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Isometric Training for Neuromuscular Performance and Injury-Risk Management in Beach Volleyball: A Narrative Review

Treinamento Isométrico para Desempenho Neuromuscular e Gerenciamento de Risco de Lesões no Vôlei de Praia: Uma Revisão Narrativa

Entrenamiento isométrico para el rendimiento neuromuscular y la gestión del riesgo de lesiones en el vóley playa: una revisión narrativa

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Abstract:
Objective: To critically examine the rationale for incorporating isometric strength training into beach volleyball conditioning and evaluate its potential effects on performance and injury-risk management. Methods: Narrative review integrated evidence on beach volleyball match demands and injury patterns with systematic reviews and controlled studies investigating isometric training in athletic and physically active populations. Results: The literature indicates that isometric training improves maximal isometric strength and can transfer to dynamic performance when exercise prescription considers contraction intent, joint angle, muscle length, and training intensity. High-intensity contractions performed at longer muscle lengths appear particularly effective for enhancing force production and tendon adaptations. Isometric exercise may also help maintain strength and manage symptoms during selected rehabilitation phases because it imposes relatively low movement demands. Conclusions: Isometric training should be used as a complementary component within a periodized strength and conditioning program rather than as a stand-alone strategy. Further randomized controlled trials involving beach volleyball athletes are required to establish sport-specific training recommendations.

Keywords: isometric exercise; neuromuscular performance; injury risk; strength and conditioning.

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Resumo:
Objetivo: Analisar criticamente a justificativa para a inclusão do treinamento de força isométrico na preparação física do vôlei de praia e avaliar seus possíveis efeitos sobre o desempenho esportivo e o gerenciamento do risco de lesões. Metodologia: Foi realizada uma revisão narrativa integrando evidências sobre as demandas da modalidade e os padrões de lesões no vôlei de praia com revisões sistemáticas e estudos controlados que investigaram o treinamento isométrico em atletas e indivíduos fisicamente ativos. Resultados: A literatura demonstra que o treinamento isométrico melhora a força isométrica máxima e pode ser transferido para o desempenho dinâmico quando a prescrição considera a intenção da contração, o ângulo articular, o comprimento muscular e a intensidade do treinamento. Contrações de alta intensidade realizadas em maiores comprimentos musculares parecem favorecer adaptações de força e dos tendões. Além disso, os exercícios isométricos podem auxiliar na manutenção da força e no controle de sintomas durante fases específicas da reabilitação. Conclusões: O treinamento isométrico deve ser utilizado como componente complementar de um programa periodizado de preparação física, e não como estratégia isolada. Ensaios clínicos randomizados com atletas de vôlei de praia ainda são necessários para estabelecer protocolos específicos para a modalidade.

Palavra-chave: exercício isométrico; desempenho neuromuscular; risco de lesão; força e condicionamento.

Resumen:
Objetivo: Analizar críticamente la justificación para incorporar el entrenamiento de fuerza isométrica en la preparación física del vóley playa y evaluar sus posibles efectos sobre el rendimiento deportivo y la gestión del riesgo de lesiones. Metodología: Se realizó una revisión narrativa que integró evidencia sobre las demandas competitivas y los patrones de lesiones en el vóley playa con revisiones sistemáticas y estudios controlados que investigaron el entrenamiento isométrico en atletas y personas físicamente activas. Resultados: La evidencia indica que el entrenamiento isométrico mejora la fuerza isométrica máxima y puede transferirse al rendimiento dinámico cuando la prescripción considera la intención de la contracción, el ángulo articular, la longitud muscular y la intensidad del entrenamiento. Las contracciones de alta intensidad realizadas a mayores longitudes musculares parecen favorecer las adaptaciones de fuerza y del tendón. Además, los ejercicios isométricos pueden contribuir al mantenimiento de la fuerza y al control de los síntomas durante fases específicas de la rehabilitación. Conclusiones: El entrenamiento isométrico debe utilizarse como un componente complementario dentro de un programa periodizado de preparación física y no como una estrategia aislada. Se necesitan ensayos clínicos aleatorizados con jugadores de vóley playa para establecer protocolos específicos para este deporte.

Palabras clave: ejercicio isométrico; rendimiento neuromuscular; riesgo de lesión; fuerza y acondicionamiento.

