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ASSESSMENT OF TRAINING LEVELS IN MALE BEACH HANDBALL: THEORETICAL FOUNDATIONS, CURRENT GAPS, AND PERSPECTIVES FOR THE ASIAN CONTEXT

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Abstract:
Beach handball is a rapidly developing, mixed-metabolic team sport that requires unique physical, technical, and tactical adaptations. Despite the sport's global expansion and imminent professionalization, current scientific literature lacks a comprehensive and standardized assessment framework for evaluating the sport-specific fitness and training levels of elite athletes. This review aims to systematize the theoretical and practical foundations of training level assessments in beach handball, identifying critical research gaps. A comprehensive analysis highlights the sport's high-intensity nature, driven by specific sand surface demands and a high frequency of critical two-point scoring actions. Findings reveal that while core physical components such as lower-limb power, speed, and change of direction ability are well-documented, there is a severe lack of multidimensional studies focusing on male national teams, particularly within the Asian and Southeast Asian demographics. Consequently, this review underscores the necessity of establishing sand-specific, position-differentiated assessment protocols and longitudinal tracking methodologies. Establishing normative values for the Asian context will bridge current scientific gaps and optimize long-term athlete development in beach handball.

Keywords: beach handball, training level assessment, sports performance, physical fitness, sand-specific training, Asian national teams

1. Introduction

Beach handball has become one of the fastest-growing disciplines governed by the International Handball Federation (IHF). Since its emergence in Italy in 1992 and official recognition by the IHF in 1994, the sport has undergone remarkable international

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expansion. The first IHF Beach Handball World Championship was organized in 2004, and beach handball has since been included in major international multisport events, notably the 2018 Youth Olympic Games. Continued efforts by the IHF to promote the sport, together with its demonstration at the Paris 2024 Olympic Games, reflect its increasing international recognition and its potential inclusion in future Olympic programs (International Handball Federation [IHF], 2024).

Unlike indoor handball, beach handball is played on an unstable sand surface that requires athletes to perform repeated high-intensity movements, including sprinting, jumping, rapid changes of direction, throwing, and defensive actions under constantly changing environmental conditions. These unique demands place considerable stress on the neuromuscular, metabolic, and technical systems of athletes. Previous investigations have demonstrated that successful beach handball performance depends on the interaction of anthropometric characteristics, muscular strength and power, speed, agility, anaerobic capacity, technical proficiency, and psychological readiness (Pueo, B, *et al.*, 2017; Wang, X, *et al.*, 2024; Eils, Eils, E., *et al.*, 2022). Furthermore, Eils, E, *et al.* (2022) emphasized that sport-specific testing on sand provides more valid information regarding athletes' functional adaptations than laboratory-based assessments alone, highlighting the importance of monitoring performance under competition-like conditions.

Scientific evaluation of training level has become an essential component of contemporary high-performance sport. Rather than serving merely as a periodic measurement of performance, athlete assessment provides objective evidence for monitoring adaptation, optimizing training loads, identifying individual strengths and weaknesses, and supporting long-term athlete development. Bompa and Buzzichelli (2019) proposed that systematic evaluation should be integrated throughout the training process according to the principles of stimulus, adaptation, and supercompensation. Likewise, the American College of Sports Medicine (Riebe, D., *et al.*, 2018) recommends multidimensional monitoring that incorporates anthropometric, physiological, psychological, physical, and sport-specific performance indicators to guide evidence-based coaching and maximize athletic performance.

Although the scientific literature on handball has expanded substantially during the past decade, research focusing specifically on beach handball remains relatively limited. Existing studies have primarily examined isolated aspects such as physical fitness, physiological responses, injury characteristics, match analysis, or specific technical skills using cross-sectional or short-term intervention designs (Pueo, B., *et al.*, 2017; Wang, X, *et al.*, 2024; Eils, E. *et.al.*, 2022). Comprehensive multidimensional assessment systems capable of evaluating athletes' overall training level are still scarce. In particular, longitudinal investigations integrating morphological, physiological-biochemical, psychological, physical, and technical indicators within a unified evaluation framework have rarely been reported, especially among elite national teams in Asia (Eils, E., *et al.*, 2022).

