

Retraction

Retracted: A Basketball Technique Balance Control Technology Based on Ant Colony Algorithm

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] Y. Wang and Y. Du, "A Basketball Technique Balance Control Technology Based on Ant Colony Algorithm," *Security and Communication Networks*, vol. 2021, Article ID 6559098, 10 pages, 2021.

Research Article

A Basketball Technique Balance Control Technology Based on Ant Colony Algorithm

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Aiming at the problems of low accuracy, poor stability, and effect of balance control in the current basketball skill balance control process, a basketball skill balance control method based on ant colony algorithm is proposed. The principle and characteristics of ant colony algorithm are analyzed, the mathematical model of ant colony algorithm is established, and the implementation steps of ant colony algorithm are given. According to the balance and stability control principle of basketball skills, this paper constructs the balance and stability control model of basketball skills. By establishing the knee-ankle-foot joint analysis model and using the ant colony algorithm, the basketball movement path is constructed. Through the fitness function, select the basketball motion path nodes and update the pheromone, obtain the relationship between the internal stress and displacement of the body under different force directions, and obtain the influence law of the effective knee joint stress with the varus and internal rotation, so as to achieve the balance and stability of the basketball skills sexual control analysis. The experimental results show that the proposed method has better stability and effect of basketball technique balance control and can effectively improve the accuracy of basketball technique balance control.

1. Introduction

With the continuous development of society, various movements are also advancing rapidly. Among them, the development of basketball is even more amazing. The professional basketball technology is becoming more and more exquisite. The players' offensive and defensive technology has gradually reached a balance. The defensive enthusiasm and aggressive consciousness have been continuously strengthened, prompting the offensive players to constantly select effective coping methods to get rid of the defense and complete the attack [1]. The jump shot in basketball can complete the pitch in a short time, making use of the sudden stop in the process of dribbling, so as to achieve the effect that the opponent is caught off guard. It is a basketball skill to increase the shooting height of players by taking off quickly to get rid of the blocking of defenders [2]. In the process of basketball skill jump shot, the athlete's body

is likely to tilt and be imbalanced. Only under the guarantee of coordinated force between the core area and the foot arch can the trunk be firmly supported and the upper limbs can effectively carry out coordinated shooting movements [3]. Therefore, how to control the balance and stability of basketball skills shooting and taking off has become the main problem to be solved in the field of sports at this stage and has attracted extensive attention.

At present, some progress has been made in the research of basketball sports balance control. Reference [4] proposed the use of a single-plane unstable balance platform for an 8-week basketball special proprioception training control effect. This study investigated an 8-week basketball special proprioception training program, using a newly developed single-plane unstable balance board during warm-up to improve the control effect of basketball players' balance ability. The athletes who received basketball special balance training were compared with the control group. Seventeen

participants were assigned to the basketball special 8-week balance training group, and 14 participants served as the control group. Both groups underwent Y balance test and posture stability test at baseline and 8 weeks later. This method has certain feasibility and effectiveness. Reference [5] puts forward the influence of hip adductor on the balance control of basketball players. The purpose of this study was to explore the correlation between hip adductor shortening and Patrick test, balance and coordination ability, and shark technology test. 65 healthy and active basketball players in basketball club were tested. These two tests shall be conducted at least 12 hours after the training. The shortness of the hip adductors is evaluated by Patrick's test and the balance and coordination skills are evaluated by shark skill test. Basketball can cause hip adductors to shorten in men and adolescents. It is necessary to expand balance control through physical therapy of shortened hip adductors. This method has good fault-tolerant tracking control performance. However, the above methods still have the problems of poor stability and effect of balance control and low accuracy. Ant colony algorithm is a positive feedback algorithm with good robustness and easy parallel implementation, which is based on the behavior of ants searching for food in nature. It has certain advantages in dealing with constraint satisfaction. In order to introduce adaptive mechanism and mutation strategy, shorten the calculation time of ant colony algorithm, accelerate the convergence speed of CPS algorithm, and improve the prediction accuracy of distributed CPS, reference [6] analyzed the research status and significance of ant colony algorithm. In this paper, the development background and current situation of ant colony optimization algorithm are described, the principle and method of ant colony optimization algorithm model and mathematical description of CPS task scheduling are described, and a distributed CPS task management model based on improved ant colony algorithm is proposed. The problem of distributed CPS task scheduling based on improved ant colony algorithm is studied. Finally, numerical simulation is carried out to verify the effectiveness of the proposed algorithm and model. Reference [7] proposed a routing protocol based on the performance of ant colony optimization algorithm and carried out simulation. This method uses a routing method based on energy level criterion, conflict reduction, distance from cluster head to target, and neighborhood energy. Cluster heads are selected according to the maximum remaining energy, the minimum distance from other clusters, and the energy consumed. This energy is minimized to reach the base station. Nodes with energy greater than the threshold are selected as new cluster heads. Routing then applies four criteria: shortest path, lead path, shortest distance to source and destination nodes, and route.

