WALKMECH

ENERGY-EFFICIENT TRANSFEMORAL PROSTHESIS

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Outline

- The Problem
- The Classification
- Proposed Concept
- Working Principle
- The Realization
- Tests
- Results
- Conclusions

THE PROBLEM

transfemoral prosthesis

Amputation level	Energy above healthy subject [%]	Speed [m/min]
Long transtibial	10	70
Average transtibial	25	60
Short transtibial	40	50
Bilateral transtibial	41	50
Transfemoral	65	40
Wheelchair	0-8	70

THE CLASSIFICATION

transfemoral prosthesis – passive

MAUCH GM - Ossur

MAUCH XG - Ossur

Total Knee 2100 - Ossur

3R95 – Otto Bock

3R80 – Otto Bock

THE CLASSIFICATION

transfemoral prosthesis

C-Leg & C-Leg compact – Otto Bock

Rheo Knee - Ossur

Smart Adaptive - Endolite

THE CLASSIFICATION

transfemoral prosthesis

Power Knee - Ossur

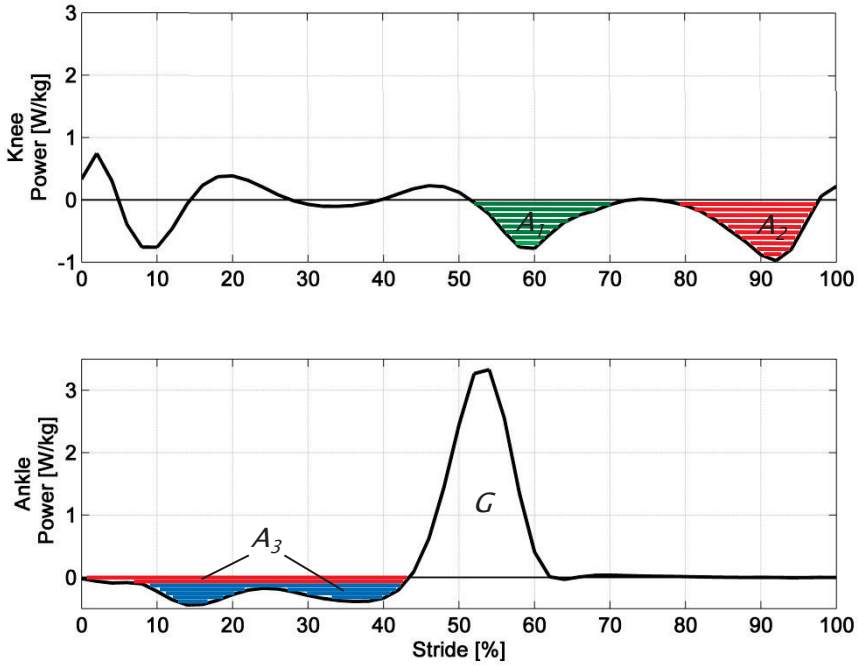
THE CLASSIFICATION

transfemoral prosthesis

Passive	MP Controlled	Powered
– No speed adaptation	+ Adaptive walking	+ Adaptive walking
– No push off	– No push off	+ Push off support
– High metabolic cost	– High metabolic cost	+ Reduced metabolic cost
+ No battery	Requires batteries	– Big batteries
+ Low price	Medium price	– High price

PROPOSED CONCEPT

in theory walking is almost energy free…



$A_1 + A_2$
~ 0.20 J/kg

A_3
~ 0.13 J/kg

G
~ 0.35 J/kg

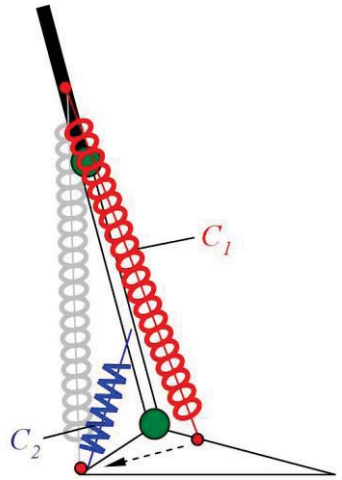
PROPOSED CONCEPT

in theory walking is almost energy free…

to design an actuation system;

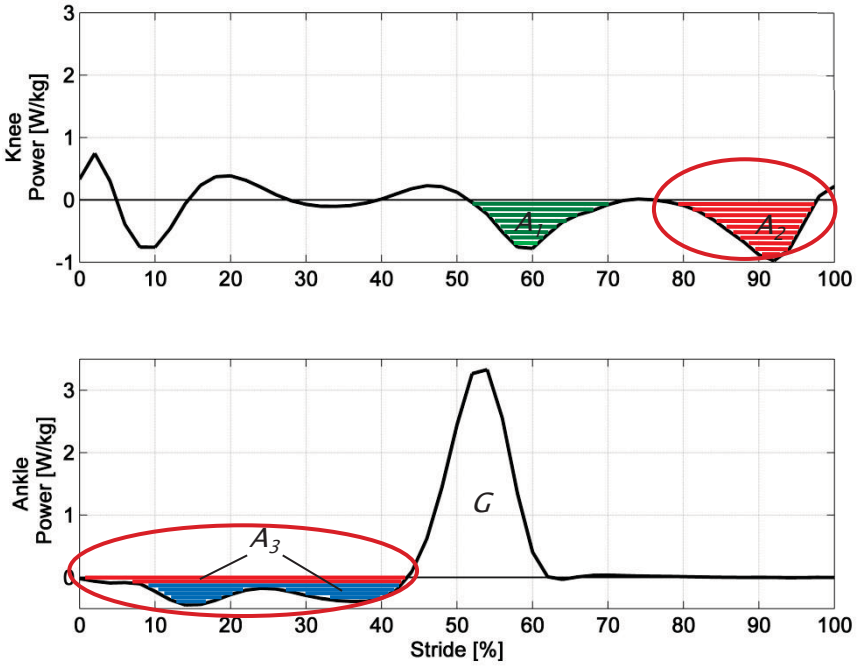
- that is able to store (power absorption) and release the energy (power generation)
- that provides energy exchange between the knee and ankle joints.

