Research on the Physical Training Model for University Cheerleading Courses Based on Student Career Development

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Abstract: *University physical education is increasingly emphasizing the cultivation of students' comprehensive competencies. Cheerleading courses, due to their composite demands on physical fitness, skills, and teamwork, have become an effective vehicle bridging athletic training with professional competence development. However, existing teaching models generally focus on technical instruction and lack a systematic physical training framework oriented toward students' long-term career development. To address this, this study aims to construct a competency-oriented physical training model for university cheerleading courses. By systematically analyzing the physiological and biomechanical mechanisms of cheerleading-specific physical fitness, the intrinsic constraints on the coordinated development of physical fitness and skills are clarified. Furthermore, from the perspective of transfer effects, the study explains how physical training promotes cognitive functions, psychological resilience, and professional competencies. On this basis, a structured model is constructed that integrates periodic load regulation, neuromuscular and metabolic synergistic training modules, and a long-term multidimensional assessment and feedback system. This model provides a theoretical foundation and practical pathway for transcending traditional skill-based teaching and achieving an in-depth expansion of the educational function of physical education courses.*

Keywords: *cheerleading; physical training; career development; competency-oriented; transfer effects; training model*

Introduction

The function of university physical education courses is shifting from skill transmission and physical fitness enhancement towards promoting students' holistic development and lifelong competence cultivation. Cheerleading, as an activity integrating athleticism, artistry, and teamwork, inherently correlates with modern core professional competencies due to its composite demands on neuromuscular control, metabolic adaptation, psychological regulation, and collaborative communication. However, the physical training within current university cheerleading instruction often appears fragmented, disconnected from both specialized techniques and competency cultivation, and lacks a systematic theoretical training framework oriented towards developing students' career development potential. Consequently, constructing a structured, logically coherent curricular physical training model from multidisciplinary perspectives-including exercise physiology, biomechanics, and sport psychology-holds significant theoretical importance and practical necessity for elevating the scientific standard of teaching and realizing the profound educational value of physical education courses.

1. The Composition of Cheerleading-Specific Physical Fitness and Its Physiological Basis

1.1 Analysis of Core Physiological Indicators for Cheerleading Performance

1.1.1 Advanced Parameters of Neuromuscular Function

The core driving force of athletic performance originates from the efficient operation of the neuromuscular system. This is specifically reflected in the recruitment rate and synchronization level of motor units, particularly high-threshold motor units corresponding to fast-twitch muscle fibers, which directly determine the peak explosive power during lifts and aerial phases. Intramuscular and intermuscular coordination patterns influence the fluidity and power output efficiency of multi-joint compound movements, such as tuck jumps followed by heel touches. Furthermore, post-activation potentiation and reflexive regulatory capacity of muscles are crucial for maintaining continuous explosive efforts throughout a routine[1].

1.1.2 Comprehensive Capacity of the Energy Metabolism System

The functional state of the cardiovascular and metabolic systems provides the energy substrate for athletic performance. Maximum anaerobic power and repeated-sprint ability constitute the metabolic foundation for completing short-duration, high-intensity skill sequences, reflecting the maximal output and recovery capacities of the phosphagen and glycolytic systems. Aerobic capacity, particularly the efficiency of maximal oxygen uptake utilization and the rate of blood lactate clearance, supports the sustained exercise intensity throughout the entire routine and enables rapid recovery during rest intervals, thereby delaying fatigue caused by the accumulation of metabolic byproducts.

1.1.3 The Supporting Role of Flexibility and Proprioception

Joint structure and neural control provide the necessary spatial range and stability for technical movements. Both dynamic and static flexibility, particularly the range of motion in key joints such as the shoulders, hips, and spine, serve as prerequisite anatomical conditions for executing specific dance lines and high-scoring body postures. Complementing this is refined proprioception and dynamic balance ability. Through the integration of the vestibular, visual, and proprioceptive systems, these faculties ensure bodily control and safety during high-difficulty states, such as post-rotation positioning and maintaining stability at the top of a pyramid formation.

