



Descending aorta subject-specific one-dimensional model validated against *in vivo* data

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ABSTRACT

The aorta plays a major role in the cardiovascular system and its function and structure are primarily affected by aging, eating habits, life style and other cardiovascular risk factors, inducing increased stiffness which is associated with cardiovascular and cerebral morbi-mortality. Our objective was to develop and validate a robust subject-specific one-dimensional wave propagation numerical model of the descending aorta. This model with a cross-sectional area, velocity and pressure formulation is built using geometric and hemodynamic data measured on a specific person and is validated against *in vivo* data acquired on the same subject at three distinct anatomical locations along the thoracic aorta. We studied seven healthy volunteers, who underwent carotid applanation tonometry and aortic cardiovascular magnetic resonance (CMR). Responses of our model in terms of changes in central pressure waveform with arterial alterations were consistent with previously described physiological knowledge. Quantitative validation averaged over the three descending aortic locations and the seven subjects provided low rms errors (given in percentage of the maximal clinical value) between simulated and CMR data, i.e. area: $10 \pm 6\%$, velocity: $11 \pm 3\%$, flow rate: $9 \pm 3\%$. Finally, we also found low rms ($5 \pm 2\%$) when comparing simulated pressure in the proximal aortic location against tonometric carotid pressure curves. In conclusion, this simple model performs similar to more complex models of the entire systemic arterial tree at a fraction of the cost, and could be of major usefulness in the non-invasive and local estimation of proximal biomechanical and hemodynamic indices.

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1. Introduction

Both structural and functional alterations of large arteries, especially the aorta, occur with aging as well as with aggravating pathologic, genetic and environmental factors (Lakatta and Levy, 2003), resulting in arterial stiffening which has been associated with cardiovascular and cerebral morbi-mortality (Mitchell et al., 2010). One-dimensional (1D) computational fluid dynamics models, simulating parts or the entire systemic circulation, are widely used for studying arterial pressure and flow waves (Stergiopoulos

et al., 1992; Olufsen et al., 2000; Segers and Verdonck, 2000; Sherwin et al., 2005; Steele et al., 2003; Wang and Parker, 2004; Bessens et al., 2007; Matthys et al., 2007; Alastruey et al., 2008; Bessens et al., 2008; Raymond et al., 2009, 2011, 2012). Indeed, they can provide insights into wave propagation and reflection, allowing for a better characterization of the arterial system and its interactions with target organs. Despite their approximations and sensitivity to changes in arterial caliber and distensibility, as well as to peripheral wave reflections, 1D models are computationally attractive, compared to the more accurate three-dimensional models. Valid questions are whether 1D models may be easily adapted to a specific subject, i.e. which features and parameters must be precisely tuned? and how to quantitatively validate model predictions? To date, when available, validations of 1D models including the aorta were performed against either *in vitro* (Segers and Verdonck, 2000; Matthys et al., 2007; Huberts et al., 2012) or *in vivo* (Stergiopoulos et al., 1992; Olufsen et al., 2000; Steele et al., 2003; Raymond et al., 2009, 2011) data. Among these studies,

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Template Journal Of Biomechanics

