IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

A COMPREHENSIVE REVIEW OF RESISTED HARNESS TRAINING ON EXERCISE SAFETY REHABILITATION AND ATHLETIC PERFORMANCE

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Abstract

Resisted harness training has gained considerable attention as an effective intervention for enhancing athletic performance, improving exercise safety, and facilitating rehabilitation. Harness-based systems, including resisted sled towing, partner-resisted sprinting, body-weight-supported treadmill training (BWSTT), lower-body positive-pressure treadmills (LBPPT), and supportive strength harnesses, provide controlled resistance or body-weight support to optimize movement mechanics and reduce injury risk. This comprehensive narrative review synthesizes published evidence from 2000 to 2026 on the biomechanical, physiological, rehabilitative, and performance-related effects of resisted harness training. Relevant literature was identified from peer-reviewed studies and critically analyzed to summarize current evidence across sports performance and clinical rehabilitation. The available evidence indicates that resisted harness training effectively improves sprint acceleration, lower-limb power, gait mechanics, balance, and functional mobility while providing a safe environment for individuals with neurological disorders, musculoskeletal impairments, and mobility limitations. However, its effects on maximal sprint velocity, vertical jump performance, and long-term neuromuscular adaptations remain inconsistent. Training outcomes are influenced by factors such as harness attachment point, loading intensity, body-weight support level, and training protocol. Although harness-based interventions demonstrate substantial practical value in both athletic and rehabilitation settings, further high-quality longitudinal studies are required to establish standardized training guidelines and optimize exercise prescription. This review provides an updated synthesis of current evidence and highlights practical applications, safety considerations, research gaps, and future directions for resisted harness training.

Keywords: Resisted harness training; Exercise safety; Athletic performance; Rehabilitation; Sprint training; Body-weight-supported treadmill training (BWSTT).

Introduction

Resisted harness training has emerged as an effective training modality for improving athletic performance, enhancing exercise safety, and facilitating rehabilitation. Unlike traditional resistance training methods that primarily apply vertical loading, harness-based systems provide controlled horizontal resistance or body-weight support, allowing targeted biomechanical and physiological adaptations while reducing the risk of injury (Harrison & Bourke, 2009; Scott et al., 2014). These systems have become increasingly popular in sports science and clinical rehabilitation because they enable the manipulation of external loads without substantially altering natural movement patterns.

In athletic settings, resisted harness systems such as sled towing and partner-resisted sprinting are widely used to improve sprint acceleration, lower-limb power, and neuromuscular performance (Bentley et al., 2016; Chaalali et al., 2022). Similarly, customized supportive harnesses have been developed for resistance training, allowing individuals with limited shoulder mobility or upper-limb impairments to perform exercises such as the back squat safely without excessive stress on the shoulder complex (Scott et al., 2014). Beyond sports performance, harness systems are extensively applied in rehabilitation, including body-weight-supported treadmill training (BWSTT) and lower-body positive-pressure treadmills (LBPPT), to facilitate gait retraining, improve balance, and promote functional recovery in individuals with neurological disorders, spinal cord injuries, and lower-limb amputations (Chen & Patten, 2006; Crompton Sarah et al., 2001; Lamberg et al., 2014).

The growing application of harness-based training has generated considerable research on its biomechanical, physiological, and clinical effects. Previous studies have demonstrated improvements in sprint acceleration, gait mechanics, muscular endurance, and movement safety; however, the reported outcomes remain inconsistent across different training protocols and populations (Clark et al., 2017; Harrison & Bourke, 2009; Jc et al., 2020). Furthermore, occupational safety research has highlighted the importance of proper harness design and fit to minimize suspension trauma and other safety risks during prolonged suspension (Hsiao et al., 2012).

Although numerous studies have investigated specific applications of resisted harness training, the available evidence remains fragmented across sports performance, rehabilitation, strength training, and occupational safety. Moreover, variations in harness design, loading strategies, attachment points, and training protocols make it difficult to establish clear practical recommendations. Therefore, a comprehensive synthesis of the current evidence is needed to better understand the effectiveness, safety considerations, and practical applications of resisted harness training.

Therefore, the purpose of this comprehensive narrative review is to critically summarize and synthesize the evidence published between 2000 and 2026 on the biomechanical principles, physiological adaptations, exercise safety, rehabilitation applications, and athletic performance outcomes associated with resisted harness training, while identifying current knowledge gaps and future research directions.

