and injury history.

Combining load management and periodization

It is important to incorporate plyometric training into more comprehensive periodized training regimens to make sure athletes develop their strength and power gradually and avoid over training. Good load management techniques should be used to maximize recuperation and avoid fatigue, especially for athletes who are participating in multiple events or who have rigorous training schedules.

Programs with an injury prevention focus

Athletes participating in sports requiring frequent overhead movements should give priority to plyometric exercises that strengthen the shoulder and other weak points. Incorporating targeted exercises such as medicine ball throws, and plyometric push-ups into a workout regimen can help coaches prevent overuse injuries while simultaneously improving performance.

Recommendations for future research

Future research should explore the effects of the strength-power regime on sports where shoulder explosive strength is not the primary performance factor, such as swimming, fencing, or cycling. Longitudinal evidence is crucial to ascertain the longevity performance advantage of SSE, examining how athletes maintain improvements in power, strength, and skill-based performance over multiple seasons or years. Standardized protocols and intervention designs are needed to ensure consistency across studies and address optimal SSE volumes and intensities tailored to specific athletic demands. Lower-body plyometric exercises, such as jump squats and bounding, may have considerable benefits for sports relying heavily on lower-body strength and power. Additionally, more studies should explore the relationship between SSE and injury prevention, focusing on optimal load management strategies and periodization techniques to mitigate injury risks associated with high-impact plyometric training.

Conclusions

The narrative review supports the effectiveness of upper body plyometric interventions in enhancing physical fitness and performance outcomes in healthy youth, young adults, and elite athletes across all sports by notably improving maximal strength, medicine ball throwing performance, accuracy, endurance, power sport-specific throwing performance, and muscle volume.

Conflict of Interest: Nil

Source of Support: Nil

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Ethical consideration

In this study no human participants are involved. Since it's a review article, Ethics approval is not required.

Authors' Contribution

AC : Data collection, draft manuscript preparation, analysis and interpretation of results; SS : study conception and design, analysis and interpretation of results

Data availability statement

Data used for the present study is available in public domain

References

1. Güllich A, Macnamara BN, Hambrick DZ. What makes a champion? Early multidisciplinary practice, not early specialization, predicts world-class performance. Perspectives on Psychological Science. 2022 Jan;17(1):6-29.
2. Sunde A, Johansen JM, Gjøra M, et al. Stronger is better: the impact of upper body strength in double poling performance. Frontiers in physiology. 2019 Aug 23;10:1091.
3. Komi PV. Stretch-shortening cycle: a powerful model to study normal and fatigued muscle. Journal of biomechanics. 2000 Oct 1;33(10):1197-206.

4. Nicol C, Avela J, Komi PV. The stretch-shortening cycle: a model to study naturally occurring neuromuscular fatigue. Sports medicine. 2006 Nov;36:977-99.

5. Bosco C, Rusko H. The effect of prolonged skeletal muscle stretch-shortening cycle on recoil of elastic energy and on energy expenditure. Acta Physiologica Scandinavica. 1983 Nov;119(3):219-24.

6. Davids K, Araújo D, Vilar L, Renshaw I, Pinder R. An ecological dynamics approach to skill acquisition: Implications for development of talent in sport. Talent Development and Excellence. 2013;5(1):21-34.

7. Williams AM, Ford PR. Expertise and expert performance in sport. International Review of Sport and Exercise Psychology. 2008 Mar 1;1(1):4-18.

8. Shah S. Effect of Pushup Training on Upper Body Strength and Power in Young Adults. Int. J. Curr. Res. Rev. 2012;4(2):43-53.

9. Powell A, Williamson S, Heneghan NR, Horsley I. Investigation of the Closed Kinetic Chain Upper Extremity Stability Test in elite canoe/kayak slalom athletes. Physical Therapy in Sport. 2020 Nov 1;46:220-5.

10. Kumar KS, Arumugam S. Influence of plyo push up exercises on shoulder strength and explosive power among sports participants. IJCRT Volume 6, Issue 1 January 2018 ISSN: 2320-2882.

11. Singla D, Hussain ME. Adaptations of the upper body to plyometric training in cricket players of different age groups. Journal of sport rehabilitation. 2019 Oct 18;29(6):697-706.

12. Pramod R, Divya K. The effect of medicine ball training on shoulder strength and abdominal strength and endurance among Sudan school boy's football players in Qatar. International Journal of Physical Education, Sports and Health. 2019;6(1):151-4.