**Jingwei Zhang, Cheng-Kung
Cheng, Chia-Ying Lin**



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Biomechanics of the Upper Limbs Andris Freivalds, 2011-02-16 There is already a wealth of literature covering cumulative trauma disorders and medical management as well as the biomechanics of manual material handling and lower back problems. However, despite a spike in the number of work-related musculoskeletal disorders (WRMSDs) in the upper limbs due to a sharp increase in the amount of computer-related jobs, few if any books have focused exclusively on WRMSDs until now. *Biomechanics of the Upper Limbs: Mechanics, Modeling, and Musculoskeletal Injuries*, Second Edition, offers vital information and tools to improve analysis of external forces and their effects on the human body. This can help ergonomists better understand job stressors and the role they play in the development of disorders, enabling them to modify the work environment and educate practitioners to better control harmful situations. Using the author's medical and engineering expertise to distill essential subject matter and useful technical data, this comprehensive text explores Biomechanics of the upper limbs and the motor control system. The structure and physiology of the human musculoskeletal and neuromuscular systems. Recent research findings and solutions to various ergonomic problems. Models of various components of the neuromuscular systems as well as larger systems in the upper limbs. Risk factors for disorders and tools used to identify their causes. Designed as a textbook for a typical semester-long graduate-level engineering or kinesiology course, this book includes a link to an ancillary website that offers materials such as PowerPoint slides, sample exams, and an instructor's manual with complete solutions. It also serves as a practical up-to-date engineering-oriented resource for researchers, industrial ergonomists, industrial hygienists, and medical professionals who require supplementary material. [Biomechanics in Orthopaedic Diseases and Surgery](#) Jingwei Zhang, Cheng-Kung Cheng, Chia-Ying Lin, 2025-01-30 The mechanical environment of the musculoskeletal system plays a fundamental role in orthopaedic diseases. Understanding the magnitude, pattern, and duration of biomechanical factors and how they impact surgical treatment is an ongoing topic of interest in biomechanics. However, the way forces and stresses acting on the skeletal system affect disease progression and treatment outcomes is not yet fully elucidated. As a result, investigating the biomechanical responses in the incidence and surgical treatment of orthopaedic diseases such as osteoarthritis can significantly enhance existing surgical treatment strategies and foster the development of new pharmaceutical interventions. Our goal is to consolidate groundbreaking studies in this field to advance the understanding of the biomechanical principles underlying disease progression and create a foundation for novel therapeutic strategies. **Journal of Biomechanical Engineering**, 1980 **Orthopaedic Biomechanics** Beth A. Winkelstein, 2012-12-18 Given the strong current attention of orthopaedic biomechanical and biomedical engineering research on translational capabilities for the diagnosis, prevention, and treatment of clinical disease states, the need for reviews of the state of art and current needs in orthopaedics is very timely. *Orthopaedic Biomechanics* provides an in-depth review of the current knowledge of orthopaedic biomechanics across all tissues in the musculoskeletal system at all size

scales and with direct relevance to engineering and clinical applications. Discussing the relationship between mechanical loading function and biological performance, it first reviews basic structure function relationships for most major orthopedic tissue types followed by the most relevant structures of the body. It then addresses multiscale modeling and biologic considerations. It concludes with a look at applications of biomechanics focusing on recent advances in theory, technology and applied engineering approaches. With contributions from leaders in the field, the book presents state of the art findings, techniques and perspectives. Much of orthopaedic biomechanical and biomedical engineering research is directed at the translational capabilities for the real world. Addressing this from the perspective of diagnostics, prevention and treatment in orthopaedic biomechanics, the book supplies novel perspectives for the interdisciplinary approaches required to translate orthopaedic biomechanics to today's real world. *Biomechanics and Gait Analysis* Nicholas Stergiou, 2020-03-25

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. Research Methods in Biomechanics D. Gordon E. Robertson, Graham E. Caldwell, Joseph Hamill, Gary Kamen, Saunders Whittlesey, 2013-11-01. *Research Methods in Biomechanics* Second Edition demonstrates the range of available research techniques and how to best apply this knowledge to ensure valid data collection. In the highly technical field of biomechanics, research methods are frequently upgraded as the speed and sophistication of software and hardware technologies increase. With this in mind, the second edition includes up to date research methods and presents new information detailing advanced analytical tools for investigating human movement. Expanded into 14 chapters and reorganized into four parts, the improved second edition features more than 100 new pieces of art and illustrations and new chapters introducing the latest techniques and up and coming areas of research. Additional enhancements in this edition include the following: Special features called 'From the Scientific Literature' highlight the ways in which biomechanical research techniques have been used in both classic and cutting edge studies. An overview summary and list of suggested readings in each chapter guide students and researchers through the content and on to further study. Sample problems appear in select chapters and answers are provided at the end of the text. Appendixes contain mathematical and technical

references and additional examples A glossary provides a reference for terminology associated with human movement studies Research Methods in Biomechanics Second Edition assists readers in developing a comprehensive understanding of methods for quantifying human movement Parts I and II of the text examine planar and three dimensional kinematics and kinetics in research issues of body segment parameters and forces and energy work and power as they relate to analysis of two and three dimensional inverse dynamics Two of the chapters have been extensively revised to reflect current research practices in biomechanics in particular the widespread use of Visual3D software In part III readers can explore the use of musculoskeletal models in analyzing human movement This part also discusses electromyography computer simulation muscle modeling and musculoskeletal modeling it presents new information on MRI and ultrasound use in calculating muscle parameters Part IV offers a revised chapter on additional analytical procedures including signal processing techniques Also included is a new chapter on movement analysis and dynamical systems which focuses on how to assess and measure coordination and stability in changing movement patterns and the role of movement variability in health and disease In addition readers will find discussion of statistical tools useful for identifying the essential characteristics of any human movement The second edition of Research Methods in Biomechanics explains the mathematics and data collection systems behind both simple and sophisticated biomechanics It assists both beginning and experienced researchers in developing their methods for analyzing and quantifying human movement