The actuation system is to be controlled without dissipation (brakes) and will make use of every joule of energy during walking cycle (energy efficient).

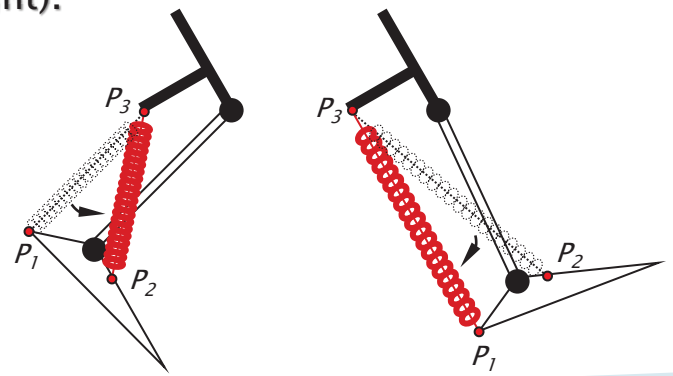


WORKING PRINCIPLE

bi-directional element

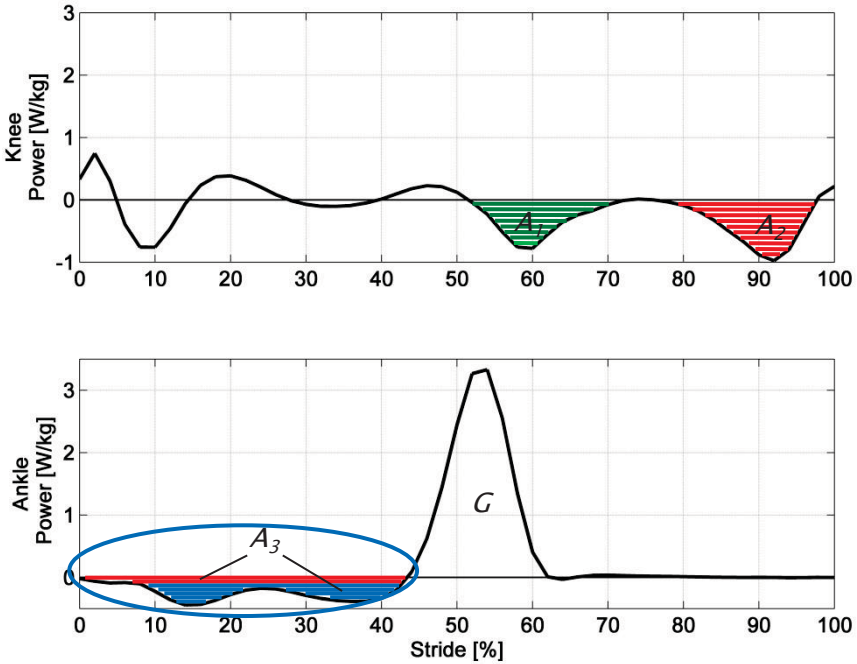


After pre-swing phase, the attachment point of the spring is changed from the heel (P_1) to the upper part of the foot (P_2) (left).
At the end of the swing, the spring is loaded and its position changes back to the P_1 (right).

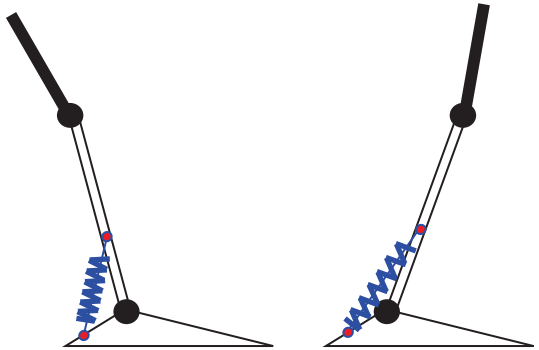


WORKING PRINCIPLE

ankle elastic element

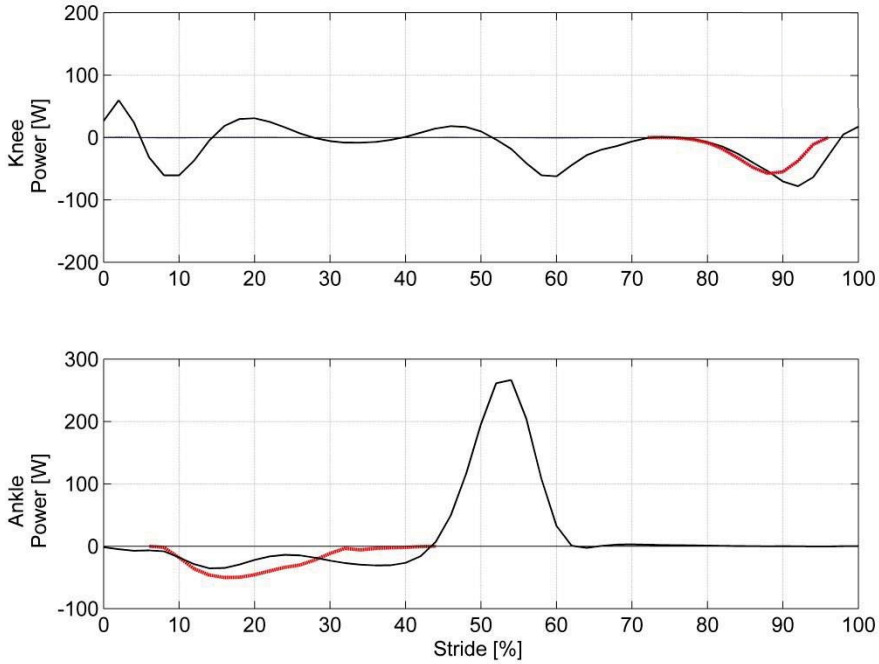


At the beginning of the stance phase, both elements C_2 and C_3 are ready for the storage of absorption A_3 (left).
At the end of the stance phase, both springs are loaded (right).