To solve the above problems, a basketball skill balance control method based on ant colony algorithm is proposed. According to the principle and characteristics of ant colony algorithm, the mathematical model is established and the implementation steps are given. According to the balance and stability control principle of basketball

skills, this paper constructs the balance and stability control model of basketball skills. By establishing the knee-ankle-foot joint analysis model and using the ant colony algorithm, the effect of the effective stress of the knee joint with the change of varus and internal rotation is obtained, and the control analysis of the balance and stability of basketball skills is realized. This method has high precision in the balance control of basketball skills and poor stability and effect.

Our contribution is threefold:

- (1) The principle and characteristics of ant colony algorithm are analyzed, the mathematical model of ant colony algorithm is established, and the implementation steps of ant colony algorithm are given. According to the balance and stability control principle of basketball skills, this paper constructs the balance and stability control model of basketball skills.
- (2) Through the fitness function, select the basketball motion path nodes and update the pheromone, obtain the relationship between the internal stress and displacement of the body under different force directions, and obtain the influence law of the effective knee joint stress with the varus and internal rotation
- (3) The experimental results show that the proposed method has better stability and effect of basketball technique balance control and can effectively improve the accuracy of basketball technique balance control.

The remainder of this paper is organized as follows. Section 2 introduces the ant colony algorithm. Section 3 discusses the basketball skill balance control method. Section 4 discusses experiment and analysis. Section 5 presents the conclusions of the study.

2. Ant Colony Algorithm

Ant colony algorithm is a biological algorithm, which belongs to the field of intelligent algorithm. Through the observation of ant foraging behavior, it is found that ants can release pheromones in the process of looking for food sources and moving, and ant individuals communicate through pheromones [8]. The shorter the path, the more the ants that will walk, and the greater the pheromone concentration accumulation of this path, the more the ants that will walk this path, so as to quickly find the best path.

2.1. Principle of Ant Colony Algorithm. The path selection of ants in the initial state is random, but when ants choose a path, they will release pheromones in the process of moving forward [9]. When future ants encounter pheromones through the path, they determine their forward direction by detecting the content of pheromones and the concentration in this direction. Ants usually choose the path with more pheromones. Due to the positive feedback mechanism, ants

also leave their pheromones on the path. At this time, the number of pheromones on the shortest path increases with the increase of the number of ants. On the contrary, the number of pheromones on the nonoptimal path will decrease accordingly.

The concentration of pheromone will volatilize continuously with the passage of time. The concentration of residual pheromone and the length of path also have a great impact on ants' path selection. Within a limited time range, the more the ants passing through, the greater the probability of ants choosing the path [10]. The above is the way for ants to find the optimal path. When ants encounter obstacles in their movement, ants can also make timely adjustments according to the changes of the surrounding environment to find the optimal path again. The simulation of ant foraging behavior is as Figure 1.

According to Figure 1, point A represents the nest where the ant is located, and point D represents the point where the ant wants to get food, that is, the end point the ant wants to reach. Ants need to find the shortest route from point A to point D. Currently there are two routes available for selection: ABECD and ABFCD. If several ants start from point A to point D to find food, the pheromone retained by the ant after one pass is 1, and the pheromone retention time is also 1.

According to Figure 1(a), it can be seen that, initially, there is no pheromone left, and the ants starting from point A arbitrarily choose the two routes, ABECD and ABFCD, and the probability of the ants choosing the two routes is the same.

According to Figures 1(b) and 1(c), since the length of BFC is one-half of the length of BEC, after a period of time, the number of ants arriving at point D from BFC is twice as many as the number of ants arriving at point D from BEC. At this time, the accumulated amount of pheromone concentration accumulated through the route BFC is twice as much as the accumulated amount of pheromone concentration accumulated through the BEC. As time goes by, the ants in the future will continue to choose the path BFC, until finally the BFC is used as the optimal route to point D.

As an intelligent computing method, ant colony algorithm is mainly based on the following assumptions:

- (1) Ants are affected by the environment and respond to it. Ants communicate with each other using pheromones.
- (2) As a genetic organism, ant's adaptability to genes is reflected in ant's behavior.
- (3) Each ant makes an independent choice of the surrounding information. The behavior of the ant group is random, but it will form a highly ordered behavior through the process of self-organization.

Through the above analysis and assumptions, it is concluded that the optimization process of ant colony algorithm includes two basic stages: Adaptation stage and cooperation stage. In the adaptation stage, the process of ant foraging behavior is a positive feedback process. For path

selection, the shorter the path, the higher the pheromone concentration accumulation, and the easier the route to be selected. The longer the path, the less the pheromone concentration accumulation, and the route is not easy to be selected. In the process of cooperation, individual ants communicate with each other through pheromones, so that pheromones are constantly updated.

2.2. Characteristics of Ant Colony Algorithm. Ant colony algorithm has unique advantages when dealing with complex optimization problems and has a good development prospect [11]. The main features of ant colony algorithm are as follows:

- (1) Although the information that each ant can perceive is one-sided, it can obtain global information by secreting pheromones and affect the choices of other ants through pheromones.
- (2) It is self-organizing, similar to genetic algorithm. The complex behavior of ant colony is produced by each ant influencing each other's choice.
- (3) It belongs to a kind of probabilistic global search. Randomness is the basis and guarantee for the algorithm to obtain the global optimal solution.
- (4) Distributed search: each ant search in each round is carried out at the same time, which is conducive to improve the operation efficiency of the algorithm.
- (5) Robustness, no centralized control constraints: individual ant errors will not directly lead to the failure of the whole optimization process.

