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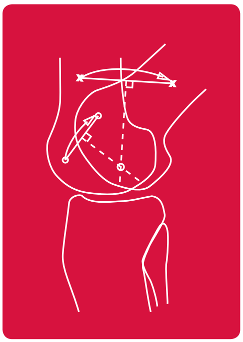
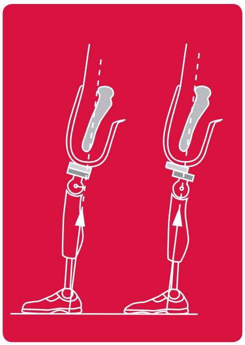
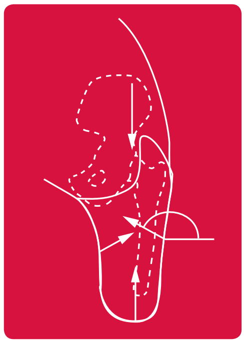
(Bundesfachschule für Orthopädie-Technik) Dortmund, Germany

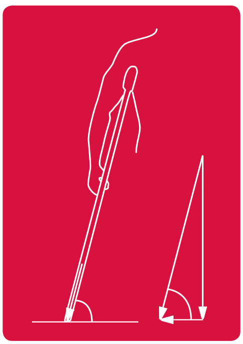
Biomechanical Basics of Orthopedic Technology

Selected Problems

With step-by-step solutions
2nd expanded edition

Burkhard Drerup | Paul Brinckmann | Stefan Stankowski



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Preface

The challenges of patient care and the use of modern measuring techniques require orthopedic technicians to have knowledge of biomechanics. In order to upgrade and broaden this knowledge, the exercises compiled in this booklet address mechanical topics such as force, pressure, moment, center of mass, velocity and acceleration, each with examples from the field of orthopedic technology. The integration of biomechanics in the well-known context aims at reducing the 'fear' of the theory. The problems presented are intended for self-study or as courses for orthopedic technicians and bachelor students.

The mathematical background knowledge required is nominal. Essentially, one has to know how to construct a triangle from three given elements (angles or sides), for example to determine the equilibrium of three forces, how to apply the lever rule, for example when determining an unknown force in the equilibrium of moments, and how to use the trigonometric functions. When adding vectors, for example when adding two forces, the graphical method is used exclusively for reasons of clarity. Freehand sketches suffice in most cases.

There are specific reasons why solving some problems appears to be difficult at first glance. In the field of biomechanics, one is often confronted with complicated structures and systems. In order to gain insight, it is necessary to rely on model assumptions and simplifications. However, it is sometimes difficult to determine which assumptions are really justified and which simplifications falsify a result. Is it, for example, permissible to pool the forces of all muscles effecting the extension of the back into one single muscle force? Is it permissible to replace the mechanical effect of pressure distribution in the socket of a prosthesis by the effect of a single resultant force?

To meet these difficulties, all problems include detailed instructions for solving them. This approach was selected deliberately. Starting from practical examples should generate interest for scientific problem solving. The solution process thus leads to initial training in the methods and provides an insight in the line of reasoning of biomechanics. Irrespective of their prior knowledge, students can gain new knowledge and broaden their horizons.

Sincere thanks are given to the authors. I hope the booklet will be widely accepted and that the methodological concept will attain success among interested students.

Dortmund, June 2016 Stefan Bieringer

Preface to the 2nd edition

Two years after the first edition, the authors present a revised and significantly expanded version of the exercises in biomechanical foundations of orthopedic technology. The feedback from students and colleagues confirms that the goal of acquainting students with biomechanical methods was accomplished. The book can be used for study as well as for reference.

The authors are to be complimented again on this expanded edition.

Dortmund, May 2018 *Stefan Bieringer*

The authors are grateful to Orthopädie-Technik Publishers and thank Kirsten Abel for the pleasant experience during the preparation of this book.