SIMULATIONS

power flow for each joint



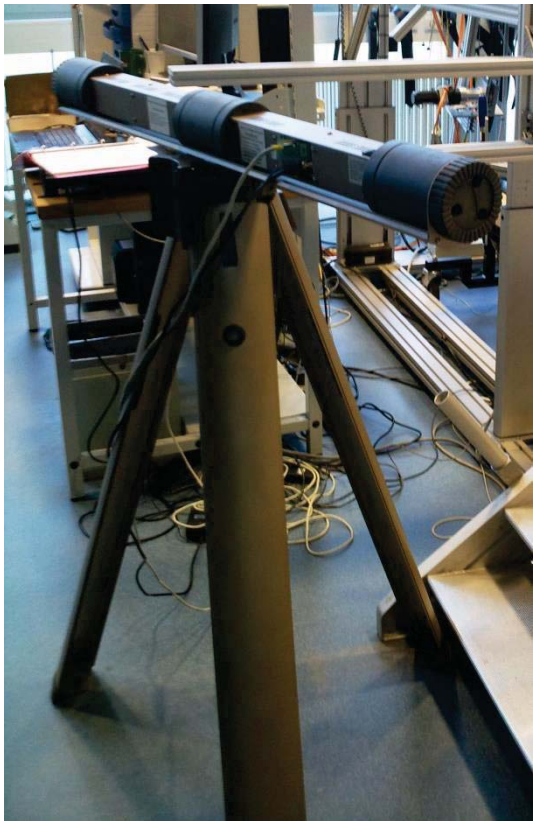
64% overall system efficiency

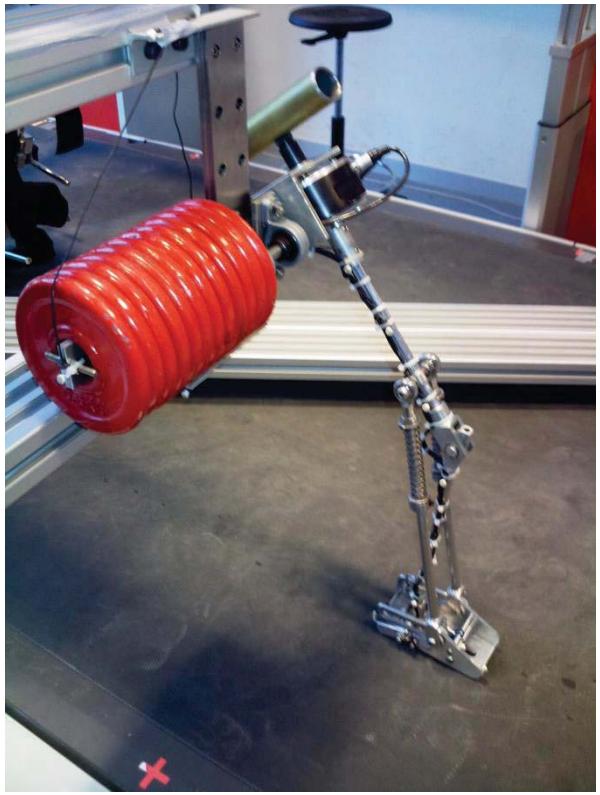
THE REALIZATION

Energy is stored, exchanged and released

TESTS

set-up

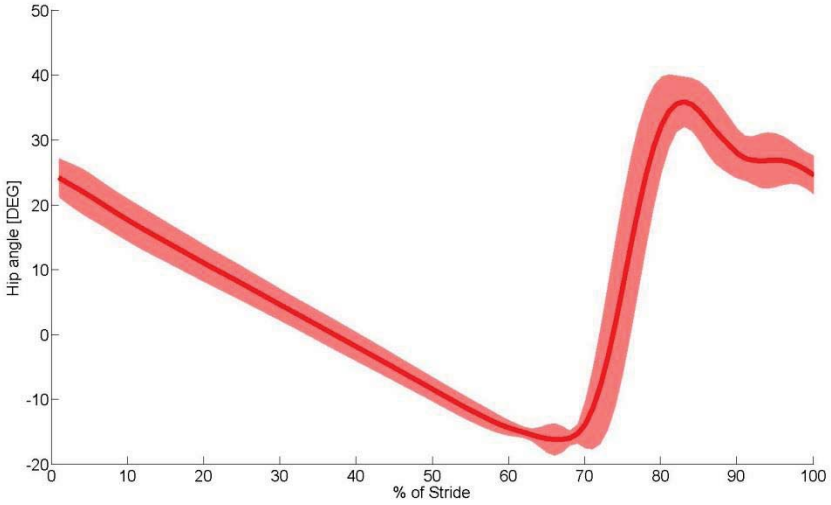


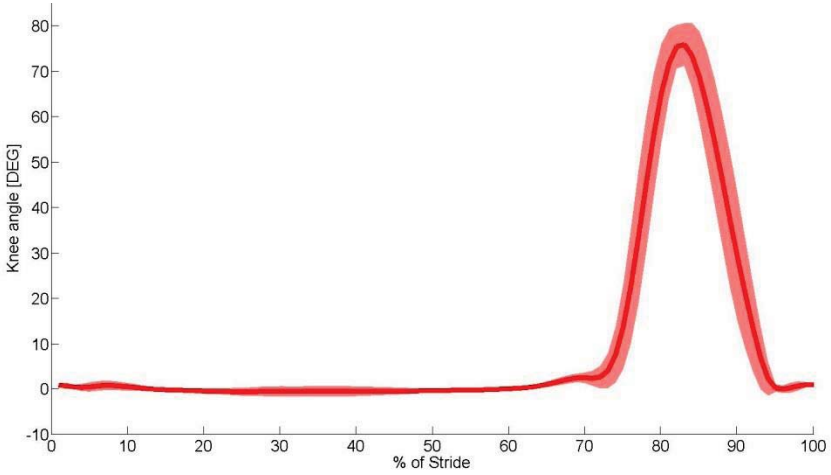


