Research Article

# IMPACT OF PLYOMETRIC TRAINING ON REACTIVE AGILITY, EXPLOSIVE POWER, AND FUNCTIONAL PERFORMANCE IN KARATE PLAYERS: A PRISMA-BASED SYSTEMATIC REVIEW

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**Abstract**

Plyometrics training is among the most efficient methods of training that have been used by many athletes to improve their muscular power, speed and neuromuscular efficiency. This technique of training involves rapid eccentric contraction of muscles that is immediately followed by the concentric contraction, and is called stretch shortening cycle (SSC). This adaptation is achieved through efficient motor unit recruitment, faster rate of force development, increase in muscle-tendon stiffness and better intermuscular coordination. As a consequence, athletes can develop their explosive movements and sustain their performance during competitions due to the above-mentioned adaptation mechanisms. That is why plyometrics training is an important component of strength and conditioning training programs in various individual and team sports. Moreover, plyometrics training promotes the development of improved neuromuscular coordination and increases the efficiency of the stretch – shortening cycle (SSC).

**Keywords:** Plyometric, Training, Reactive, Agility, Explosive, Power, Functional Performance

## 1. Introduction

One of the most efficient forms of exercise for improving the performance of athletes through increased muscular power and speed is Plyometrics training. This training involves an eccentric contraction of the muscles rapidly followed by a concentric contraction. This is referred to as the stretch-shortening cycle. Some examples of exercises that are included in Plyometrics include box jumps, depth jumps, bounding, squat jumps, and lateral hops. Because of its efficiency, Plyometrics training has become an integral part of the conditioning program of many sports.

### Importance of Reactive Agility

Reactive Agility refers to the ability to make changes of direction as quickly as possible in reaction to an external stimulus. As opposed to Planned Agility, Reactive Agility involves not just the physical skills but also the perceptual, cognitive, and decision-making skills of the player. It is regarded as one of the most important factors in determining athletic performance in games like soccer, basketball, volleyball, badminton, rugby, tennis, and other combat sports where players have to react constantly to their opponents or fellow players.( Faigenbaum, A, 2019)

### Explosive Power and Athletic Performance

Explosive strength is the ability to produce the highest possible force in the minimum amount of time, and is essential for the successful performance in any sport. It affects sprint start, jumping, quick changes in the direction of movement, kicking, throwing, etc. The plyometrics increase the explosive strength through the improvement of neuromuscular coordination, muscle stiffness and the effectiveness of stretch-shortening cycle. Increased explosive strength leads to improved speed and agility, as well as enhanced sports performance.

### Functional Performance in Athletes

Performance function is concerned with how the athlete is able to move through the sport-specific skills in an effective manner without any harm and consistently in training and in competition. Several physical factors come into play here, including balance, coordination, muscular strength, speed, agility, endurance, and movement control. Functional

improvements do not only improve competitiveness but also prevent any injuries due to efficient mechanics and neuromuscular control. Plyometrics is known to improve functional capabilities in athletes of various sports and age groups.( Purwanto, S et al., 2020)

**Role of Plyometric Training in Sports Performance**

Several studies have revealed that plyometric exercises lead to improvements in sprinting, vertical jumping, agility, muscular power, and change of direction. This is due to increased motor unit activation, force development rate, muscle-tendon stiffness, and intermuscular coordination. Therefore, athletes can carry out explosive movements effectively and maintain performance throughout the competition period. Due to these benefits, plyometric exercises have become essential components of strength training for athletes participating in both individual and team sports.

**Objectives Of The Study**

1. To study on Role of Plyometric Training in Sports Performance
2. To study on Explosive Power and Athletic Performance

## Research Method

**Research Design**

The present systematic review was done using the SLR method in accordance with the PRISMA guidelines. The goal of the methodology is to find, analyze and integrate scientific research results systematically in order to get a scientifically valid and reproducible conclusion (Page et al., 2021).

**Data Sources and Search Strategy**

The literature search of articles was done in four major scientific databases: Scopus, PubMed, Google Scholar, and SINTA (Science and Technology Index Indonesia). The time period was set from 2016 to 2024 in order to obtain the most recent results. The key words used during the search were the combinations of the following phrases: ("plyometric training" OR "plyometric exercise") AND ("athletic performance" OR "muscle power" OR "jump performance" OR "sport training"). The strategy of the search was organized with the help of Boolean operators and the other filters: humans, athletes, training interventions. The selected articles were processed through Mendeley Reference Manager.

