Biomechanical Analysis of Wrist Movements in Sabaragamuwa Traditional Dance.

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Abstract

Sabaragamuwa traditional dance, originating from Sabaragamuwa Province, demonstrates distinctive expressive hand gestures characterized by fluid and circular wrist movements. This study investigates the biomechanical principles underlying wrist movements in Sabaragamuwa dance, focusing on muscular involvement, joint mechanics, and movement coordination. A mixed-method research design was employed, integrating primary data collected through literature surveys, empirical reports, and field observations and semi-structured interviews with dancers and instructors, alongside secondary data derived from academic literature and relevant theoretical sources. Motion patterns were analyzed using kinematic and kinetic frameworks to identify joint angles and muscular activation patterns. The findings reveal that wrist flexion, extension, medial deviation, and lateral deviation are the dominant movement patterns. Flexion and extension movements of the wrist joint performed within the sagittal plane, around a coronal axis that passes through the wrist joint. Medial and lateral deviations of the wrist occur within the coronal plane, around a sagittal axis. Circumduction of the wrist joint is achieved through a sequential combination of movements. It begins with extension of approximately 60°, followed by lateral deviation (radial abduction) of up to 25°, medial deviation (ulnar adduction) of up to 40°, and finally flexion of approximately 80°. These movements were achieved through coordinated activation of forearm flexors and extensors, particularly the flexor carpi radialis, flexor carpi ulnaris, extensor carpi radialis, and extensor carpi ulnaris. Forearm rotational stability is supported by the pronator teres and supinator muscles. The results indicate that controlled muscular co-contraction is essential for maintaining fluidity and aesthetic precision while minimizing strain. The study concludes that Sabaragamuwa wrist movements reflect an efficient biomechanical system that balances artistic expression with functional joint mechanics, contributing to dance science literature and providing practical implications for performance optimization and injury prevention.

Keywords: Sabaragamuwa dance, Biomechanics, Wrist movement, Dance kinesiology

Introduction

Dance is a universal form of human expression that combines artistic creativity with structured physical movement. It exists across cultures and historical periods, serving social, ritualistic, and performance purposes. From classical traditions such as *Ballet, Lating dance, Contemporary Dance to Asian forms like Bharatanatyam, Kathak,Kathakali,Mnipuri* dance requires coordination, rhythm, strength, flexibility, and neuromuscular control.

Sri Lankan traditional dance represents a rich cultural heritage rooted in ritual, religion, and community practice. The three main classical traditions Kandyan dance, Low Country dance and Sabaragamuwa dance developed in different regions of Sri Lanka and are closely associated with temple ceremonies, healing rituals, and royal court performances. Kandyan dance, originating from the hill country, is characterized by vigorous jumps, spins, and expressive gestures, while Low Country dance is traditionally linked with ritual healing ceremonies (thovil). Sabaragamuwa dance is known for its graceful movements and strong rhythmic patterns.

Although research has been conducted on Sri Lankan dance, studies specifically related to its biomechanics are very limited. Research on Kandyan dance and semiotics has been conducted by Sudeesh Mantillake, while Lakshman Manchanayake has examined the mathematical structures of Kandyan dance. Additionally, studies on Bharata Natyam and Kandyan dance have been carried out by S. Bhananath and Dr. V. Gopinath. Aravinda Ravibahu and Kuruppu Bandara have analyzed the movements of Sabaragamuwa dance according to Hrdlička's theory. However, no research has been found regarding the biomechanics of Sabaragamuwa dance. Therefore, this study has been conducted by the researcher to address this research gap.

Sri Lankan traditional dance demands high levels of coordination, flexibility, balance, and muscular strength. The movements involve complex footwork, dynamic torso control, and expressive hand gestures, reflecting both artistic creativity and biomechanical efficiency. According to cultural and performance studies, these dance forms preserve indigenous knowledge systems while also requiring systematic physical training for performance excellence (De Zoete, 1957; Reed, 2010).

Human movement has been examined as a structured and systematic phenomenon (Greene, 2010). Within this broader analytical framework, dance movement occupies a distinct position, transcending quotidian physical activity to function as an embodied form of expressive communication (Krasnow, 2015). Through the body as a medium of non-verbal discourse, dancers construct and transmit meaning to audiences, transforming movement into a semiotic and aesthetic practice (Green, 2010). Thus, dance is not merely kinetic activity but a complex integration of physical technique, expressive intention, and communicative function (Krasnow, 2015).

Despite the increase in scholarships offered, the expansion of theoretical discourse in areas such as performance studies and movement analysis, particularly within the Sri Lankan context, has paid poor attention to the internal biomechanical processes that underpin movement execution (Bronner, Ojofeitimi, & Rose, 2008). Practical engagement within the field of dance indicates that many dancers prioritize the external, formal, and stylistic dimensions of movement while insufficiently attending to the internal physiological and biomechanical processes that enable efficient execution (Shultz & Houglum, 2010). This imbalance between aesthetic output and internal bodily awareness has prompted the development of Dance Science as a specialized interdisciplinary field (Krasnow, 2015).