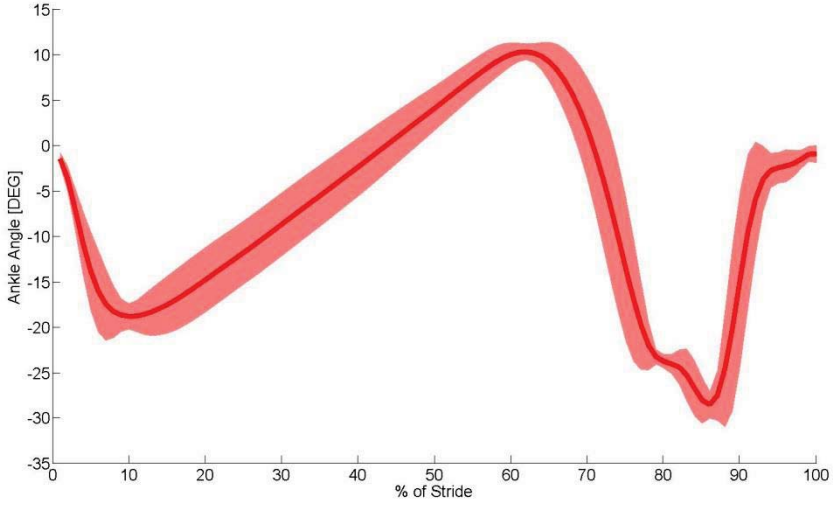
TESTS

RESULTS

joint angles

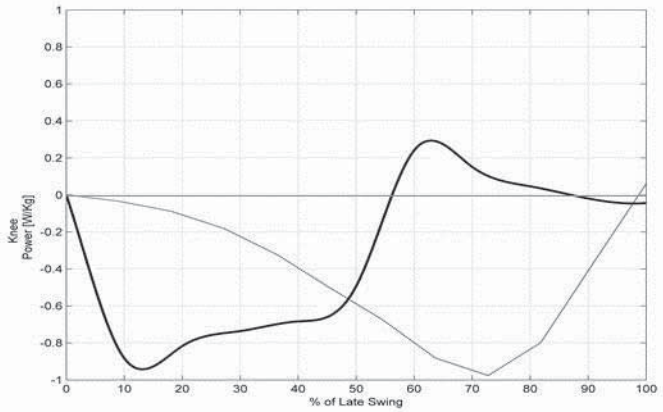


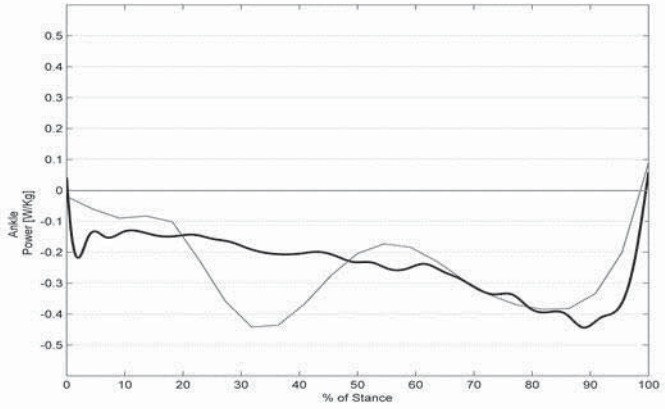


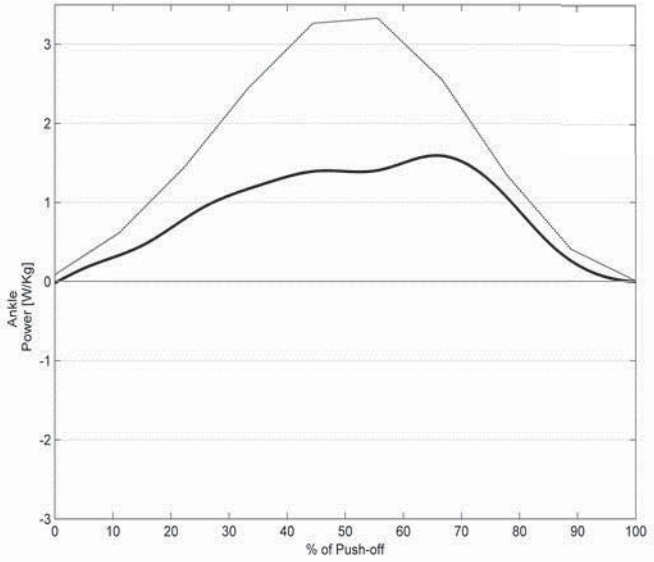


RESULTS

joint power





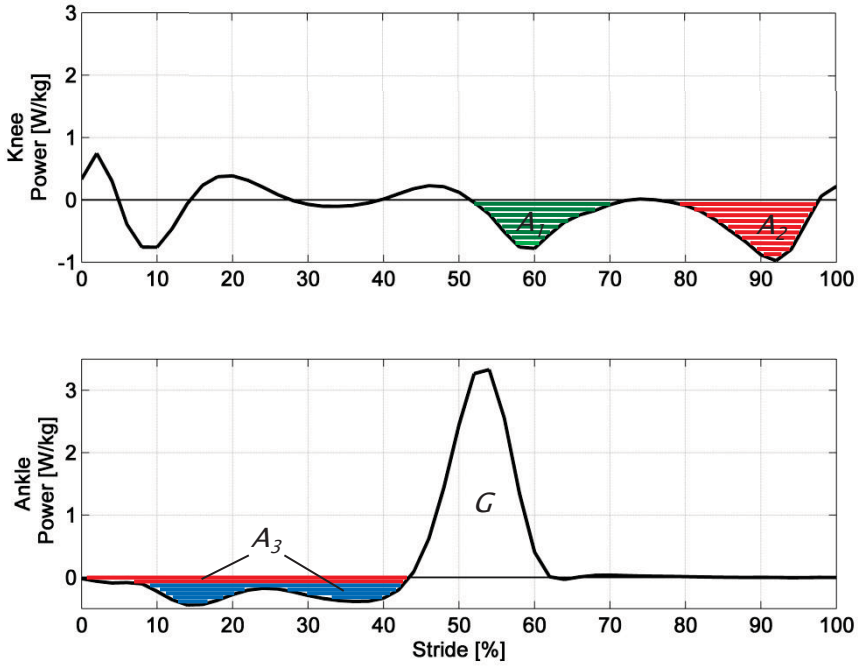


Almost all of A_2 portion is stored

50% of push-off is provided

PROPOSED CONCEPT – II

