

Sports Value and Practical Dilemmas of Agility and Change-of-Direction in Badminton-specific Competition

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Abstract: Focusing on agility and change-of-direction in badminton, this review examines the competitive value, biomechanical characteristics and training challenges involved, with the aim of offering practical references for training optimization. The analysis draws on existing literature across three areas: kinematic analysis, training intervention and injury mechanisms. Change-of-direction ability showed strong correlations with coordination ($r = 0.91$), movement speed ($r = 0.86$), reaction ability ($r = 0.81$) and lower limb explosive power ($r = 0.79$). In men's singles, an average rally contained 8.9 ± 2.1 shots, with 77.0 ± 7.5 total points played per match. Side-step footwork incurred a net energy cost of $19.59 \text{ J} \cdot \text{kg}^{-1} \cdot \text{m}^{-1}$, compared with $20.38 \text{ J} \cdot \text{kg}^{-1} \cdot \text{m}^{-1}$ for running footwork. Fatigue led to reduced knee flexion angles and greater valgus moments, raising the likelihood of anterior cruciate ligament injury. Training practice currently struggles with several issues, including a lack of variety in methods, insufficient individualization, and limited use of technological tools. These findings point to the need for a multi-factor training approach, better sport-specific assessment tools, and greater attention to load management and injury prevention.

Keywords: Badminton; Agility and Change-of-Direction; Sport-Specific Physical Fitness; Sports Injuries; Training Difficulties.

1. Introduction

Badminton is a team sport with a net, and the players need to use their bodies and change their speed at all times according to the path of the shuttlecock in the playing area. The capacity to change direction quickly refers to a person's ability to alter the direction of movement rapidly and connect the next shot according to changes in the path of the ball while running. Biomechanical analysis of a complete change of direction includes the initial and final phases of acceleration and deceleration during the motion, braking, and a secondary start. It should have good neuromuscular coordination, a low centre of gravity, and strong lower limbs.

The level of the change-of-direction ability includes both technical tactics and physical fitness. Good technical tactics for direction change can help a player reach a good hitting position earlier, get to a higher hitting spot, and have enough time for the stroke; they can also increase the range of shots they can play. Change-of-direction training strengthens the muscles in the lower body and core and improves stability, etc. Li and Ding (2021) tested 101 badminton players at or above Level 3 according to the Chinese National Sports Administration's Technical Grade Standards for Badminton Players, built a structural equation model using the SpeedCourt system, and found that the change-of-direction ability was most closely related to coordination ($r = 0.91$), followed by movement speed ($r = 0.86$), reaction time ($r = 0.81$), and lower limb explosive power ($r = 0.79$). Therefore, the change-of-direction ability is limited by several factors of physical fitness [1].

Current training still has some deficiencies. In university and grassroots training, the practice of agility exercises is often monotonous, there is a lack of differentiated design according to the specific features of the sport, and traditional assessment methods fail to fully simulate the cognitive load in competitions, resulting in limited external validity. The high-intensity impact of the change-of-direction movement causes continuous pressure on the lower limb joints, reduces

the flexion angle of the knee joint, increases the valgus moment, and thus raises the risk of anterior cruciate ligament injury. The above problems restrict the improvement of athletes' performance and are also health risks. Therefore, based on the systematic research of the competitive value of agility and change-of-direction, actual difficulties in training are identified, and corresponding adjustments are made to the training method to prevent sports injuries.

2. The Core Value of Agility and Change-of-Direction in Badminton-specific Competition

In badminton competitions, a player needs to be able to predict where the incoming shuttlecock will land and move accordingly in a short amount of time by changing direction quickly. Due to the frequent offensive and defensive transitions and the short duration of each round in this type of competition, the athlete needs to change the direction of movement constantly according to changes in the trajectory of the ball at high speed, and quickly return to the starting position after hitting the ball to prepare for the next shot.