13. Chaouachi A, Hammami R, Kaabi S, Chamari K, Drinkwater EJ, Behm DG. Olympic weightlifting and plyometric training with children provides similar or greater performance improvements than traditional resistance training. The Journal of Strength & Conditioning Research. 2014 Jun 1;28(6):1483-96.

14. Vishen PK, Sen S. Comparision of dynamic push-up training and plyometric push-up training on upper body performance test in cricket player. Int J Phys Educ Sports Health. 2015;2(1):199-203.

15. Turgut E, Cinar-Medeni O, Colakoglu FF, Baltaci G. "Ballistic Six" upper-extremity plyometric training for the pediatric volleyball players. The Journal of Strength & Conditioning Research. 2019 May 1;33(5):1305-10.

16. Palao JM, Femia P, Ureña A. Effect of eight weeks of upper-body plyometric training during the competitive season on professional female volleyball players. The Journal of sports medicine and physical fitness. 2017 Jul 25;58(10):1423-31.

17. Uzor TN, Iwuoha ED, Ujuagu NA, Offodile HN. The Effects of Upper Body Plyometric Training on Serving Skill of Female University Volleyball Players. Athena: Physical Education and Sports Journal. 2023 Jul 31;1(2):68-76.

18. Guadie WT. Effects of plyometric training on technical skill performance of handball team players at Debre Markos Town. International Journal of Sports Science and Physical Education. 2021;6:41-7.

19. Ferraz R, Marques MC, Branquinho L, Marinho DA. Effects of applying a training program on basketball shooting in young players. Journal of Human Sport and Exercise. 2021, 16(2proc): S307-S318

20. Pienaar C, Coetzee B. Changes in selected physical, motor performance and anthropometric components of university-level rugby players after one microcycle of a combined rugby conditioning and plyometric training program. The Journal of Strength & Conditioning Research. 2013 Feb 1;27(2):398-415.

21. Fernandez-Fernandez J, Ellenbecker T, Ulbricht A. Effects of a 6-week junior tennis conditioning program on service velocity. Journal of sports science & medicine. 2013 Jun;12(2):232.

22. Newton RU, McEvoy KI. Baseball throwing velocity: A comparison of medicine ball training and weight training. The Journal of Strength & Conditioning Research. 1994 Aug 1;8(3):198-203.

23. Pereira A, M Costa A, Santos P, Figueiredo T, Vicente João P. Training strategy of explosive strength in young female volleyball players. Medicina. 2015 Apr;51(2):126-31

24. Vivek R, Singh RR. Effect of plyometric training on explosive strength of volleyball players. International Journal of Physiology, Nutrition and Physical Education 2019; 4(1): 1725-1728.

25. Santos EJ, Janeira MA. Effects of complex training on explosive strength in adolescent male basketball players. The Journal of Strength & Conditioning Research. 2008 May 1;22(3):903-9.

26. Hermassi S, Chelly MS, Tabka Z, Shephard RJ, Chamari K. Effects of 8-week in-season upper and

lower limb heavy resistance training on the peak power, throwing velocity, and sprint performance of elite male handball players. The Journal of Strength & Conditioning Research. 2011 Sep 1;25(9):2424-33.