The aforementioned imbalance presents both artistic and pedagogical challenges. Without a systematic understanding of the coordinated functioning of the muscular and skeletal systems, dancers may achieve visual accuracy while lacking biomechanical efficiency (Hamill, Knutzen, & Derrick, 2015). Such disjunction not only constrains expressive clarity and technical refinement but also increases vulnerability to both acute and chronic injuries arising from improper alignment, muscular imbalance, or repetitive strain (Bronner, Ojofeitimi, & Rose, 2008).

Accordingly, this study seeks to examine the relationship between internal biomechanical awareness and movement execution within indigenous dance practice (Cohen & Ranganathan, 2011). By integrating principles of movement science with performance theory, the research aims to articulate a framework through which dancers may cultivate embodied precision, technical sustainability, and injury prevention while preserving aesthetic authenticity (Krasnow, 2015).

A lack of awareness of internal body mechanics may restrict expressive refinement and increase the risk of injury due to misalignment, muscular imbalance, or repetitive strain. Consequently, a systematic understanding of the coordinated functioning of the musculoskeletal system is essential for sustainable dance practice.

Dance Science integrates knowledge from exercise physiology, dance physiology, and kinesiology to examine the scientific principles underlying human movement in dance contexts. These disciplines collectively address how muscular, skeletal, and neuromuscular systems function in the production, regulation, and sustainability of movement. Krasnow (2015) characterizes Dance Science as a relatively recent development that gained clearer institutional and academic recognition toward the late twentieth century.

The emergence of Dance Science was influenced by earlier advancements in related scientific domains, including sports science, sports medicine, biomechanics, exercise physiology, nutrition, and psychology. The formal scientific investigation of human movement began to consolidate around the mid-twentieth century (Luttgens & Wells, 1971). These developments laid the theoretical and methodological foundation for applying movement science principles specifically to dance training and performance.

The genesis of this study is rooted in a personal experience of musculoskeletal discomfort encountered during a practical engagement at a traditional dance performance. This experience prompted a critical re-evaluation of prevailing approaches to the study and training of traditional dance forms. While substantial scholarly and pedagogical emphasized information on the external, aesthetic, and stylistic dimensions of performance, comparatively information on internal biomechanical mechanisms that underpin and regulate these movements were almost non-existent. Consequently, a significant gap came to light between performative practice and scientific anatomical awareness.

As scholarly interest expanded, greater attention was directed toward understanding the physiological demands of dance and the importance of injury prevention, conditioning, and biomechanical efficiency. Consequently, scientific knowledge has become increasingly integrated into pedagogical models and professional dance practice, contributing to enhanced technical sustainability and performer well-being.

Dance as an artistic discipline refines and systematizes codified movement vocabularies through established aesthetic and technical principles. While traditional dance training emphasizes the preservation and transmission of stylistic conventions, Dance Science provides a scientific framework for analyzing the underlying biomechanical and physiological foundations of these codified forms. In this sense, artistic practice and scientific inquiry function as complementary domains: the former cultivates performative excellence, while the latter elucidates the structural and functional mechanisms that enable such excellence.

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Objective

The primary objective of this research is to conduct a detailed biomechanical analysis of movements in Sabaragamuwa dance, with particular emphasis on joint articulation and muscular activation pattern. Accordingly, the present study seeks to direct scholarly attention toward the biomechanical principles embedded within classical dance practice.

Limitations of the study

For the purpose of conceptual clarity and analytical depth, the scope of this study is limited to the traditional Sabaragamuwa dance tradition. Within this stylistic framework, particular emphasis is placed on examining how both external movement form and internal bodily mechanics: especially the coordinated functioning of the musculoskeletal system that interacts to produce refined and controlled execution. By investigating the integration of internal movement dynamics with external aesthetic structure, this study aims to contribute to a more scientifically informed understanding of Sabaragamu classical dance.