1.2 Biomechanical Characteristics and Energy Metabolism Demands of Sport-Specific Movement Patterns

1.2.1 Biomechanical Mechanisms of Explosive Movements

The mechanical essence of jumping movements lies in the efficient generation and transmission of ground reaction force. This involves a rapid extension sequence of the hip, knee, and ankle joints in the lower limbs, coupled with the angular momentum contribution generated by the swinging motion of the upper limbs. Lifts and pyramids constitute static-dynamic composite loads. They require supporting athletes to possess powerful isometric contraction strength, core stiffness, and a precise force transmission chain. Simultaneously, the flyers must demonstrate excellent bodily tension and aerial posture control capability[2].

1.2.2 Temporal Transition of Metabolic Pathways

From an energy metabolism perspective, the execution of a competitive routine is a process involving the precise coordination of multiple energy systems. The instantaneous completion of a single high-difficulty skill primarily relies on the rapid energy supply from the phosphagen system. In contrast, consecutive skill combinations and rapid formation transitions challenge the power output and acid tolerance capacity of the glycolytic system. The lower-intensity movements, transitions, and expressive segments within the full routine depend on the aerobic metabolic system as the foundation for energy recovery and replenishment. The proportional contribution of each system dynamically changes according to the choreography, intensity, and density of the movements.

1.2.3 The Coupling Relationship Between Movement Patterns and Energy Demands

Specific movement patterns determine their corresponding energy metabolism profiles. For instance, consecutive high-impact jumps in place primarily challenge anaerobic capacity and shock absorption capacity, whereas maintaining extended dance segments tests aerobic endurance and movement economy. Therefore, training design must be precisely aligned with the biomechanical and metabolic characteristics of the targeted movement patterns to achieve an efficient translation from physiological capacity to athletic performance.

1.3 Physiological Limiting Factors in the Synergistic Development of Physical Fitness and Skills

1.3.1 The Asymmetrical Relationship Between Neural Adaptation and Skill Transfer

The efficiency with which neural gains in strength and power translate into specific skills is constrained by the specificity of the movement patterns. Neuromuscular adaptations acquired through training are highly specific, and optimal transfer occurs only to techniques that share highly similar biomechanical characteristics with the trained movements. Furthermore, the speed and stability required for the consolidation of central nervous system patterning in skill automation develop independently of general physical fitness. This consolidation process may even be disrupted by the premature or excessive application of physical training loads.

1.3.2 Temporal Differences in Organismic Adaptation

Significant temporal window differences exist in the adaptation of various physiological systems. For instance, improvements in neuromuscular strength and anaerobic capacity occur relatively quickly, whereas the strengthening of connective tissues, increases in bone density, and the structural optimization of the aerobic metabolic system (such as mitochondrial biogenesis and capillary proliferation) require longer periods of sustained stimulus and recovery cycles. This discrepancy can lead to asynchronous training responses, potentially creating temporary performance deficiencies or increasing the risk of injury.

1.3.3 The Individualized Boundaries of Recovery and Supercompensation

There exist individualized limits to the fatigue induced by physical training and the subsequent supercompensation process. Central nervous system fatigue, peripheral muscle damage, and the depletion of energy substrates collectively influence the rate of recovery. Overtraining or insufficient recovery can erode the neural acuity and coordination required for skill training, potentially even triggering maladaptation, which manifests as performance plateaus or declines. Therefore, the precise monitoring of fatigue and recovery states constitutes a key physiological constraint for balancing physical training loads with skill acquisition, ensuring their synergistic and positive development.

2. The Transfer Effects of Physical Training from a Career Development Perspective

2.1 Potential Impact of Physical Fitness Components on Professionally Required Non-Cognitive Abilities

2.1.1 The Physiological Coupling Between Cardiorespiratory Endurance and Stress Tolerance

The optimized cardiovascular system adaptations induced by regular cardiorespiratory endurance training not only enhance maximal oxygen uptake and metabolic efficiency but also more profoundly regulate the balance of the autonomic nervous system, manifesting as decreased resting heart rate and increased heart rate variability. This alteration in physiological state exhibits a significant physiological correlation with an individual's emotional stability and resistance to mental fatigue under high-pressure tasks. The training experience of enduring incremental loads to the point of exhaustion helps reshape an individual's cognitive appraisal and reactive patterns to stressors, potentially translating into psychological resources for coping with high-intensity workloads and tight deadlines in professional environments.

