# Biomechanical Analysis Of Walking Effects Of Gait

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## NORRIS RIVERS

**Effects of Asymmetrical Load Carrying on the Biomechanics of Walking** Frontiers Media SA

Every year workers' low-back, hand, and arm problems lead to time away from jobs and reduce the nation's economic productivity. The connection of these problems to workplace activities-from carrying boxes to lifting patients to pounding computer keyboards-is the subject of major disagreements among workers, employers, advocacy groups, and researchers. Musculoskeletal Disorders and the Workplace examines the scientific basis for connecting musculoskeletal disorders with the workplace, considering people, job tasks, and work environments. A multidisciplinary panel draws conclusions about the likelihood of causal links and the effectiveness of various intervention strategies. The panel also offers recommendations for what actions can be considered on the basis of current information and for closing information gaps. This book presents the latest information on the prevalence, incidence, and costs of musculoskeletal disorders and identifies factors that influence injury reporting. It reviews the broad scope of evidence: epidemiological studies of physical and

psychosocial variables, basic biology, biomechanics, and physical and behavioral responses to stress. Given the magnitude of the problem-approximately 1 million people miss some work each year-and the current trends in workplace practices, this volume will be a must for advocates for workplace health, policy makers, employers, employees, medical professionals, engineers, lawyers, and labor officials.

*Musculoskeletal Disorders and the Workplace* Elsevier Health Sciences

Abstract: This study aimed to investigate the effects of eight weeks of barefoot running exercise on sand versus control on measures of walking kinetics and muscle activities in individuals with diagnosed pronated feet. Sixty physically active male adults with pronated feet were randomly allocated into an intervention or a waiting control group. The intervention group conducted an 8-weeks progressive barefoot running exercise program on sand (e.g., short sprints) with three weekly sessions. Pre and post intervention, participants walked at a constant speed of 1.3 m/s ± 5% on a 18 m walkway with a force plate embedded in the middle of the walkway. Results showed significant group-by-time interactions for peak impact vertical and lateral ground reaction forces. Training but not control resulted in significantly lower peak impact vertical and lateral ground reaction forces. Significant group-by-time interactions were observed for vastus lateralis activity during the loading phase. Training-

induced increases were found for the vastus lateralis in the intervention but not in the control group. This study revealed that the applied exercise program is a suitable means to absorb ground reaction forces (e.g., lower impact vertical and lateral peaks) and increase activities of selected lower limb muscles (e.g., vastus lateralis) when walking on stable ground

Eight Weeks of Exercising on Sand Has Positive Effects on Biomechanics of Walking and Muscle Activities in Individuals with Pronated Feet: a Randomized Double-blinded Controlled Trial National Academies Press

FOUR STARS from Doody's Star Ratings™ The expanded and fully updated second edition of Orthopedic Biomechanics explains the effects of mechanical influences on the musculoskeletal system and highlights the importance of biomechanical knowledge in the prevention, treatment, and rehabilitation of orthopedic injuries and disorders. Clear and concise discussion of the forces acting on bones, tendons, and ligaments facilitates a solid understanding of current and past research, complex concepts, and technical information in orthopedic biomechanics. Readers will also find practical guidance for applying their knowledge to solving actual clinical problems. The book begins by summarizing the basic principles of biomechanics and mathematical theory, including biomaterials science, vector algebra, and movement in two and three dimensions. It then moves on to the

mechanical properties of musculoskeletal tissues, with chapters devoted to muscle and muscle function; the modeling of joint loads; gait analysis; and the mechanical aspects of the hip, knee, spine, shoulder, and foot. Key Features: New "Solved Problems" chapter with clinically relevant biomechanical questions and their step-by-step solutions using mathematical and mechanical reasoning New chapters on biomechanics of the foot and gait analysis Detailed descriptions of simplified model calculations for determining static and dynamic joint load-a fundamental issue in orthopedic biomechanics Essential physics and mathematics only, with limited use of complex vector equations More than 300 line illustrations References and suggestions for further reading at the end of each chapter, serving as an overview of scientific work on the topic Orthopedic Biomechanics, 2nd Edition, is an essential resource for practitioners and students of orthopedics, orthopedic surgery, prosthetics and orthotics, and physiotherapy. Comprehensive in scope but approachable in coverage, the book provides the insights and tools needed to make informed clinical decisions.

