Article

Research on Optimization of Functional Physical Training and Injury Prevention of College Basketball Players Driven by Data

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Abstract: The development of basketball has attracted numerous college students passionate about the sport. Through basketball training, students can not only enhance physical fitness and regulate emotions but also expand their social networks. This paper focuses on optimizing functional physical training and injury prevention for college basketball players from a data-driven perspective. By reviewing relevant literature and conducting theoretical analysis, it explores the application value of data in functional physical training for college basketball players, proposes data-based training optimization strategies, and elucidates their significance in injury prevention. The study demonstrates that data-driven approaches can provide precise guidance for physical training, effectively reduce the risk of sports injuries, and improve training outcomes and competitive performance.

Keywords: data-driven; college basketball players; functional physical training; injury prevention

1. Introduction

As basketball continues to develop toward higher speed, intensity, and physical confrontation, the technical and physical demands placed on athletes have increased substantially. Frequent high-intensity movements, rapid changes of direction, jumping, landing, and body contact during competition expose college basketball players to a high risk of sports injuries, which may interrupt systematic training plans and negatively affect long-term athletic development. Therefore, improving physical performance while reducing injury risk has become a key concern in contemporary college basketball training. Functional physical training has emerged as an effective training approach that emphasizes movement patterns, neuromuscular coordination, and the integrated function of multiple body segments. By focusing on core stability, balance control, and coordinated force transmission, functional training not only enhances sport-specific performance but also plays an important role in injury prevention [1].

However, traditional physical training methods are often characterized by standardized content and limited adaptability, making it difficult to fully address individual differences in physical condition, movement quality, and injury susceptibility among college basketball players. Such limitations reduce training efficiency and may even increase the risk of overuse injuries. With the rapid development of information technology and data processing techniques, data-driven training strategies provide new possibilities for optimizing functional physical training [2]. Through systematic collection and analysis of performance indicators, movement characteristics, and physical load data, coaches can obtain objective and comprehensive insights into athletes' physical states and functional capacities. This evidence-based approach allows training programs to be adjusted in a more targeted and scientific manner, thereby improving training effectiveness, enhancing competitive performance, and reducing injury occurrence.

Consequently, integrating data-driven methods into functional physical training represents an important direction for advancing college basketball training practice.

2. Application Value of Data-Driven Approach in Functional Physical Training for College Basketball Players

2.1. Accurate Assessment of Athletes' Physical Condition

Data-driven approaches provide an objective and systematic pathway for accurately assessing the physical condition of college basketball players. Through the application of quantitative measurement technologies, athletes' physiological and functional characteristics can be evaluated with high precision, thereby overcoming the limitations of traditional observation-based assessments. Techniques such as bioelectrical impedance analysis and dual-energy X-ray absorptiometry enable comprehensive evaluation of body composition indicators, including muscle mass distribution, body fat percentage, and bone-related structural parameters. These measurements form an important basis for understanding athletes' physical readiness and long-term training adaptability [3].

In addition to body composition analysis, strength diagnostics play a critical role in identifying potential injury risks. Data derived from isokinetic strength testing systems, including peak torque and power output under different angular velocities, allow for the detection of strength asymmetries between bilateral or antagonistic muscle groups. Such imbalances are widely regarded as important contributing factors to movement inefficiency and injury susceptibility during high-intensity basketball activities. Furthermore, indicators reflecting autonomic nervous system regulation, such as heart rate variability, provide valuable information for monitoring athletes' responses to training load and recovery status. Sustained deviations in these indicators may signal cumulative fatigue and reduced physiological resilience, suggesting the need for timely training adjustments.

From a movement mechanics perspective, biomechanical data collected during sport-specific actions offer additional insight into injury risk patterns. Parameters related to jump landing, including the rate of force development and lower-limb alignment characteristics, can be captured through the integration of force measurement platforms and three-dimensional motion analysis systems [4]. These data help identify movement patterns that may place excessive stress on joints during repetitive high-impact actions. By integrating physiological, mechanical, and neuromuscular regulation data, coaching teams can establish individualized physical condition profiles for athletes, enabling more accurate risk identification and training decision-making while reducing reliance on subjective experience.