1. Introduction

Beach volleyball is an intermittent sport in which two players must repeatedly perform jumps, short accelerations, multidirectional movements, defensive actions, and overhead skills while coping with environmental and surface-related constraints. Time-motion and match-demand research shows that playing role and sex influence the frequency and distribution of physical actions, while tournament play can impose meaningful cumulative external load (Bellinger et al., 2021; Natali et al., 2019). The compliant sand surface also changes force application and requires continuous postural adjustment. Consequently, physical preparation must address both the capacity to produce force and the ability to control that force in sport-specific positions.

The injury profile reinforces this need. Studies involving high-level beach and indoor volleyball players consistently identify the knee, ankle, shoulder, fingers, and lower back as relevant sites of acute or overuse problems (Bahr and Reeser, 2003; Bere et al., 2015; Kilic et al., 2017). These injuries are multifactorial and cannot be prevented by a single exercise method. Nevertheless, strength capacity, tissue tolerance, movement control, exposure management, and progressive sport-specific loading are modifiable components of a broader risk-reduction strategy.

Isometric exercise produces muscular force without visible joint movement. Depending on how it is prescribed, it may involve overcoming contractions against immovable resistance or yielding contractions that maintain a position against an external load. Isometric training is attractive in sport because it can provide high force with limited joint excursion, emphasize specific joint angles, and be implemented with relatively little equipment. Reviews indicate that its adaptations depend on muscle length, intensity, contraction intent, volume, and duration (Lum and Barbosa, 2019; Oranchuk et al., 2019).

The original beach volleyball literature does not yet contain a sufficiently large and homogeneous group of trials to support a sport-specific systematic review of isometric interventions. The purpose of this narrative review is therefore to integrate verified evidence from beach-volleyball demands and injury epidemiology with the broader isometric-training literature, and to translate that evidence into cautious, practical recommendations for strength and conditioning professionals.

2. Methods

This article was developed as a narrative review. A structured literature search was conducted to identify peer-reviewed publications relevant to three themes: (1) the physical and neuromuscular demands of beach volleyball; (2) injury patterns in beach and indoor volleyball; and (3) chronic or acute responses to isometric strength training. PubMed/MEDLINE and reference lists of eligible publications were consulted, with emphasis on literature published from 2015 to 2024. Earlier landmark beach volleyball studies were retained when they provided sport-specific epidemiological or physiological context not adequately replaced by newer evidence.

Search concepts included combinations of ‘isometric training’, ‘isometric strength’, ‘isometric contraction’, ‘tendon stiffness’, ‘dynamic performance’, ‘beach volleyball’, ‘volleyball’, ‘match demands’, ‘injury’, and ‘injury prevention’. Priority was given to systematic reviews, controlled training studies, surveillance studies, and direct beach-volleyball research. Because no prospective protocol was registered, a complete database-by-database search record was unavailable, and study selection was not documented with a reproducible PRISMA flow diagram, the manuscript is not presented as a systematic review. No meta-analysis was performed.

The evidence was synthesized according to neuromuscular adaptations, potential transfer to sport performance, tendon and joint considerations, injury-risk management, and practical programming. Conclusions specific to beach volleyball were explicitly treated as indirect when they were derived from other athletic populations.

3. Neuromuscular and Mechanical Adaptations

Isometric training can substantially increase maximal voluntary force. A systematic review by Oranchuk et al. (2019) showed that improvements occur across a range of intensities, while the magnitude and type of adaptation depend on the joint angle, muscle length, contraction intent, and loading scheme. Training at longer muscle lengths appears to favor hypertrophic adaptation and transfer across a wider range of motion. High-intensity contractions are particularly relevant when the objective includes tendon adaptation.

Contraction intent is another important variable. When athletes are instructed to produce force as rapidly as possible against an immovable resistance, isometric training can target neural drive and early rate of force development. This may be

relevant to blocking, acceleration, and the initial force-production phase of jumping. Conversely, longer sustained contractions may be useful when the aim is positional strength, local capacity, or controlled loading. These approaches should not be considered interchangeable.

Kubo, Ishigaki and Ikebukuro (2017) compared plyometric and isometric plantar-flexor training and found distinct mechanical adaptations: isometric training increased tendon stiffness, whereas plyometric training produced adaptations more closely related to fast stretch-shortening-cycle behavior. This distinction is important for beach volleyball. Isometrics may build force and tendon capacity, but the rapid eccentric-concentric actions of jumping and landing still require dynamic and plyometric exposure.

