IJARCCE ISSN (O) 2278-1021, ISSN (P) 2319-5940

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ∺ Peer-reviewed & Refereed journal ∺ Vol. 14, Issue 6, June 2025

DOI: 10.17148/IJARCCE.2025.14667

KINESIOLOGICAL ANALYSIS OF FUNDAMENTAL HUMAN MOVEMENTS

Jai Bhagwan Singh Goun

Maharana Pratap Government P.G College – Hardoi

Abstract: Kinesiology, the scientific study of human movement, integrates anatomy, physiology, biomechanics, and motor learning to understand the principles of movement. Fundamental movements—such as walking, running, jumping, lifting, pushing, pulling, and throwing—form the basis of more complex motor skills and physical activities. A kinesiological analysis examines these movements to identify joint actions, muscular involvement, planes of motion, axes of rotation, and the forces acting upon the body.

This paper presents a comprehensive kinesiological analysis of fundamental human movements. Each movement is deconstructed by evaluating the biomechanical and anatomical components, focusing on joint kinematics, muscle activation, and force generation. For instance, during walking, coordinated activity between the hip flexors, knee extensors, and ankle plantarflexors allows forward propulsion while maintaining balance. In a vertical jump, triple extension at the hip, knee, and ankle, powered by concentric muscle contractions, is critical for maximizing lift-off force. The analysis of throwing reveals coordinated sequential activation, from the lower limbs to the upper extremities, emphasizing the kinetic chain's role.

Understanding the kinesiological basis of these movements has practical implications in physical education, sports science, rehabilitation, and ergonomics. It allows professionals to enhance performance, prevent injuries, and design movement interventions tailored to individual needs. Through integrated kinesiological knowledge, fundamental movements can be optimized for various population groups, including athletes, patients, and sedentary individuals, fostering efficient and safe movement practices.

Keywords: Kinesiology, Fundamental Movement, Joint Kinematics, Muscle Activation, Biomechanics, Human Motion

I. INTRODUCTION

Kinesiology, derived from the Greek words "kinesis" (movement) and "logos" (study), encompasses the multidisciplinary science of human movement. It integrates anatomical, biomechanical, physiological, and neurological principles to analyze and improve movement efficiency and effectiveness (Neumann, 2017). At the core of kinesiology are **fundamental movements**, which include actions such as walking, running, jumping, lifting, squatting, pushing, pulling, and reaching. These movements are foundational to more complex motor skills and serve essential functions in daily life, sport, and rehabilitation.

Fundamental movements are not only essential for motor development and athletic performance but are also critical for maintaining functional independence across the lifespan (Knudson, 2021). A kinesiological analysis of these movements involves the study of three primary elements: anatomical structure (muscles, joints, bones), mechanical forces (gravity, resistance, inertia), and neurological control (motor units, coordination, proprioception). This integrated approach enables a holistic understanding of how the human body moves and how these movements can be optimized or corrected.

Each movement occurs in specific **planes of motion**—sagittal, frontal, and transverse—and around particular **axes of rotation**—mediolateral, anteroposterior, and vertical (Enoka, 2008). For example, a forward lunge primarily takes place in the sagittal plane, involving joint actions like hip flexion/extension and knee extension. The muscles primarily involved include the gluteus maximus, quadriceps femoris, and hamstrings, with core stabilization provided by the abdominal and lower back muscles.

The **muscular analysis** of movement distinguishes between concentric (muscle shortening), eccentric (muscle lengthening), and isometric (no change in muscle length) contractions. These contractions play distinct roles in various phases of movement. For instance, in landing from a jump, eccentric contractions of the quadriceps and gastrocnemius absorb impact forces, while in takeoff, concentric actions provide propulsive force.

 This work is licensed under a Creative Commons Attribution 4.0 International License

DOI: 10.17148/IJARCCE.2025.14667

Kinesiological insights are indispensable in sports training, injury prevention, physiotherapy, and ergonomics. For example, improper lifting mechanics can be identified through kinesiological analysis, helping reduce the risk of lower back injuries. In athletic contexts, movement inefficiencies can be corrected through targeted interventions, thereby improving performance and reducing injury risk (McGinnis, 2013).

