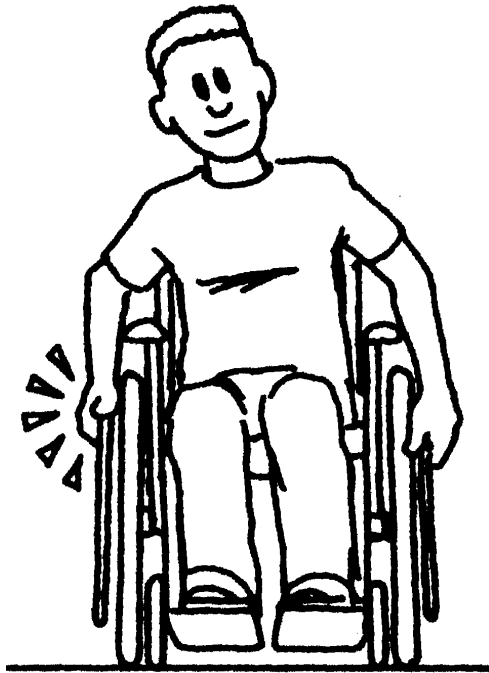
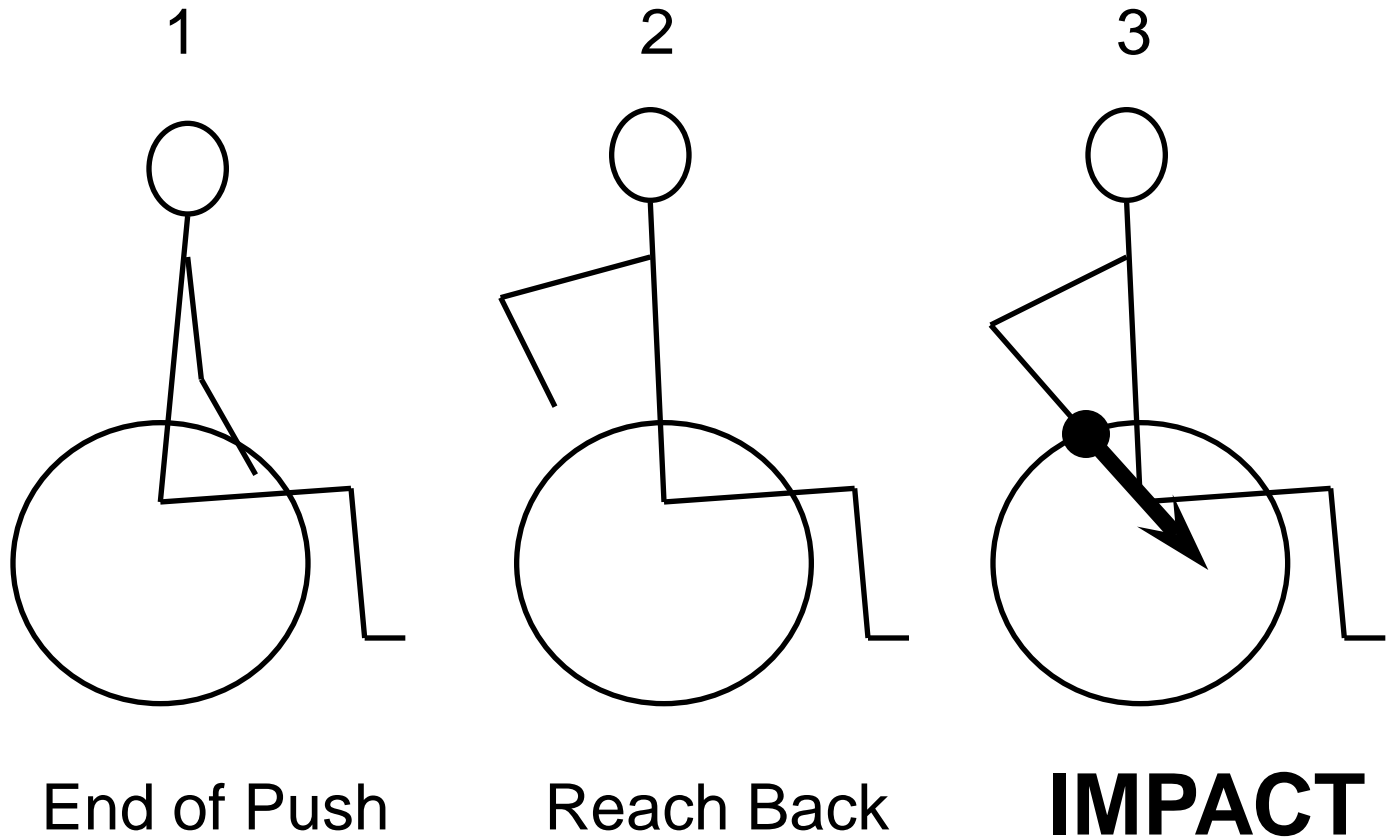