*The Effects of Walking Speed and Backpack Weight on Gait Biomechanics*

Garland Science

"A text for upper-level undergraduate and graduate courses in human performance, it uses an integrated scientific approach to explore solutions to problems in human movement. As an interdisciplinary reference volume for

biomechanists, exercise physiologists, motor behaviorists, athletic trainers, therapists, kinesiologists, and students, Biomechanics and Biology of Movement offers an in-depth understanding and appreciation of the many factors comprising and affecting human movement. In addition, it will give you the insights and information you require to address and resolve individual performance problems."--BOOK JACKET.

Biomechanics and Gait Analysis
Routledge

Ten female track runners (E age = 21.5) volunteered as subjects to determine if 4 lb hand weights would alter shoulder and elbow displacements and angular velocities under various locomotion speeds. Subjects were videotaped walking at 3.0 mph and running at 6.0 mph at a 0% grade, with and without hand weights. The ARIEL (APAS) system was used to create a 2-dimensional image of each subject while performing. A 2-way ANOVA with repeated measures (p

**Human Walking** Thieme

Biomechanics and Gait Analysis presents a comprehensive book on biomechanics that focuses on gait analysis. It is written primarily for biomedical engineering students, professionals and biomechanists with a strong emphasis on medical devices and assistive technology, but is also of interest to clinicians and physiologists. It allows novice readers to acquire the basics of gait analysis, while also helping expert readers update their knowledge. The book covers the most up-to-date

acquisition and computational methods and advances in the field. Key topics include muscle mechanics and modeling, motor control and coordination, and measurements and assessments. This is the go to resource for an understanding of fundamental concepts and how to collect, analyze and interpret data for research, industry, clinical and sport. Details the fundamental issues leading to the biomechanical analyses of gait and posture Covers the theoretical basis and practical aspects associated with gait analysis Presents methods and tools used in the field, including electromyography, signal processing and spectral analysis, amongst others

**Biomechanics and Biology of Movement** Academic Press

Provides a comprehensive overview of the key concepts in exercise and sport biomechanics.

*International Research in Sports Biomechanics* Routledge

Locomotion is an important and inherent part of daily life and is integral in maintaining an independent lifestyle, especially in older adults whose functional capacity has declined. Physiological changes with aging, including loss of muscle mass, strength and power are manifested in walking, notably at the ankle joint. Old adults exhibit decreased power of the plantarflexors and increased power of the hip extensors. This distal to proximal shift in function could be due to plantarflexor weakness, so strengthening the plantarflexors may help reverse the negative physiological

effects of aging and help preserve functional capacity in old adults. The purpose of this study was to determine the effect of plantarflexor strength training on gait biomechanics during level walking at a self-selected, a safe maximum and a standard speed of 1.5 m/s in healthy old adults. A total of 12 healthy adults between the ages of 65 and 85 participated in this study (6 strengthening, 6 stretching). After baseline tests, the strengthening group performed resistance exercises for gastrocnemius and soleus muscles and the stretching group stretched them three times per week for 12 weeks. All subjects underwent gait assessments and maximal strength testing at the beginning and end of the 12 week training period. A 2 by 2 analysis of variance was used to determine significant interactions and main effects with an alpha level of p

*The Effects of Carrying Internal and External Frame Backpacks on the Biomechanical Efficiency of the Walking Pattern of Males* MIT Press