Methods: This comprehensive narrative review summarizes published evidence on resisted harness training, exercise safety, rehabilitation, and athletic performance from 2000 to 2026. Relevant literature was identified through electronic databases, including PubMed, Scopus, Web of Science, Google Scholar, and SPORTDiscus, using keywords such as *resisted harness training*, *sled towing*, *body-weight supported treadmill training*, *exercise safety*, *rehabilitation*, and *athletic performance*. Peer-reviewed articles published in English were included. The selected studies were critically reviewed and narratively synthesized according to major themes, including biomechanical principles, physiological adaptations, exercise safety, rehabilitation applications, athletic performance, and future research directions.

Overview of Resisted Harness Training

Resisted harness training refers to exercise methods that use an external harness to apply resistance, provide body-weight support, or guide movement during physical activity. These systems are designed to improve athletic performance, facilitate rehabilitation, and enhance exercise safety by modifying external loading and movement mechanics (Harrison & Bourke, 2009; Scott et al., 2014; Wallis et al., 2002).

The fundamental principle of resisted harness training is to manipulate mechanical loading to achieve specific biomechanical, physiological, and functional adaptations. In sports, harnesses are primarily used to improve sprint acceleration, power, and neuromuscular performance through horizontal resistance (Bentley et al., 2016; Chaalali et al., 2022). In rehabilitation, body-weight support systems reduce postural and cardiovascular demands, enabling safe gait retraining and functional recovery in individuals with neurological or musculoskeletal impairments (Lamberg et al., 2014). Harnesses are also employed to correct movement patterns and ensure safety during balance training and occupational activities (Hsiao et al., 2012; Wallis et al., 2002).

Types of Harness Training

The major forms of harness training include resisted sled and partner towing for sprint development, body-weight-supported treadmill training (BWSTT) and lower-body positive-pressure treadmills (LBPPT) for gait rehabilitation, rigid supportive strength harnesses for resistance training in individuals with limited shoulder function, physical guidance harnesses for movement correction, and fall-arrest harnesses used in rehabilitation and occupational safety (Crompton Sarah et al., 2001; Lee et al., 2021; Scott et al., 2014; Wallis et al., 2002).

Biomechanical Principles

The effectiveness of resisted harness training depends largely on the characteristics of the harness attachment and support. Waist-mounted harnesses produce greater horizontal force and better preserve sprint mechanics than shoulder-mounted systems, making them preferable for sprint acceleration (Bentley et al., 2016). In rehabilitation, the stiffness of body-weight support systems influences gait biomechanics, where compliant supports allow more natural pelvic movement than rigid systems (Chen & Patten, 2006). Appropriate harness selection and loading are therefore essential for maximizing performance benefits while ensuring safety.

Findings and Discussion

Physiological Effects

The physiological responses to resisted harness training depend largely on the type and magnitude of applied resistance. In athletic populations, harness training has been associated with improvements in cardiopulmonary fitness, including increased vital capacity and reduced resting heart rate (Mahulkar, 2021). Experimental evidence also suggests that prolonged harness-based endurance training promotes muscle plasticity by enhancing capillary density and improving metabolic efficiency(de Meeûs d'Argenteuil et al., 2021). However, studies using lower-body positive-pressure treadmills (LBPPTs) indicate that reducing body weight without proportionally increasing treadmill speed may fail to improve aerobic capacity because of the reduced metabolic demand (Lee et al., 2021). Similarly, short-term assisted harness training has shown minimal effects on biochemical markers of fatigue or muscle stiffness in young athletes (Jc et al., 2020).

Exercise Safety

Harness systems provide substantial safety benefits in both sports and rehabilitation settings. Supportive strength harnesses enable individuals with shoulder instability or upper-limb impairments to perform resistance exercises safely while minimizing stress on the shoulder complex (Scott et al., 2014). During maximal treadmill testing, safety harnesses improve participants' confidence and perceived safety without affecting physiological performance (Mermier et al., 2013). Nevertheless, prolonged suspension in fall-arrest harnesses may lead to suspension trauma due to venous pooling, emphasizing the importance of proper harness fitting and rapid rescue procedures (Hsiao et al., 2012).

Applications in Rehabilitation

Body-weight-supported treadmill training (BWSTT) is widely used to improve gait, balance, and functional mobility in individuals with neurological disorders. By reducing weight-bearing demands, harness systems enable repetitive and task-specific gait training during the early stages of rehabilitation (Crompton Sarah et al., 2001; Lamberg et al., 2014). In lower-limb amputees, partial body-weight support reduces energy expenditure and protects the residual limb during prosthetic gait training, although long-term functional outcomes appear comparable to those of conventional treadmill training with a safety harness alone (Lamberg et al., 2014). Motorized harness systems have also demonstrated effectiveness in balance rehabilitation by providing dynamic protection during perturbation-based training (Berkovich & Meisterheim, 2018).