in theory walking is almost energy free…



$A_1 + A_2$
~ 0.20 J/kg

A_3
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G
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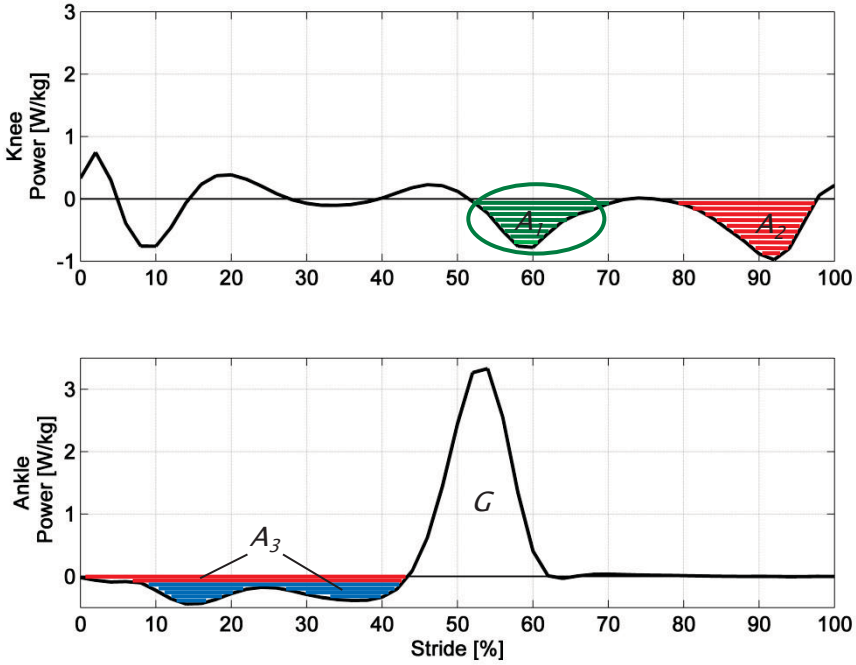
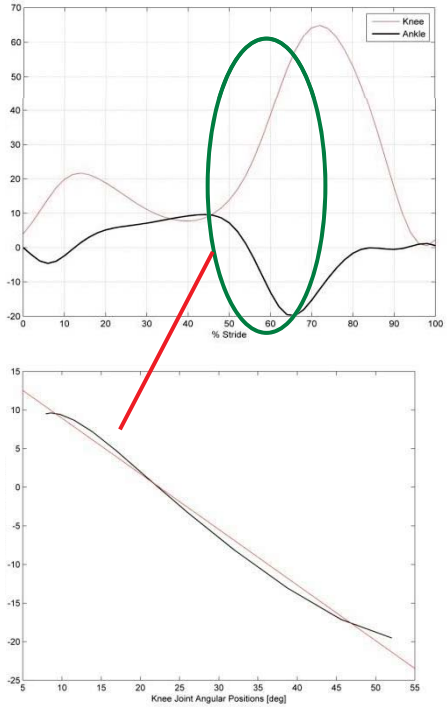
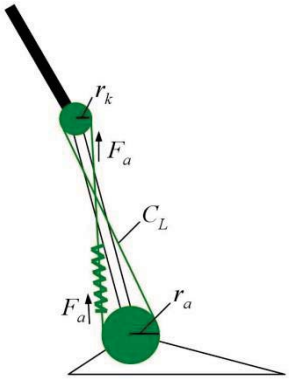
WORKING PRINCIPLE