The primary aim of this study was to investigate the variation of human gait biomechanics during different walking conditions, with and without optic flow. The secondary aim was to investigate the accuracy of the two motion-analysis systems used. Following ethical approval of this investigation, testing was initiated. Participants walked under four different walking conditions, over ground, treadmill walking, treadmill walking with a virtually generated grass pathway, and treadmill walking with a

grass pathway and a simplified interactive avatar. In addition to fully instrument biomechanical analysis of gait, an unstructured interview was used to gain insight to participants' sensations experienced during the different environments. Data was then subjected to an analysis that determined the effect of the optic flow environment on the six chosen gait parameters. A static and dynamic accuracy analysis was performed in both laboratories to determine the accuracy of the motion analysis systems. The study reported a variation in the gait cycle parameters between the four walking conditions evaluated. The results obtained in this study were negatively influenced by the repercussive effects of fixed treadmill speeds and the level of immersion in the virtual environment due to optic flow. The negative effects of fixed treadmill speed had a distinct effect on the cadence and stride length values, while the negative effect of optic flow echoed similar cadences and stride lengths from the treadmill walking environment to the treadmill walking with optic flow (grass pathway only) environment, due to the participants' similar sensations during the two walks. The knee kinematics measured showed that they are not affected by the change in environment, while the ankle kinematics showed significantly different results for the various walking conditions, such that it was speculated that this gait parameter varies in relation to the level of optic flow immersion. Furthermore, the accuracy analysis performed in this

study showed both motion analysis systems analysed showed excellent accuracies.

*Physical Activity and the Role of Walking in Knee Osteoarthritis* Garland Science This dissertation used both cross-sectional and intervention studies to investigate the implication of childhood obesity on the musculoskeletal system during locomotion. Specifically, it compared the gait biomechanical and energetic differences between obese and normal children. Two different intervention studies (weight loss and muscle strength training) were carried out to investigate the cause-and-effect relationship between body mass, muscle strength and gait strategies. In addition, this study applied subject-specific musculoskeletal modelling and simulation to quantify compressive tibiofemoral force and individual muscle function. These results suggested that the excess body mass plays a dominant role in a larger joint load and greater energy cost in obese children. The obese children preferred to walk at a speed that has minimal energy cost and maximal mechanical efficiency. Weight loss reduced the differences in gait kinetics and energetics between obese and normal weight children, but the change of spatiotemporal gait parameters is not a necessary outcome for a short-term weight loss. By contrast, obese children walked with a faster self-selected speed and a larger hip flexor moment after an eight week strength training program. This finding suggested that lower extremity muscle

strengthening improves obese children's ability to promote locomotion through greater propulsion. However, it may not reverse the impact of excess body weight on natural walking biomechanics and energetics. A further simulation study was carried out to investigate the knee joint reaction force and muscle function in obese children using subject-specific model. The simulation results showed that obese children and normal weight children use similar muscles to support and accelerate body COM, but normal weight children had significantly greater normalized compressive tibiofemoral force and individual muscle contribution to COM. The absolute compressive tibiofemoral force and muscle forces were still greater in obese children. Therefore, the obese child may adapt a compensation gait strategy to avoid increasing compressive tibiofemoral force and muscle requirements during walking.

*Gait Analysis* Human Kinetics

This book reports the ensuing research and is comprised of several elements of the search for a comprehensive understanding of the effect of functional and anatomical leg length discrepancy on gait. It includes a literature review that defines leg length discrepancy, clinical relevance, measuring methods, and what is known regarding the influence of leg length discrepancy on pathological conditions and gait deviations. Gait kinematics and how it is affected by leg length discrepancy is thoroughly presented. A newly proposed dynamic concept of measuring leg

length and leg length discrepancy during gait and its implementation is offered. This is an essential book for clinicians, not only those working in gait labs, but for all clinicians dealing with patients suffering from pain, asymmetry and gait deviations. It provides an in-depth understanding and evidence-based research on this important topic. Walking with leg length discrepancy contains material that has previously been published in peer reviewed journals and is noted within the text. The material presented in this book has been written as a part of the author's PhD studies involving intensive research and clinical work concerning leg length discrepancy and gait. This book is comprised of several elements of the research into this topic: 1. To investigate the effect of LLD on kinematic gait deviations and to examine to what extent LLD changes occur in gait kinematics; to identify the most common gait deviations associated with LLD by establishing a systematic review. 2. To propose and evaluate a new dynamic concept of measuring LLD based on a gait model in both normal and pathological gait. 3. To evaluate the ability of the gait model to detect anatomical LLD. 4. To evaluate the validity of the proposed concept by assessing its ability to detect LLD on healthy subjects simulated with LLD. 5. To detect functional leg length discrepancy on patients presenting pathological gait deviations diagnosed with either anatomic LLD or anatomic LLD accompanying abnormal clinical findings and assess the correlations

between dynamic leg length (DLL), gait deviations, and LLD in both groups of patients.