Moreover, understanding motor learning principles is essential when analyzing how movements are acquired and refined over time. Theories such as Schmidt's schema theory and Adams' closed-loop theory highlight the cognitive and feedback-based components of learning new motor tasks, which are fundamental in kinesiological studies (Schmidt & Lee, 2011).

This paper aims to provide a comprehensive kinesiological analysis of fundamental human movements, with emphasis on their mechanical, anatomical, and functional aspects. The ultimate goal is to translate scientific understanding into practical strategies for performance enhancement, rehabilitation, and daily living.

II. MECHANICAL AND MUSCULAR ANALYSIS OF FUNDAMENTAL HUMAN MOVEMENTS

1. Walking

Mechanical Analysis:

Walking is a cyclical, bipedal gait pattern involving alternating single- and double-support phases. The gait cycle includes two major phases: **stance phase** (approximately 60%) and **swing phase** (40%). The center of gravity (COG) shifts smoothly with minimal vertical oscillation, conserving energy through pendulum-like motion of the limbs (McGinnis, 2013).

Muscular Involvement:

- **Stance Phase:** The **gluteus maximus**, **hamstrings**, and **quadriceps** stabilize the pelvis and extend the hip and knee. The **gastrocnemius** and **soleus** provide plantarflexion during toe-off.
- **Swing Phase:** The **iliopsoas**, **tibialis anterior**, and **hamstrings** contribute to hip flexion, dorsiflexion, and knee flexion to clear the foot.

2. Running

Mechanical Analysis:

Running differs from walking due to the presence of a **flight phase** and higher ground reaction forces (GRFs). The stride length increases, and contact time with the ground is reduced. There is greater reliance on **elastic energy recoil** from tendons and muscles (e.g., Achilles tendon).

Muscular Involvement:

- The **gluteus maximus** and **hamstrings** dominate during hip extension.
- **Quadriceps** extend the knee during push-off.
- **Calf muscles** (gastrocnemius, soleus) produce explosive plantarflexion.
- **Core stabilizers** (transverse abdominis, erector spinae) maintain trunk alignment and counterbalance rotational forces.

3. Jumping (Vertical Jump)

Mechanical Analysis:

Jumping is a ballistic movement initiated by a **triple extension** at the hip, knee, and ankle. Newton's third law (action-reaction) explains the ground pushing back against the body, propelling it upward.

- **Force-Time Relationship**: Peak force is generated during the concentric phase of joint extension.
- **Impulse** (force × time) directly affects vertical displacement.

Muscular Involvement:

- **Hip Extension:** Gluteus maximus
- **Knee Extension:** Quadriceps femoris
- **Ankle Plantarflexion:** Gastrocnemius and soleus
- **Arm Swing:** Contributes to upward momentum by involving **deltoids** and **latissimus dorsi**

4. Lifting (e.g., Deadlift, Squat)

Mechanical Analysis:

Lifting movements involve overcoming external resistance with minimal spinal loading. Proper **lifting mechanics** emphasize a neutral spine, engaged core, and use of hip hinge movement to reduce lumbar stress.

DOI: 10.17148/IJARCCE.2025.14667

- Squats: Center of mass must remain over the base of support. Force vectors align vertically with the body to maintain balance.
- Deadlift: Mechanical advantage is maximized through optimal lever arm length (bar close to shins).

Muscular Involvement:

- **Primary Movers:** Gluteus maximus, quadriceps, hamstrings
- **Stabilizers:** Erector spinae, multifidus, abdominal muscles
- **Synergists:** Adductors and calf muscles

Improper form increases shear forces on the lumbar spine and knee joint.

5. Pushing (e.g., Push-Up)

Mechanical Analysis:

Pushing involves horizontal force generation against an external resistance. In a push-up, the body acts as a lever rotating around the toes or knees. Proper alignment ensures even load distribution across the upper limb joints.

- Force generation involves torque created at the shoulder and elbow joints.
- The center of gravity must be controlled to maintain balance.