27. Lust KR. The effects of a six-week open kinetic chain/closed kinetic chain and open kinetic chain/closed kinetic chain/core stability strengthening program in baseball. West Virginia University; 2007.
28. Rathod HD. Effect of plyometric exercises for development of shoulder strength and speed among basketball players of RTM Nagpur University. International Journal of Physical Education, Sports and Health 2021; 8(6): 25-28.
29. Kurniawan GPD. Effectiveness of plyometric push up to increase the explosive power of arm muscles (Quasi-experimental study on team members matador volleyball club). Indones J Physiother Health. 2022 Apr.
30. Behringer M, Neuerburg S, Matthews M, Mester J. Effects of two different resistance-training programs on mean tennis-serve velocity in adolescents. Pediatric exercise science. 2013 Aug 1;25(3):370-84.
31. Mangine GT, Ratamess NA, Hoffman JR, Faigenbaum AD, Kang J, Chilakos A. The effects of combined ballistic and heavy resistance training on maximal lower-and upper-body strength in recreationally trained men. The Journal of Strength & Conditioning Research. 2008 Jan 1;22(1):132-9.
32. Suárez García M, López Mardomingo P, Nah-Mohamed M, Cuesta Barriuso R. Improved shoulder stability through plyometric, proprioceptive and strength exercises in rugby players. A randomized clinical trial. JMensHealth2021vol.17(2),127-134.
33. Dhawale T, Yeole U, Jedhe V. Effect of upper extremity plyometric training on strength and accuracy in archery players. Journal of Medical Science and Clinical Research. 2018 Dec 4;6(12):143-7.
34. Peitz M, Behringer M, Granacher U. A systematic review on the effects of resistance and plyometric training on physical fitness in youth-What do comparative studies tell us?. PloS one. 2018 Oct 10;13(10):e0205525.
35. Singla D, Hussain ME, Moiz JA. Effect of upper body plyometric training on physical performance in healthy individuals: a systematic review. Physical Therapy in Sport. 2018 Jan 1;29:51-60.
36. Garcia-Carrillo E, Ramirez-Campillo R, Thapa RK, Afonso J, Granacher U, Izquierdo M. Effects of upper-body plyometric training on physical fitness in healthy youth and young adult participants: A systematic review with meta-analysis. Sports medicine-open. 2023 Oct 13;9(1):93.
37. Deng N, Soh KG, Zaremohzzabieh Z, Abdullah B, Salleh KM, Huang D. Effects of combined upper and lower limb plyometric training interventions on physical fitness in athletes: a systematic review with meta-analysis. International Journal of Environmental Research and Public Health. 2022 Dec 28;20(1):482.
38. Deng N, Soh KG, Abdullah B, Huang D, Xiao W, Liu H. Effects of plyometric training on technical skill performance among athletes: A systematic review and meta-analysis. Plos one. 2023 Jul 17;18(7):e0288340.
39. Eraslan L, Castelein B, Spanhove V, Orhan C, Duzgun I, Cools A. Effect of plyometric training on sport performance in adolescent overhead athletes: a systematic review. Sports health. 2021 Jan;13(1): 37-44.
40. Silva AF, Clemente FM, Lima R, Nikolaidis PT, Rosemann T, Knechtle B. The effect of plyometric training in volleyball players: A systematic review. International journal of environmental research and public health. 2019 Aug;16(16):2960.
41. Deng N, Soh KG, Huang D, Abdullah B, Luo S, Rattanakoses W. Effects of plyometric training on skill and physical performance in healthy tennis players: A systematic review and meta-analysis. Frontiers in Physiology. 2022 Nov 24;13:1024418.

Supplementary Table 1: Summary of included articles

Sr. No.	Author	Population	Purpose	Study design	Interv-ention	Outcome measures	Outcomes	Key findings
01	Newton et al.	Baseball players	This study looked at how baseball throwing velocity and upper-body strength levels were affected by upper-body plyometric training, which used medicine balls, and upper-body traditional weight training.	Pre-test, post-test	Freq. - 8 weeks	6 RM chest press and MBT.	The study showed that although the medicine ball group showed a substantial increase in strength, the weight training group saw the greatest rise in strength and velocity.	The weight training group was the only one, according to analysis, to have a significant change in velocity from pre-to post-training (two-tailed t-=2.56,p = 0.038). The weight training group saw a mean increase in throwing velocity of 1.3 m·s, or 4.1%, from 31.7 to 33.0 m·s-.There was no significant difference in the percentage changes in throwing velocity between any of the groups before and after training. The 6-RM data before and after training, as well as the percent-age changes, show a significant repeated measures effect and training group interaction, F(2,21)=12.4, p = 0.000. After training, the two experimental groups' strengths grew noticeably. With a substantial rise of 11.1 kg (22.8%) (two-tailed t-=6.57,p<0.000), the weight training group showed the biggest improvement. Additionally, the medicine ball group significantly increased their strength by 4.5 kg (8.9%) (two-tailed t7=3.53,p=0.01). However, there was no discernible difference in 6-RM produced by the control group.
02	Powell et al.	British Canoe/ Kayak Slalom athletes	British Canoe/ Kayak Slalom athletes. This study looked at normal values, gender differences, correlations, and variations in hand test positions in an effort to find the most effective method of accounting for arm length disparities in the application of the CKCUEST.	Quasi-experime -ntal		CKUEST and arm-length	The study found a positive correlation between arm length and CKCUEST score and normalized-CKCUEST score but no significant correlation between modified-CKCUEST score and arm length.	The modified-CKCUEST scores showed no discernible variation between the genders; t ¼ 0.297, p ¼ 0.772; mean difference, 0.4 (95% CI, -2.2 to 2.9). The three CKCUEST variations and arm length were found to have the following Pearson's correlation coefficients: CKCUEST, r ¼ 0.807, p ¼ 0.001; modified-CKCUEST, r ¼ 0.100, p ¼ 0.745; and normalised-CKCUEST, r ¼ 0.654, p ¼ 0.015. The CKCUEST scores showed a significant difference between the narrower (mean 26.5 ± 3.57) and wider (mean 23.3 ± 2.86) hand positions; t ¼ 5.186, p ¼ 0.000; mean difference, 3.2 (95% CI, 1.8 to 4.5).