*A Biomechanical Analysis of the Effects of Hand Weights on the Arm-swing While Walking and Running* North Atlantic Books

The aim of this study was to investigate the effects of military load carriage on the biomechanics of walking gait and to determine whether male and female soldiers exhibit different movement strategies in response to load. Twelve Air Force cadets, comprising six males and six females, performed walking trials under four conditions: unloaded, carrying a 4kg rifle, wearing a 23kg rucksack, and the 23kg rucksack with the 4kg rifle. A multivariate analysis of variance was conducted to assess the impact of load carriage on ground reaction force (GRF) parameters, sagittal plane joint range of motion (ROM), and sagittal plane joint moments. The results revealed that rifle carriage increased propulsive forces, while rucksack carriage increased all the selected GRF parameters, and that females produced a greater mediolateral impulse than males while carrying the rucksack. Rucksack carriage led to increased hip and ankle joint ROM and decreased knee joint ROM. Females exhibited greater ROM at the ankle, knee, and trunk during rifle carriage and at the ankle, knee, and hip while carrying the rucksack. Males produced greater joint moments at the ankle, knee, and hip during rifle carriage and at the ankle while carrying the rucksack, while

females produced greater hip joint moments while carrying the rucksack. The observed compensations may contribute to the high prevalence of load carriage injuries, while sex-dependent differences in movement strategies may help explain the disproportionality of these injuries reported in epidemiologic studies. Additionally, the results of this study may inform the development of more effective training and load-carrying equipment that considers the specific biomechanical effects of different types of loads on walking gait.

*The Effects of Walking Speed on the Biomechanics of Backpack Load Carriage*

Osteoarthritis (OA) of the knee is associated with decline in functional capacity and ultimately leads to Total Knee Arthroplasty (TKA) in many of these patients. Exercise regimens prior to surgery may potentially enhance pre and post TKA functional performance. However, assessment of such performance should involve biomechanical factors that characterize the mechanisms with which tasks are performed, and not just the quantity of task performed. The present overall study investigated walking biomechanics of end stage knee OA and TKA patients. Throughout the three sub-studies that comprised the overall investigation, particular emphasis was placed on heelstrike and the loading response phase of gait, in addition to functional ability parameters. The first sub-study investigated gait biomechanics and fatigue during a 6 minute walk for patients with end stage knee OA. Results

demonstrated that even if patients were able to maintain their gait velocity throughout the walk, subtle but statistically significant differences at the ankle were present after the 6 minute walk. Knee OA patients may be experiencing higher loading conditions at the knee after 6 min. In order to adapt to fatigue, knee OA patients appear to adopt ankle strategies alleviating the load from a painful knee, rather than knee strategies, causing greater instability and reduced performances. A single walking trial for gait analysis may be insufficient to assess gait compensations due to fatigue in daily activities. In light of the initial results on end stage knee OA walking biomechanics, the second sub-study included investigation of the effects of a 4 to 6 weeks exercise program on TKA outcomes. Results demonstrated that exercise therapy was effective at improving function and reducing pain to a certain extent pre-surgery. However, assessment of the walking biomechanics raised the question of whether improving physical ability improved knee OA condition or caused further knee joint degeneration and possibly the onset of OA in the opposite leg. Control patients exhibited a more careful gait pattern with lower speed and gait parameters reflecting potentially lower impact at heelstrike which may be more beneficial for knee OA conditions. The exercisers' walking characteristics showed evidence of an overstriding gait pattern with potentially reduced shock absorption mechanisms that can lead to lower leg

injuries. The third sub-study investigated walking biomechanics of prehab and non prehab subjects one month after surgery and results suggested that the effects of the pre-surgery exercise program did not remain post-surgery. Even if patients in the exercise group had increased physical ability performances and experienced less pain just prior to surgery compared to the control group, one month after surgery there was no difference between the groups. The lack of a significant effect of the exercise program on gait changes post surgery may indicate that the exercise regimen prior to surgery requires an additional component such as gait retraining. Adding a gait retraining component to the prehab protocol may improve the rate of recovery and help patients to maintain the prehab benefits even post TKA surgery.