Research Question

In particular, the internal biomechanical dynamics of Sabaragamuwa traditional dance remain underexplored within academic discourse. A comprehensive review of existing literature indicates the absence of systematic research examining the coordinated functioning of the skeletal and muscular systems in generating and sustaining Sabaragamuwa dance movements. Addressing this lacuna (Bronner, Ojofeitimi, & Rose, 2008) the present study is structured around the central research question: *How do the osteological and myological components of the human body interact biomechanically to facilitate the internal movement patterns characteristic of the Sabaragamuwa dance tradition?*

Materials and Methodology

A Sri Lankan professional Sabaragamuwa dancer from the Rathnapura District was analyzed for one of the characteristic upper-limb movement patterns, namely the "wrist rotation movement" of Sabaragamuwa dance. The following biomechanical features were examined: the sequential array of wrist joint movements, the plane of joint movement, the axis of joint movement, and the range of motion of the joint. The study adopted a mixed-method research design, incorporating both qualitative and quantitative approaches (Wu et al., 2005). Data were gathered through systematic field observations, video-based motion analysis, semi-structured interviews with practitioners, and anatomical movement mapping (Krasnow, 2015). Quantitative elements included joint movement measurements, while qualitative data were subjected to thematic and interpretative analysis (Green, 2010). The triangulation of these methods ensured analytical rigor and strengthened the validity of the findings (Robertson et al., 2014).

Results

This study identified the biomechanical features involved in the wrist during movements. Wrist motion occurs primarily between the distal radius and the proximal carpal row, consisting of the scaphoid, lunate and triquetrum. In Sabaragamuwa dance, wrist joint movements start with extension of the wrist. Then there is a maximum radial deviation of the joint followed by forearm supination. After this hand goes to maximum ulnar deviation followed by flexion with forearm pronation.

Extension is primarily executed by the extensor carpi radialis longus, extensor carpi radialis brevis, and extensor carpi ulnaris as prime movers (Figure 1). The synergists include the extensor digitorum, extensor digiti minimi, extensor indicis, and extensor pollicis longus muscle. The antagonistic muscles are the flexor carpi radialis and flexor carpi ulnaris. In this extension movement by the joint allows 60^0 of extension.

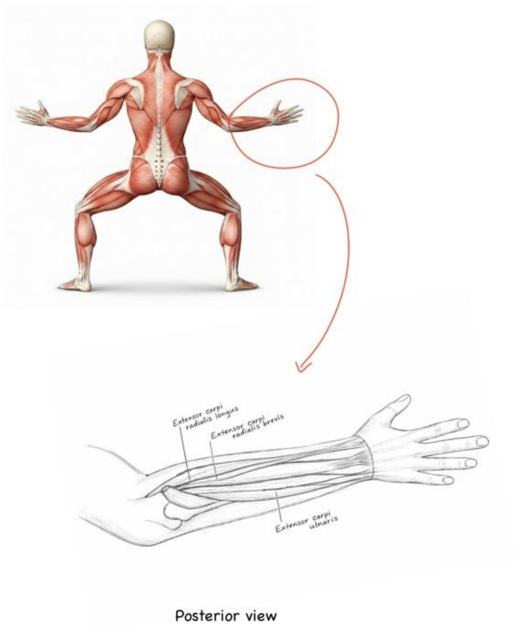

Figure 1. Prime movers of the posterior compartment of forearm

Radial deviation mainly occurs at the midcarpal joint and is produced by the extensor carpi radialis longus, extensor carpi radialis brevis, and flexor carpi radialis as prime movers. The abductor pollicis longus acts as a synergist, while the extensor carpi ulnaris and flexor carpi ulnaris function as antagonists.

Supination of the forearm involves the outward rotation that turns the palm upward. The supinator muscle and biceps brachii serve as the prime movers. The antagonists in supination are the pronator quadratus and pronator teres, which counteract the outward rotation and return the forearm to pronation.

Ulnar deviation primarily occurs at the wrist joint and is generated by the flexor carpi ulnaris and extensor carpi ulnaris as prime movers. Synergistic muscles include the flexor digitorum profundus, flexor digitorum superficialis, extensor digitorum, and extensor digiti minimi. The antagonists are the extensor carpi radialis longus, flexor carpi radialis, and extensor carpi radialis brevis. The wrist abducts up to 25°, whereas it adducts up to 40° (Figure 2).

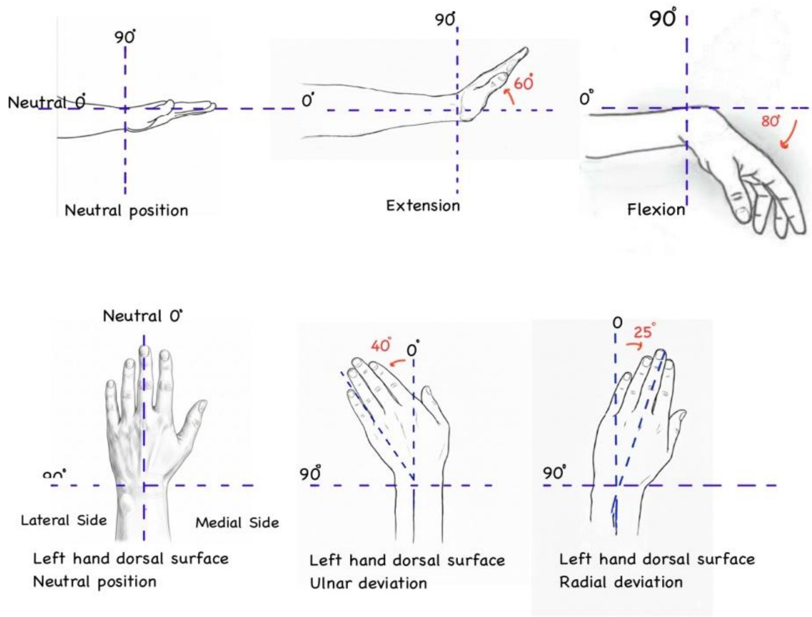

Figure 2. Range of motion of wrist; Upper raw -flexion and extension, Lower raw- ulnar deviation and radial deviation.