**Inclusion and Exclusion Criteria**

Selection criteria have been defined in order to make the selection process of articles systematic, as seen in Table 1..

**Table 1. Inclusion and Exclusion Criteria**

| No. | Criteria | Inclusion Criteria | Exclusion Criteria |
|---|---|---|---|
| 1 | Study Type | Experimental design studies, quasi-experimental design studies, RCTs, systematic reviews | Opinion articles, qualitative studies, case reports, and studies without empirical data |
| 2 | Population | Athletes or individuals participating in regular sports training | Non-athletes and clinical populations |
| 3 | Intervention | Plyometric training program with a duration of ≥ 4 weeks | Other types of training interventions or studies with unclear intervention methods |
| 4 | Outcome Variables | Muscle power, speed, jumping performance, and change-of-direction ability | Psychological, behavioral, or social outcome variables |
| 5 | Language | Studies published in English or Indonesian | Studies published in languages other than English or Indonesian |
| 6 | Methodological Quality | Articles published in journals indexed in Scopus or SINTA (Levels 1–3) | Unindexed journals or publications in predatory journals |

**Table 2. Article Selection Procedure Following PRISMA Stages**

| No. | PRISMA Stage | Number of Articles | Description |
|---|---|---|---|
| 1 | Identification | 476 | Articles identified from electronic databases, including Scopus (180), PubMed (120), Google Scholar (140), and SINTA (36). |
| 2 | Screening | 245 | Articles were screened based on titles and abstracts after removing duplicate records. |
| 3 | Eligibility | 58 | Full-text articles were assessed for eligibility based on the predefined inclusion and exclusion criteria, study content, and methodological quality. |
| 4 | Inclusion | 15 | Articles that fulfilled all inclusion criteria were included in the final review and data analysis. |

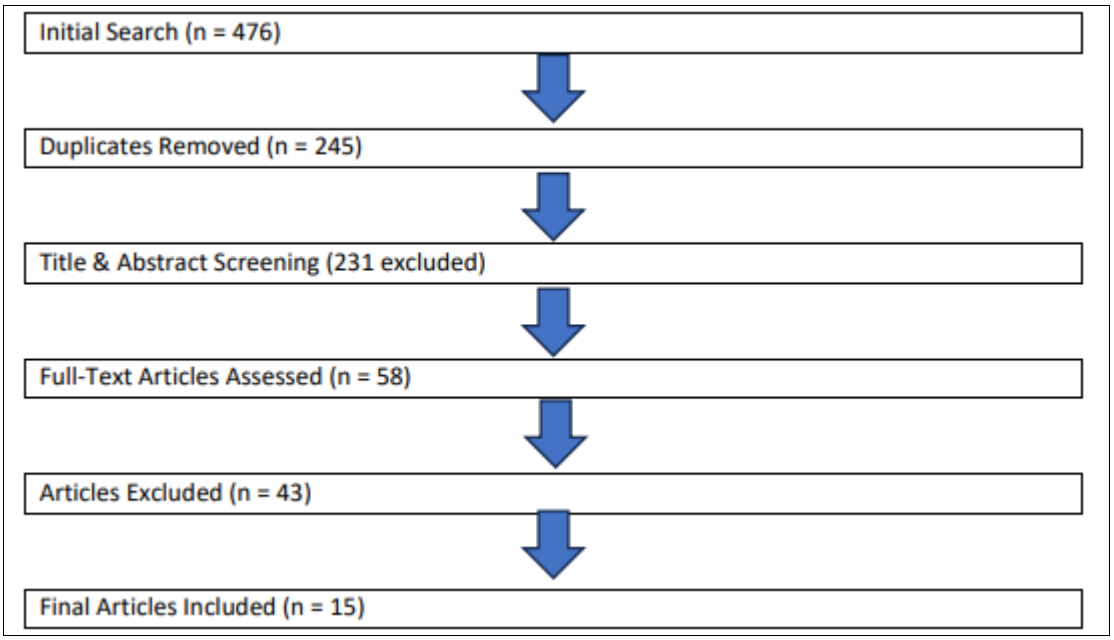


**Figure 1 PRISMA Flow Diagram**

The diagram shows the process of eliminating articles gradually until 15 relevant articles were found for the subsequent analyses.