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03	Hermassi et al.	National-level male handball players.	To assess the effects of an 8-week biweekly HR in-season training program against a conventional conditioning program in terms of improving the muscular strength and power of elite handball players.	RCT	Freq. - 2 times/week for eight weeks.	Cycle-ergometer, handball throwing test, one repetition maximum bench press	The research showed gains in muscle volume and 1RM strength. Resistance training significantly increased 1RMPO and 1RMBP values.	Within the Human Resources department, the eight-week period of resistance training led to notable enhancements in muscle mass across the legs and thighs (total leg and thigh, $p < 0.001$; upper limbs, $p < 0.01$). The circumference of the thigh cross-sectional area (CSA) also saw a similar rise ($p < 0.001$). The maximum power output of both the upper and lower body increased in comparison to the control group, yet the initial velocity, force, initial leg and thigh force, and initial lower leg force stayed the same. The vertical jump (SJ) and broad jump (CMJ) performances of the participants also showed an increase when compared to the control group ($p < 0.01$). The enhancement in lower body peak power was linked to quicker running speeds ($p < 0.01$ for vertical jump and broad jump; $p < 0.001$ for peak power). Additionally, there were significant improvements in various throwing activities ($p < 0.01$) and in the one-rep maximum (1RM) strength for both the upper and lower body (1RMHS, 1RMBP, 1RMPO; $p < 0.001$ for all measurements).
04	Vishen et al.	Cricket players	The aim of the research was to examine how dynamic push-up training and plyometric push-up training impact upper body performance.	RCT	Freq. - 3 times/week for six weeks.	One arm hop test and Medicine ball put test	Pre & post one arm hop test of the right side both showed significant difference; the medicine ball put test	Group A demonstrated a notable change in both the right and left sides of the body during the pre-post one-arm hop test, with p values of 0.033 and 0.003, respectively, indicating a significant difference. The same was observed in the medicine ball throw test, with a significant difference noted between the pre-post tests. In Group B, the right and left sides of the body also showed significant changes in the one-arm hop test, with p-values of 0.004 and 0.011, respectively. The medicine ball throw test also revealed a significant difference between the pre-post tests. The data from the one-arm hop tests for the right and left sides of both groups showed no significant differences between the pre-post tests. Similarly, the medicine ball throw test for both groups did not show any significant differences between the pre-post tests.

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Sr. No.	Author	Population	Purpose	Study design	Interv-ention	Outcome measures	Outcomes	Key findings
05	Kumar et al.	Active sports participants	The aim of the research was to examine how dynamic push-up training and plyometric push-up training impact upper body performance.The aim of the research was to determine how plyo push-up exercises affected athletes' explosive power and shoulder strength.	RCT	Freq. - 3 times/week for six weeks.	Push-Up Test and Medicine Ball Throw	Sports players' shoulder strength and explosive power were found to be impacted by plyo push-up exercises.	The experimental group and control group had pre-test mean values for shoulder strength of 20.66 and 19.46, respectively, and post-test means of 25.80 and 20.00. Between the pre-and post-test means of the plyo push-up exercise group and the control group, the dependent t-ratio values obtained are 17.69 and 1.42, respectively. The experimental group and control group had pre-test mean values for shoulder strength of 20.66 and 19.46, respectively, and post-test means of 25.80 and 20.00. Between the pre- and post-test means of the plyo push-up exercise group and the control group, the dependent t-ratio values obtained are 17.69 and 1.42, respectively.
06	Suárez et al.	Rugby players	To assess if a physiotherapy intervention can help rugby players' shoulder stability by using plyometric exercises in their training regimen	RCT	Freq. - 2 times/week for four weeks Intensity - 15 repetitions for 15 minutes.	Closed Kinetic Chain Upper Extremity Stability Test and Upper Quarter Y-Balance Test.	Changes were observed in the experimental group of athletes for all measuring instruments.	With the CKCUEST test, we saw that stability varied with evaluation time ($F(1.3, 36.47) = 13.56$; $P < 0.001$; $\eta 2\ p = 0.32$); additionally, the two groups differed at each of the three assessment times ($F = 13.63$; $P < 0.001\ \eta 2\ p = 0.32$). Using the Y-Balance test to measure shoulder stability on the right shoulder, variations were observed based on the evaluation time ($F(1.06, 29.83) = 16.99$; $P < 0.001$; $\eta 2\ p = 0.37$), as well as variations among the three assessment times ($f = 26.15$; $P < 0.001$; $\eta 2\ p = 0.48$). Using theY-Balance test to evaluate left shoulder stability, there were variations based on the evaluation time ($F(1.02, 28.81) = 11.63$; $P < 0.001$; $\eta 2\ p = 0.29$), as well as variations between the three times of assessment ($F = 17.61$; $P < 0.001$; $\eta\ 2\ p = 0.38$). When calculating the partial Eta-squared, we found high effect size values in all measured variables $\eta 2p > 0.14$).