Determination of an Optimal Handrim Compliance

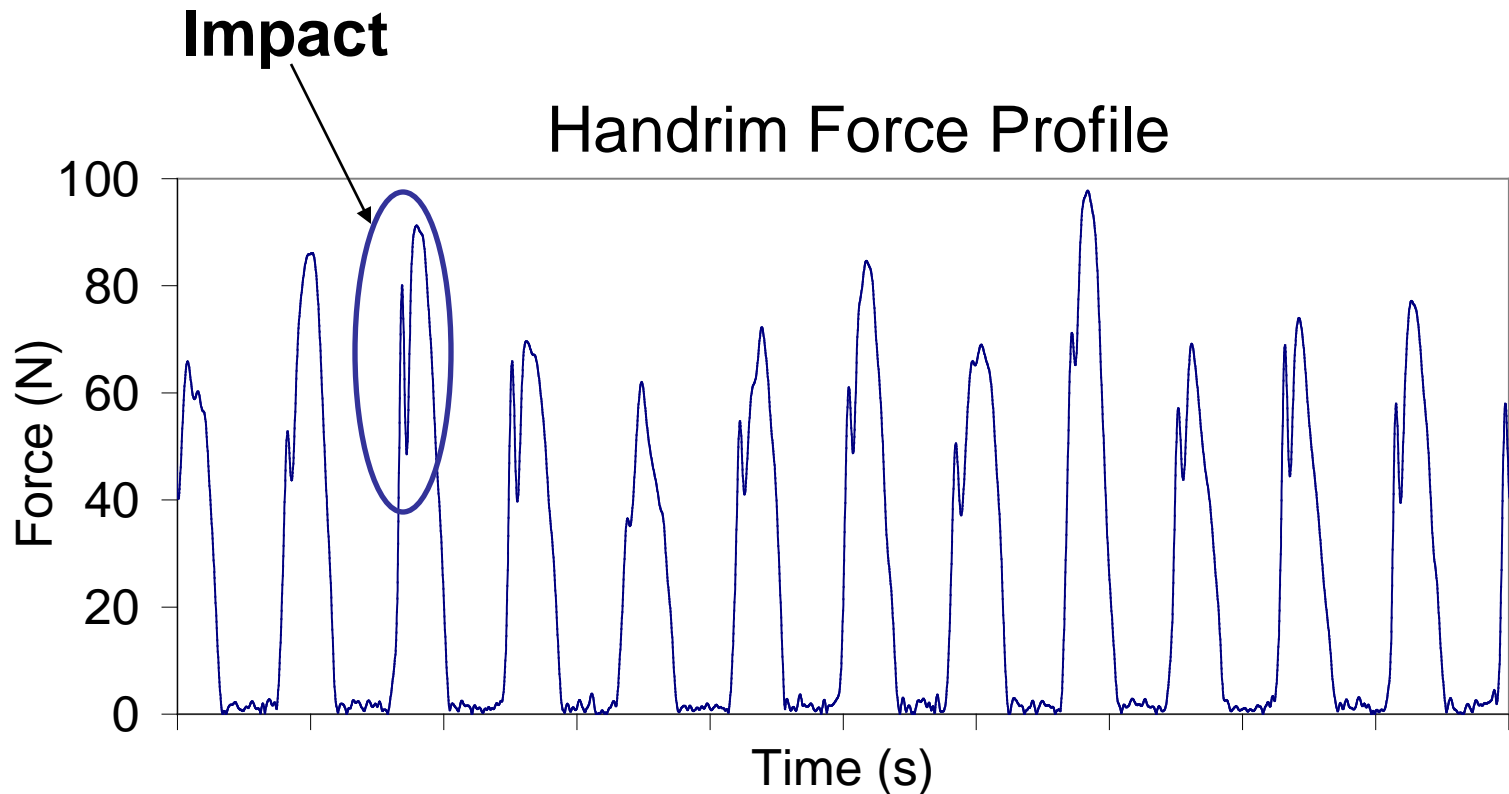


W Mark Richter and Peter W Axelson
Beneficial Designs, BioMobility Lab
Nashville TN, USA