Muscular Involvement:

- **Pectoralis major** and **triceps brachii** are primary movers.
- **Deltoids** assist in shoulder flexion.
- **Serratus anterior** stabilizes the scapula.
- **Core muscles** maintain spinal stability in the plank position.

6. Pulling (e.g., Pull-Up, Rowing)

Mechanical Analysis:

Pulling requires force application toward the body’s center of mass. In a pull-up, bodyweight is lifted vertically, demanding concentric contractions against gravity.

- Requires overcoming body weight with a positive force vector.
- In rowing, pulling is coordinated with leg drive and torso extension, enhancing force generation.

Muscular Involvement:

- **Latissimus dorsi**, **rhomboids**, and **biceps brachii** are the primary pulling muscles.
- **Posterior deltoid** and **brachialis** support elbow flexion and shoulder movement.
- **Scapular stabilizers** (trapezius, levator scapulae) prevent shoulder impingement.

7. Throwing (e.g., Overhand Throw)

Mechanical Analysis:

Throwing is a complex, sequential motion involving the **kinetic chain**—from legs to torso to arm. Energy is transferred from large proximal segments (legs, hips) to smaller distal segments (wrist, hand).

- **Wind-up Phase:** Energy storage via hip and trunk rotation.
- **Acceleration Phase:** Peak angular velocity occurs at the shoulder.
- **Deceleration Phase:** Eccentric contraction to absorb forces.

Muscular Involvement:

- **Lower Body:** Gluteus maximus and quadriceps initiate trunk rotation.
- **Torso:** Obliques and rectus abdominis drive rotation.
- **Shoulder:** Rotator cuff stabilizes the glenohumeral joint.
- **Arm:** Triceps extend the elbow, wrist flexors control the release.
- **Scapula:** Serratus anterior and trapezius maintain scapular stability.

III. CONCLUSION

Understanding the mechanical and muscular demands of fundamental movements through the lens of joint function and posture allows practitioners to identify underlying causes of movement dysfunction and injury risk. The interplay between mobility and stability at key joints forms the basis for both movement efficiency and long-term musculoskeletal health. Employing movement screens as routine assessment tools ensures early detection of imbalances and facilitates targeted corrective strategies. Overall, an integrated kinesiological approach bridges scientific knowledge and practical application, enhancing performance and safeguarding athlete and patient wellbeing.

© IJARCCE This work is licensed under a Creative Commons Attribution 4.0 International License

International Journal of Advanced Research in Computer and Communication Engineering

Impact Factor 8.471 ⋇ Peer-reviewed & Refereed journal ⋇ Vol. 14, Issue 6, June 2025

DOI: 10.17148/IJARCCE.2025.14667

REFERENCES

[1]. Boyle, M., & Cook, G. (2009). *Advances in functional training: Training techniques for coaches, personal trainers and athletes*. On Target Publications.
[2]. Cook, G. (2010). *Movement: Functional movement systems: Screening, assessment, corrective strategies*. On Target Publications.
[3]. Enoka, R. M. (2008). *Neuromechanics of human movement* (4th ed.). Human Kinetics.
[4]. Knudson, D. V. (2021). *Fundamentals of biomechanics: Equilibrium, motion, and deformation* (3rd ed.). Springer.
[5]. McGill, S. M. (2015). *Back mechanic: The secrets to a healthy spine your doctor isn't telling you*. Backfitpro Inc.
[6]. McGinnis, P. M. (2013). *Biomechanics of sport and exercise* (3rd ed.). Human Kinetics.
[7]. Neumann, D. A. (2017). *Kinesiology of the musculoskeletal system: Foundations for rehabilitation* (3rd ed.). Elsevier Health Sciences.
[8]. Page, P., Frank, C. C., & Lardner, R. (2010). *Assessment and treatment of muscle imbalance: The Janda approach*. Human Kinetics.
[9]. Schmidt, R. A., & Lee, T. D. (2011). *Motor control and learning: A behavioral emphasis* (5th ed.). Human Kinetics.