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07	Turget et al.	Pediatric female volleyball	To look into how pediatric overhead athletes' upper body power, endurance, and reaction time are affected after a 12-week upper-extremity plyometric training program.	RCT	Freq. - 3 times/week for 12 weeks	Medicine ball throw, push-up and reaction time	Comparisons between the baseline and 12-week follow-up showed that the intervention group's upper-body strength and endurance had improved more.	When the auditory reaction time was compared between the first and the 12-week follow-up, it was found that the intervention group's response time had improved (p, 0.001; MD, 67.07 ms), while the control group showed no change (p = 0.03; MD, 4.2 reps). Comparisons between the initial and the 12-week follow-up indicated that the auditory reaction time was improved in the intervention group (p 0.001; MD, 67.07 ms), whereas there was no difference found in the control group (p . 0.05).
08	Palao et al.	Volleyball players	This study aimed to evaluate how the addition of targeted upper-body plyometric training for spiking impacts the competitive season of a women's professional volleyball team.	Quasi-experime-ntal	Freq. - 8 weeks	1RM-benchpress and pullover, MBT	From phase A to phase B, the experimental group's spike speed increased significantly by 3.8%, and this improvement persisted after retention.	The experimental group showed a notable increase in spike speed of 3.8% from phase A to phase B, and they sustained this improvement through the retention phase. In contrast, the control group did not exhibit any improvements. The experimental group also experienced significant enhancements from phase A to phase B in dominant arm muscle area (+10.8%), one-rep max (1RM) for the bench press (+8.41%), 1RM for the pullover (+14.75%), and in overhead medicine ball throws with weights of 1 kg (+7.19%), 2 kg (+7.69%), and 3 kg (+5.26%). No changes were observed in these metrics within the control group.
09	Rathod	Basketball players	To determine how plyometric exercises impact shoulder strength and speed in basketball players.	RCT	Freq. - 3 times/week for six weeks.	Push-ups, medicine ball throws, hopping, bounding, tuck jumps, box jumps, and dumbbell throws.	The study's findings indicate that the experimental group's performance in terms of shoulder strength and speed improved.	In the pre-test, the Experimental Group's average for the 30 M Run was 4.53, while the Controlled Group's average was 4.66, showing a difference of 0.13. In the post-test, the Experimental Group's average dropped to 4.23, and the Controlled Group's average increased to 4.73. This indicates that the Experimental Group improved by 0.30 from the pre-and post-test, as their average decreased from 4.53 to 4.23. Meanwhile, the control group's performance increased slightly by 0.07, from 4.66 in the pre-test to 4.73 in the post-test.