4. Transfer to Beach-Volleyball Performance

The performance value of isometric training depends on transfer. Evidence summarized by Lum and Barbosa (2019) indicates that isometric training can improve dynamic performance, particularly when exercise position, contraction intent, and force-time demands are aligned with the target action. Nevertheless, angle specificity remains a central limitation: large gains at a trained joint angle do not guarantee equivalent gains throughout the complete range of motion.

In beach volleyball, possible applications include isometric squat or split-squat positions that resemble the preparatory posture for defense and take-off; calf isometrics for ankle plantar-flexor capacity; trunk anti-extension, anti-rotation, and lateral-bracing tasks; and shoulder external-rotation or scapular isometrics. These exercises can strengthen positions that contribute to force transmission and control, but they do not reproduce the full coordinative, elastic, perceptual, and technical requirements of competition.

Isometric force-time characteristics are associated with a variety of dynamic athletic tasks, but correlation does not demonstrate that improving an isometric test will automatically improve match performance (Lum, Haff and Barbosa, 2020). Testing should therefore be selected for a clear purpose and interpreted alongside jump, sprint, change-of-direction, repeated-effort, workload, and sport-specific indicators.

5. Injury-Risk Management and Rehabilitation

Volleyball injury surveillance shows that prevention priorities include acute ankle and finger injuries and overuse problems involving the knee, lower back, and shoulder (Bere et al., 2015; Kilic et al., 2017). In beach volleyball, early epidemiological work similarly identified low-back, knee, and shoulder complaints as common overuse problems (Bahr and Reeser, 2003). These patterns justify comprehensive programs that integrate strength, landing and movement skill, progressive overhead exposure, workload management, recovery, and individualized rehabilitation.

Isometric exercise may contribute to this process by providing a controllable loading option with limited joint excursion. It can maintain or restore capacity force when dynamic movement is temporarily restricted and can be useful for graded tendon loading. In athletes with patellar tendinopathy, a single heavy isometric session has been reported to reduce pain immediately and increase maximal voluntary isometric contraction; however, this acute response should not be generalized to all tendinopathies, all athletes, or long-term injury prevention (Rio et al., 2015). Symptom response is variable, and rehabilitation must progress toward the energy-storage, movement, and sport loads required in competition.

It is therefore more accurate to describe isometrics as a tool for injury-risk management and rehabilitation rather than an independently proven injury-prevention intervention for beach volleyball. Claims that isometric exercise alone reduces shoulder pain by a fixed percentage or prevents a defined proportion of injuries are not supported by the verified sport-specific evidence reviewed here.

6. Limitations and Future Research

The principal limitation is the scarcity of direct isometric-training trials in competitive beach volleyball athletes. Much of the mechanistic and training evidence comes from healthy adults or athletes in other sports, limiting certainty about sport-specific transfer. Protocol heterogeneity also prevents a single optimal prescription from being recommended. This narrative review did not use a registered protocol, exhaustive reproducible searches across multiple databases, duplicate risk-of-bias assessment, or meta-analysis.

Future research should use randomized or well-controlled designs in beach-volleyball athletes and report sex, age, playing role, competitive level, training history,

adherence, and concurrent technical and physical loads. Trials should compare joint angles, muscle lengths, contraction intent, intensity, weekly frequency, and seasonal timing. Outcomes should include maximal and rapid force production, jump and change-of-direction performance on sand, repeated-jump ability, pain and function, time-loss and overuse injury surveillance, and adverse events.

7. Conclusion

Isometric strength training is a useful complementary method for beach volleyball preparation. Verified evidence supports improvements in maximal isometric force and indicates that joint angle, muscle length, intensity, and contraction intent determine the resulting adaptation. Isometrics may also provide a controllable way to expose muscles and tendons to force during selected training and rehabilitation phases. However, direct beach volleyball intervention evidence is limited, and isometric exercise has not been shown to prevent injuries as a stand-alone strategy in this population. Practitioners should integrate isometrics with dynamic resistance training, plyometrics, landing and movement training, technical practice, and workload management. The strongest conclusion is not that isometric exercise replaces other methods, but that it can fill a specific role within an individualized and periodized program.

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Declarations

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