Effects on Athletic Performance

Evidence consistently demonstrates that resisted harness training effectively enhances sprint acceleration, lower-limb power, and stride frequency, particularly during the initial 10–30 m of sprinting (Chaalali et al., 2022; Clark et al., 2017; Harrison & Bourke, 2009). However, improvements in maximal sprint velocity, vertical jump performance, and muscular hypertrophy are generally limited (Jc et al., 2020). Harness-based training also improves muscular endurance and respiratory capacity (Devika & Johnson, 2017), whereas movement-restriction harnesses can facilitate technical skill acquisition during practice, although these improvements may not be retained after harness removal (Wallis et al., 2002).

Comparison with Other Resistance Training Methods

Compared with unresisted sprinting, harness-resisted sprint training is more effective for developing acceleration and horizontal force production, whereas traditional sprint training remains superior for improving maximal running speed and stride length (Chaalali et al., 2022; Harrison & Bourke, 2009). Weight-jacket training has demonstrated greater improvements in agility than harness running in soccer players (Islam Mallick & Shaikh, 2013). Furthermore, the rigid-harness squat provides a reliable alternative to the conventional back squat for individuals with limited shoulder mobility, producing comparable lower-body strength outcomes (Scott et al., 2014).

Factors Influencing Training Outcomes

The effectiveness of resisted harness training is influenced by several biomechanical and training variables. Sprint performance is optimized when resistance produces approximately a 10% reduction in unresisted sprint velocity, preserving natural running mechanics while providing sufficient overload (Bentley et al., 2016). Waist-mounted harnesses generally produce more favorable horizontal force vectors than shoulder-mounted systems, thereby improving sprint mechanics. In addition, training surface characteristics influence injury risk, with harder surfaces increasing musculoskeletal stress during harness-assisted locomotion (Audigié et al., 2017).

Discussion

The available evidence indicates that resisted harness training is an effective intervention for enhancing athletic performance while supporting safe rehabilitation. In sports, harness-resisted sprint training consistently improves acceleration, explosive power, and stride frequency, although its effects on maximal sprint velocity and jumping performance remain limited. In rehabilitation, body-weight-supported systems facilitate early gait retraining, improve balance, and enable repetitive practice in individuals with neurological and musculoskeletal impairments. Supportive harnesses also allow safe participation in resistance training among individuals with reduced shoulder function.

Despite these benefits, training outcomes depend on appropriate exercise prescription, including resistance magnitude, harness attachment point, body-weight support, and movement speed. Improper loading or harness configuration may reduce training effectiveness or alter movement mechanics. Furthermore, evidence on long-term physiological adaptations and optimal training parameters remains limited due to heterogeneous study designs and intervention protocols.

From a practical perspective, coaches should prescribe resisted sprint loads that disrupt sprint mechanics as little as possible, whereas clinicians should individualize body-weight support and treadmill speed based on the patient's functional ability. Proper fitting of occupational safety harnesses and timely rescue procedures are essential to minimize suspension-related complications.

Conclusion

Resisted harness training is a versatile and evidence-based approach for improving athletic performance, enhancing exercise safety, and supporting clinical rehabilitation. Current evidence demonstrates its effectiveness in improving sprint acceleration, gait performance, balance, and lower-body strength while providing a safe training environment for individuals with functional limitations. However, its effectiveness is strongly influenced by training variables such as resistance intensity, harness attachment, body-weight support, and exercise velocity. Future high-quality longitudinal studies are required to establish standardized training guidelines and optimize harness-based interventions across athletic and clinical populations.

Limitations of Current Literature

The current literature is limited by small sample sizes, inconsistent methods for quantifying resistance, and underrepresentation of female participants, reducing the generalizability of findings. Additionally, variations in harness design and training protocols make comparisons across studies difficult, while the long-term effects of different harness attachment strategies remain insufficiently investigated.

Future Research Directions

Future research should focus on standardizing harness-training protocols and resistance measurements, conducting longitudinal studies, and including more diverse participant populations, particularly female athletes. Further investigation is also needed to optimize harness design, evaluate long-term biomechanical and physiological adaptations, and improve safety features for occupational and rehabilitation applications.

Conflict of Interest: No conflicts of interest related to this manuscript.

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