2.3. Mathematical Model of Ant Colony Algorithm. Ant colony algorithm was first used to solve traveling salesman problem (TSP) [12]. In order to establish the mathematical model of ant colony algorithm, it is assumed that ants can transfer between cities according to the probability function, release pheromones related to the path length in the transfer process, and stipulate that all cities can be visited only once in a cycle.

Suppose that m represents the total number of ants in the group, $b_i(t)$ is the number of ants in the element i at time t , $\tau_{ij}(t)$ is the pheromone concentration on the path (i, j) at time t , and n represents the scale of the traveling salesman TSP. Then the set of residual pheromones on l_{ij} connected by the elements in set C at time t is

$$\Gamma = (\tau_{ij}(t) | c_i, c_j \in C),$$

$$m = \sum_{i=1}^n b_i(t). \quad (1)$$

At the initial moment, the pheromone concentration on each path is the same, and $\tau_{ij}(0) = \text{const}$ and $g = (C, L, \Gamma)$ represent directed graphs. During the movement of ant k ($k = 1, 2, \dots, m$), its transfer direction is determined by the concentration of pheromone at the next node. The city

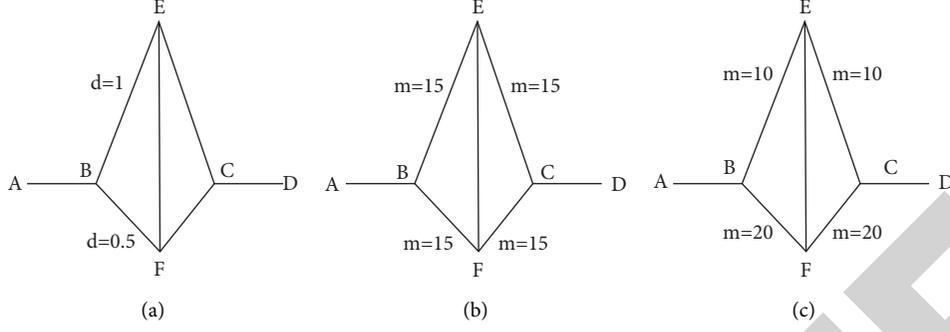


FIGURE 1: Simulation diagram of foraging behavior of ants. (a) Distance between points. (b) Randomly select E, F. (c) Choose BFC path with high probability.

currently traveled by ant k is recorded with a taboo table $\text{tab } u_k (k = 1, 2, \dots, m)$. The collection is dynamically adjusted with the evolution of $\text{tab } u_k$. In the search process, the state transition probability is calculated based on the ant based on the amount of pheromone on each path and the heuristic information of the path. The state transition probability of ant k from one position i to another position j at time t is expressed as

$$p_{ij}^k(t) = \begin{cases} \frac{[\tau_{ij}(t)]^\alpha [\eta_{ij}(t)]^\beta}{\sum_{k \in \{N - \text{tab } u_k\}} [\tau_{is}(t)]^\alpha [\eta_{is}(t)]^\beta}, & j \in \{C - \text{tab } u_k\}, \\ 0, & \text{otherwise.} \end{cases} \quad (2)$$

In formula (2), $\{C - \text{tab } u_k\}$ represents the node to be selected by ant k in the next step, and α represents the heuristic factor of pheromone, which reflects the importance of pheromone, highlighting the impact of the information accumulated by ants in the process of movement on ant movement. The larger the value of α , the greater the path that the ants will choose to pass through than other paths, and the better the cooperation between the ants. β is called the expected heuristic factor, which represents the degree of influence of the heuristic information on the ant's path selection during the ant's movement and indicates the relative importance of visibility. The higher the β value, the greater the probability that the ant will approach the target location. The expected degree of the ant from the initial point to the target point can be expressed by the heuristic function on the paths i and j in time t as

$$\eta_{ij}(t) = \frac{1}{d_{ij}}. \quad (3)$$

In formula (3), d_{ij} represents the distance from the initial point to the target point. For ant k , when d_{ij} becomes smaller, $\eta_{ij}(t)$ becomes larger, and $p_{ij}^k(t)$ becomes larger.

Pheromone needs to be updated in time. If there are too many residual pheromones, it will overwhelm the enlightening information [13]. In other words, after each ant completes a step or completes a cycle, the residual information must be updated. Thus, the pheromone on path (i, j) at time $t + n$ is updated as

$$\tau_{ij}(t + n) = (1 - \rho)g\tau_{ij}(t) + \Delta\tau_{ij}(t), \quad (4)$$

$$\Delta\tau_{ij}(t) = \sum_{k=1}^m \Delta\tau_{ij}^k(t). \quad (5)$$

In formulas (4) and (5), ρ is the pheromone volatilization coefficient, and $1 - \rho$ is the pheromone residual factor. Pheromone accumulation cannot exceed a certain limit, and the range of ρ is $\rho \in [0, 1]$. $\Delta\tau_{ij}(t)$ represents the pheromone increment on the path (i, j) in this cycle; the initial time $\Delta\tau_{ij}(t) = 0$. $\Delta\tau_{ij}^k(t)$ represents the pheromone left by the k ant on path (i, j) in this cycle.