Understanding Mammalian Locomotion John E. A. Bertram, 2016-01-19 *Understanding Mammalian Locomotion* will formally introduce the emerging perspective of collision dynamics in mammalian terrestrial locomotion and explain how it influences the interpretation of form and functional capabilities The objective is to bring the reader interested in the function and mechanics of mammalian terrestrial locomotion to a sophisticated conceptual understanding of the relevant mechanics and the current debate ongoing in the field

Human Orthopaedic Biomechanics Bernardo Innocenti, Fabio Galbusera, 2022-02-24 *Human Orthopaedic Biomechanics Fundamentals Devices and Applications* covers a wide range of biomechanical topics and fields ranging from theoretical issues mechanobiology design of implants joint biomechanics regulatory issues and practical applications The book teaches the fundamentals of physiological loading and constraint conditions at various parts of the musculoskeletal system It is an ideal resource for teaching and education in courses on orthopedic biomechanics and for engineering students engaged in these courses In addition all bioengineers who have an interest in orthopedic biomechanics will find this title useful as a reference particularly early career researchers and industry professionals Finally any orthopedic surgeons looking to deepen their knowledge of biomechanical aspects will benefit from the accessible writing style in this title Covers theoretical aspects mechanics stress analysis constitutive laws for the various musculoskeletal tissues and mechanobiology Presents components of different regulatory aspects failure analysis post marketing and clinical trials Includes state of the art methods used in orthopedic biomechanics and in designing orthopedic implants experimental methods finite element and

rigid body models gait and fluoroscopic analysis radiological measurements **Numerical Methods and Advanced Simulation in Biomechanics and Biological Processes** Miguel Cerrolaza, Sandra Shefelbine, Diego

Garzón-Alvarado, 2017-12-28 Numerical Methods and Advanced Simulation in Biomechanics and Biological Processes covers new and exciting modeling methods to help bioengineers tackle problems for which the Finite Element Method is not appropriate. The book covers a wide range of important subjects in the field of numerical methods applied to biomechanics including bone biomechanics, tissue and cell mechanics, 3D printing, computer assisted surgery, and fluid dynamics. Modeling strategies, technology, and approaches are continuously evolving as the knowledge of biological processes increases. Both theory and applications are covered, making this an ideal book for researchers, students, and R D professionals. Provides non conventional analysis methods for modeling. Covers the Discrete Element Method, DEM, Particle Methods, PM, MeshLess, and MeshFree Methods, MLMF, Agent Based Methods, ABM, Lattice Boltzmann Methods, LBM, and Boundary Integral Methods, BIM. Includes contributions from several world renowned experts in their fields. Compares pros and cons of each method to help you decide which method is most applicable to solving specific problems. Computational Biomechanics for Medicine Karol Miller, Poul Nielsen, 2010-03-10 Mathematical modelling and computer simulation have proved tremendously successful in engineering. One of the greatest challenges for mechanists is to extend the success of computational mechanics to fields outside traditional engineering, in particular to biology, biomedical sciences, and medicine. The proposed workshop will provide an opportunity for computational biomechanics specialists to present and exchange opinions on the opportunities of applying their techniques to computer integrated medicine. For example, continuum mechanics models provide a rational basis for analysing biomedical images by constraining the solution to biologically reasonable motions and processes. Biomechanical modelling can also provide clinically important information about the physical status of the underlying biology, integrating information across molecular, tissue, organ, and organism scales. The main goal of this workshop is to showcase the clinical and scientific utility of computational biomechanics in computer integrated medicine. *Knees, Ankles, Feet, and Toes: The Biomechanics of Bipedal Human Walking* Daniel Renjewski, 2025-01-01 For most humans, bipedal walking is the natural mode of locomotion, so instinctive that it requires little conscious thought. Despite nearly 2 500 years of research, the biomechanics of human gait remains a complex puzzle. This book revisits and proposes several mechanisms of bipedal walking that have been subjects of scientific discussion for several decades. It explores gait stabilization, efficiency, and general dynamics. Readers will encounter surprising facts and a mechanistic explanation for the puzzling double humped ground reaction force profile observed in human walking. The insights provided can assist engineers and medical professionals involved in the remobilization of patients. Additionally, these biomechanical insights are framed by reflections on science and higher education, leading to proposals for remedies aimed at creating a more vibrant, inclusive, and goal directed academic system. Für die meisten Menschen ist das zweibeinige Gehen die natürliche Fortbewegungsart. Es ist so natürlich, dass kein bewusster