2.2. Development of Personalized Training Programs

The comprehensive athlete profiles generated through multi-source data integration have fundamentally reshaped the design logic of functional physical training, shifting it toward a more individualized and precision-oriented paradigm. Advanced motion analysis techniques allow for the extraction of joint kinematics during key basketball-related movements such as squatting, jumping, and rapid directional changes. Time-series joint angle data derived from these analyses provide detailed descriptions of movement coordination and joint control throughout different phases of motion.

When combined with synchronized muscle activation data obtained from surface electromyography, deficiencies within the movement control chain can be identified more clearly. For example, delayed or insufficient activation of specific stabilizing muscles may be associated with altered joint trajectories during dynamic tasks [5]. Based on these findings, targeted neuromuscular training modules can be developed, emphasizing closed-chain exercises, balance challenges, and proprioceptive feedback to enhance movement stability and coordination. The integration of biofeedback mechanisms further

supports athletes in developing correct motor patterns through real-time sensory reinforcement.

For athletes exhibiting lower explosive performance indicators, individualized load configurations can be designed according to force-velocity relationship analysis. By adjusting external resistance and movement speed, training stimuli can be optimized to improve power output efficiency during key phases of muscle contraction. In parallel, endurance-related training content can be personalized based on aerobic capacity indicators, with interval structures adjusted to match individual metabolic characteristics. Such data-informed adjustments ensure that training intensity and volume are aligned with each athlete's adaptive capacity. Overall, this closed-loop process linking assessment data to training content represents a transition from uniform group-based programs to individualized functional training strategies [6].

2.3. Real-Time Monitoring of Training Effectiveness

The effectiveness of data-driven functional physical training is further enhanced through real-time monitoring and adaptive regulation mechanisms. Wearable sensor systems play a central role in this process by continuously collecting movement-related data during training sessions. Inertial sensors embedded in training garments record parameters such as angular velocity, acceleration, and displacement, providing a detailed representation of athletes' movement dynamics under actual training conditions.

Through real-time data processing algorithms, key performance indicators such as take-off characteristics and movement rhythm can be calculated continuously. Changes in these indicators across training sessions offer valuable information regarding neuromuscular fatigue and performance stability. When predefined thresholds are exceeded, the monitoring system can provide timely alerts, prompting adjustments to training intensity or duration in order to prevent the emergence of compensatory movement patterns. Simultaneously, heart rate monitoring systems enable precise control of internal training load by tracking heart rate reserve and ensuring that exercise intensity remains within planned target ranges [7].

At the analytical level, accumulated training data are incorporated into longitudinal evaluation models to identify trends in performance adaptation over time. This approach allows for early detection of non-linear changes in training response, supporting proactive adjustments to training plans. By combining real-time feedback with long-term data analysis, data-driven monitoring systems enhance the predictability and safety of functional physical training, contributing to improved training efficiency and reduced risk of overload-related injuries.

3. Optimization Strategies for Functional Physical Training of College Basketball Players Based on Data

3.1. Building a Data Collection System

The precise optimization of functional physical training depends on the comprehensive and synchronized acquisition of multimodal physiological and kinematic data. The construction of a data collection system should follow the principle of integration and coordination, combining wearable sensing technologies, motion analysis systems, and on-site physical testing platforms to establish a unified spatiotemporal data acquisition framework. Such a framework ensures the consistency and comparability of data collected across different training scenarios and time periods, thereby enhancing the scientific basis of training regulation [8].

Wearable inertial sensors embedded in close-fitting training equipment enable continuous monitoring of joint angular velocity and linear acceleration of the lower limbs during basketball-specific movements. When these data are synchronized with ground reaction force measurements collected from force platforms, it becomes possible to analyze impulse characteristics and force transmission efficiency during take-off, landing,

and rapid directional changes. This integrated analysis provides valuable insights into the functional integrity and coordination of the lower-limb kinetic chain. At the same time, heart rate variability monitoring devices are used to assess autonomic nervous system responses to training load, offering objective indicators of recovery capacity and physiological readiness.