linkage element

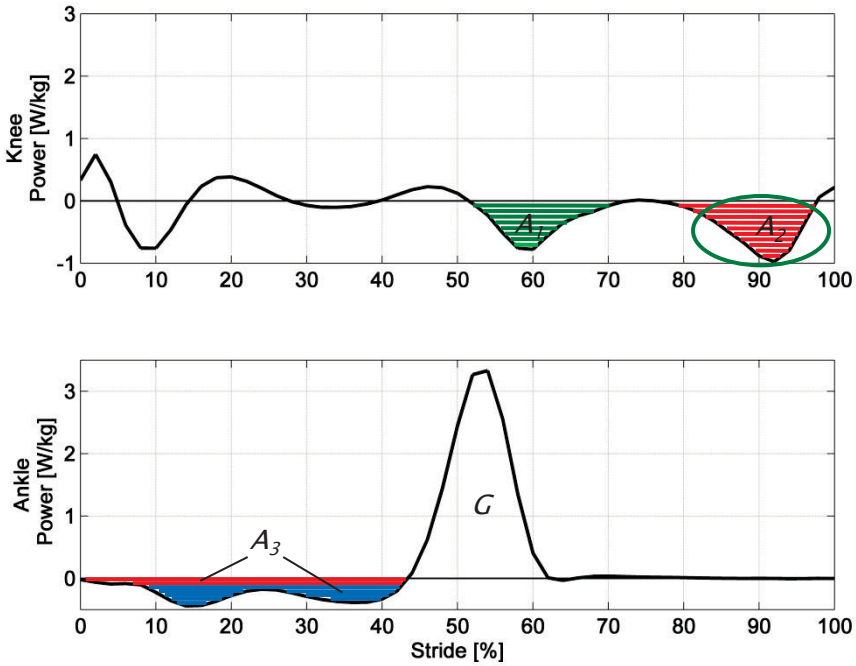


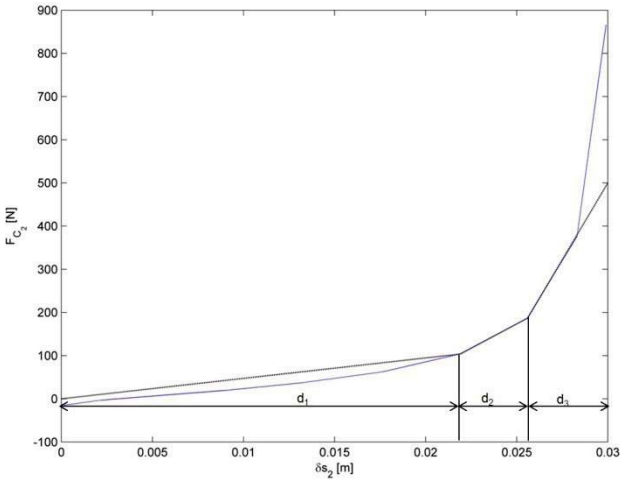




WORKING PRINCIPLE

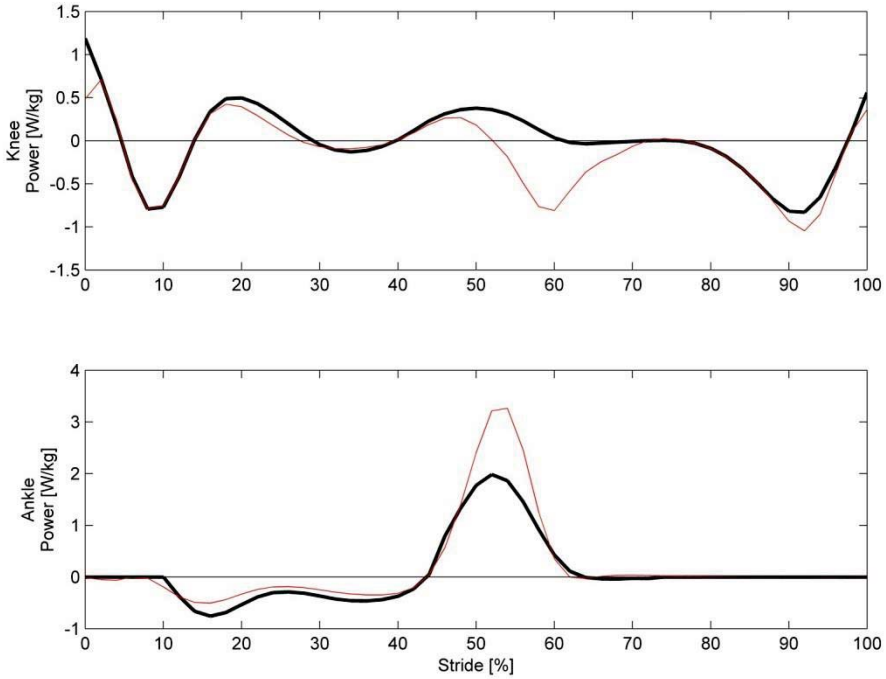
progressive element





SIMULATIONS

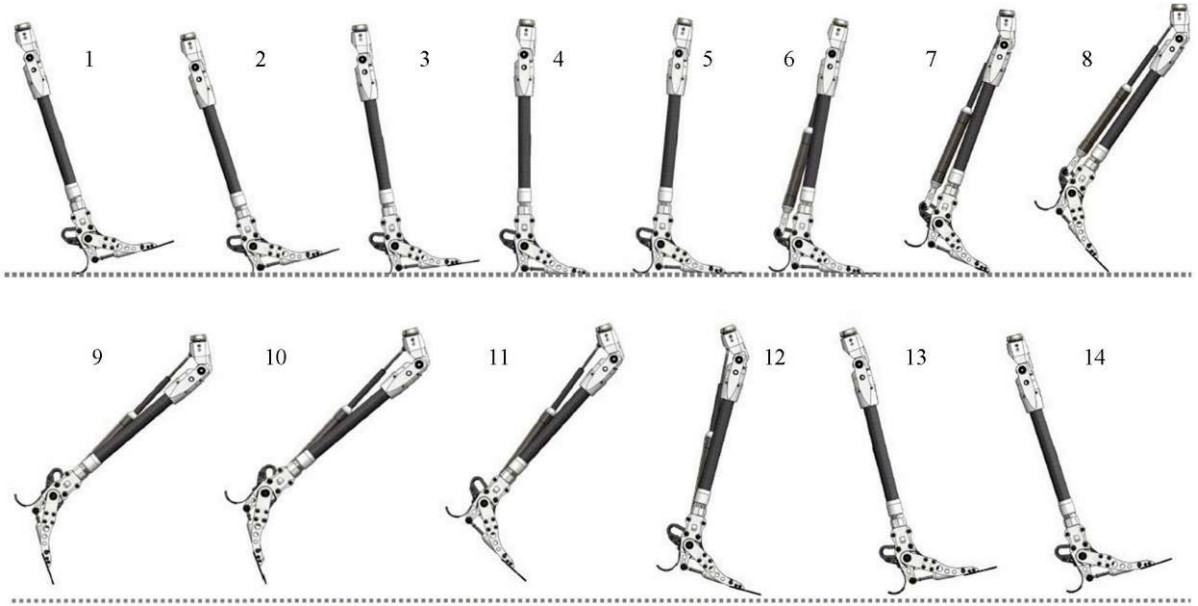
power flow for each joint