Gedanke erforderlich ist Die Biomechanik des menschlichen Ganges bleibt jedoch selbst nach fast 2500 Jahren Forschung ein komplexes R tsel Dieses Buch befasst sich mit verschiedenen Mechanismen des zweibeinigen Gehens die seit Jahrzehnten Gegenstand wissenschaftlicher Diskussionen sind Es behandelt die Stabilisierung des Gangs seine Effizienz und allgemeine Dynamik Der Leser wird einige berraschende Fakten und eine mechanistische Erkl rung f r das r tselhafte doppelgipfelige Bodenreaktionskraftmuster des menschlichen Gehens finden Die bereitgestellten Einblicke k nnen Ingenieuren und medizinischen Fachkr ften helfen die mit der Remobilisierung von Patienten betraut sind Die biomechanischen Erkenntnisse werden von berlegungen zur Wissenschaft und zur Hochschulbildung im Allgemeinen umrahmt die Vorschl ge f r Ma nahmen zur Schaffung eines lebendigeren inklusiveren und zielgerichteten akademischen Systems enthalten *Routledge Handbook of Motor Control and Motor Learning* Albert Gollhofer, Wolfgang Taube, Jens Bo Nielsen, 2013 This text offers a comprehensive survey of neurophysiological behavioural and biomechanical aspects of motor function Adopting an integrative approach it examines the full range of key topics in contemporary human movement studies explaining motor behaviour in depth from the molecular level to behavioural consequences **DHM and Posturography** Sofia Scataglini, Gunther Paul, 2019-08-22 DHM and Posturography explores the body of knowledge and state of the art in digital human modeling along with its application in ergonomics and posturography The book provides an industry first introductory and practitioner focused overview of human simulation tools with detailed chapters describing elements of posture postural interactions and fields of application Thus DHM tools and a specific scientific practical problem the study of posture are linked in a coherent framework In addition sections show how DHM interfaces with the most common physical devices for posture analysis Case studies provide the applied knowledge necessary for practitioners to make informed decisions Digital Human Modelling is the science of representing humans with their physical properties characteristics and behaviors in computerized virtual models These models can be used standalone or integrated with other computerized object design systems to design or study designs workplaces or products in their relationship with humans Presents an introductory up to date overview and introduction to all industrially relevant DHM systems that will enable users on trialing procurement decisions and initial applications Includes user level examples and case studies of DHM application in various industrial fields Provides a structured and posturography focused compendium that is easy to access read and understand *Experimental Robotics* Oussama Khatib, Vijay Kumar, Gaurav Sukhatme, 2013-08-20 Incorporating papers from the 12th International Symposium on Experimental Robotics ISER December 2010 this book examines the latest advances across the various fields of robotics Offers insights on both theoretical concepts and experimental results *Spine and Joint Articulation for Manual Therapists* Giles Gyer, Jimmy Michael, Ben Calvert-Painter, 2016-09-01 The book focuses on the practical application of articulation and mobilisation techniques with clear explanations and visual support of the techniques Techniques are described for all body regions Most other books for therapists include only one chapter on these important techniques This

book covers a variety of best practise techniques for all areas of the body Examples are given to show how to adapt the techniques with the patient in different positions It also addresses the use of these techniques on children the elderly and pregnant women The mechanisms of each technique are explained with reference to the related anatomy and physiology Information is also given to help the therapist use the techniques safely for both themselves and their patients by adapting their own stance and posture to get maximum effect with minimum effort Animal Locomotion Malcolm S.

