

Review on the Biomechanics in the Technical Actions of Fast-Pitch Softball

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Abstract: Biomechanics is the study of the principles and laws of human movement. It plays a pivotal role in the advancement of fast-pitch softball. This article adopts bibliometric methods to analyze and research the biomechanics of fast-pitch softball technical actions from various angles. The paper specifically reviews the current state of biomechanical development, the biomechanical status of fast-pitch softball technical actions, and the relevant biomechanical principles of pitching and batting techniques in fast-pitch softball. The goal is to enhance the understanding and recognition of biomechanical research in fast-pitch softball and to serve as a reference for future biomechanical studies in this sport.

Keywords: Fast-Pitch Softball; Technical Action; Biomechanics; Review

1. Introduction

Fast-pitch softball is a team sport played within a defined playing field, with nine players on each side. The primary tools are a ball, bat, and glove. The sport involves techniques like batting, base running, pitching, passing, and catching, making it a complex sport requiring extensive coordination among various body parts. Sport Biomechanics is a significant branch of biomechanics that studies the mechanical laws of human movement in sports. It integrates the intricate motion patterns and variations of the human body (or equipment) in sports with principles of mechanics and biology [1]. Accelerating the progress of biomechanical studies in fast-pitch softball is crucial for the sport's development. Such research can guide sports practices, analyze the characteristics of athletes' technical actions, and establish a proper motion model, thereby enhancing athletes' technical proficiency [2]. However, domestic

research on the biomechanics of fast-pitch softball is relatively shallow. A literature review found 1943 articles related to fast-pitch softball, of which only 19 (or 0.97%) were biomechanical studies. This research, by utilizing online searches and library resources, collected the current state and theoretical knowledge of biomechanical studies on fast-pitch softball techniques from the past 30 years. It systematically categorizes and summarizes the collected data, providing a comprehensive literature review on the biomechanics of fast-pitch softball.

2. Analysis of the Current Development of Sports Biomechanics

Sports Biomechanics, as an essential component of sports science, fundamentally applies principles and methods of mechanics to study the forms, patterns, and principles of human motion. Its primary focus encompasses sports technique, training, sports injuries and fitness, and sports equipment. Sports Biomechanics plays a crucial role in improving athletic techniques, refining training methods, innovating sports equipment, and preventing and rehabilitating sports injuries [1].

Based on a review of the China National Knowledge Infrastructure (CNKI) for the past 10 years concerning Sports Biomechanics, a total of 1584 articles were identified. There has been a continuous upward trend in the annual number of publications. The leading institutions publishing on the subject are Beijing Sport University and Shanghai Sport University. Out of these articles, 327 were published in core journals, with 2021 seeing a peak in research output, totaling 64 publications. With the advancement of science and technology, state-of-the-art instruments have become more sophisticated. Diverse methods for biomechanical analysis, such as video analytics, high-speed photography,

sensor measurements, infrared high-speed motion capture systems, laser testers, and three-dimensional force platforms, have been used predominantly. The main focus has been two-dimensional and three-dimensional video analysis of sports techniques. Simultaneously, studies combining various biomechanical methods to analyze technical actions have also emerged [3].

3. Analysis of the Biomechanical Development of Technical Actions in Fast-Pitch Softball

3.1 Biomechanical Development Analysis of Fast-Pitch Softball Technical Actions Based on Research Methods

Biomechanical data collection can be generally categorized into kinematics, dynamics, and biological data collection. A review of domestic literature categorized by research methods is summarized in Table 1. Experimental methods, particularly three-dimensional fixed-point photography, are the most prevalent, with a primary focus on kinematics. Dynamics and biology (electromyography) analyses are almost non-existent. The research methods and tools for fast-pitch softball need further in-depth study. The research approach for specific technical actions should be standardized, facilitating subsequent comparative studies by other researchers.

Table 1. Biomechanical Research on Softball Techniques in China (Categorized by Research Method)

Method Category	Experimental	Literature Review	Total
Number of Articles	13	6	19

3.2 Biomechanical Development Analysis of Fast-Pitch Softball Technical Actions Based on Technical Actions

Technical actions in fast-pitch softball can be broadly classified into offensive and defensive actions. Offensive actions include hitting techniques, bunting, base running, sliding, and diving techniques. Defensive actions consist of pitching, passing, and catching techniques [4]. Based on an analysis in CNKI concerning the biomechanics of fast-pitch softball technical actions, it was observed that the primary focus has been on pitching and batting techniques,

with other techniques receiving no biomechanical research attention, as summarized in Table 2. This research mainly involves sports biomechanics, kinematic analysis, and biophysics, highlighting the significance of defensive pitching and offensive batting techniques in fast-pitch softball.

