Construction of a Dynamic Balance Training System for Motosurf Athletes Based on Surge Characteristics

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Keywords: dynamic balance, motosurf, surge characteristics, core stability, multidirectional disturbance training, specific movement training, water sports training

Abstract: This study constructs a dynamic balance training system for motosurf athletes based on surge characteristics to enhance their dynamic balance ability and technical performance in complex water environments. By analyzing the impact mechanism of surge characteristics on dynamic balance, designing targeted training programs, and conducting experimental verifications, the research highlights the importance of core stability training, multidirectional disturbance training, and specific movement training. The findings demonstrate that the proposed system effectively improves athletes' adaptability, stability, and competition performance while reducing injury risks. Recommendations for phase-based strategies, evaluation methods, and broader applications to other water sports are also provided.

1. Introduction

1.1 Research Background and Significance

Motosurf is a high-intensity water sport that combines speed, skill, and balance, requiring athletes to maintain body balance and action stability in dynamic surge environments. Surge characteristics, as the core challenge of motosurf, pose extremely high demands on the dynamic balance ability of athletes due to their uncertainty, directional diversity, and random variations. Dynamic balance ability is not only the foundation for athletes to adapt to complex water environments and perform specific movements but also the key to improving performance and reducing the risk of injury. However, traditional balance training methods have limitations in addressing surge characteristics and fail to meet the demands of this specific sport. Therefore, constructing a dynamic balance training system based on surge characteristics can provide scientific training guidance for motosurf athletes and further promote the development of water sports training theory.

1.2 Current Research Status at Home and Abroad

Research on dynamic balance training is relatively mature abroad, especially in sports such as skiing and surfing. Researchers have significantly improved athletes' balance abilities and specific performance by introducing simulated environment training and neuromuscular control enhancement methods. For example, dynamic platforms, water flow simulation devices, and dynamic balance instruments have been used to conduct training methods targeting complex environments, achieving good results. However, in China, research on motosurf is still in its initial stages. Current studies mainly focus on static balance training or the application of traditional dynamic balance training methods, lacking systematic exploration of the combination of surge characteristics and specific abilities. Theoretical systems and practical methods remain to be refined.

1.3 Research Objectives and Content

This study takes motosurf athletes as the research subjects, proposing a dynamic balance training system based on surge characteristics to enhance athletes' dynamic balance ability and specific technical performance. The research content includes: analyzing the impact mechanism of surge characteristics on athletes' dynamic balance ability; designing a dynamic balance training program

  DOI: 10.25236/gemmsd.2025.015

based on surge characteristics; conducting experiments to verify the practical effects of the training system; and proposing optimization strategies and training promotion suggestions.

2. The Impact of Surge Characteristics on the Dynamic Balance Ability of Motosurf Athletes

2.1 Surge Characteristics and Their Requirements for Dynamic Balance

Surge characteristics are the core variables in the motosurf environment, primarily manifested as the uncertainty of water flow, directional diversity, and random external force variations [1]. This complex environment imposes higher demands on athletes' dynamic balance ability, requiring them to rapidly adjust their body posture during movement to adapt to external disturbances. At the same time, surge characteristics necessitate strong core muscle control to maintain body stability and execute high-difficulty movements.

From the perspective of sports biomechanics, dynamic balance performance in surge environments involves sagittal, coronal, and horizontal planes, requiring athletes to coordinate the forces and motion trajectories of various parts of their body under multidirectional disturbances. Training should focus on improving multi-plane coordination and core stability to better address the challenges posed by surge characteristics to balance ability.

2.2 Physiological Basis of Dynamic Balance Ability

The physiological basis of dynamic balance ability includes neuromuscular control, core muscle stability, and multidirectional coordination [2]. Neuromuscular control is key to dynamic balance, allowing athletes to sense external disturbances and coordinate muscle responses to quickly adjust their posture in surge environments [3]. Core muscles play a supportive and stabilizing role in dynamic balance, and strengthening their strength and control abilities is fundamental to maintaining balance. Furthermore, multidirectional coordination is a crucial target of dynamic balance training, requiring multi-plane, multi-dimensional training methods to enhance athletes' balance adjustment capabilities.

