

Proprioception Training on Basketball Special Technical Performance

Zhihan Zhu*

¹Yaxin College of Life and Health,
Wuhan Institute of Design and
Sciences, Wuhan 430205, China

*Corresponding author:
michaelcavendish0418@gmail.com

Abstract:

Proprioception is an important sensory basis for human perception of joint position, movement direction and muscle tension changes, and plays an important role in maintaining body posture stability, dynamic balance and movement coordination. Basketball has the characteristics of fast speed, strong confrontation, frequent movement changes and so on. Athletes need to constantly rely on proprioception to complete body control and technical movement adjustment in the process of passing, shooting, dribbling, emergency stop direction change and defensive movement. Therefore, proprioception training may have a positive impact on basketball special technical performance. This paper uses the method of narrative review to sort out the application research of proprioception training and its related training forms in basketball special technical training, focusing on the analysis of its impact on passing accuracy, shooting stability, dribble control ability and defensive movement performance. Existing studies have shown that proprioception training can provide support for the stable completion of basketball technical movements by improving balance ability, posture control, lower limb stability and sensory motor coordination ability. On the whole, proprioception training has certain application value in basketball special training, but at present, there are still some problems in related research, such as small sample size, inconsistent training scheme, and imperfect special technical evaluation index. Future research should further expand the sample range, standardize the training intervention program, and establish a more scientific technical evaluation system combined with the basketball special situation, so as to provide a more sufficient theoretical basis for basketball training practice.

Keywords: Proprioception training; basketball; special technology; balance training; athletic performance

1. Introduction

Proprioception, that is, the ability of the human body to perceive the movement of joints and the position of various parts of the body in space, is an important sensory basis for maintaining posture control, dynamic balance and motion coordination [1]. Proprioception training, which takes this as the core, aims to improve athletes' position perception, balance ability, movement coordination and neuromuscular control [2].

Proprioception plays an important role in motion control. First, it helps the human body perceive the changes of joint position and body posture, so as to maintain posture stability in the process of standing, moving and moving. Second, participate in dynamic balance adjustment. In the rapid movements such as running, taking off, landing, emergency stop and changing direction, athletes need to rely on proprioception to continuously monitor the center of gravity and joint angle, and make timely adjustments accordingly. Third, the sensory information of muscles, tendons and joints is transmitted to the nervous system, so that the brain can fine regulate the range of motion, force and motion rhythm. Fourth, it is related to sports learning and movement relearning. Athletes need to rely on sensory feedback to correct the details of movements in the process of repeated training, so as to improve the stability and accuracy of technical movements. It can be seen that proprioception is not only the sensory basis for maintaining body balance, but also an important condition for completing complex motor skills [1,2]. In basketball, special technical actions such as shooting, dribbling, passing and emergency stop direction change require athletes to complete body posture control, center of gravity adjustment and action output in the competition situation [3]. This is precisely highly dependent on the above proprioception. Based on this, this paper systematically combs the impact of proprioception training on basketball special technical performance, focusing on the relationship between proprioception training and technical performance such as shooting, passing, dribbling, defense, etc.

2. The innovation of this review lies in the following three aspects. First, building on previous reviews of balance-related training in basketball, this review narrows the focus to basketball-specific technical performance and examines individual skills in greater detail. Second, the available evidence is organized according to passing, shooting, dribbling and defensive movements, allowing the strength and consistency of evidence across different technical skills to be compared. Third, this review identifies limitations in existing assessment methods, particularly the reliance on completion time in the evaluation of dribbling and defensive movements, and proposes the use of more compre-

hensive and game-specific indicators in future research. Definition of Proprioception Related Training Forms

In research on basketball-specific training, proprioceptive training usually does not exist in isolation, but is often associated with balance training, unstable-support training, dynamic postural-control training and neuromuscular-coordination training. The balance-control process requires the participation of visual, vestibular, proprioceptive and other sensory information [1,2]. Proprioception can provide athletes with information about joint position, body posture, muscle tension and movement rhythm. Therefore, single-leg support, eyes-closed balance, unstable-surface training, dynamic landing-stability training and balance training combined with sport-specific movements may stimulate proprioceptive function by increasing the demands on body-position perception and postural adjustment. In view of the frequent overlap between proprioceptive training and the above training forms in the existing literature, the operational scope of "proprioceptive training" is appropriately expanded in this paper to include balance and proprioceptive training, unstable-surface functional balance training, unstable multidimensional-surface balance training and sensorimotor balance training [2,3].

It should be clear that balance training is not the same as proprioceptive training, but the two overlap in their training-adaptation mechanisms. Considering that most basketball intervention studies use such combined training, this paper discusses these interventions as proprioception-related training in order to reflect the actual nature of the available research evidence [2,3].