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10	Guadie	Debre Markos handball team players	To assess how plyometric training influences the technical skills of handball players on the Debre Markos team.	RCT	Freq. - 3 times/week for 12 weeksIntensity - 60 mins	Squat jump, split squat jump, wall clap push-ups, zip zap hop, clapping push-ups, depth push-ups, single leg vertice jump.	The results showed that plyometric training significantly improved shooting accuracy intercollegiate level men handball players.	The average values for handball skill metrics in the experimental group were 9.31 for speed dribbling, with a standard deviation of 0.682, compared to the control group's average of 10.20 and a standard deviation of 0.695. For shooting accuracy, the experimental group had a mean score of 25 with a standard deviation of 3.66, while the control group had a mean of 21.27 and a standard deviation of 2.453. Regarding passing accuracy, the experimental group's mean value was 18.82 with a standard deviation of 1.834, while the control group's mean was 19.18 with a standard deviation of 1.537.
11	Uzor et al.	Volleyball players	The study aims to investigate how upper-body plyometric training impacts the serving skills of female volleyball players at the university level.	RCT	Freq. -3 times/week for six weeks. Intensity - 50 mins	Plyometric push-ups and medicine ball throw.	The results show that the upper body plyometric training using the medicine ball and push-ups has a positive effect on the serving skills of the exposed group.	The average scores for female volleyball players during upper body training with the chest pass were 9.8 in the pre-test and 12.2 in the post-test, based on ten participants, with a Standard Deviation of 1.54. In contrast, the control group recorded pre-test and post-test mean scores of 9.8 and 10.2, respectively, with a Standard Deviation of 0.63.
12	Kurniwan	Volleyball team at the Matador Volleyball Club.	To assess how well plyometric push-up exercises enhance explosive strength in arm muscles.	RCT	Freq. - 3 times/week for six weeks	Plyometric push-up and conventional push-up.	The research found that plyometric training increased the explosive power of arm muscles in Matador Volleyball Team members.	The change in arm muscle explosive power before and after treatment in the plyometric training group for push-ups had a mean difference of 0.66 meters and a standard deviation of 0.094. In contrast, the conventional exercise group for push-ups showed a difference in arm muscle explosive power of 0.46 meters with a standard deviation of 0.149.

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13	Mangine et al.	Resistance -trained Men	The aim of this study was to examine the combined impact of ballistic training alongside a standard heavy resistance training program on maximum strength in both the upper and lower body.	RCT	Freq. - 3 times/week for eight weeks Intensity - 3-4 sets of 6-8 repetitions	1 RM Bench-press and squat, ballistic push-up and jump squat, SMBT	The study found that lean body mass increased significantly in both groups while the percentage of body fat decreased.	HR measurements showed a change from 69.5 ± 6.8 kg (pre) to 71.8 ± 8.4 kg (post), while COM measurements changed from 69.3 ± 10.5 kg (pre) to 71.4 ± 9.9 kg (post). Additionally, the percentage of body fat significantly decreased in both groups, with no notable differences between them: HR went from 14.1 ± 5.3% (pre) to 12.8 ± 4.8% (post), and COM decreased from 15.5 ± 5.0% (pre) to 14.7 ± 3.5% (post).
14	Pienaar et al.	University level rugby players	The aim of this study was to examine the impact of a 4-week program that combined rugby conditioning and plyometric training on specific physical, motor performance, and anthropometric traits of university rugby players in comparison to the effects of a rugby conditioning program by itself.	RCT	Freq.- 3 times/week for four weeks Intensity - 2 hours	3-kg medicine ball put, vertical jump, acceleration and Wingate anaerobic tests.	For 5, 10, 15, 20, and 25 seconds, the experimental group saw a substantial training effect for peak power, average power, relative peak power, relative average power, total work, and relative total work.	The differences in individual skeletal mass from pre- to post-test for the experimental group ranged from a minimum of 20.493 to a maximum of 1.656, with a standard deviation of 0.587. In the control group, muscle mass differences ranged from 20.406 (minimum) to 0.582 (maximum), with a standard deviation of 0.301. For the experimental group, muscle mass differences ranged from 20.461 (minimum) to 1.490 (maximum), with a standard deviation of 0.766. The differences in fat percentage for the control group varied from a minimum of 22.388 to a maximum of 4.227, with a standard deviation of 1.818. For the experimental group, fat percentage differences ranged from a minimum of 24.126 to a maximum of 6.618, with a standard deviation of 2.409