**PRISMA Flow:**
Initial search (n = 476) → Removal of duplicates (n = 245) → Articles based on title & abstract (n = 231 articles were excluded) → Articles based on full texts (n = 58) → Articles deemed ineligible (n = 43) → Final articles (n = 15). Initial search (n = 476) At this preliminary phase, articles were extracted from some popular scientific databases, which include: Scopus, PubMed, Google Scholar, Sinta (Science and Technology Index of Indonesia). The keyword combination used is: “plyometric training” OR “plyometric exercises” AND “athletic performance” OR “muscle power” OR “explosive strength”. From all databases, 476 articles were collected.

This is the raw total number of all the articles on the following topics: Plyometric training, Muscle power, Physical performance, Athletes and sports At this stage, however, there are many articles that are: Duplicates, Not relevant to the topic of athletic, Not up to scientific standard. Therefore, a further elimination process was needed. Duplicates Eliminated (n = 245) Since the articles were gathered from different databases, the same article can appear several times. For instance: Article A appears in Scopus The same article also appears in Google Scholar In this case, the article will be counted twice even though it is only one article. In order to fix this problem: All the articles were uploaded into Mendeley Reference Manager The duplicate detection tool was used Articles having the same title, author and publication year were eliminated. After elimination of duplicates: Unique articles left: 245 What does this stage mean? At this stage, there was no loss in quality of data, only cleaning up of the data set.

**Title & Abstract Screening** (231 articles excluded) At this point, an initial screening was conducted via reading: The title, The abstract (research summary). The following criteria were applied to each article: Does it really talk about plyometric exercises? Are the subjects athletes or sport students? Is it related to physical performance, muscle strength, sprinting, jumping, or agility? Is it an experimental study or a scientific review. Articles that did not pass this phase were those that talked only about Yoga, Pilates or stretching exercises; Those concerned with injuries or rehabilitation rather than performance issues; Those whose subjects were elderly people or patients; Not related to sport and athletes; They were just opinions, blogs or any other article that is not peer-reviewed and journal article. Out of 245 articles, 231 articles were excluded 14+ articles were left for further screening (+ 1 important Indonesian article from SINTA → total of 15 articles). Importance of this stage This phase made sure that only relevant articles were considered.

**Full-Text Articles Assessed –** 58 articles Articles which successfully passed title and abstract screening were next read in full (full text): 1) the methodology was analyzed, 2) experimental design was assessed, 3) whether: the plyometric training was actually performed; pre and post-test data were provided; the duration of training was specified; results were measurable. Nevertheless, a detailed analysis revealed that: certain articles lacked enough information about the training program; some interventions lasted for only 2-3 weeks (which is too short); certain experiments were conducted using inappropriate/unclear methods; some articles were taken from low quality journals. Hence, additional screening was necessary at this stage.

**Ineligible Articles (n = 43)** Of the 58 articles analyzed for their full texts, 43 articles were excluded for the following reasons: The plyometric training program is not adequately described, no quantitative result data were given, it was just non-systematic literature review, Subjects were not athletes (such as patients or elderly people), The journal where the article was published was not indexed in Scopus/SINTA, weak or invalid methodology. Final Articles Included (n=15) Eventually, 15 high-quality articles were selected that: Were indexed in Scopus and/or SINTA, employed plyometric training, used athletes as subjects, assessed power, sprinting, jumping, agility, or change of direction (COD), had reliable and valid methodology, appropriate as the core sources for the review. They were utilized in: The results table, Narrative analysis, Discussion, Conclusion, Coaching recommendations. The selection procedure was performed by PRISMA method. Out of 476 screened articles, 231 were excluded because of irrelevance or duplicates. In total, 58 articles underwent full text review (full-text analysis) and 43 articles were excluded as failing to meet the required quality criteria. Eventually, 15 articles met all the inclusion criteria.

**Data Extraction and Analysis**

The data for each article were gathered through the use of data extraction sheets which include the following information: Author(s) and year of publication, Population and type of sport, Duration and frequency of the plyometric training program, Outcome variables (outcome measures), Results/ findings and implications. The data analysis process was done through the use of descriptive narratives highlighting the trends of efficacy of plyometric training in terms of power and speed.

## Result And Discussion

Totally 15 articles which fulfilled the inclusion criteria were analyzed thoroughly. The articles were taken from journals indexed by Scopus (10 articles) and Sinta (5 articles) in the period of 2016 to 2024. Table below presents the summary of main features of each study.