Proprioception-related training can be further classified according to task type and training environment. Static forms mainly include single-leg standing, eyes-closed balance and posture-maintenance exercises. Dynamic forms include landing stabilization, multidirectional movement, rapid changes of direction and balance recovery after movement. Unstable-surface training uses balance boards, foam pads or other unstable devices to increase the demands on joint-position perception and neuromuscular control. Sensorimotor training further combines sensory input, postural adjustment and coordinated movement. In basketball training, these exercises may also be integrated with sport-specific tasks such as passing, shooting, dribbling, landing and defensive footwork [2,3].

Different training forms may place different demands on proprioceptive and motor-control functions. Static balance exercises mainly emphasize postural stability and joint-position maintenance, whereas dynamic and unstable-surface exercises require continuous adjustment of the center of gravity, joint angles and muscle activation. When proprioception-related exercises are combined with basketball-specific movements, athletes are required to

maintain technical accuracy while adapting to changes in body position and support conditions. Therefore, the effects of proprioception-related training on basketball performance may depend not only on the training form itself, but also on its specificity, difficulty, progression and integration with technical practice [2,3].

3. The Influence of Proprioception Training on Basketball Special Technology

3.1 Impact on Passing

Passing is an important special technology connecting individual technology and team tactics in basketball games. Its completion quality directly affects the attack organization, tactical cohesion and scoring opportunity creation. Different from the simple in-situ movement, the passing in the game often occurs after running, emergency stop, confrontation, turning or changing direction. Athletes need to complete observation, judgment and action output under the condition of changing body posture. Therefore, passing depends not only on upper limb strength and hand control, but also on body stability, center of gravity adjustment, trunk control and upper and lower limb coordination. Proprioception can help athletes perceive body position, joint angle and force rhythm, and provide sensory feedback basis for the stable completion of passing movement.

In the existing research, passing is one of the special techniques with the most sufficient evidence of the intervention effect of proprioception training. A study of 26 adult athletes, using 12 weeks of balance and proprioception training intervention, in which the experimental group added 12 weeks of balance and proprioception training on the basis of conventional basketball training, the control group did not receive additional balance and proprioception training. The results showed that the passing performance of the experimental group increased by 14.92%, while that of the control group increased by only 1.72%, ($p=0.002$) [4]. Further analysis according to the position on the field, the guard, forward and center experimental groups increased by 13.25%, 15.34% and 17.01% respectively, suggesting that balance and proprioception training can promote the passing performance of athletes in different positions [4]. It shows that the body stability and posture control ability may have an important impact on the accuracy of passing.

The research among young basketball players also supports this view. A study of 13-14-year-old basketball players as the object, using 8 weeks of balance and pro-

prioception training intervention. The results showed that the pass accuracy of the men's test group increased from 185.4 to 206.9 points, and that of the women's test group increased from 181.4 to 225.0 points, an increase of about 11% and 19% respectively [5]. This shows that balance and proprioception training can not only improve the passing performance of adult basketball players, but also have a positive impact on the passing accuracy of adolescent basketball players.

In general, the performance of passing is the item that can better reflect the training effect of proprioception in the current basketball special technology. Balance and proprioception training, unstable surface training and other training forms may improve the accuracy and stability of athletes' passing actions in different body postures by improving physical stability, dynamic balance, trunk control and upper limb movement coordination [4-6].

3.2 Impact on Shooting

Shooting is one of the most direct scoring techniques in basketball, and it is also an important content to evaluate the technical performance of basketball. The shooting action is not simply completed by upper limb strength or wrist action, but a continuous action process including preparation, take-off, ball lifting, release and landing. A review of basketball jump shots has pointed out that the performance of shooting is affected by factors such as the height of the ball, the angle of the ball, the speed of the ball, the body posture and the coordination of different shooting stages [7]. This shows that the performance of shooting is not only determined by the action of the ball at the moment of leaving the hand, but also related to the control of body posture, the connection of action stages and the coordination of multiple body links in the whole shooting process.

From the perspective of proprioception, the completion of complete shooting action requires athletes to constantly perceive and adjust their own physical state. Before shooting, athletes need to feel the support position of both feet, the angle of lower limb joints and the center of gravity of the body to form a stable preparation posture; When taking off, it is necessary to adjust the lower limb force according to the position of hip, knee and ankle joints and muscle force state; In the process of lifting and releasing the ball, it is necessary to maintain the stability of the trunk, and coordinate the movement rhythm of the shoulder, elbow, wrist and other joints, so that the strength can be transmitted from the lower limb to the upper limb in a more consistent manner; At the landing stage, it is also necessary to re-perceive the change of body gravity and restore balance. Therefore, the consistency, stability and

accuracy of shooting movement are related to the athletes' perception and adjustment ability of body position, joint movement and force rhythm.