Impact occurs at the beginning of the push

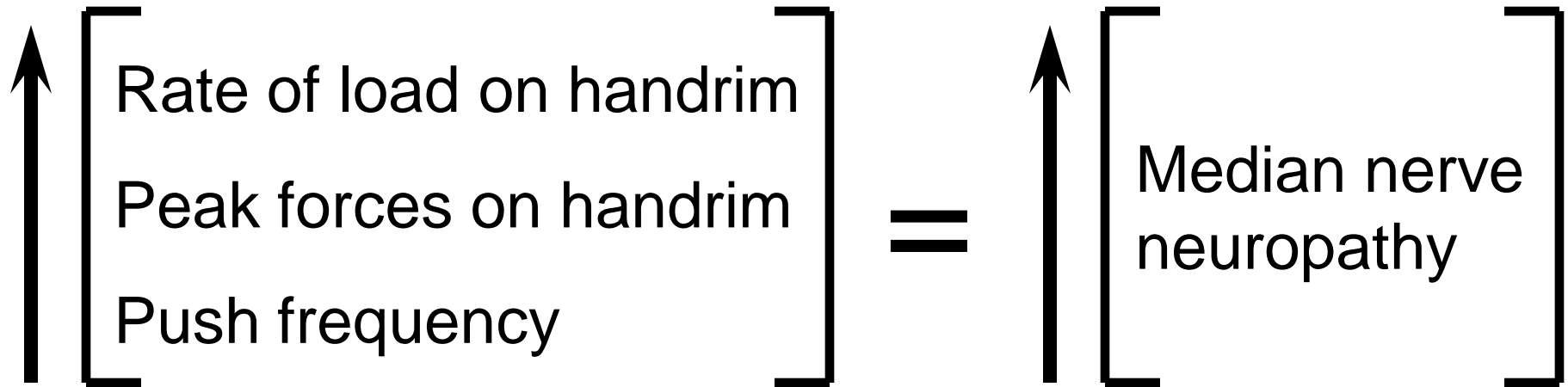


Impact spikes measured at the handrim during propulsion