76% overall system efficiency

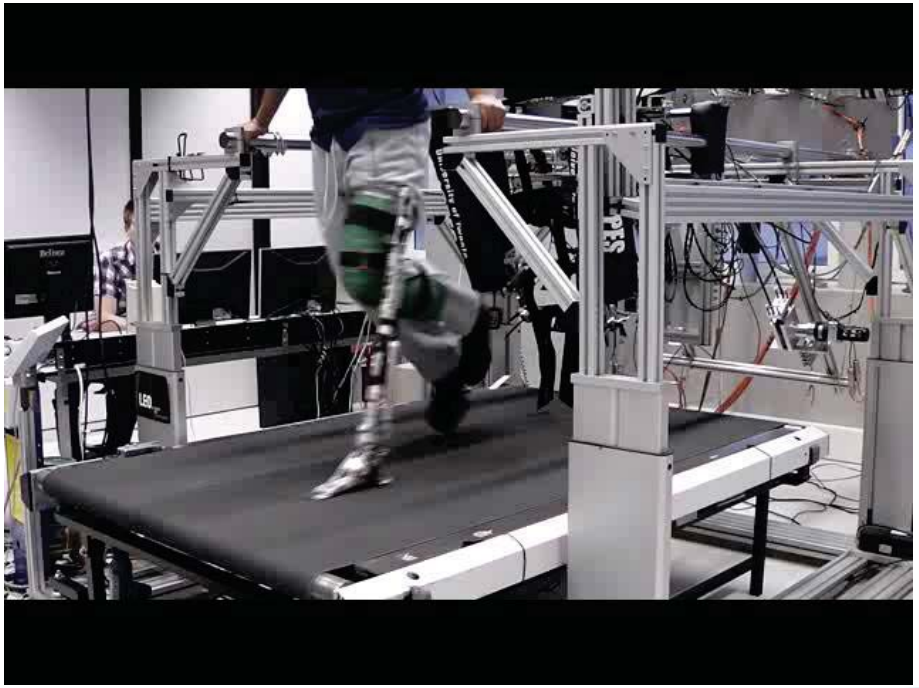
THE REALIZATION

Energy is stored, exchanged and released



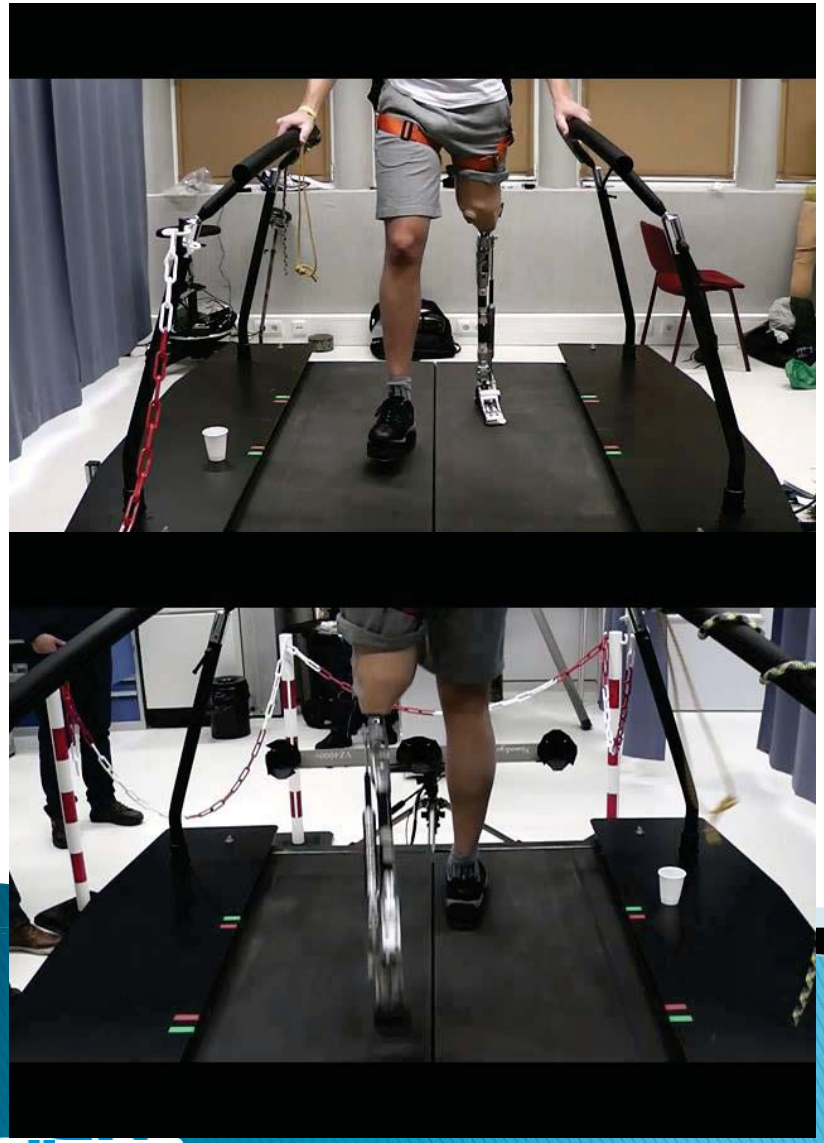
TESTS

healthy subjects



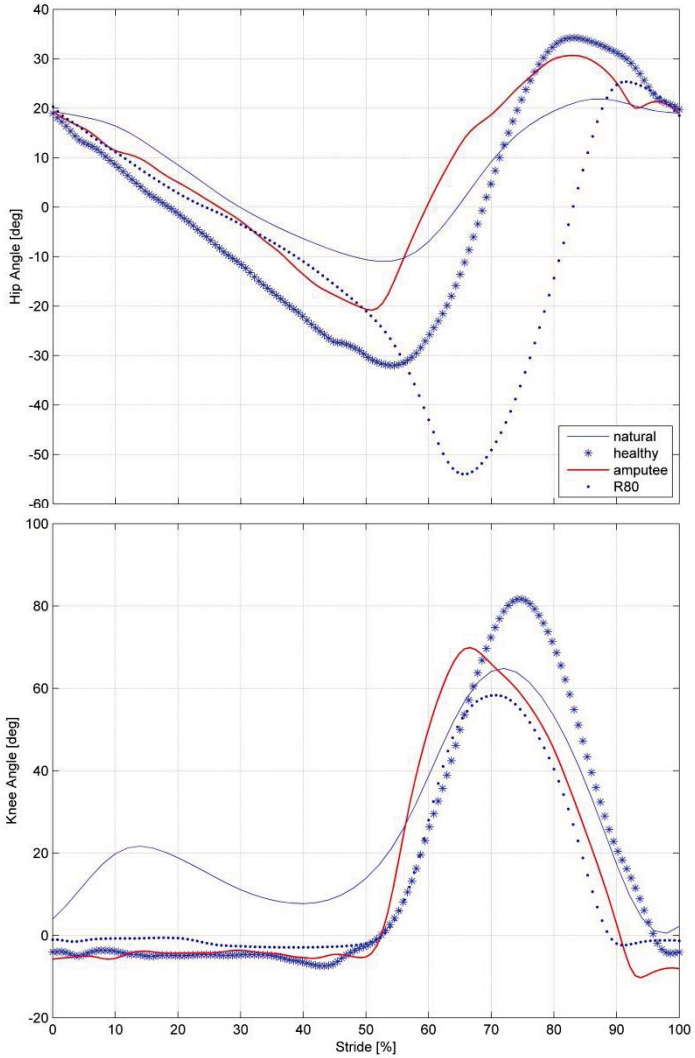
TESTS

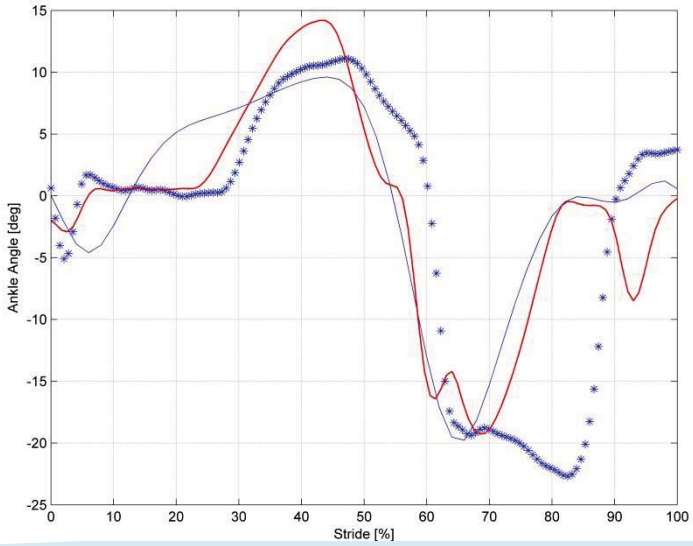