The features of the energy supply are that a single match has several rounds, and within each round, there are many turns, steps, sudden stops and kicks. Each application of badminton footwork includes acceleration, mid-run movement, deceleration braking and direction change. Direction change plays a role in connecting the preceding and subsequent movements, and its complexity and energy consumption are at a relatively high level. Pugliese et al. (2025) quantified the energy cost of badminton-specific footwork using indirect calorimetry, and the results showed that the net energy cost of the side-step footwork was $19.59 \text{ J} \cdot \text{kg}^{-1} \cdot \text{m}^{-1}$, while the running footwork reached $20.38 \text{ J} \cdot \text{kg}^{-1} \cdot \text{m}^{-1}$ [2]. Based on the above data, the metabolic demand of agile movement has reached or exceeded the unit energy consumption level of some periodic endurance events, and this level is relatively high for racket sports. Thus, the

athlete's energy-metabolism system will be significantly damaged.

In practice, the level of agile direction change ability is mainly shown by the strength of "pointing". That is to say, reach a high point in the shot and an early time point to ensure the quality of the return shot and change the direction of the ball. The prerequisite for pointing is whether the athlete can move quickly and accurately to the ball's landing position. Players who are slow to turn generally have to play the ball at a low height because they cannot move quickly; as a result, they often miss a scoring opportunity. Phomsoupha and others have shown that the prediction ability and the speed of change in body direction directly affect the performance of badminton players on the court [3]. Players with good mobility and quick changes of direction can run around the court to drive the opponent repeatedly in an offensive or defensive transition. Therefore, the ability to adapt to changes in the direction of the game flexibly is required to turn basic skills into actual advantages, and this quality must be displayed at every stage and in every contest.

3. The Structural Characteristics and Biomechanical Analysis of Agile Direction Change

The reason for the above-mentioned value of agile direction change is closely related to its specific structural features in badminton. The method of changing direction in badminton is not the same as that for running. In terms of structural features, a full direction-changing movement can be divided into four consecutive and sequential links: prediction initiation, mid-run adjustment, braking and hitting, and return position preparation. In the prediction stage, based on the opponent's racket movement and the flight arc of the ball, the athlete determines where to land, lowers the centre of gravity, and generates a large burst of force by kicking; during the movement, they continuously adjust the direction and speed according to the actual trajectory; before reaching the hitting position, they complete braking and deceleration, stabilise their body posture, and then strike; subsequently, they kick back and return to the preparatory position. These four links are interconnected, and if any of them is slow, the entire trip will be delayed.

Agile Direction Change places a high load on the lower-limb joints. At the beginning, the plantar flexor muscles of the ankle joint and the extensor muscles of the knee joint need to generate a large burst of force in a short time; at the end, eccentric muscle contraction is employed to reduce the body's momentum. The Degree of knee joint flexion and the direction and size of the ground reaction force directly affect braking performance and joint injury. Wang (2022) conducted a study on 20 badminton-specific college students to investigate the effect of fatigue on the biomechanical features of the single-leg landing for overhead shots [4]. Fatigue significantly reduced the knee joint flexion angle at the landing moment, increased the valgus angle, and significantly increased both the knee joint valgus moment and the external rotation moment; additionally, the anterior tilt angle of the trunk at the peak of ground reaction force was also reduced significantly. The changes in the above biomechanical indicators together increase the risk of anterior cruciate ligament injury.

Another problem is that the direction change of the badminton swing is not symmetrical. Due to the unilateral

advantage of the racket-hand, the movement patterns, turning angles and joint forces of an athlete's forward- and backcourt overhead shots are not symmetrical. Kimura and others (2012) recruited 17 right-handed female badminton players to compare the lower-limb biomechanical parameters of single-leg landing after backcourt overhead shots on the forehand and backhand sides [5]. The results showed that the valgus angle and valgus moment of the knee joint during landing on the backhand side were both larger than those on the forehand side. There are both technical requirements for this strengthening of directional change ability in the dominant side is focused on without attention to the non-dominant side, a capability gap will easily occur, and an increased risk of injury due to uneven load on both sides will also arise.