Within Southeast Asia, Vietnam has established itself as one of the region's leading beach handball nations. The Vietnamese men's national team has won multiple SEA Games gold medals, achieved a fifth-place finish at the Asian Beach Games, and earned a bronze medal at the 2021 Asian Men's Beach Handball Championship. The women's national team has likewise achieved podium finishes in major continental competitions. Despite these accomplishments, scientific evidence supporting athlete monitoring and training evaluation in Vietnamese beach handball remains extremely limited. To date, no published master's thesis, doctoral dissertation, or peer-reviewed study has proposed a comprehensive system for assessing the training level of elite Vietnamese male beach handball athletes. This lack of standardized evaluation criteria restricts coaches' ability to objectively monitor training adaptations, optimize long-term preparation, and compare athlete development with international standards.

Therefore, the present review aims to synthesize the theoretical and empirical foundations of training-level assessment in male beach handball. Specifically, the review summarizes current scientific evidence regarding multidimensional athlete evaluation, identifies existing research gaps, and discusses future perspectives for developing standardized assessment frameworks applicable to elite beach handball athletes in Asia. The findings are expected to provide an important scientific basis for future longitudinal studies and contribute to evidence-based athlete monitoring and coaching practice in Vietnamese and Asian beach handball.

2. Theoretical Framework of Training Level Assessment

In modern sports science, a player's "training level" (sport-specific fitness level) is a complex concept reflecting the body's comprehensive adaptation to specialized training stimuli. According to Bompa and Buzzichelli (2019), the objective of a sports training system is to develop, maintain, and enhance an athlete's physical capabilities to achieve optimal competitive performance, fundamentally relying on the pillars of individualization and specialization. Evaluating this training level involves a systematic, scientifically grounded process of measuring physical, physiological, technical, and tactical components through standardized testing.

The assessment process in beach handball must adhere to five core theoretical principles:

- **Mixed-Metabolism Nature:** Beach handball is categorized as a high-intensity, mixed-metabolism sport. Assessments must comprehensively evaluate the ATP-PCr (alactic anaerobic), lactic anaerobic, and aerobic energy systems.
- **Sand Surface Specificity:** The sand surface provides higher impact absorption but significantly diminishes the stretch-shortening cycle (SSC) effect, reducing mechanical reflexes and elastic energy. Therefore, testing must be conducted directly on sand to ensure ecological validity.

- **Playing Position Differentiation:** Body composition, somatotypes, and technical demands vary significantly across positions. Assessments must differentiate between goalkeepers, wings, joker/specialists, line players, and defenders.
- **Long-Term Athlete Development (LTAD):** Assessments serve as longitudinal tracking tools. Utilizing a "sand test profile" at key points of the season allows for individualized planning based on progressive overload principles.
- **Predictive Decision-Making Value:** Tests must possess functional relevance, demonstrating the ability to differentiate improvements in force production and predict competitive performance and decision-making capabilities under pressure.

3. Constituent Elements of Training Level in Beach Handball

The training level of a beach handball athlete is a multifaceted construct structured around four primary interactive components.

3.1. Physical Components

Physical conditioning is the foundational determinant of performance. Core physical elements include:

- **Strength and Power:** Explosive strength is critical for specific throwing techniques and goalkeeper movements. Implementing plyometric and high-speed training on sand for six weeks has been shown to significantly improve all physical indices ($p < 0.05$), specifically the squat jump (SJ), countermovement jump (CMJ), Abalakov jump, and jump-throw velocities.
- **Speed and Acceleration:** There is a significant negative correlation between the standing horizontal jump and 5 m/15 m acceleration times on sand. Furthermore, elite male athletes demonstrate significantly superior high-speed 15 m sprint results compared to female athletes ($p = 0.004$).
- **Change of Direction Ability (COD):** COD is a sensitive indicator of training adaptation. Interventions utilizing plyometric and eccentric-overload training elicit equivalent COD improvements in male beach handball players (effect sizes approximately 0.58–0.64).
- **Specific Endurance:** While the majority of match time is spent at walking or light running paces, high-speed running accounts for roughly 4.4% of total distance and is decisive for ball possession and scoring.
- **Flexibility and Joint Stability:** These are crucial for injury prevention and performance optimization. A 10-day specialized training camp improved the sit-and-reach range of motion from 35.5 cm to 39.6 cm and enhanced shoulder stability from 31.8 to 35.4 repetitions.

3.2. Morphological and Anthropometric Characteristics

Body composition acts as the foundation for physical output. Elite senior players exhibit superior body composition with lower body fat percentages compared to youth players.

Notably, height serves as a powerful discriminant factor; analyzing world championship data reveals that teams ranking in the top 8 average 192.19 ± 6.80 cm in height, while teams in the 17-24 bracket average 186.96 ± 7.68 cm.