amputee subjects



RESULTS

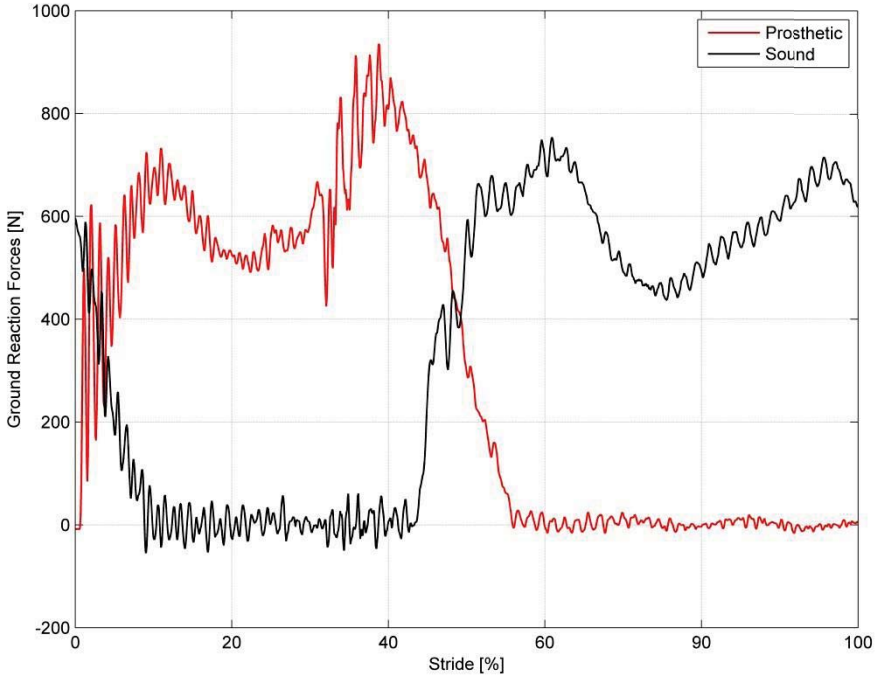
joint angles





RESULTS

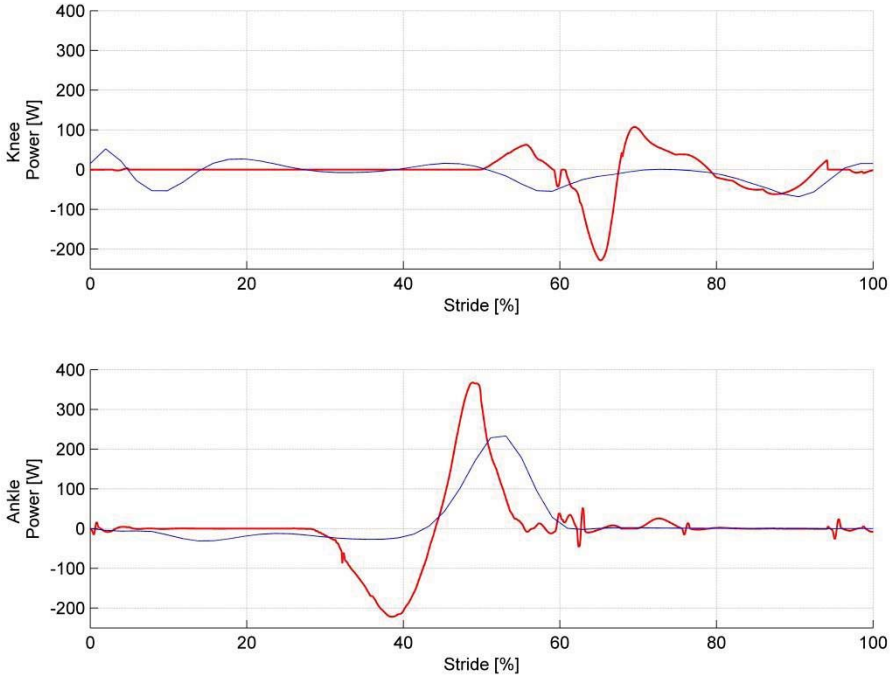
ground reaction forces



symmetric ground reaction force behavior

RESULTS

joint power



Significant ankle push-off generation