**Table 3. Summary of Studies on the Effects of Plyometric Training on Athletes' Physical Performance**

**Table 3. Characteristics of Studies Included in the Review**

| No. | Author (Year) | Research Subjects | Duration & Frequency | Main Variables | Main Results | Journal Index |
|---|---|---|---|---|---|---|
| 1 | Ramírez-Campillo et al. (2023) | 36 youth soccer athletes | 8 weeks, 3 sessions/week | Leg power, sprint | Significant improvement in leg power and sprint speed | Scopus Q1 |

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| 2 | Sammoud et al. (2021) | 28 soccer players | 8 weeks, 2 sessions/week | Vertical jump, agility | Significant improvement in vertical jump and agility | Scopus Q2 |
| 3 | Thomas et al. (2017) | 30 basketball athletes | 6 weeks, 3 sessions/week | Explosive power | Significant increase in jump height | Scopus Q1 |
| 4 | Ramírez-Campillo et al. (2018) | Youth soccer athletes | 7 weeks | Change of Direction (COD) | COD ability improved by 12% | Scopus Q1 |
| 5 | Dodd & AlNakeeb (2019) | 40 volleyball athletes | 10 weeks, 2 sessions/week | Spike jump, reaction time | Improvement in spike jump and reaction time | Scopus Q2 |
| 6 | Latorre-Román et al. (2020) | 25 youth basketball athletes | 8 weeks | Strength, sprint | Significant improvements in strength and sprint speed | Scopus Q2 |
| 7 | Cherif et al. (2018) | 32 futsal players | 6 weeks, 3 sessions/week | Agility, sprint | Improvements in agility and sprint performance | Scopus Q1 |
| 8 | Ramírez-Campillo et al. (2020) | 27 U-17 soccer players | 6 weeks | Jump performance | Improved lower-limb explosive power | Scopus Q1 |
| 9 | Faigenbaum et al. (2019) | 50 youth multi-sport athletes | 9 weeks | Lower limb strength | Significant increase in lower-limb strength | Scopus Q1 |
| 10 | Beato et al. (2021) | 35 professional soccer players | 8 weeks | Sprint, Change of Direction (COD) | Sprint and COD performance increased by approximately 10% | Scopus Q1 |
| 11 | Susanti et al. (2022) | 20 Indonesian youth volleyball athletes | 6 weeks | Leg power | Lower-limb explosive power increased by 18% | SINTA 2 |
| 12 | Purwanto et al. (2020) | 25 high school soccer athletes | 8 weeks | Leg muscle power | Significant improvement ($p < 0.05$) | SINTA 2 |
| 13 | Mahendra & Yulianto (2021) | 30 university basketball players | 6 weeks | Vertical jump | Jump height increased by 15% | SINTA 2 |
| 14 | Hidayat et al. (2023) | Youth futsal athletes | 8 weeks | Speed, explosive strength | Significant improvement in speed and explosive | SINTA 1 |

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|---|---|---|---|---|---|---|
| | | | | | strength ($p < 0.01$) | |
| 15 | Widodo & Rachman (2019) | Volleyball athletes | 10 weeks | Spike performance, block performance | Improvement in spike and block performance | SINTA 3 |

From the analysis of the information provided in the above table, a clear pattern is observed in which plyometric training greatly enhances explosive performances and leg strength in various sports. The majority of the studies indicated significant increases in factors such as vertical jump, sprint speed, agility, and change of direction (ramírez-campillo et al., 2023; beato et al., 2021; susanti et al., 2022). The average period of an effective training program was 6-10 weeks, with a frequency of training sessions twice to thrice per week (markovic & mikulic, 2010). All these results indicate that moderate and regular training volumes are better than long sessions without the correct periodization process. Moreover, plyometric training was found to be efficient for both professional and young athletes, which means that neuromuscular adaptation is achieved regardless of the fitness level (faigenbaum et al., 2019). Research carried out in indonesia (susanti et al., 2022; hidayat et al., 2023) also proves that this training can be successfully used in schools and universities, resulting in notable results. However, the variation in research outcomes may have been caused by the difference in the type of exercises performed (depth jump or bounding drills), intensity, and physical condition of the participants. For instance, the study carried out by dodd & al-nakeeb (2019) showed more progress in reaction time than in absolute strength, suggesting that this kind of training not only increases muscular strength but also improves neuromotor reactivity.