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15	Lust	Baseball players	The goal was to assess how much throwing accuracy, core stability, and proprioception improved following a 6-week training program that included open kinetic chain (OKC), closed kinetic chain (CKC), and/or core-stability exercises.	Pre-test and post-test.	Freq. - 3 times/ week for six weeks	Open kinetic chain and closed kinetic chain exercises.	There was no significant difference between groups. An increase was evident in all pretest-to-posttest results, with improvement ranging from 1.36% to 140%.	The analysis indicated a notable difference in post-test results among the three groups. Both the OKC/CKC/CS group and the OKC/CKC group showed significantly higher scores compared to the control group following the training. A significant main effect of the test was identified ($F1,31 = 15.69$, $P < .001$, $ES = .336$, $1 - \beta = .970$). Although post-test scores exceeded pre-test scores, no significant difference ($P = .014$) was found based on the P value (.008) across the testing occasions. Additionally, while the percent change from pre-test to post-test varied from 18.87% to 22% for the OKC/CKC/CS and OKC/CKC groups, respectively, no significant main effect of the group was observed.
16	Fernandez et al.	Tennis players	The purpose of this research was to assess how a 6-week conditioning regimen involving throwing, elastic resistance exercises, and stretching impacts serve velocity.	RCT	Freq.- 3 times/ week for six weeks Intensity- 60-70 mins	Core strength, elastic resistance and medicine ball throw.	The training group showed significant improvement in serve velocity, while the control group showed no significant difference.	The training group showed a notable increase in serve velocity ($p = 0.0001$) following the intervention, while there were no changes in the serve velocity for the control group before and after the intervention ($p = 0.29$). Serve accuracy remained consistent in both the training group ($p = 0.10$) and the control group ($p = 0.15$) throughout the 6-week study.
17	Vivek et al.	Volleyball players	The study aimed to determine how Plyometric training impacts the explosive strength of volleyball players.	RCT	Freq. - 3 times/week for six weeks	Medicine ball throw and standing broad jump.	The study reveals that there was a significant the difference in explosive power in the experimental group than the control group	The pre-test scores for the medicine ball throw among the control and experimental groups are both recorded at 8.40. The calculated F ratio value is 0.00, indicating that the pre-test mean is less than the critical table value of 4.20, which is necessary for statistical significance at the 0.05 level.

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18	Santos et al.	Basketball players	The objective of the present investigation was to assess the impact of a multifaceted training regimen, which integrates resistance training and plyometric exercises, on the enhancement of explosive strength among adolescent basketball athletes.	RCT	Freq. - 2 times/week for ten weeks.	Squat jump, Counter-movement jump, Abalakov test, depth jump, mechanical power, and medicine ball throw	The EG showed significant increases in all variables. The MBT test showed a significant increase in the CG. Resistance training involved a 5% increase in training load while plyometric equipment was used.	The EG demonstrated significant increases in each of the variable scores, with the exception of the DJ and MP. On the other hand, the CG's CMJ, ABA, and MP scores were much lower. On the other hand, the MBT test results indicated a noteworthy rise in the CG. Pre-test results for the groups showed similarity, but after training, substantial variations were seen in every variable with the exception of ABA and MP.
19	Ferraz et al.	Basketball players.	The main objective of this study was to verify whether the application of a strength training program induced improvements in the effectiveness of the throw in young basketball players.	RCT	Freq. - 2 times/week for six weeks.	Counter-movement jump, a 2 kg medicine ball throw, sit-ups, and push-ups,	The results of this study suggest that the application of a strength training program with a duration of six weeks is sufficient to obtain positive effects in relation to the effectiveness of two-point launching exercises in female basketball players at the under-14 level.	When comparing the pre-training and post-training periods, the strength training program's effects were found to be positive for two of the four variables that were analyzed (mean difference; 90% CL – 0.6; ± 0.7). The performance for the variables free throw, variable stationary two-point shooting test, and stationary three-point shooting test tended to be similar with an unclear influence when comparing the pre-training and detraining moments (-0.5; ± 1.1; 0.4; ± 0.8; 0.0; ± 0.8).

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20	Behringer et al.	Tennis players	The current study's goal was to assess how well two distinct resistance training regimens transferred to junior tennis players' service velocity and precise consistency.	RCT	Freq. - 2 times/week for eight weeks	Chest press, leg press, pull down, abdominal press.	The 8-week training intervention significantly improved service velocity (Vsub) in participants who trained with plyometric exercises compared to the control group.	The impact of the eight-week training program on service performance metrics. While mean service velocity (Vsub) increased only somewhat (1.18%) as a result of RG's less focused training regimen, gains in Vsub were much higher in PG as compared to CG values (group by time interaction). In other words, only those who trained with plyometric exercises increased their Vsub considerably more than those in the control group. The results of the performed service precision tests showed no discernible alterations.
21	Singla et al.	Cricket players	The purpose of this study was to examine how MPBT affected the neuro-muscular adaptations in cricket players across various age groups, as shown by muscle activation, upper body balance, upper body power, and muscle strength.	RCT	Freq. - 3 Times/week for eight weeks. Intensity - 3 sets of 10 repetitio-ns	Upper quarter Y balance test and medicine ball throw.	Improvement in muscle activation in terms of EMG activity observed in the experimentals in the present study following plyometric training	Regardless of age, the experimental group exhibited the largest and most significant increases in BBrms, NUQYBT, DUQYBT, and BOMBscore (p-value <0.001, 0.007, 0.009, and 0.004, respectively). TBrms and MS did not exhibit this pattern (p-values of 0.079 and 0.158, respectively).
22	Pereira et al.	Volleyball players	The purpose of this study was to investigate how young volleyball players' upper body performance was affected by an 8-week program that incorporated plyometrics and ball tossing.	RCT	Freq. - 2 times/week for eight weeks.	Counter-movement jump and throwing a medicine and volleyball ball	Concerning the upper body, significant Improvements in the medicine ball and volleyball ball throwing distance was found in the experimental group.	In terms of the upper body, the experimental group showed notable gains in the 1.5 kg medicine ball and 1 kg volleyball ball throwing distances (3% and 19.6%, respectively, P = 0.00). Additionally, there were notable gains in the countermovement jump performance (20.1%, P = 0.05). On CMJ, MBT, and VBT, significant main effects for time were noted (F = 31.6, 29, and 14.7, respectively; P < 0.05). There were no discernible improvements in MBT, VBT, and CMJ (P > 0.05) for the control group.