According to different pheromone update strategies, the ant colony algorithm model can be divided into three types: Ant-Cycle model, Ant-Quantity model, and Ant-Density model. The difference between them lies in the different ways of seeking $\Delta\tau_{ij}(t)$.

2.3.1. In the Ant-Cycle Model

$$\Delta\tau_{ij}^k(t) = \begin{cases} \frac{Q}{L_k}, & \text{if } k \leq (i, j), \\ 0, & \text{other wise.} \end{cases} \quad (6)$$

In formula (6), Q is the intensity of pheromone, which has an impact on the speed of algorithm convergence. L_k represents the total length of the path taken by the k ant in this cycle.

2.3.2. In the Ant-Quantity Model

$$\Delta\tau_{ij}^k(t) = \begin{cases} \frac{Q}{d_{ij}}, & \text{if } k \leq (i, j), \\ 0, & \text{other wise.} \end{cases} \quad (7)$$

2.3.3. In the Ant-Density Model

$$\Delta\tau_{ij}^k(t) = \begin{cases} Q, & \text{if } k \leq (i, j), \\ 0, & \text{other wise.} \end{cases} \quad (8)$$

Formulas (7) and (8) update the local pheromone; that is, the ant updates the pheromone on the path immediately after walking a node. Formula (6) uses the overall information to update; that is, the ant updates the pheromone on the path after completing a cycle. This method has a good performance for solving the TSP problem. Formula (6) is usually used as the basic model of ant colony algorithm to calculate the concentration of released pheromone. In other words, the shorter the path the ant passes, the higher the pheromone concentration on this path.

2.4. Implementation Steps of Ant Colony Algorithm. The steps of ant colony algorithm to solve the problem are mainly divided into initializing parameters, constructing solution space, updating pheromone, and finally judging whether to terminate or not. The structure flow of ant colony algorithm is as Figure 2.

The specific implementation steps are as follows:

- (1) Parameter initialization. Let the number of cycles $N_c = 0$ and the time $t = 0$. Set the maximum number of cycles $N_{c_{\max}} = 0$. The amount of information $\tau_{ij} = \text{const}$ is initialized for each edge (i, j) on the directed graph, where const is a constant and $\Delta\tau_{ij}(0) = 0$ is at the initial time.
- (2) The number of cycles $N_c \leftarrow N_c + 1$.
- (3) The index number $k = 1$ of the taboo table of ants.
- (4) The number of ants $k \leftarrow k + 1$.
- (5) Each ant calculates the probability to choose the position of the next point and goes forward $j \in \{C - \text{tab } u_k\}$.
- (6) Modify the taboo table pointer, after evolutionary selection, move the ant to a new location, and store the location in the ant individual taboo table [14].
- (7) If the position in the set C has not been traversed, and k, m , then jump to step (4); otherwise go to step (8).
- (8) Update the pheromone on each path.
- (9) When the above requirements are met, that is, $N_c \geq N_{c_{\max}}$, the loop stops and the result is output. Otherwise, clear the taboo table and skip to step (2).

3. Basketball Skill Balance Control Method

Balance refers to the special state in which an object is at rest or moving in a uniform straight line relative to the Earth [15]. The balance of basketball includes static balance and dynamic balance. Static balance ability refers to the static posture ability to maintain the relative stillness of the center of gravity and posture of the human body. Dynamic balance refers to the ability to adjust and control the center of gravity and posture of the human body in the state of motion. The function of human dynamic posture balance involves the sensitivity of receptors, the afferent pathway of sensory information, the integration of central nervous system, and the efferent pathway of nerve and bone muscle. The human body maintains dynamic balance mainly by ankle, while the

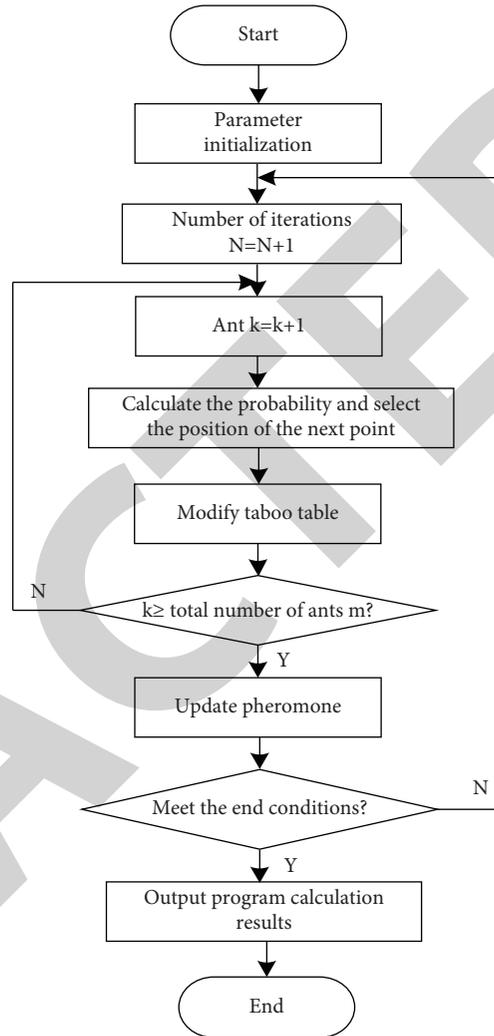


FIGURE 2: Flowchart of ant colony algorithm structure.

human body is easy to fall when maintaining balance mainly by hip.