4. Training Methods and Approaches for Enhancing Agility and Change-of-Direction Ability

Many ways have been used in practice to train the agility and change-of-direction ability of badminton players. Multi-directionally moving exercises aim to mimic the movement patterns at various angles at the start and during braking in a race, and plyometric training is focused on fast transitions between eccentric and concentric muscle contractions. Both of these will help to improve the efficiency of the change-of-direction. SAQ (Speed, Agility and Quickness) exercises are divided into straight-line sprints, multi-directional runs, reaction drills, etc., to improve all-around abilities. Recently, it has begun to attract some attention.

Sun and others (2025) have conducted a systematic review and meta-analysis of the performance benefits of SAQ training. A total of 11 randomised controlled trials and 499 athletes from all four sports were included in this study [6]. The results showed that the effect sizes of SAQ training on improving change-of-direction ability were 0.39 ($p < 0.01$), on enhancing reaction time were 0.52 ($p = 0.01$), and on boosting lower limb explosive power were 0.96 ($p < 0.01$). SAQ training also had a positive effect on the 5-metre sprint ($ES = 0.63$), 20-metre sprint ($ES = 0.49$) and 30-metre sprint ($ES = 0.55$). Based on the above results, SAQ training can help develop all parts of agility in multiple ways.

Loureiro and de Freitas (2016) developed the Badcamp agility test specifically for badminton players to assess their agility and change-of-direction ability, and systematically tested the reliability and validity of this test [7]. Specific movements in badminton will be selected for this test to evaluate the agility of athletes at different levels effectively. Badminton-specific general agility tests, such as the start, change-of-direction and braking actions in the Badcamp test, are more ecologically valid than traditional general agility tests (e.g., T-shaped run and Illinois run). It is a reasonably scientific instrument for the quantitative evaluation of training effects.

In short, SAQ training and multi-directional training, plyometric training, etc., are all complementary parts of the training system for agility and change-of-direction ability in badminton. Badcamp and other specific tests can be used to quantify the effect of training reliably. At the same time, new training methods and evaluation tools have been added to assess the results of training better and adjust the training plan accordingly.

5. Risk of Sports Injuries Caused by Frequent Change-of-direction Movements

Although the above training methods enhance the efficiency of change-of-direction, they also subject the joints of the lower limbs to repeated high-intensity mechanical stress. Badminton has many sudden stops and changes in direction, as well as jumps; therefore, the knee and ankle joints are subjected to high stress for a long time. During sudden stops and changes in direction, the knee joint needs to counteract the inertial force caused by deceleration and change of direction, and all parts of the articular cartilage, meniscus, and medial and lateral collateral ligaments are subjected to significant stress.

ACL injuries are relatively serious and occur frequently in sports with many changes of direction. This ligament needs to keep the front-to-back position of the knee joint stable. If the knee joint is in a valgus or excessive rotation position when flexed during a sudden stop or change in direction, a ligament may be damaged. Tan et al. (2024) conducted a retrospective survey of 66 elite badminton players ranked in the top 200 of the world. Forty-nine cases (74.2%) of ACL injuries occurred during competitions, 14 cases (21.2%) during training; 47 cases (74.6%) occurred after landing from a jump, and 31 cases (49.2%) occurred on the backhand side of the court [8].

The ankle joint is also a relatively weak place during changes in direction. During a change of direction in badminton, the ankle joint needs to support the body weight and ground reaction forces in various directions. If the supporting muscles near a joint are weak or unstable, it is more likely to be sprained. He et al. (2024) selected 13 female badminton players as the research subjects and investigated how certain types of fatigue affect the ankle biomechanics during the landing phase of backhand backcourt jump shots (BRJS) and backhand lateral jump shots (BLJS) [9]. The plantar flexion and inversion angles of the ankle joint at the initial moment of landing after fatigue were significantly larger ($p < 0.05$), and the peak inversion moment also increased significantly. BLJS had a larger angle of inversion and peak inversion moment upon landing than BRJS. The strength of the peroneus longus muscle decreased more significantly with fatigue, and thus the risk of a lateral ankle sprain increased.