In a controlled study involving 21 male teenagers aged 15-18 years old, the experimental group (n=11) received 10 weeks of unstable surface functional balance training on the basis of conventional basketball training, while the control group (n=10) received traditional resistance training. The results showed that the accuracy score of jump shot in the experimental group increased from 30.50 points before training to 36.00 points after training, and that in the control group increased from 30.30 points to 32.60 points; The comparison between groups showed that the improvement of the experimental group was significantly better than that of the control group ($P=0.004$, $d=1.07$) [8]. These results suggest that proprioception related training characterized by unstable support and dynamic balance may improve the accuracy of jump shot by improving dynamic posture control and body coordination. Another control test showed that the fast-shooting score of the men's experimental group increased from 40.5 points to 44.5 points, an increase of about 8.6% [5], while that of the men's control group increased from 34.6 points to 34.9 points, with little change. Fast shooting has high requirements for athletes' movement rhythm, physical stability and release speed.

Overall, the relationship between shooting performance and proprioception is mainly reflected in body posture control, movement chain continuity, hand stability and landing balance. Existing studies have shown that functional balance training on unstable surfaces, balance and proprioception training, sensory motor balance training and other proprioception related training forms may have a positive impact on jump shot accuracy, fast shooting and jump shot kinematics [7-9].

3.3 Impact on Dribbling and Defensive Movement

Compared with passing and shooting, the evidence of proprioception related training on dribbling and defensive movement performance in the existing research is relatively limited, but they are still related to body perception, dynamic balance and posture control in the movement mechanism. Basketball dribbling is not a simple hand stroke, but a perception action control task with the participation of visual information, body control, upper limb joint adjustment and field judgment. Relevant studies have shown that under different perceptual conditions, athletes can maintain dribbling control by adjusting the movement variability of upper limb joints [10]. Therefore, from the perspective of movement mechanism, proprioception may

affect dribble stability by improving body position perception, upper limb joint control, center of gravity adjustment and movement rhythm control.

From the existing training intervention data, the improvement of balance and proprioception training on the change dribble performance is not obvious. Some researches regard the changing direction dribble as one of the basketball technical test indicators. The results show that after 8 weeks of balance and proprioception training, the changing direction dribble performance of the men's experimental group changes from 17.3 s to 17.1 s, and the women's experimental group changes from 18.8 s to 18.9 s, with a small overall improvement [5]. The results suggest that the impact of proprioception related training on dribble performance may be limited by the test methods and evaluation indicators. If only the time required to complete the scheduled route is taken as the evaluation standard, the results may reflect the speed, sensitivity and route completion efficiency more, but cannot fully reflect the stability of ball control, the number of low head observation, the error rate, the ability of weak side hand control and the quality of ball control in complex situations.

In terms of defensive movement, defensive sliding is the basic movement technology in basketball defense. The completion process requires athletes to maintain low center of gravity, control body posture and quickly adjust direction in lateral movement. From the perspective of movement characteristics, defensive sliding is closely related to dynamic balance, supporting foot stability, body center of gravity control and direction conversion ability, so it has a certain relationship with proprioceptive function. The relevant experimental data showed that after 8 weeks of balance and proprioception training, the defensive sliding performance of the men's experimental group changed from 23.3 s to 23.1 s, with a small improvement; The female experimental group was shortened from 24.6 s to 23.8 s, showing some improvement [5]. But at the same time, the defensive sliding performance of the control group was also improved, so the results can only suggest that proprioception related training may have an impact on the performance of some defensive movements, which cannot be used as strong evidence to significantly improve the defensive sliding ability.

On the whole, dribbling and defensive movement are related to proprioception in theory, but the supporting evidence of the existing experimental research on the improvement of their special technical performance is not as sufficient as passing and shooting. On the one hand, dribbling and defensive movement require athletes to complete body posture control, center of gravity adjustment and direction conversion during movement; On the other hand, most of the existing studies use the completion time

as the evaluation index, which may be difficult to fully reflect the quality of ball control, the stability of defensive posture and the quality of technical completion in the game situation.

4. Conclusion

As an important part of human motion control, proprioception plays an important role in maintaining body posture stability, dynamic balance, movement coordination and neuromuscular control. These abilities are also an important basis for the completion of basketball special technology. Existing studies have shown that proprioception related training mainly includes balance training, unstable support training, sensorimotor training and functional balance training, with the common goal of improving body position perception, posture control and movement coordination [1-3].

Based on the existing research results, it can be found that proprioception training has a certain role in promoting the performance of basketball special technology, but the evidence intensity of different technical projects is different. Among them, passing and shooting are the special techniques with sufficient research evidence at present. Most studies have shown that after 6-12 weeks of balance and proprioception training or unstable surface training, athletes' passing accuracy, passing speed, jump shot accuracy and some shooting kinematics indexes have been significantly improved [4-9]. The mechanism may be related to the fact that proprioception training can enhance body stability, dynamic balance ability, trunk control and upper and lower limb coordination ability, so as to improve the stability and accuracy of technical movements.