Based on the control principle of basketball technique balance and stability, this paper constructs a basketball technique balance and stability control model. By establishing a knee-ankle-foot joint analysis model, the ant colony algorithm is used to control the balance and stability of basketball technique.

3.1. Balance and Stability Control Principle of Basketball Skills.

In the process of controlling the balance and stability of basketball skills, a 6-degree-of-freedom human body model composed of 6 rigid body models is first established to obtain the relationship between the torque of each muscle and the joint angle of the basketball player during the shooting and jumping. Obtain the maximum cross-sectional stress value of the athlete's distal joint under the force of the body, thereby constructing a control model of the balance and stability of basketball skills. The specific process is as follows:

Assuming that the head and neck, upper and lower torso, forearms, upper arms, thighs, and calves of a basketball

player during the shooting and take-off process are each one shot, W_i represents the role of the basketball player's feet and the ground in the shooting and take-off process, and K_s represents the sequence of activities of the joints of the human body in the shooting and take-off process. The 6-degree-of-freedom human body model composed of 6 rigid human body models is expressed as

$$R_s = \frac{Z_s \times W_i}{K_s} \times F_u \times \theta_r. \quad (9)$$

In formula (9), θ_r represents the angle between each joint of the athlete and the horizontal direction, F_u represents the distance between the muscle torque of each joint of the athlete and the joint angle, Z_s represents the length of each joint, and K_s represents the distance between the athlete's joint muscle moments at the joints.

Based on the action of the athlete's feet and the ground and the sequence of joint activities, let u represent the quality of each joint. This model mainly considers the knee joints, hip joints, shoulder joints, and elbow joints of basketball players [16], and its constraint conditions are expressed as

$$U_f = \frac{e_s \times K}{u \times h_s} \times \theta_r \otimes W_i. \quad (10)$$

In formula (10), e_s represents the critical point of different stages of the basketball player's shooting and take-off process, and h_s represents the five action stages of the athlete's left foot braking, right foot swing, ball lifting, jumping, and vacant shots during the sudden stop and jump shot human inertia parameters. The relationship between the muscle torque and the joint angle of each joint of the basketball player in the take-off and jump of the basketball player is expressed as

$$C_i = Q_{yy} (e_s \times P_r) \frac{\kappa s \otimes (d_{DE} + d_{FT} + d_{UR})}{D_e}. \quad (11)$$

In formula (11), Q_{yy} represents the stretching amplitude of the corresponding leg muscles as the athlete's center of gravity decreases, P_r represents the muscle strength of the leg muscles, and κs represents the ankle muscle torque. As the equivalent amount of the action of the attached tissue around each joint, the joint torque is the sum of the torque d_{DE} generated by the hip joint muscle in the braking stage of the athlete's left foot, the torque d_{FT} generated by the contact force between the knee joint and the ankle joint in the forward swing stage of the right leg, and the torque d_{UR} generated by the lower ligament of the lower leg driven by knee flexion in the ball lifting stage. D_e represents the compressive stress between the two condyles of the femur and the tibial plateau. The maximum cross-sectional stress value of the distal joint under the force of the hip and ankle can be obtained and expressed as

$$Y_e = \frac{\kappa s \times W_i}{\theta_r \otimes h_s} \otimes \frac{Q_{yy} \times P_r}{\sigma^2 \times O_r} I f. \quad (12)$$

In formula (12), $I f$ represents the supplementary angle of each joint, σ^2 represents the physiological cross-sectional

area of the athlete's calf muscle, and O_r represents the angle at which the legs begin to jump to the moment the feet are off the ground. Thus, the balance and stability control model of basketball skills is constructed as

$$TR = \sum_{j=1}^n P_r \times \frac{\vartheta \times Q_{yy}}{\sigma^2 \times \lambda_b} \zeta. \quad (13)$$

In formula (13), ϑ represents the degree of passive stretching of the hind leg muscles corresponding to the angle difference λ_b at the knee joint under the shooting take-off, and ζ represents the angle with the hip joint as the axis relative to the horizontal plane.