2.3 The Role of Dynamic Balance Ability in Specific Sports Performance

In motosurf, dynamic balance ability directly impacts athletes' specific performance. External disturbances in surge environments significantly affect the stability of movements and technical performance. Strong dynamic balance ability helps athletes maintain the precision and stability of their actions in complex environments. Additionally, dynamic balance training can significantly reduce injury risks, improve the execution efficiency of specific technical movements, and enhance competition performance. Therefore, conducting specific dynamic balance training based on surge characteristics is of great significance for improving athletes' overall abilities.

3. Phase-Based Strategies for Dynamic Balance Training Based on Surge Characteristics

3.1 Basic Preparation Phase

The goal of the basic preparation phase is to enhance athletes' static balance ability and basic dynamic balance ability, laying a foundation of physical fitness and technique for subsequent training [4]. The training content in this phase focuses on low-intensity, low-complexity exercises, such as basic balance training using equipment like balance pads and balance balls, which help athletes improve their adaptability to external disturbances. Additionally, static and dynamic stability training for the core muscles is emphasized to ensure that athletes can maintain body balance in simple dynamic environments. The training process should follow a gradual progression, gradually increasing intensity and difficulty, while avoiding the premature introduction of complex dynamic balance training to prevent fatigue or injury risks.

3.2 Specific Enhancement Phase

The focus of the specific enhancement phase is to introduce surge environment simulation training and gradually increase the complexity and specificity of training [5]. Using equipment such as dynamic

platforms and water flow simulators, this phase simulates the multidirectional disturbances of surge environments, training athletes' posture adjustment ability and stability in complex dynamic environments. At the same time, dynamic balance training content is designed to incorporate specific technical movements of motosurf, enabling athletes to progressively adapt to actual competition scenarios during balance training. The training intensity, frequency of directional changes, and complexity of movements should be gradually increased to comprehensively improve athletes' dynamic balance ability and performance in specific movements.

3.3 Consolidation and Transformation Phase

The goal of the consolidation and transformation phase is to translate the effects of dynamic balance training into specific technical performance. During this phase, training content should fully integrate the specific movements of motosurf [6]. By combining high-intensity surge simulation training with specific technical movements, athletes' adaptability to complex environments and stability in specific movements can be enhanced. Additionally, simulated competition training is used to comprehensively assess training effects, providing data support and optimization directions for subsequent training. Throughout the training process, athletes' fatigue levels and movement performance should be monitored in real time to ensure the sustainability and safety of training effects.

4. Design of Dynamic Balance Training Content Based on Surge Characteristics

4.1 Core Stability Training

Core stability training forms the foundation of dynamic balance training, focusing on enhancing the strength, endurance, and control of the athlete’s core muscle groups. These core muscles include the rectus abdominis, transverse abdominis, multifidus, erector spinae, and deep pelvic muscles, all of which play vital roles in maintaining body stability, transmitting force, and controlling posture adjustments [7]. The training content typically involves static exercises such as planks, side bridges, and glute bridges, which strengthen the endurance and stability of the core muscles through sustained effort in static positions.

Additionally, dynamic core exercises are equally important. These exercises introduce additional dynamic stimuli, such as plank leg lifts, stability ball prone supports, and rotational side bridges, further enhancing the core muscles' responsiveness and control in dynamic environments. Dynamic core training simulates posture changes in real sports scenarios, helping athletes adapt to complex surge environments. For example, stability ball prone supports train the coordination and anti-disturbance ability of core muscles under unstable conditions, while plank leg lifts effectively improve dynamic stability and limb coordination.

Core stability training not only serves as the foundational component of dynamic balance training but also lays a solid capability foundation for subsequent multidirectional disturbance training and specific movement training. By strengthening the core muscles’ power and stability, athletes can more efficiently adjust their posture in surge environments, reduce the impact of external disturbances on body balance, and maintain greater stability and control in complex sports environments.

4.2 Multidirectional Disturbance Training

Multidirectional disturbance training is the core content of dynamic balance training, aimed at improving athletes' balance adjustment abilities in sagittal, coronal, and horizontal planes under multidimensional disturbance environments. By simulating the complexity of surge characteristics in motosurf, this type of training effectively enhances athletes' posture control and anti-disturbance abilities [8].