Gordon,Reinhard Blickhan,John O. Dabiri,John J. Videler,2017-05-25 Animal Locomotion Physical Principles and Adaptations is a professional level state of the art review and reference summarizing the current understanding of macroscopic metazoan animal movement The comparative biophysics biomechanics and bioengineering of swimming flying and terrestrial locomotion are placed in contemporary frameworks of biodiversity evolutionary process and modern research methods including mathematical analysis The intended primary audience is advanced level students and researchers primarily interested in and trained in mathematics physical sciences and engineering Although not encyclopedic in its coverage anyone interested in organismal biology functional morphology organ systems and ecological physiology physiological ecology molecular biology molecular genetics and systems biology should find this book useful Corrosion Protection and Control Using Nanomaterials V S Saji,R. M. Cook,2012-02-21 Corrosion is an expensive and potentially dangerous problem in many industries The potential application of different nanostructured materials in corrosion protection prevention and control is a subject of increasing interest Corrosion protection and control using nanomaterials explores the potential use of nanotechnology in corrosion control The book is divided into two parts Part one looks at the fundamentals of corrosion behaviour and the manufacture of nanocrystalline materials Chapters discuss the impact of nanotechnology in reducing corrosion cost and investigate the influence of various factors including thermodynamics kinetics and grain size on the corrosion behaviour of nanocrystalline materials There are also chapters on electrodeposition and the corrosion behaviour of electrodeposited nanocrystalline materials Part two provides a series of case studies of applications of nanomaterials in corrosion control Chapters review oxidation protection using nanocrystalline structures at various temperatures sol gel and self healing nanocoatings and the use of nanoreservoirs and polymer nanocomposites in corrosion control With its distinguished editors and international team of expert contributors Corrosion protection and control using nanomaterials is an invaluable reference tool for researchers and engineers working with nanomaterials in a variety of industries including aerospace automotive and chemical engineering as well as academics studying the unique protection and control offered by nanomaterials against corrosion Explores the potential use of nanotechnology and nanomaterials for corrosion prevention protection and control Discusses the impact of nanotechnology in reducing corrosion cost and investigates various factors on the corrosion behaviour of nanocrystalline materials Provides a series of case studies and applications of nanomaterials for corrosion control Novel Bioinspired Actuator Designs for Robotics Philipp Beckerle,Maziar Ahmad Sharbafi,Tom

Verstraten, Peter P. Pott, André Seyfarth, 2021-09-04 This book discusses biologically inspired robotic actuators designed to offer improved robot performance and approaching human like efficiency and versatility It assesses biological actuation and control in the human motor system presents a range of technical actuation approaches and discusses potential applications in wearable robots i e powered prostheses and exoskeletons Gathering the findings of internationally respected researchers from various fields the book provides a uniquely broad perspective on bioinspired actuator designs for robotics Its scope includes fundamental aspects of biomechanics and neuromechanics actuator and control design and their application in wearable robotics The book offers PhD students and advanced graduate students an essential introduction to the field while providing researchers a cutting edge research perspective **Frontiers in Nano-therapeutics** Nishat Tasnim, Baiju G.

Nair, Katla Sai Krishna, Sudhakar Kalagara, Mahesh Narayan, Juan C. Noveron, Binata Joddar, 2017-06-22 This brief highlights recent research advances in the area of nano therapeutics Nanotechnology holds immense potential for application in a wide range of biological and engineering applications such as molecular sensors for disease diagnosis therapeutic agents for the treatment of diseases a vehicle for delivering therapeutics and imaging agents for theranostic applications both in vitro and in vivo The brief is grouped into the following sections namely A Discrete Nanosystems B Anisotropic Nanoparticles C Nano films coated layered and D Nano composites *Digital Human Modeling and Medicine* Gunther Paul, Mohamed H.

Doweidar, 2022-12-04 Digital Human Modeling and Medicine The Digital Twin explores the body of knowledge and state of the art in Digital Human Modeling DHM and its applications in medicine DHM is the science of representing humans with their physical properties characteristics and behaviors in computerized virtual models These models can be used standalone or integrated with other computerized object design systems to both design or study designs of medical devices or medical device products and their relationship with humans They serve as fast and cost efficient computer based tools for the assessment of human functional systems and human system interaction This book provides an industry first introductory and practitioner focused overview of human simulation tools with detailed chapters describing body functional elements and organs organ interactions and fields of application Thus DHM tools and a specific scientific practical problem functional study of the human body are linked in a coherent framework Eventually the book shows how DHM interfaces with common physical devices in medical practice answering to a gap in literature and a common practitioner question Case studies provide the applied knowledge for practitioners to make informed decisions A non specialist level up to date overview and introduction to all medically relevant DHM systems to inform trialing procurement decisions and initial application Includes user level examples and case studies of DHM applications in various medical fields Clearly structured and focused compendium that is easy to access read and understand

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