3.2. Establish a Knee-Ankle-Foot Joint Analysis Model. In the process of controlling the balance and stability of basketball skills, the main reason that affects the stability of the body is not only the balance of the body's center of gravity, but also the correlation between the knee, ankle, and the foot joints which can cause body imbalance [17]. Therefore, the analysis mainly focuses on the knee-ankle-foot joints. The orthogonal anisotropic material parameter x, y, z is used to represent the three orthogonal directions, respectively. Among them, x represents the left and right direction, y represents the up and down direction, and z represents the front and back direction. Constrain the athlete's knee-ankle-foot joint model and apply a 0.1 mm displacement in the y direction to the model. According to the principle that the acting force is equal to the reaction force, a 1500 N vertical load is applied to the upper surface of the model knee joint fibula, and the elastic modulus and Poisson's ratio are $E = 2.06 \times 10^5$ MPa, $\nu = 0.3$, respectively. The yield function of the model under the same displacement of the knee, ankle, and foot joint is obtained and expressed as

$$\nu = \frac{\vartheta \times \rho_r}{\omega(f_o)} \times \zeta_t \mu(\psi). \quad (14)$$

In formula (4), ρ_r represents the balance coefficient of the whole ankle joint and foot support state at this stage, $\omega(f_o)$ represents the correlation between the node load f_o and the node degree of freedom displacement of the knee-ankle-foot model, ζ_t represents the deformation displacement of the athlete's hip joint section, $\mu(\psi)$ represents the torque acting on the hip joint surface, and ψ represents the parameter controlling the shape of the yield surface.

Assuming that φ_{uk} represents the downward load transmitted by the tibia and fibula of the knee joint, and τ_v represents the upward reaction force transmitted by the adjacent bones, the displacement of the knee-ankle-foot model at each node is expressed as

$$I(z_d) = \sum_{l=1}^{n'} \frac{\varphi_{uk}}{\zeta_t \times \tau_v} \times [\chi \times o_\phi]. \quad (15)$$

In formula (15), χ represents the displacement function of any point in the calcaneal joint, φ_{uk} represents the cortical bone thickness function of the calcaneal joint, o_ϕ represents

the bearing force of the Achilles tendon attachment point, l represents the Achilles tendon contraction strength coefficient, and n' represents the equivalent node force on the Achilles tendon bearing surface.

3.3. Balance and Stability Control Analysis of Basketball Skills. Based on the displacement of the knee-ankle-foot model at each node, the ant colony algorithm is used to construct the basketball path. Through the adaptation function, the path node of basketball is selected, and the pheromone is updated to obtain the relationship between

stress and displacement in the body under different stress directions. The influence law of knee joint effective stress with varus and pronation is given, and the control analysis of basketball skill balance and stability is completed. The specific process is as follows:

Draw 20 line segments L_1, L_2, \dots, L_{20} with equal spacing and equal length and perpendicular to the X axis, where $L_1 \sim L_6, L_7 \sim L_{10}, L_{11} \sim L_{16}, L_{17} \sim L_{20}$, respectively, represent the effective digits of $K_{pp}, K_{vp}, K_{vi}, K_{fv}$. Assuming that the plane grid node uses the symbol $\text{Knot}(x_i, y_{i,j})$, its basketball path can be expressed as

$$\text{Path} = \{O, \text{Knot}(x_1, y_{1,j}), \text{Knot}(x_2, y_{2,j}), \dots, \text{Knot}(x_{19}, y_{19,j}), \text{Knot}(x_{20}, y_{20,j})\}. \quad (16)$$

In formula (16), O is the origin of the coordinates, the starting position of the ant, Path is the path formed by the ant crawling from the starting point O to the end point, and $\text{Knot}(x_i, y_{i,j})$ is the coordinate of the node where the ant is crawling.

The fitness function is established by using two indicators: the contour error and the following error of the basketball trajectory. The following error variance $Q_{\text{track_var}}$ and contour error variance $Q_{\text{contour_var}}$ are normalized as its comprehensive dynamic performance index, and its fitness function expression is as follows:

$$J = \frac{w_1 \times Q_{\text{track_var}}}{Q_c} + \frac{w_2 \times Q_{\text{contour_var}}}{Q_d}. \quad (17)$$

In formula (17), w_1 is the influence proportion of $Q_{\text{track_var}}$ on dynamic performance index J , w_2 is the influence proportion of $Q_{\text{contour_var}}$ on dynamic performance index J , Q_c is the following error variance $Q_{\text{track_var}}$ value corresponding to the first cycle reference path of $Q_{\text{track_var}}$, and Q_d is the contour error variance $Q_{\text{contour_var}}$ value corresponding to the first cycle reference path of $Q_{\text{contour_var}}$.

The ant colony algorithm selects the basketball path in turn according to the reference number sequence according to the amount of information at each node, that is, the transition probability. Assuming that the time of the nodes of the basketball motion path is the same and has nothing to do with the distance between the front and back nodes, the expression of the probability $P^k(x_i, y_{i,j}, t)$ of the basketball motion path from node i to node j at time t is as follows:

$$P^k(x_i, y_{i,j}, t) = \frac{[\tau(x_i, y_{i,j}, t)]^\alpha [\eta(x_i, y_{i,j}, t)]^\beta}{\sum_{j=0}^p [\tau(x_i, y_{i,j}, t)]^\alpha [\eta(x_i, y_{i,j}, t)]^\beta}, \quad (18)$$

$$\eta(x_i, y_{i,j}, t) = \frac{10 - |y_{i,j} - y_{i,j}^*|}{10}.$$

In formula (18), α represents the relative importance of basketball trajectory, β represents the relative importance of visibility, $\tau(x_i, y_{i,j}, t)$ represents the pheromone intensity at

node $(x_i, y_{i,j})$ at time t , and $\eta(x_i, y_{i,j}, t)$ represents the expected degree of transition from node i to node j , $y_{i,j}$ represents the ordinate value of the crawling path node in this cycle, and $y_{i,j}^*$ represents the ordinate value of the optimal path node in the previous cycle.