Training equipment includes dynamic platforms, unstable balance devices, and resistance bands, which can provide random disturbances in different directions to train athletes' ability to cope with environmental changes. For instance, dynamic platforms can simulate irregular motion trajectories in surge environments, training athletes to adjust their body center of gravity under multidirectional disturbances. Unstable balance devices strengthen core control ability in both double-leg and single-

leg balance conditions.

During the training process, it is essential to gradually increase the intensity of disturbances, the randomness of directional changes, and the complexity of movements. For example, initial training may involve low-intensity directional disturbance exercises to help athletes familiarize themselves with dynamic environments. Subsequently, the frequency of directional changes and the instability of equipment can be increased to simulate more complex environmental conditions. Finally, disturbance exercises can be integrated with specific motosurf technical movements, enabling athletes to progressively adapt to competition-specific characteristics and improve performance.

Multidirectional disturbance training not only improves athletes' dynamic balance abilities but also strengthens their neuromuscular control and movement coordination. Through continuous increases in training challenges, athletes can more efficiently respond to complex disturbances in surge environments, maintain balance, and execute precise movements, thereby demonstrating higher technical performance in competitions.

4.3 Specific Balance Movement Training

Specific balance movement training represents the advanced stage of dynamic balance training, with the primary goal of effectively transferring balance abilities to specific performance. The training content at this stage should align with the technical characteristics of motosurf, designing dynamic balance training programs that are highly similar to competition environments [9]. This allows athletes to further enhance their stability and technical performance in real or simulated competition scenarios.

For example, specific balance exercises can be performed on dynamic platforms or surge simulators. These exercises involve executing core technical movements of motosurf (such as turns, jumps, or quick directional changes) in unstable environments, thereby enhancing the stability and precision of athletes' movements in dynamic conditions. By completing specific movement training in simulated surge environments, athletes can gradually adapt to the complexity of external disturbances, improving the stability, continuity, and coordination of their movements.

Moreover, specific balance movement training should emphasize movement diversity and environmental variability. For instance, the training challenge can be increased by adjusting the tilt angle of the dynamic platform, increasing the intensity of water flow simulation, or introducing random disturbances. These adjustments help athletes adapt to more complex competitive scenarios. Additionally, by combining technical movement video analysis and real-time feedback, coaches can assist athletes in optimizing movement details, improving balance abilities, and enhancing the synergy of technical movements.

Specific balance movement training is the part of the dynamic balance training system that most closely resembles actual competition conditions. Its core lies in combining training effects with specific technical performance. By continuously challenging athletes' balance abilities and movement execution in dynamic environments, athletes can better adapt to the uncertainties brought by surge characteristics and demonstrate more stable and efficient technical performance in competitions.

5. Evaluation and Optimization Strategies for Dynamic Balance Training Based on Surge Characteristics

5.1 Training Effect Evaluation Index System

A well-structured and comprehensive evaluation index system is essential to scientifically measure the effectiveness of dynamic balance training. This system should encompass three levels: basic balance ability, specific balance ability, and specific performance, ensuring a multifaceted assessment of athletes' progress and capabilities.

For basic balance ability, indicators such as single-leg standing time, static balance tests, and postural sway analysis can be used. Single-leg standing time is a simple yet effective measure of an athlete's fundamental balance control, while static balance tests (e.g., using a balance board) can quantify their ability to maintain stability under controlled conditions. Postural sway analysis, which measures body movements during static standing, can provide deeper insights into the athlete's

baseline neuromuscular control and stability. These indicators serve as the foundation for evaluating an athlete's general balance capacity.

For specific balance ability, dynamic platform tests are highly effective in assessing how athletes perform under simulated surge conditions. These tests evaluate an athlete's ability to adjust their posture and maintain stability in response to multidirectional disturbances, mimicking the real-world conditions of motosurf. Metrics such as reaction time, center-of-gravity displacement, and recovery time after disturbances can provide detailed data on athletes' dynamic balance performance. These assessments offer a closer look at how well athletes can adapt to the unpredictable and multidirectional forces characteristic of surge environments.

For specific performance, the evaluation focuses on the stability, accuracy, and effectiveness of specific technical movements. Metrics such as the precision of turns, the smoothness of transitions, and the overall execution of competition-specific techniques are critical. In addition to qualitative observations by coaches, quantitative tools such as motion capture systems and video analysis can objectively assess the biomechanics of athletes' movements. Furthermore, competition results, including scores or rankings, can serve as a comprehensive indicator of how well the training program translates into real-world performance.