To capture the spatial characteristics of basketball movement patterns, ultra-wideband positioning systems are employed to track players' movement trajectories with high temporal and spatial resolution. Key indicators such as displacement speed, frequency of acceleration and deceleration, sudden stops, and directional changes during offensive and defensive phases are recorded, allowing for quantitative evaluation of movement intensity distribution. In addition, high-speed camera systems combined with motion recognition algorithms enable three-dimensional reconstruction of complex technical actions such as dribbling, breakthrough movements, and shooting sequences. Through this approach, compensatory movement patterns and biomechanical imbalance points can be identified more accurately. The parallel acquisition of multi-source heterogeneous data not only improves the reliability of performance assessment but also provides a robust data foundation for the subsequent development of individualized training adaptation models.

3.2. Establishing a Data Management and Analysis Platform

The effective utilization of collected data requires the establishment of a standardized data management and intelligent analysis platform. A distributed database architecture is adopted to integrate time-series physiological signals, spatial movement parameters, and periodic physical testing results into a unified storage environment. Through standardized data labeling and cross-temporal alignment, heterogeneous datasets can be efficiently associated, ensuring continuity and integrity in long-term athlete monitoring.

Based on this data infrastructure, advanced analytical methods are introduced to extract meaningful information from complex datasets. Statistical modeling approaches are used to distinguish individual-specific training responses from general group trends, enabling the identification of nonlinear adaptation trajectories under different training interventions. In parallel, time-series prediction models are applied to analyze historical relationships between training load and performance outcomes, thereby supporting short-term training planning and recovery scheduling.

The platform also incorporates automated anomaly detection modules to identify abnormal fluctuations in physiological or movement-related indicators, such as sudden changes in muscle activation patterns or gait symmetry. These functions assist coaching teams in recognizing early signs of functional decline and adjusting training content in a timely manner. Through visualized interfaces, athletes' integrated profiles linking physiological state, movement mechanics, and performance indicators can be dynamically displayed, facilitating intuitive comparison across training phases. This comprehensive analytical framework promotes the transformation of training management from experience-based judgment to data-supported decision-making.

3.3. Dynamic Adjustment of Data-Based Training Schemes

The continuous optimization of functional physical training relies on the establishment of a closed-loop feedback and adjustment mechanism. Training data collected in real time are compared against predefined thresholds and historical baselines to evaluate athletes' adaptive status. When indicators such as explosive performance output show sustained declines beyond acceptable ranges, and are accompanied by signs of increased metabolic stress, the system initiates load adjustment strategies to prevent excessive fatigue accumulation.

Training schemes are further refined according to positional characteristics and energy system demands. Based on individual metabolic response profiles, aerobic and

anaerobic contribution zones are delineated to guide intensity distribution during conditioning sessions. For perimeter players, training emphasizes the alternation between short-duration high-intensity efforts and rapid recovery, while interior players focus more on sustaining force output under repeated loading conditions. Such differentiation ensures that training stimuli are aligned with positional functional requirements.

To control overall training stress, rolling monitoring methods are used to track weekly load variation trends, maintaining training progression within a stable and manageable range. Periodic re-evaluations using standardized performance tests are conducted to verify the effectiveness of training interventions and recalibrate intensity thresholds. Through this iterative process of monitoring, evaluation, and adjustment, data-based training schemes remain dynamically aligned with athletes' adaptation progress and competitive performance demands.

4. Application of Data-Driven Approach in Injury Prevention for College Basketball Players

4.1. Identification of Risk Factors for Injury

Sports injuries among college basketball players are typically the result of long-term accumulation of multiple interacting factors, rather than isolated acute events. From a functional perspective, injuries often represent the external manifestation of underlying structural asymmetries, neuromuscular control deficiencies, and load adaptation imbalances. By integrating wearable sensor technology with three-dimensional motion analysis systems, it becomes possible to quantitatively assess key biomechanical indicators during dynamic basketball-specific tasks. These indicators include lower-limb joint torque distribution, joint range of motion, and temporal characteristics of ground reaction forces during actions such as landing, cutting, and abrupt stopping.