2.1.2 Behavioral Isomorphism Between Muscular Strength and Resilient Execution

The progressive overload principle followed in strength training constitutes a cyclical process of continuously setting and surpassing physiological limits. While enhancing neuromuscular output, this process simultaneously reinforces goal-directed persistence and the willpower to overcome discomfort at the behavioral level. The behavioral pattern of completing prescribed training tasks exhibits a structural isomorphism with the perseverance and tenacity required to face challenges in professional domains. Strength gains, serving as visible and immediate feedback, can effectively reinforce self-efficacy, a key psychological factor driving career exploration and achievement motivation.

2.1.3 The Cognitive Basis Linking Flexibility/Coordination with Teamwork

Flexibility and coordination training necessitate refined perception and regulation of body posture, force application timing, and spatial positioning. This acute awareness of one's own state serves as a physiological-cognitive prerequisite for developing "empathy" and "situational awareness" in interpersonal interactions. During synchronized movements in cheerleading, individuals must continuously monitor and anticipate teammates' status to adjust their own output in real-time. This highly synergistic mode of interaction directly parallels the behavioral paradigms of immediate feedback, shared responsibility, and mutual support required for professional teams to achieve common goals.

2.2 Mechanisms by Which Long-Term Physical Training Promotes Cognitive Function and Psychological Resilience

2.2.1 Optimization of Neuroplasticity and Higher-Order Cognitive Functions

Long-term aerobic and complex training can promote the expression of brain-derived neurotrophic factor (BDNF), inducing structural plasticity changes in key brain regions such as the hippocampus and prefrontal cortex. These changes include increases in gray matter volume and white matter integrity. These neuroadaptive alterations are directly linked to the enhancement of executive functions, encompassing working memory, task switching, inhibitory control, and decision-making speed. Enhanced cognitive flexibility enables individuals to perform more efficient information integration and strategic adjustment when processing complex and variable professional information.

2.2.2 Adaptation of the Stress Axis and Improvement of Emotion Regulation Capacity

Systematic training serves as an effective pathway for regulating the functional homeostasis of the hypothalamic-pituitary-adrenal axis. It can optimize the cortisol response curve to acute stress, avoiding excessive reactions or delayed recovery. This neuroendocrine adaptation is closely associated with the improvement of emotion regulation capacity, manifesting as faster resilience to negative emotions and a more positive emotional baseline. Concurrently, changes in the activity of endogenous neurotransmitter systems provide physiological support for maintaining the psychological well-being required for long-term professional engagement.

2.2.3 The Constructive Process of Self-Regulation and Psychological Resilience

Adhering to a structured training plan itself constitutes continuous practice in self-monitoring, goal setting, and sustaining motivation. Confronting plateaus and setbacks in training requires individuals to mobilize strategies such as cognitive reappraisal to maintain engagement. The accumulated experience of successfully navigating these challenges converts into "psychological capital," fostering a solid belief in one's capacity to handle difficulties-this is psychological resilience. Such resilience endows individuals with greater adaptability and recovery capacity when facing professional adversity.

2.3 The Formation Pathway of Behavioral Habits and Professional Competencies Through Motor Skill Acquisition

2.3.1 The Paradigmatic Homology Between Deliberate Practice and Professional Skill Refinement

Mastering high-difficulty cheerleading skills must adhere to the principle of "deliberate practice": engaging in repetition with clear objectives, obtaining immediate feedback, and continuously correcting errors. This process intrinsically cultivates habits of focusing on details, embracing critical feedback, and tolerating short-term setbacks for long-term refinement. This deep learning paradigm is highly homologous to the developmental path from novice to expert in any professional field and can be transferred to the ongoing acquisition of professional knowledge and skills.