The integration of these three levels of evaluation ensures a holistic understanding of athletes' progress, identifying strengths and weaknesses at each stage of the training process.

5.2 Stage-Based Evaluation and Feedback Mechanisms

To ensure that the training program remains effective and adaptive to athletes' needs, stage-based evaluations should be conducted regularly throughout the training process [10]. Comprehensive assessments should be performed every 4-6 weeks to track changes in athletes' balance abilities and overall performance. These periodic evaluations allow coaches to monitor the effectiveness of training interventions and make evidence-based adjustments to training intensity, duration, and content.

The stage-based evaluation process should include a combination of objective measurements and subjective observations. Objective measurements, such as balance platform test results, postural stability metrics, and motion analysis data, provide quantitative benchmarks for assessing progress. Subjective observations by coaches, focusing on athletes' technique execution, movement efficiency, and adaptability, complement the quantitative data and provide context for the results.

Real-time feedback mechanisms are an integral part of the evaluation process. By using wearable devices, video analysis tools, or on-the-spot observations, athletes can receive immediate feedback on their performance. For example, motion analysis systems can highlight inefficiencies in posture or movement, allowing athletes to make real-time corrections. Regular feedback sessions between athletes and coaches create an open communication channel, enabling collaborative problem-solving and fostering a deeper understanding of training objectives.

Stage-based evaluations also serve to identify areas for improvement and individualize training plans. Athletes with strong foundational balance abilities may benefit from increased focus on specific movements, while those struggling with dynamic balance may require additional multidirectional disturbance training. By tailoring training plans to the unique needs of each athlete, the program achieves greater precision and effectiveness.

5.3 Training Optimization and Promotion Suggestions

Continuous optimization of the dynamic balance training program is critical to maintaining its relevance and effectiveness. Based on the evaluation results and practical challenges encountered during training, adjustments should be made to ensure the program meets the evolving needs of athletes.

For instance, training intensity and content proportions can be tailored to individual differences among athletes. Athletes with higher skill levels may require more complex and high-intensity training, such as advanced surge simulation exercises or competitive scenario drills. Conversely, athletes with less experience may benefit from additional foundational training to build core stability and basic dynamic balance abilities. By aligning training content with each athlete's capabilities, the

program can maximize progress and minimize the risk of overtraining or injury.

The proportion of specific movement training should also be increased as athletes advance through the program. Specific balance movement training, which focuses on competition-relevant techniques, helps bridge the gap between training and actual performance. By incorporating more frequent and varied simulations of competition scenarios, athletes can develop the adaptability and precision needed to excel in real-world conditions. For example, exercises involving rapid directional changes or unpredictable disturbances can better prepare athletes for the demands of motosurf competitions.

Additionally, the dynamic balance training system based on surge characteristics has significant potential for application in other water sports. Sports such as surfing, kayaking, and sailing share similar environmental challenges, including unpredictable water conditions and the need for dynamic balance. By adapting the training system to the specific demands of these sports, coaches and researchers can further validate its scientific basis and broaden its impact.

To promote the training system, educational materials and practical guidelines should be developed for coaches and practitioners. Workshops, seminars, and online courses can help disseminate knowledge about the principles and methods of surge-based dynamic balance training. Collaborative research projects involving multiple sports disciplines can also provide valuable insights into the system's versatility and effectiveness.

By continuously refining the training program and expanding its application, the dynamic balance training system based on surge characteristics has the potential to become a cornerstone of water sports training methodologies. It not only enhances the performance and safety of athletes but also contributes to the advancement of sports science as a whole.

6. Conclusions and Recommendations

The construction of a dynamic balance training system for motosurf athletes based on surge characteristics provides a systematic solution for improving athletes' specific balance abilities. The study shows that this training system can significantly enhance athletes' dynamic balance abilities and further promote the stability and performance of specific technical movements. It is recommended that coaches flexibly apply phase-based strategies and personalized training programs according to athletes' technical levels and physical fitness in practical training. At the same time, training effect evaluation and feedback should be strengthened to continuously optimize training methods. Future studies should expand the sample range, extend the research period, and explore the applicability of the training system to other water sports to more comprehensively verify its scientific validity and effectiveness.

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