3.3. Technical Components

The technical proficiency in beach handball is uniquely dictated by the IHF's dual-point scoring system. Spectacular goals are awarded 2 points, heavily influencing tactical execution. World Championship data indicates that successful offensive actions consist of spin shots (41%), specialist shots (20%), and inflight shots (14%). There is a significant positive correlation between dominant hand grip strength and the throwing speed of 6-m and inflight shots. Lower-limb driven techniques, such as the 360° spin-shot and jump throws, are highly responsive to sand-specific plyometric training, whereas stationary penalty throws rely heavily (73%) on shoulder rotation and elbow extension.

3.4. Psychological and Tactical Components

High-intensity training and the pressure of elite competition frequently lead to muscular fatigue, joint pain, and psychological burnout. Tactical proficiency is largely reflected in an athlete's ability to execute complex decision-making under intense pressure, heavily supported by modern video analysis integration.

4. Sport-Specific Characteristics and Training Phases

Beach handball dictates highly specific environmental and physiological demands. Matches are played on a 27x12 m court with a minimum sand depth of 40 cm, featuring four players per team on the court simultaneously. The game consists of two 10-minute halves; tie scores are resolved via a shootout.

Time-motion analyses utilizing GPS technology reveal the following match characteristics:

- **Distance and Speed:** Male athletes cover an average of 1,234.7 ± 192.0 m per match at an average relative speed of 69.7 m/min. Maximum speeds range between 17 and 20.5 km/h.
- **Cardiovascular Load:** The maximum heart rate (HRmax) averages 173 ± 13 bpm, and the mean heart rate is 137 ± 12 bpm. Approximately 20.3% of total match time is spent in the anaerobic zone (81-90% HRmax).
- **Kinematics:** Athletes undergo roughly 40 accelerations per match (1 acceleration every 23 seconds) and experience a collision frequency of approximately 3.9 times per minute, which is lower than indoor handball, basketball, or rugby.

Training periodization consists of three macro-phases:

1) **Preparation Phase:** Focuses on sensorimotor coordination, neuromuscular adaptation on sand, plyometrics, and stabilization.

2) **Tournament Phase:** Prioritizes specific endurance and competition stress adaptation, regulating neuroendocrine responses at a Rating of Perceived Exertion (RPE) of 6-8.
3) **LTAD Phase:** Aims to improve aerobic-anaerobic power, structural adaptations of the musculoskeletal system, and ligament consolidation. Training exclusively on sand can cause a slight regression in complex jump throws (decreased jump height by 2.5-5.1%), requiring supplemental explosive strength training on hard surfaces.

5. Current Research Landscape and Key Gaps

The scientific profiling of beach handball performance is expanding but remains in its infancy. The primary research directions have historically focused on:

1) Anthropometric profiling and establishing baseline physical data.
2) In-game physiological demands using GPS and time-motion analysis.
3) Efficacy of sand-specific training interventions.
4) Differentiating skill levels based on strength and kinematic markers.

Despite these advancements, contemporary literature exhibits substantial limitations, including small sample sizes (typically 20-70 participants), an over-reliance on cross-sectional designs centered around European and South American cohorts, and an absence of standardized testing protocols.

Explicitly, six major research gaps have been identified:

1) **Lack of multidimensional studies** on elite male national teams incorporating comprehensive assessments.
2) **Lack of an internationally standardized assessment framework**, particularly tailored for male national teams.
3) **Lack of data originating from Asia and Southeast Asia**.
4) **Lack of longitudinal tracking studies** to map developmental trajectories.
5) **Lack of assessment models** that seamlessly integrate long-term periodization with quantitative evaluation.
6) **Lack of clear skill level and performance differentiation** across highly specific playing positions on the court.

6. Conclusion and Future Directions

The evolution of male beach handball mandates a paradigm shift in how athletes are evaluated and trained. The sport's specific mixed-metabolic demands and the unique biomechanical constraints of the sand surface require a departure from generic indoor handball testing methodologies. It is imperative to establish a comprehensive, multi-dimensional, and sand-specific assessment system.

Future research must prioritize longitudinal tracking methodologies to accurately monitor physiological and technical adaptations over multi-year training cycles. Furthermore, establishing normative reference values specifically tailored to the Asian

demographic will address a critical void in current sports science literature. Methodologically, future testing protocols should heavily emphasize sand-specific diagnostics and prioritize the evaluation of complex, high-value technical actions—such as two-point spin shots and inflight shots—which fundamentally dictate competitive success in modern beach handball.

Conflict of Interest Statement
The authors declare no conflicts of interest.

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