The residual information of each node of the basketball movement path is updated. Because the residual information is too much, the enlightening information is flooded. Therefore, after the ant colony completes a cycle, it is necessary to update the residual information of each node. In order to make better use of the overall information, the Ant-Cycle model is used to update the pheromone, and its expression is as follows:

$$\tau(x_i, y_{i,j}, t + 1) = (1 - \rho)\tau(x_i, y_{i,j}) + \Delta\tau(x_i, y_{i,j}),$$

$$\Delta\tau(x_i, y_{i,j}) = \sum_{k=1}^m \Delta\tau^k(x_i, y_{i,j}), \quad (19)$$

$$\Delta\tau(x_i, y_{i,j}) = \begin{cases} \frac{Q_{\text{set}}}{J_k}, & \text{if } k \leq (i, j), \\ 0, & \text{other wise.} \end{cases}$$

In formula (19), m is the ant colony scale, $\Delta\tau^k(x_i, y_{i,j})$ is the amount of information left by the k ant on node $(x_i, y_{i,j})$ in this cycle, $\Delta\tau(x_i, y_{i,j})$ is the pheromone increment on node $(x_i, y_{i,j})$ in this cycle, and J_k is the fitness function value corresponding to the path taken by the k ant in this cycle.

Through the above steps, the relationship between the internal stress and displacement of the ankle-foot joint under different force directions is as follows:

$$V_o = \frac{aAC_m \times vo(mn)}{l^M \times \delta t} \times \frac{[(\gamma^{F'} \times \xi_{n'}) \otimes R_x']}{qv}. \quad (20)$$

In formula (20), F' represents the characteristic parameters of ankle-foot ligament, $vo(mn)$ represents the reciprocal of bulk elastic modulus mn , $\gamma^{F'}$ represents the exponential stress coefficient, $\xi_{n'}$ represents the initial strain

of ankle-foot ligament, δt represents the maximum vertical load, R'_x represents the maximum horizontal load on the athlete's left knee joint subjected to the ground, and qv represents the maximum impact load on the ankle-foot joint subjected to the ground. The influence law of the effective stress of the knee joint with the change of varus and internal rotation is given, and the control analysis of the balance and stability of basketball skills is completed. The expression is

$$o = (\delta t \times R'_x) \times \frac{(qv \times \Gamma d)}{\psi_{er} \times A_{dz}}. \quad (21)$$

In formula (21), A_{dz} represents the maximum muscle torque received by the human ankle and foot joints, Γd represents the stress of the medial ligament of the knee, ankle, and foot joints, and ψ_{er} represents the isotropic index. Based on the above analysis, the balance control of basketball skills can be realized.

4. Experimental Simulation and Analysis

4.1. Set Up the Experimental Environment. In order to verify the effectiveness of the basketball skill balance control method based on ant colony algorithm, MuJoCo simulation software is used as the experimental simulation environment. Under the Visual C++ compiling environment, the basketball skill balance control based on ant colony algorithm is realized and its performance is verified by using C++ language. The test subjects selected 5 players from a basketball club, using the CCD high-speed scanning camera produced by PULNIX of the United States, with a shooting frequency of 60 p/s. The calculation results of the basketball player's knee, ankle, and foot model were compared with the previous simulation results of human specimens. Our parameters are adjusted in the training set and selected in the test set. We chose the set of parameters that worked best in the test set as the final parameters.

4.2. Analysis of the Effect of Basketball Skill Balance Control. In order to verify the effect of the balance control of basketball skills based on the ant colony algorithm, the actual situation of the balance and stability control of the basketball player's shooting and take-off is based on the actual situation. Under the load of internal rotation torque of 1.7 N·m, the proposed method is used to establish the knee-ankle-foot joint analysis model, and the obtained basketball players' emergency stop jumper knee-ankle-foot joint medial ligament stress values are compared with the method of [4], the method of [5] is compared with the actual simulated knee, ankle, and foot joint medial ligament stress value, and the comparison result is as Figure 3.

It can be seen from Figure 3 that the stress value of the medial ligament of the knee, ankle, and foot joint obtained by the methods of [4] and the methods of [5] is quite different from the actual stress value of the medial ligament of the knee, ankle, and foot joint. The stress value of the medial ligament of the knee, ankle, and foot joint obtained by the proposed method analysis model is consistent with the actual stress value of the medial ligament of the knee, ankle,