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23	Pramod et al.	Football players	The study's goal was to determine how medicine ball training affected the football players from Sudanese schools in Qatar in terms of shoulder strength, abdominal strength, and endurance.	RCT	Freq. - 3 times/ week for sixweeks. Intensity - 2-3 sets of 8-10 repetiti-ons.	Shoulder Strength (SS) and Abdomina l Strength a n d Endurance (ASE)	There was a significant improvement in shoulder Strength, abdominal strength and endurance due to medicine ball training	With a standard deviation of 1.68%, the control group's pre-test mean score on shoulder strength components was 16 points87, and its post-test mean score was 17.57%, with a standard deviation of 1.84%. In the experimental group, the mean pre-test score was 16 points98, with a standard deviation of 1 point59, and the mean post-test score was 19 points53, with a standard deviation of 1 point89, respectively. The mean score for the pre-test on abdominal strength and endurance was 37 points with a standard deviation of 8 points, and the post-test mean was 39 points with a standard deviation of 9 points60. This information represented the second independent variable. The experimental group's mean pre-test score was 40 points with an 8-point standard deviation, and its mean post-test score was 57 points with a 12-point standard deviation.
24	Dhawale et al.	Archers	The purpose of the study was to determine how Upper Extremity plyometrics affected archers' accuracy and strength.	RCT	Freq. - 3 times/we ek for six weeks.	Accuracy, 1RM and CKCUE-ST.	Our study result shows that there is more improvement in performance and significant neuromuscular benefits if they are implemented earlier into Shoulder rehabilitation programs	Group B did not exhibit any significant changes in accuracy, RM1 (right and left), or the closed kinetic stability test, and the differences between Group A and Group B were statistically significant ($p = 0.0001$). The results indicate that Group A significantly improved across all outcome measures from pre to post ($p = 0.0001$).
25	Chaouac hi et al.	Wrestlers	To evaluate in boys aged 10 to 12 the training effects of 12 weeks of OWL, plyometric, and standard RT.	RCT	Freq. - 3 times/ week for 12 weeks	Olympic-s t y l e weightli-f t i n g , plyomet-rics, and traditional RT	The study found that Olympic weightlifting and plyometric training significantly improved children's performance adaptations, with plyometric training eliciting better adaptations in balance, isokinetic force, and sprint times.	In comparison to plyometric training, OWL was found to be 96% likely to be superior (mean difference, lower to upper 95% confidence limits, effect size; 3.2 cm, 0.6–5.8, 0.78) and 93% likely to be superior to traditional RT (mean difference, lower to upper 95% confidence limits, effect size; 4.1 cm, 0.2–7.9, 4.71). Mean difference; lower to upper 95% confidence intervals; effect size: 13 ± 5 cm; 20 ± 9 to 27 ± 9; 0 ± 63. Compared to plyometric, traditional RT was 92% likely to cause noticeably higher increases in BMI (mean difference, lower to upper 95% confidence limits, effect size: 0.6 kg m22, 0.0–1.2, 0.67). Plyometric training was 84 percent likely to elicit substantially greater increases in Force60 than traditional RT mean difference, lower to upper 95 percent confidence limits, effect size; 13.0 kg, 23.7 to 29.8, 0.54 and 81 percent likely than OWL mean difference, lower to upper 95 percent confidence limits, effect size; 13.8 kg, 25.1 to 32.6, 0.50 training.