Flexion is primarily performed by the flexor carpi radialis and flexor carpi ulnaris as prime movers (Figure 3). The synergistic muscles assisting this movement include the flexor digitorum superficialis, flexor digitorum profundus, flexor pollicis longus, and palmaris longus muscle. The antagonistic muscles are the extensor carpi radialis longus, extensor carpi radialis brevis, and extensor carpi ulnaris.

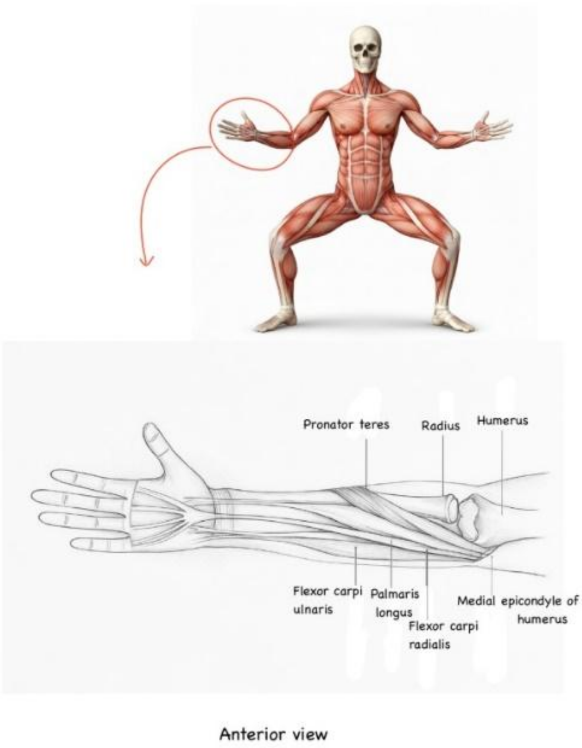

Figure 3. Prime movers of the anterior compartment of forearm.

Pronation of the forearm refers to the inward rotation that turns the palm downward. The prime mover for this action is the pronator quadratus, a deep muscle near the wrist that provides the primary force for pronation. The pronator teres acts as a synergist, assisting in the movement. The antagonists opposing this motion are the supinator and the biceps.

Discussion

The biomechanical assessment of wrist movements in Sabaragamuwa dance highlights the complexity and coordination required for expressive hand gestures. The sequence of movements beginning with wrist extension, progressing through radial deviation, supination, ulnar deviation, flexion, and finally pronation, demonstrates how dancers rely on a finely tuned interplay of prime movers, synergists, and antagonists. Each stage of motion recruits specific muscle groups, ensuring both stability and fluidity. The rotational actions not only expand the expressive range of the wrist but also demand precise coordination between agonists and antagonists to maintain rhythm and grace. Overall, the findings reveal that Sabaragamuwa dance integrates a full spectrum of wrist biomechanics, transforming anatomical function into aesthetic artistry.

Conclusion

In Sabaragamuwa dance, the fundamental hand gesture referred to as the "wrist rotation movement" was subjected to anatomical analysis. This examination identified six distinct types of wrist movements associated with the execution of this dance pattern. It begins with extension of approximately 60°, followed by lateral deviation (radial abduction) of up to 25° with forearm supination, medial deviation (ulnar adduction) of up to 40°, flexion of approximately 80° and forearm pronation. During wrist flexion, the muscles located in the anterior compartment of the forearm are primarily activated. During wrist extension, the muscles of the posterior compartment of the forearm are mainly involved. Radial deviation is produced by muscles situated on the lateral side of the forearm, while ulnar deviation is generated by the muscles on the medial side of the forearm. The coordinated activation of these muscle groups enables smooth and continuous circumduction movement characteristic of this traditional dance gesture.

Importantly, there has been no prior scientific research analyzing dance biomechanics in the Sri Lankan context. Thus, this study represents the first systematic biomechanical investigation of wrist movements in Sabaragamuwa dance, marking a turning point in the dance research arena. By bridging anatomical science with traditional performance, it establishes a foundation for future interdisciplinary studies and elevates Sri Lankan dance into the global discourse on movement analysis.

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