Table 2. Biomechanical Research on Softball Techniques in China (Categorized by Technique)

Technique Category	Pitching	Batting	Other	Total
Number of Articles	12	7	0	19

4. Biomechanical Analysis of Fast-pitch Softball Techniques

4.1 Biomechanical Analysis of Fast-pitch Softball Pitching Techniques

There are three methods of pitching in softball: windmill pitching (including figure-eight windmill pitching), circular pitching, and bent-arm windmill pitching [4]. By the mid-1980s, the development of women's softball pitching techniques in China had entered a period dominated by circular technique [5]. Zhou Zhipeng divided the entire pitching process of outstanding female fast-pitch softball athletes in China into four stages: ① pre-swing phase; ② stride phase; ③ arm-leading pitching phase; and ④ ball release phase. It is believed that a larger stride distance allows the pitcher's center of gravity to be lower, conducive to forming a more stable support effect; and benefits in increasing the forward acceleration distance of the body, lengthening the ball's acceleration distance, and increasing the ball's release speed [6]. Le Kaiyan concluded through the biomechanical analysis of excellent pitcher techniques that the stride technique has a significant impact on improving pitching speed. Under the premise of the rationality of the stride technique, it can reduce the energy consumed by the stride movement and significantly increase the speed of the entire action [7]. Fang Qinghua concluded from the three-dimensional kinematic analysis of the pitchers of the National Women's Softball Team in the Tenth Sports Games: during the pitching process, positive internal rotation of the hip joint can increase the release speed, so it is recommended to strengthen the exercises of

the back muscles and the gluteus maximus; the circling pre-swing and rotation acceleration of the pitching arm is a whipping action driven by the large muscle group leading the small muscle group, and it is suggested to strengthen the shoulder muscles and pectoral muscles [8]. In summary, after reading and analyzing the literature on the biomechanics of fast-pitch softball hitting techniques, it is found that research focuses mainly on the study of the stride phase, with less research on the ball release phase; most of them use a single-machine measurement method. Subsequent research can use multi-machine synchronous measurement methods to improve the practical value of information [9].

4.2 Biomechanical Analysis of Fast-pitch Softball Hitting Techniques

Hitting is the beginning and key technique of offense; without hitting, there is no offense. Hitting is also a more complex and challenging sports technique. Tan Jing divided the entire hitting process of outstanding female softball athletes in China into four parts when analyzing the biomechanics of the hitting swing technique: preparatory posture, bat-leading stride, swing hitting, and follow-through swing. The study found that: 1. Lower limb movements have a certain impact on the final ball speed. 2. The entire hitting action needs to be completed quickly and coherently; if the starting action is too early due to judgment errors, it will lead to an extended time in the stride or lead-body phase, which is not conducive to muscles using elastic potential energy. 3. At the moment of swinging and hitting the ball, the angle of the rear elbow joint is not necessarily larger, the better. An excessively large elbow joint is not conducive to the triceps' exertion. 4. A full extension of the stride leg helps achieve a better hitting effect [10].

Fang Qinghua found in a three-dimensional kinematic analysis of national softball player Wu Di's swing hitting technique that the bat head's speed did not reach its maximum at the moment of contact; the bat head reached its maximum speed after the bat and ball made contact [11].

Current research has found that the main factors affecting the hitting technique include lower limb strength, hitting angle, acceleration, and the center of gravity and weight of the bat.

At the same time, the rhythm of hitting also has a slight impact. The importance of rapid feedback or even real-time feedback for sports technology diagnosis is self-evident [2]. With the continuous upgrading of collection software, the development of a fast feedback system specifically for fast-pitch softball hitting techniques to provide real-time feedback during training and competition will help carry out sports technology diagnostics and enhance competitive ability.

5. Conclusions

Fast-pitch softball is a skill-dominated rotation offensive and defensive confrontational sport, and biomechanical research on its techniques is particularly important. At present, domestic research on fast-pitch softball techniques has achieved certain results, but the depth and breadth of research are insufficient.

(1) Domestic biomechanical data collection on fast-pitch softball techniques mainly focuses on kinematics, lacking dynamics and myomechanics data. The research methods and means are relatively single. It is recommended that subsequent researchers combine dynamics and myomechanics for multi-machine synchronous measurement; use standardized research methods for the same technique to facilitate horizontal comparative research.

(2) Domestic biomechanical research on fast-pitch softball mainly focuses on pitching and hitting techniques. The use of biomechanics to analyze other techniques is minimal. As the competitive level of fast-pitch softball continues to improve, biomechanical research on other technical actions should also be carried out.

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