2.3.2 The Behavioral Foundation of Rule Internalization and the Ethics of Responsibility

Cheerleading training and performance operate within a defined framework of technical specifications, safety protocols, and role-specific responsibilities. Strict adherence to safety regulations constitutes an absolute duty to ensure the safety of oneself and others. Precisely executing one's designated role within a group routine fulfills a commitment to the team. This internalization of rules and assumption of role-based duties within a high-pressure, fast-paced environment forms the behavioral precursor and character cornerstone for complying with regulations, fulfilling job responsibilities, and possessing a strong ethics of responsibility in the professional sphere.

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2.3.3 The Integrated Development of Expressive Refinement and Contextualized Communication

Cheerleading requires the conscious integration of emotional expression and audience interaction within high-difficulty skills. This trains the individual's ability to manage emotions under pressure, communicate effectively through both verbal and non-verbal means, and blend personal performance into a collective narrative. This form of "expressiveness," which integrates technical precision, emotional management, and contextualized communication, directly corresponds to the comprehensive communication competencies required in professional settings, such as professional presentations, public speaking, and team demonstrations.

3. Construction of a Competency-Oriented Physical Training Model for Cheerleading Courses

3.1 A Periodized Training Load Regulation Model Based on Developmental Stages

3.1.1 Macro-Cycle Academic Year Adaptive Planning

The macro-cycle structure should be coupled with the university academic system and the rhythm of students' physical and mental development, divided into four progressive stages. The Adaptation Phase focuses on foundational fitness assessment and the establishment of basic movement patterns, employing low-intensity, high-volume loads to lay the groundwork for safety and interest. The Development Phase implements differentiated training based on individual assessment data, applying wave-like progressive overload targeting qualities such as strength and power. The Integration Phase is dedicated to the deep fusion of physical fitness components with sport-specific techniques and teamwork, with training scenarios simulating competition demands and load characteristics shifting towards high intensity and quality. The Transition Phase promotes physiological and psychological regeneration through active recovery and activity variation, building momentum for subsequent cycles.

3.1.2 Mesocycle Modular Load Fluctuation

The mesocycle adopts a modular design, with each module lasting 3 to 6 weeks and focusing on the development of 1 to 2 core physical qualities or composite capacities. Within each module, the training adheres to a "accumulation-transformation-realization" microcycle logic: the Accumulation Phase induces physiological adaptation by increasing training volume; the Transformation Phase shifts foundational fitness towards sport-specific performance; and the Realization Phase optimizes neuromuscular function with high-intensity stimuli. Each module is non-linearly connected and its focus is rotated based on the assessment of preceding results, ensuring comprehensive and continuous capacity development while preventing performance plateaus[3].

3.1.3 The Dynamic Adjustment Mechanism for Individualized Training Loads

The core of load regulation lies in establishing an individualized adjustment mechanism based on biofeedback. This system integrates objective indicators (such as heart rate variability and countermovement jump performance decline index) with subjective scales (e.g., the Recovery-Stress Questionnaire) to monitor neural fatigue and recovery status in real time. The training plan possesses dynamic flexibility, allowing for real-time fine-tuning within preset load ranges based on the monitoring data. When early signs of overtraining are detected, the system can proactively intervene by reducing intensity or adding recovery days to ensure the training stimulus consistently remains within the optimal adaptation window.

3.2 Design of Training Modules Integrating Neuromuscular Control and Energy Metabolism Optimization

3.2.1 Neuromuscular Activation and Integration Module

This module aims to enhance motor unit recruitment efficiency and multi-joint coordination capacity. The training sequence begins with activation exercises for deep stabilizing muscles and drills for dynamic joint stability, progressively advancing to plyometric training emphasizing the rate of force development, such as multi-directional drop jumps. The advanced stage integrates multiplanar compound movement chain training, for example, variations of the power clean or combined rotational push-pull exercises, focusing on developing explosive power output and precise body control capacity in situations approximating sport-specific contexts.