Biomechanical analysis of landing mechanics indicates that movement patterns characterized by insufficient knee flexion, combined with excessive frontal-plane deviations of the hip and knee, are associated with elevated joint shear stress. Such deviations are particularly evident during high-speed directional changes and deceleration phases, which are frequently encountered in competitive play. These movement characteristics can therefore be regarded as early indicators of heightened injury susceptibility in non-contact situations. In parallel, the integration of internal and external load indicators provides a more comprehensive representation of training stress. The training load index constructed as TL = RPE × duration reflects perceived exertion, while external indicators such as high-intensity running distance and explosive acceleration frequency capture mechanical exposure.

When weekly cumulative load increases exceed a stable growth range and the acute-to-chronic load ratio rises beyond recommended thresholds, the likelihood of soft tissue micro-damage increases markedly. This trend reflects a combined deterioration process involving central fatigue accumulation and peripheral tissue overload. Further analysis of load-response relationships using dimensionality reduction methods reveals that certain athletes display a physiological profile characterized by high sensitivity to load and limited recovery capacity. These individuals tend to show prolonged elevations in biochemical fatigue markers following intensive training, accompanied by reductions in heart rate variability during sleep, suggesting impaired autonomic regulation. The cross-validation of biomechanical, physiological, and load-related data enables the identification of injury risk factors to shift from experience-based judgment to parameter-driven modeling, thereby providing a quantitative foundation for individualized early warning strategies.

4.2. Conducting Targeted Preventive Training

Based on the identified biomechanical deviations and physiological adaptation imbalances, preventive training interventions should be designed according to a

progressive framework that emphasizes targeted correction, functional compensation, and neural adaptation. For athletes exhibiting dynamic lower-limb alignment deviations during movement, proprioceptive training combined with eccentric strength control exercises can be introduced to enhance joint stability. The use of unstable support surfaces and real-time visual feedback facilitates improved timing and coordination of stabilizing muscle activation, thereby promoting more efficient movement alignment during high-load tasks.

Strength training strategies focus on improving the efficiency of force transition between eccentric and concentric phases, which is critical for reducing impact stress during landing and deceleration. Training modalities emphasizing controlled lengthening actions and rapid force reapplication contribute to enhanced tendon stiffness and elastic energy utilization, ultimately decreasing peak joint loading. At the metabolic level, training interval structures are adjusted based on individual aerobic response characteristics, with recovery durations tailored to support effective oxidative energy system engagement. This approach helps limit excessive accumulation of metabolic by-products and reduces the likelihood of localized inflammatory responses.

From a scheduling perspective, dynamic load modulation strategies are implemented according to continuous monitoring outcomes. When cumulative load indicators approach risk thresholds, low-intensity technical integration sessions are incorporated to maintain movement proficiency while minimizing additional physiological stress. This integrated preventive approach emphasizes the coordinated development of neuromuscular control and energy system compatibility, enabling athletes to establish more stable and resilient movement patterns under competitive demands.

4.3. Real-Time Monitoring of Damage Risk

Real-time injury risk monitoring is achieved through the coordinated operation of wearable sensing devices, edge-level data processing, and centralized analytical platforms. Inertial measurement units embedded within protective or training equipment continuously collect acceleration and angular velocity data from the limbs, providing high-resolution information on movement dynamics. Simultaneously, surface electromyography signals are analyzed to track changes in muscle activation patterns and frequency-domain characteristics, which serve as indicators of localized fatigue progression.

Cardiac monitoring devices record heart rate variability parameters in both time and frequency domains, reflecting short-term fluctuations in autonomic nervous system balance. When abnormal movement signatures are detected, such as sudden increases in segmental acceleration accompanied by altered muscle co-contraction patterns, the system activates a graded alert mechanism to indicate elevated injury risk. During training and competition, incoming data streams are continuously evaluated using probabilistic update models to estimate real-time injury likelihood, supporting timely decision-making by coaching and medical staff.