## Synthesis And Discussion

In general, the results of this literature review support the stretch–shortening cycle (ssc) hypothesis advanced by Komi (2003), according to which muscles under the influence of quick stretching will exhibit more intense muscle contraction due to the accumulation of greater levels of passive elastic energy and reflex activation. As for training, the best way to achieve the effect is using plyometrics, which is based on optimization of the ssc. From the perspective of the sports coach, it can be stated that the current results highlight the necessity of introducing plyometrics into the periodized training process. These findings are also in line with verkhoshansky's (2018) idea that plyometric training is not only jumping activities but rather a neuromuscular system conditioning technique that facilitates fast switching from eccentric to concentric muscle contraction, which is fundamental for explosive strength development. Contemporary research findings confirm the efficacy of plyometric training, however, the level of its efficiency varies significantly depending on moderating factors such as age, kind of sports, length of the program, and other training parameters. As can be seen from the findings of an umbrella review conducted by kons et al. (2023), the effects of plyometric training on physical performance may be trivial or significant, which implies that this technique works well but it cannot produce consistent results in all groups of athletes. It can be claimed that this confirms the idea that plyometric training without individual adaptation will not lead to good training results.

For youth athletes, however, the literature demonstrates the presence of a good adaptation to plyometric training. The meta-analysis conducted by chen et al. (2023) for adolescent athletes demonstrated considerable improvements in countermovement jump (cmj), squat jump (sj), and short-distance sprint speed. Thus, the literature demonstrates that during the periods of growth and neuromuscular maturation, an organism becomes more sensitive to the effect of stretch-shortening cycle-based training. On the other hand, the described situation also means that there exists a certain danger, and in case when the volume and intensity of training are not carefully controlled, the risk of overuse injuries is increased among youth athletes. Unfortunately, this fact is often neglected by coaches interested only in short-term results and ignoring the principles of long-term athlete development. The effectiveness of plyometric training in combat sports athletes was demonstrated by Yuan et al. (2025) for taekwondo, judo, and karate athletes; however, the size of effect was moderate ($\approx 0.45 – 1.04$). It means that the specifics of demands in sport greatly impact adaptions, which means that they should not be considered similar to what happens during the practice of team sports like football and basketball. The fact that a coach believes that the same program is applicable to all kinds of sports implies a significant mistake. Furthermore, more modern studies are starting to explore the biological mechanism that is behind the improvement in performance that was presumed theoretically before. In their study, Sun et al. (2025) showed that plyometric training not only improves the functional performance of an athlete but also affects muscle and tendon

structure, like fascicle length changes, pennation angle changes, and tendon stiffness increase. Thus, plyometric training does not affect athletes mechanically, but at a structural level. The coaches that do not know this mechanism would consider plyometric training just "jump training".

According to the study carried out among young soccer players conducted by Zheng et al. (2025), the most significant gains came in change of direction and jumping, but relatively modest gains were made with respect to pure sprint speed. It means that when the main focus of a coach is improving his player's speed performance, using only plyometric training will not be ideal. This statement is supported by Ma et al. (2025), who found that plyometric training is very good at developing explosive strength, but is inferior to strength training when it comes to maximal strength development. It means that if a coach depends only on one training method, he demonstrates a very basic knowledge about coaching science. In professional terms, this evidence is a good reason for changing the paradigm of training from "heavier weight + jumping = better performers" to "training depending on physiological needs + periodization + choosing right training methods = performance improvement". And if a coach wants to get maximum results, plyometric training + strength training + sprint training must become a norm rather than an additional tool.

## Conclusion

On the basis of the results of the Systematic Literature Review, including 15 scientific articles indexed in Scopus and SINTA databases, it can be concluded that the plyometric training has a pronounced effect on the development of muscle power, explosive strength, speed and agility in athletes engaged in different types of sports. The most effective plyometric training programs were characterized by duration of 6 to 10 weeks, frequency of 2 to 3 times per week and included the following exercise variations: depth jumps, bounding and lateral hops. Thus, it is obvious that the plyometric training is one of the most effective means of increasing the physical condition of athletes regardless of their experience level. At the same time, plyometric training contributes to improvement of neuromuscular coordination and effectiveness of the stretch–shortening cycle (SSC). That is why coaches should include plyometric training in the periodization program of their athletes' training.

**Recommendations**

To coaches: Use progressive plyometric exercises by starting at low intensity so as to reduce the possibility of injury. To young athletes: Concentrate on learning how to jump correctly before increasing intensity of training. To future researchers: Carry out a quantitative meta-analysis to ascertain the effect size of plyometric exercises in various sports and age categories. To coaching organizations: Develop a plyometric training unit in coaching courses.

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