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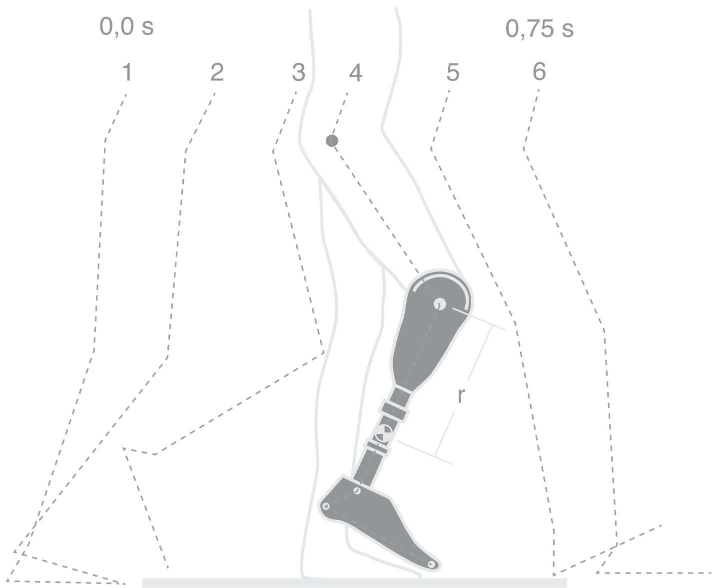
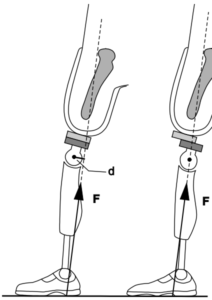


5.3 Shifting the axis of a knee prosthesis in posterior direction

If during prosthetic fitting after a transfemoral amputation, the axis of the knee joint is placed at its anatomical position, the ground reaction force exerts (as in the unimpaired state) a flexion moment on the knee (graph at left).



Reference values of the relative ground reaction force F_{rel} (force divided by the body mass m_{body}) and the relative moment M_{rel} (moment divided by the body mass m_{body}) have been determined in the phase of heel-strike from gait analysis:

F_{rel} = 8 N/kg, M_{rel} = 0.1 Nm/kg.

These numbers must be multiplied by the body mass to obtain the numerical values of the force F and the moment M.

Problem

Determine the distance d by which the axis of the knee joint must be shifted in dorsal direction by means of an adapter so that the flexion moment becomes zero (right graph). Disregard the fact that the directions of the moment arm d and the shift effected by the adapter do not agree exactly.

Instructions

In a first step, the moment arm of the ground reaction force in the initial, unimpaired state is to be determined. The magnitude of the shift is then chosen so that the moment arm becomes zero. The moment arm in the unimpaired state is determined from

$$M = d \cdot F \ \text{[Nm]}$$

Inserting the reference values for M and F yields

$$0.1 \cdot m_{body} = d \cdot 8 \cdot m_{body} \ \text{Nm}$$

The shift d is obtained from this equation.

Biomechanics? No problem!

Is it permissible to pool the forces of all muscles effecting the extension of the back into one single muscle force? Is it permissible to replace the mechanical effect of pressure distribution in the socket of a prosthesis by the effect of a single resultant force? Can the internal energy production of the body when wearing prosthetic devices be quantified?

Answers to these and many other questions relating to biomechanical aspects of orthopedic technology are presented in this practical collection of exercises. To refresh and broaden your knowledge, the problems address mechanical topics such as force, power, pressure, stress, moment, center of mass, velocity and acceleration using examples from the field of orthopedic technology.

The mathematical background knowledge required is nominal. All problems are complemented by detailed instructions for solving in order to facilitate training while at the same time providing insight into the line of reasoning of biomechanics.

Burkhard Drerup | Paul Brinckmann | Stefan Stankowski

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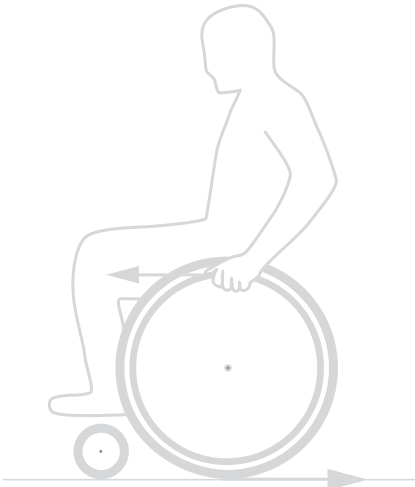

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