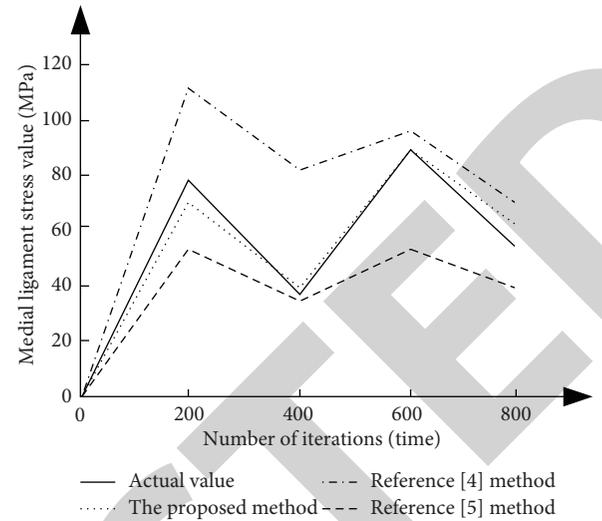


FIGURE 3: Comparison results of different methods of basketball skill balance control effect.

and foot joint. It can be seen that the basketball skill balance control effect of the proposed method analysis model is better. This is mainly because the ant colony algorithm is used to obtain the influence law of the effective stress of the knee-ankle-foot model with varus and pronation, so as to realize the basketball skill balance control, so as to ensure the basketball skill balance control effect.

4.3. Analysis of the Stability of the Balance Control of Basketball Skills. To further verify the stability of the balance control of basketball skills based on the ant colony algorithm, according to the actual situation of the joint movement of the human foot when the basketball player shoots and jumps, under the load of 2.5 N·m of varus moment, the proposed method is used to establish the knee-ankle-foot joint analysis model. The obtained basketball players' emergency stop jumper ankle-foot joint maximum equivalent stress values are, respectively, compared with the method of [4], the method of reference [5] is compared with the actual simulated maximum equivalent stress value of the ankle-foot joint, and the comparison result is as Figure 4.

It can be seen from Figure 4 that the maximum equivalent stress value of the ankle-foot joint obtained by the method of [4] and the method of [5] is quite different from the actual maximum equivalent stress value of the ankle-foot joint. The maximum equivalent stress value of the ankle-foot joint obtained by the analysis model of the proposed method is more consistent with the actual maximum equivalent stress value of the ankle-foot joint. It can be seen that the basketball skill balance control stability of the proposed method analysis model is good. This is mainly because the ant colony algorithm is used to describe the relationship between internal stress and displacement of ankle-foot joint under different stress directions, so as to complete the control analysis of basketball skill balance stability, so as to ensure the stability of basketball skill balance control.

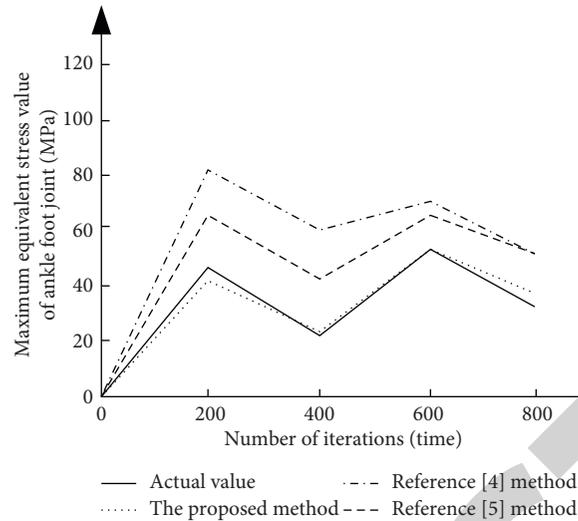


FIGURE 4: Comparison results of different methods of basketball skill balance control stability.

TABLE 1: Comparison results of different methods of basketball skill balance control accuracy.

Displacement (mm)	Actual value (mm)	The proposed method (mm)	The method of [4] (mm)	The method of [5] (mm)
X direction	0.478	0.475	0.694	0.854
Y direction	0.260	0.258	0.384	0.417
Z direction	0.750	0.748	0.954	1.032
Overall	0.954	0.949	1.175	1.198

4.4. Analysis of Balance Control Accuracy of Basketball Skills.

On this basis, the balance control accuracy of basketball skills based on ant colony algorithm is further verified, according to the actual situation of the movement of human joints when basketball players shoot and take off. 2100 n horizontal load is applied to the talus platform, and the knee-ankle-foot joint analysis model is established by the proposed method. The displacement of the talus joint in each direction obtained is compared with the method of [4], the method of [5], and the displacement of the actual talus joint in each direction. The comparison results are as Table 1.

According to the data in Table 1, the displacement of the talus joint in all directions obtained by the methods of [4] and the methods of [5] is quite different from the displacement of the actual simulated talus joint in all directions, and the maximum displacement errors are 0.124 mm and 0.157 mm, respectively. However, the displacement of the foot talar joint in all directions obtained by the analysis model of the proposed method is more consistent with the actual simulated displacement of the talar joint in all directions, and the maximum displacement error is only 0.002 mm. It can be seen that the basketball technique balance control accuracy of the proposed method is relatively high.

5. Conclusion

The basketball skill balance control method based on ant colony algorithm studied in this paper can make full use of the advantages of ant colony algorithm, effectively improve the accuracy of basketball skill balance control, and ensure

the effect and stability of basketball skill balance control. However, in the process of basketball skill balance control, the training method and application of basketball balance ability are not considered. Therefore, in the next research, we should consider using multimedia technology to strengthen the teaching content and help improve the dynamic balance of the human body, so as to directly help improve the level of basketball and prevent accidental injuries.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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