**Biomechanical Analyses of Body Movement and Locomotion as Affected by Clothing and Footwear for Cold Weather Climates**

This edited collection of papers presented at the 18th International Symposium of Biomechanics in Sport, highlights cutting-edge research material on sports biomechanics from many of the leading international academics in the field. The thirty-seven chapters presented are divided into nine sections: * biomechanics of fundamental human movement * modelling, simulation and optimisation * biomechanics of the neuro-musculo-skeletal system * sports injuries, orthopaedics and rehabilitation * the

application of electromyography in movement studies * biomechanical analysis of the internal load * methods and instrumentation * training * paediatric and geriatric exercise.

Effects of Body Mass Index and Walking Speed in Gait Biomechanics of Young Adult Males

An analysis of the effects of 3 walking speeds (1.17, 1.33, and 1.50 m/s) on gait during backpack load carriage was performed on 16 male volunteers using a cinematographic system, force platform, tri-axial accelerometer, and 6 surface electrodes located over the trapezius, spinal erector, quadricep, hamstring, gastrocnemius and tibialis anterior muscles. Conclusions: (1) As load carriage speed increased: (a) there was greater knee flexion at heel-strike, probably reducing shock, (b) hip position at toe-off became more extended, as the rear leg pushed off to a greater degree and the front leg stretched further forward, (c) there was greater total arm swing, most of which was accounted for by increased arm swing in the rearward direction, (d) the minimum vertical position of the body center of mass declined, (e) there were greater upward and downward center of mass vertical velocities, necessitated by greater stride frequency and vertical center of mass range of motion, and (f) changes occurred in load carriage technique that kept several ground reaction forces lower than proportional to the increase in speed, (2) the greatest percentage of joint torque increase with load carriage speed increase occurred about the hip,

and the least occurred about the ankle, indicating that muscles producing torque about the hip were most involved in increasing load carriage speed and those producing torque about the ankle were the least involved. The electrical activity data from the leg muscles supported the joint torque findings. Increase in load carriage speed was effected much more through increasing horizontal than vertical ground reaction force, (3) while amplitude of muscle activity tended to increase with speed, the patterns of muscle activity remained the same, and (4) eccentric tibialis anterior activity at heel-strike controlled the rate of plantarflexion to prevent the foot from slapping against the ground, and increased proportionally to speed.

**A Biomechanical Analysis of the Effects of Platform Shoes on the Stance Phase of Walking**

Gait biomechanics of forty male subjects was evaluated at normal and fast walking speeds. The forty subjects composed four groups based on their body mass index, with ten subjects in each of the groups: underweight, normal weight, overweight and obese. To our knowledge this is the first comprehensive 3-dimensional kinetic and kinematic gait analysis of all four groups based on body mass index. The obese subjects walked with significantly slower gait speed by taking shorter steps and strides, while having significantly higher step widths and longer gait cycle times than the other subjects. The obese subjects spent significantly less time in single support and more time in double

support than their non-obese counterparts. These adjustments in temporal characteristics for the obese participants may be as a result of the gait compensation for the additional body weight in order to give them the most efficient, stable and balanced walking ability. Body mass index affected significantly the forces and moments at the ankle, knee and hip in the medial-lateral plane while speed effects were more prominent in the sagittal and transverse planes. These results suggest that an increase in the body weight would affect the gait stability while increasing the speed will affect the gait progression. Contrary to most researchers beliefs that an increase of the body weight would increase the forces and moments of the knee in all three planes, this study was able to prove that the actual forces and moments in the medial-lateral plane for the knee joint decrease while the ones in the sagittal plane increase. On the other hand, the hip joint in the medial-lateral plane displays the highest forces and moment for the obese subjects. These results are indicative of a gait compensation related to increasing body weight in the medial-lateral compartment of the lower extremity joints. Recommendations for further studies and follow up experiments are enclosed.