This closed-loop monitoring framework significantly reduces the latency between risk emergence and intervention implementation. More importantly, it transforms injury prevention from a passive, outcome-driven process into a proactive, regulation-oriented strategy, thereby enhancing the overall safety and sustainability of functional physical training for college basketball players.

5. Conclusion

Data-driven approaches offer a systematic and effective pathway for enhancing functional physical training and injury prevention in college basketball players. By integrating objective data collection with scientific analysis, these approaches enable more accurate evaluation of athletes' physical condition, more precise formulation of

individualized training programs, and more reliable monitoring of training effectiveness. Compared with traditional experience-based training models, data-driven methods improve the relevance and specificity of training interventions, thereby contributing to sustained improvements in athletic performance and movement quality.

From the perspective of injury prevention, data-driven strategies demonstrate clear practical value. Through the identification of biomechanical deviations, load accumulation patterns, and physiological adaptation imbalances, potential injury risks can be detected at an early stage. Targeted preventive training interventions, guided by quantitative indicators, help correct dysfunctional movement patterns, enhance neuromuscular control, and improve the coordination between mechanical load and metabolic capacity. In addition, the application of real-time monitoring systems enables timely detection of abnormal physiological or mechanical responses during training and competition, reducing the likelihood of injury occurrence and supporting the long-term health and availability of athletes.

Despite these advantages, the application of data-driven approaches in functional physical training for college basketball players remains at a developmental stage. Practical challenges persist, including limitations in data acquisition completeness, variability in measurement accuracy under field conditions, and the need for further maturation of data analysis and interpretation techniques. Moreover, the effective translation of complex data outputs into actionable training decisions still requires ongoing refinement of interdisciplinary collaboration between coaches, medical staff, and data specialists.

Future research and practice should focus on improving the stability and standardization of data collection systems, optimizing analytical models for sports-specific applications, and strengthening the integration of data-driven insights into daily training routines. By continuously enhancing the alignment between data analysis outcomes and functional physical training objectives, data-driven approaches are expected to play an increasingly important role in supporting the safe, efficient, and sustainable development of college basketball players.

References

1. H. Baoquan, and D. Zhigang, "Biomechanical analysis on turnaround dribble in basketball," *Revista Ibérica de Sistemas e Tecnologias de Informação*, no. 17B, p. 242, 2016.
2. E. J. Santos, and M. A. Janeira, "Effects of reduced training and detraining on upper and lower body explosive strength in adolescent male basketball players," *The Journal of Strength & Conditioning Research*, vol. 23, no. 6, pp. 1737-1744, 2009. doi: 10.1519/jsc.0b013e3181b3dc9d
3. B. Dai, and Y. Yin, "Technical analysis of basketball players' shooting movements through video images," *Systems and Soft Computing*, vol. 6, p. 200141, 2024. doi: 10.1016/j.sasc.2024.200141
4. M. Doulas, "An Ethnographic Study of Defensive Practices in College Basketball (Doctoral dissertation, The Ohio State University)," 2023.
5. D. Zehao, "The Construction and Optimization of Basketball Training Mode," *Journal of Human Movement Science*, vol. 2, no. 4, pp. 30-33, 2021.
6. H. Chen, "Physical training applied to injury prevention in basketball," *Revista Brasileira de Medicina do Esporte*, vol. 29, p. e2022_0489, 2023. doi: 10.1590/1517-8692202329012022_0489
7. H. Zhang, "Analysis of College Basketball Injuries: Implications for Healthcare and Patient Well-being," *Journal of Commercial Biotechnology*, vol. 28, no. 2, 2023.
8. M. Zhang, "Analysis and interventions of common sports injuries in college basketball players," *Revista Brasileira de Medicina do Esporte*, vol. 29, p. e2022_0187, 2023. doi: 10.1590/1517-8692202329012022_0187