3.2.2 Metabolic Capacity Targeted Enhancement Module

This module delivers precise intervention for the intermittent high-intensity metabolic demands of cheerleading. Utilizing a high-intensity interval training framework, it targets the development of different energy systems through the accurate control of work-to-rest ratios. For instance, employing protocols with very short work periods and full rest targets the phosphagen system, while using cycle exercises with moderate duration and incomplete recovery enhances glycolytic capacity. Concurrently, low-intensity aerobic training that does not interfere with sport-specific movement patterns is incorporated as a means for metabolic recovery and foundational conditioning.

3.2.3 Technical-Fitness Integration Module

This module serves as the crucial link connecting foundational physical fitness with sport-specific performance, facilitating the transfer of competencies. The design includes "skill sequence endurance drills" that simulate sections of a complete routine, and "technical stability training" performed under induced metabolic fatigue, thereby testing the ability to maintain technical precision under pressure. Furthermore, the introduction of open-ended tasks, such as autonomously designing and executing formation transitions within specified constraints, aims to cultivate decision-making ability, adaptability, and teamwork competencies in complex scenarios.

3.3 Long-Term Monitoring and Evaluation System for the Transfer of Training Benefits to Career Development Dimensions

3.3.1 Establishment of a Multidimensional Assessment Framework

Construct a three-tiered assessment framework encompassing physiological function, skill application, and behavioral psychology. The first tier quantifies indicators such as strength and power, along with the quality of technical execution, through standardized tests. The second tier evaluates the ability to apply skills in complex, dynamic situations, such as during improvised choreography and presentation. The third tier utilizes validated scales and structured reflection to track the evolution of potentially transferable traits like perseverance, teamwork, and stress management, thereby comprehensively mapping the benefits derived from training.

3.3.2 Construction of the Dynamic Development Portfolio

An integrated electronic development portfolio is established for each student to continuously incorporate multidimensional assessment data, training logs, and key video materials. The core function of this portfolio is to present longitudinal development trends. Utilizing data visualization tools, it generates individual capacity development curves, clearly revealing the progress trajectories, interrelationships, and critical inflection points across various competency dimensions. This portfolio serves not only as an objective basis for providing personalized guidance but also helps students intuitively recognize their own growth, thereby reinforcing intrinsic motivation.

3.3.3 Feedback Regulation and Mode Optimization Mechanism

The monitoring and evaluation system ultimately serves the closed-loop optimization and continuous iteration of the training model. By regularly integrating and analyzing cohort data, the overall efficacy and common shortcomings of the training model are identified, and the training focus for the next cycle is adjusted accordingly. Concurrently, in-depth analysis of case studies involving individuals who show significant progress is conducted to extract effective elements from their training strategies and reflections. These qualitative insights are then fed back into the design of training modules and methods, thereby achieving the evidence-based, scientific evolution of the training model.

Conclusion

This study, through a physiological analysis of the composition of cheerleading-specific physical fitness and a theoretical explanation of the training transfer effects from a career development perspective, has ultimately constructed a competency-oriented physical training model for university cheerleading courses. The core of this model lies in coupling the principles of periodized training with student developmental stages, designing integrated training modules targeting neuromuscular control and energy metabolism optimization, and establishing a multidimensional long-term assessment and feedback system aimed at tracking the transfer of training benefits to professional competencies. It transcends the traditional training paradigm focused solely on enhancing athletic performance, establishing the dual objectives of using physical development as a medium to simultaneously cultivate sport-specific skills and transferable professional competencies. The theoretical value of this model lies in providing a concrete, physiology- and behavioral-science-based pathway for the reform of specialized university physical education courses within the context of "integrating sports and education." Future research and practice can build upon this foundation to further conduct long-term longitudinal tracking, validate the transfer effects across various competency dimensions with empirical data, and explore the adaptability and optimization of this model for different types of universities and student populations, thereby promoting its penetration and application into a broader spectrum of physical education.

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