**Biomechanical Analysis of Elite Race Walking**

A study of Army cold weather clothing was conducted to determine effects on soldiers' movements and walking gait of

adding layers of clothing to the body. Performance in a temperate duty uniform was also compared with performance in cold weather clothing, and differences in walking gait associated with regular combat boots and with cold weather foot gear were investigated. Study participants, 13 Army enlisted men, were each testing in seven clothing conditions. A video-based motion analysis system and a force plate were used to capture the maximum range of motion in various planes of the body and gait kinematics and kinetics. A total of 104 dependent variables were measured directly or derived. Analyses of variance revealed that adding clothing layers interfered with bending at the waist and moving the upper arm at the shoulder. Compared with the temperate duty uniform, cold weather clothing changed walking patterns; participants leaned further forward and moved the arms less at the shoulders with the multilayered clothing. The cold weather boots also interfered with leg swing, compared with regular combat boots. A principal components analysis yielded factors suggesting simple and complex metrics sensitive to effects of protective clothing on gait characteristics.

*Techniques for Determination of Impact Forces During Walking and Running in a Zero-G Environment*

Walking is recommended as a type of physical activity for individuals with knee osteoarthritis, yet this population is physically inactive. The quantitative effects of walking exercise on joint health to inform walking prescription

remain poorly understood. The overall aim of this thesis was to better understand whether and how physical activity, particularly walking, is prescribed to manage knee osteoarthritis, and to add to our understanding of the effects of walking on quantitative joint health outcomes for individuals with knee osteoarthritis. A healthcare quality survey of individuals with mild-to-moderate knee osteoarthritis (Chapter 3) revealed that less than half of participants received recommended care across four healthcare quality indicators, and approximately two-thirds received advice to exercise. Binary logistic regressions indicated no differences in healthcare quality based on participant demographic, social, or patient-reported factors. Within a systematic review and meta-analysis on the biomechanical and structural effects of walking interventions (Chapter 4), pooled data analysis from 33 articles indicated walking interventions elicit minimal-to-no change in discrete biomechanical metrics of joint loading, and moderately increase gait speed. Longer interventions were associated with lower peak knee flexion moments in meta-regressions. Descriptive analyses suggested walking exercise does not alter knee joint structure beyond natural history changes. A laboratory-based experimental study on the immediate biomechanical, structural, and patient-reported effects of a 30-minute walking bout (Chapter 5) indicated that continuous walking increases peak knee

joint loading, elicits minimal-to-no increases in pain, and does not change cartilage thickness. Pain and structural imaging responder and non-responder sub-groups were identified and examined in exploratory analyses. Low exercise prescription rates (Chapter 3) are unsurprising given the little quantitative evidence that currently exists to support walking exercise (Chapter 4); however, the effect of walking exercise on biomechanical, structural, and patient-reported outcomes (Chapters 4 and 5) support that more individuals with knee osteoarthritis should be advised to exercise. This thesis adds to growing evidence that exists to educate patients on the potential overall and joint health benefits of walking exercise, and absence of harms related to disease progression. Findings can be used to inform walking prescription parameters to increase physical activity for knee osteoarthritis populations.

*Biomechanical Analysis of Elite Race Walking*

First published in 1996. Routledge is an imprint of Taylor & Francis, an informa company.

Born to Walk, Second Edition

This is the clearest and most straightforward biomechanics textbook currently available. By breaking down the challenging subject of sport and exercise biomechanics into short thematic sections, it enables students to grasp each topic quickly and easily, and provides lecturers with a flexible resource that they can use to support

any introductory course on biomechanics. The book contains a wealth of useful features for teaching and learning, including clear definitions of key terms, lots of applied examples, guides to further reading, and revision questions with worked solutions. It has been significantly expanded to encompass rapidly developing areas, such as sports equipment design and modern optoelectronic motion analysis systems, and it includes a number of new sections that further develop the application of biomechanics in sports performance and injury prevention. A new companion website includes a test bank, downloadable illustrations and, where appropriate, suggestions for learning outcomes and/or lab-based sessions for lecturers. Instant Notes in Sport and Exercise Biomechanics has been an invaluable course companion for thousands of students and lecturers over the last decade. Engaging, direct, and now fully refreshed, it is the only biomechanics textbook you'll ever need.

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