In contrast, the effect of proprioception training on dribbling and defensive movement performance is still lack of consistent evidence. Although, from the theoretical analysis, proprioception can improve control of the body center of gravity, regulation of movement rhythm and direction conversion ability, and may have a positive effect on dribbling and defensive movement, the improvement of relevant technical indicators in the existing studies is small. Most studies only use the completion time as the evaluation index, which is difficult to fully reflect the quality of ball control, the stability of defensive posture and the technical performance in the game situation, so more high-quality studies are still needed for further verification [5,10].

In general, the existing evidence supports that proprioception training can improve some special technical performance of basketball players, especially in passing and shooting. However, there are still some problems in the existing research, such as small sample size, large

differences in intervention programs, lack of unity in evaluation indicators, and insufficient research on high-level athletes, which limit the popularization and application of the research results. In order to improve the reliability of research results, future studies should further expand the sample size and carry out multicenter, randomized controlled studies; At the same time, the proprioception training program should be standardized, and the training cycle, frequency, intensity, content and advanced standards should be defined to enhance the comparability between different studies; In terms of evaluation, we should establish a more objective and comprehensive basketball special technology evaluation system, and comprehensively analyze the shooting hit rate, passing accuracy, dribbling stability, direction change speed, balance control ability and other indicators. In addition, we should also pay more attention to high-level basketball players, and further explore the mechanism of proprioception training in improving basketball special technical performance by combining sports biomechanics, neuromuscular control and real game situation analysis, so as to provide more sufficient theoretical basis and practical reference for basketball special training.

References

- [1] Han J, Waddington G, Adams R, Anson J, Liu Y. Assessing proprioception: A critical review of methods. *J Sport Health Sci*. 2016;5(1):80-90. doi: 10.1016/j.jshs.2014.10.004.
- [2] Yılmaz O, Soyly Y, Erkmén N, Kaplan T, Batalik L. Effects of proprioceptive training on sports performance: a systematic review. *BMC Sports Sci Med Rehabil*. 2024;16(1):149. doi: 10.1186/s13102-024-00936-z.
- [3] Wang Z, Chen N, Cao S, Gao L, Geok SK, Liu J. The effects of balance training on physical fitness and skill-related performance in basketball players: a systematic review. *BMC Sports Sci Med Rehabil*. 2025;17(1):108. doi: 10.1186/s13102-025-01164-9. PMID: 40312426; PMCID: PMC12044794.
- [4] Kostopoulos N, Bekris E, Apostolidis N, Kavroulakis E, Kostopoulos P. The effect of a balance and proprioception training program on amateur basketball players' passing skills. *Journal of Physical Education and Sport*. 2012;12(3):316-323. doi: 10.7752/jpes.2012.03047.
- [5] Zacharakis ED, Bourdas DI, Kotsifa MI, Bekris EM, Velentza ET, Kostopoulos NI. Effect of balance and proprioceptive training on balancing and technical skills in 13-14-year-old youth basketball players. *Journal of Physical Education and Sport*. 2020;20(5):2487-2500. doi: 10.7752/jpes.2020.05340.
- [6] Fisek T, Agopyan A. Effects of six weeks of stable versus unstable multi-dimensional surfaces balance training on passing skills and balance performance in young male basketball players. *Journal of Men's Health*. 2021;17(4):264-277. doi: 10.31083/

jomh.2021.073.

[7] Okazaki VHA, Rodacki ALF, Satern MN. A review on the basketball jump shot. *Sports Biomechanics*. 2015;14(2):190-205. doi: 10.1080/14763141.2015.1052541.

[8] Ibrahim NA, Zajac T, Lupu G, Saad M, Drozd M, Shani H, Larion A, Essa W, Saleh T, Hashim M, Hamza AS, Alhasany MH. Effects on jump shooting accuracy when using unstable surfaces for functional balance training of youth basketball players. *Journal of Human Kinetics*. 2025; 98:205-216. doi: 10.5114/jhk/208790.

[9] Hassan AK. Enhancing basketball players' jump shooting performance and neuroplasticity, kinematic optimization through flash reflex-based sensory-motor perception and balance. *Scientific Reports*. 2025; 15:22762. doi: 10.1038/s41598-025-04265-0.

[10] Robalo RAM, Diniz AMFA, Fernandes O, Passos PJM. The role of variability in the control of the basketball dribble under different perceptual setups. *Eur J Sport Sci*. 2021;21(4):521-530. doi: 10.1080/17461391.2020.1759695. Epub 2020 May 14. PMID: 32321368.