Therefore, the training content for injury prevention in change-of-direction movements should not be restricted to this. Reasonable organisation of training load, high-quality warm-up and recovery, etc., are also factors that should not be overlooked. Only by combining knowledge of injury mechanisms and training experience can the risk of lower limb injury during agile change-of-direction be reduced effectively.

6. The Realistic Challenges Faced by Agility and Directional Change Training

Agility and directional change training are still subject to many constraints that affect the effectiveness of training and limit the improvement of competitive ability.

Malwanage and others (2022) selected 20 adolescent badminton players aged 12.85 ± 0.67 years for the study. The two groups of people were a control group (only regular training) and an intervention group (regular training plus

balance training). After 8 weeks, none of the footwork performance indicators in the control group showed a significant increase; thus, the regular training method did not improve footwork performance [10]. Plyometric training has been shown to improve agility; Deng et al. (2024) further studied systematically and found that it can enhance the agility of badminton players to a certain extent, with an effect size of 0.96 [11]. However, it is still restricted in practice by the evaluation system, training cycle and frequency arrangement. How to add more diverse forms within the traditional training system is a problem that needs to be solved urgently.

Individualised Design is also lacking and should not be overlooked. Athletes have different ages, training experiences, technical styles and physical conditions, but their training plans are often the same and do not take these differences into account. The direction-change methods for the dominant and non-dominant hands on both the forehand and backhand sides are different, and there are also differences in the biomechanical features of the lower limbs during landing between male and female athletes. These should have been the foundation of the training plan, but they are rarely taken into account in practice. Due to the absence of individualised arrangements, the training effect may not be optimised, and some groups are more likely to be injured.

The introduction of technological means has not occurred. Wearable devices, video analysis and force plates have been used by some top-tier teams, but they have not yet gained widespread popularity in general training. Traditional tests are unable to replicate the decision-making process and specific action features of a competition, and thus have weak predictive power for actual performance. Flaws in the assessment instruments will limit both the precision and breadth of training feedback.

Training intensity and injury prevention are in conflict at all times. The core of agility and directional change training is to continuously provide stimuli for the neuromuscular system so that it can perform movements at a higher speed under more complex circumstances. If the load exceeds the body's limit, it will be harmful. Coaches hope to inspire the students well without causing too much stress. Teenagers' bones and joints are still developing at this stage; therefore, too much high-intensity exercise may harm their future growth.

7. Conclusion

Based on the analysis in the above paragraphs, the following conclusions can be drawn.

Speed and a high-jump ability need to be developed for badminton. From anticipation to the return of the ball, all movements need to be changed at the right time, and judgment must be linked with action. The efficiency of movement, the quality of the hit, and the control of the speed in the game are all related to this ability. It is the foundation for all technical and tactical advantages that will help us win the game.

The enhancement of the ability to change direction is the result of many factors. Among the four reasons, coordination is responsible for most of the changes. Training should not be restricted to a single direction; instead, multiple directions of movement, visual response, dynamic balance and all-around footwork should be integrated into an all-encompassing system. Different training methods have different applications, and coaches can choose to use them flexibly according to the

features of the athletes.

Injury prevention and strengthening of ability are both needed. The highest impact forces during a change of direction occur at the knee and ankle joints. Anterior cruciate ligament damage, medial collateral ligament injury and ankle sprain are all relatively common types of injuries. Fatigue leads to a reduced angle of knee flexion and an increased valgus moment; therefore, the ligaments are under greater stress. Strength exercises, balance training and movement correction should be added to the training plan during the off-season to avoid high-intensity change-of-direction training when fatigued.

The current training still has problems such as a uniform approach, no individualisation, an outdated technology system, and inaccurate load management. To overcome the above problems, we need to reduce the scope of quantity, raise the standard of quality, make adjustments according to actual circumstances, and use data to support decision-making. Strengthen the construction of a specialised agility and change-of-direction assessment system. Only when it can meet the actual requirements will the training feedback be effective.

Cultivating agility and the ability to change direction should be based on multi-factor diagnosis, specialized training as the core, injury prevention as the guarantee, and scientific assessment as the feedback. The coordinated progress of all parts will allow the competitive strength of agility and change-of-direction to be fully realised.

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