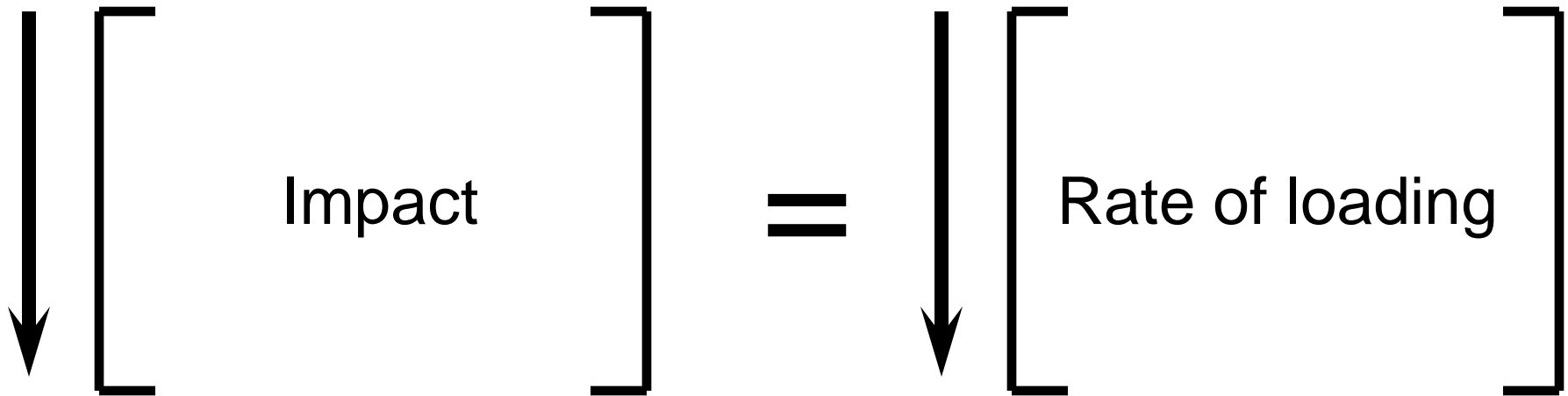


So what?

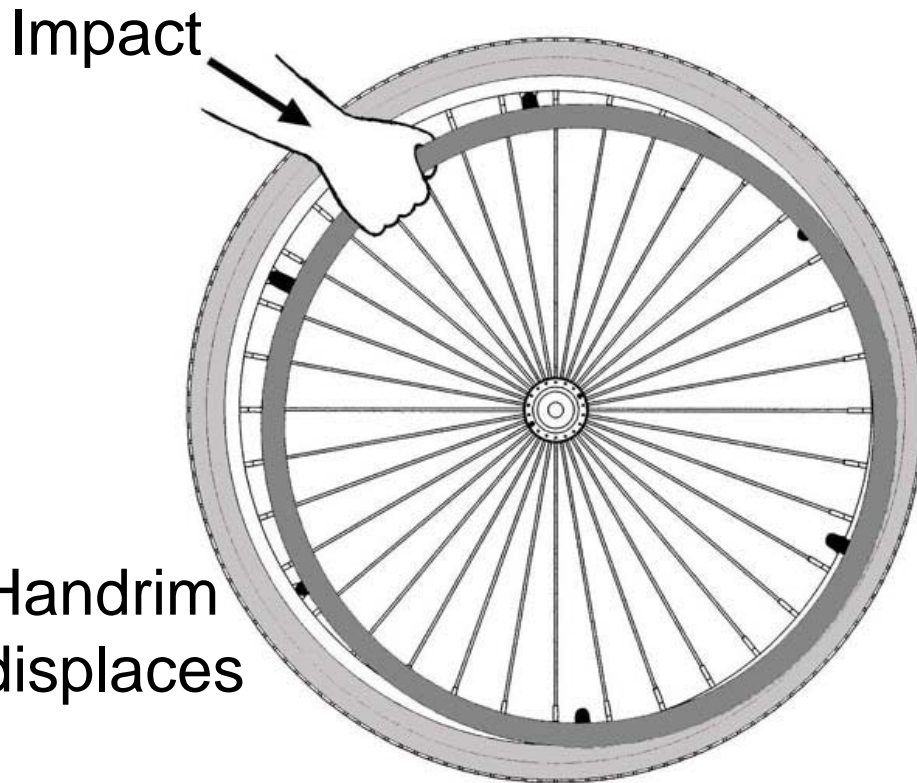
(Boninger et al., 1999)



Since impact results in a rapid rate of loading,

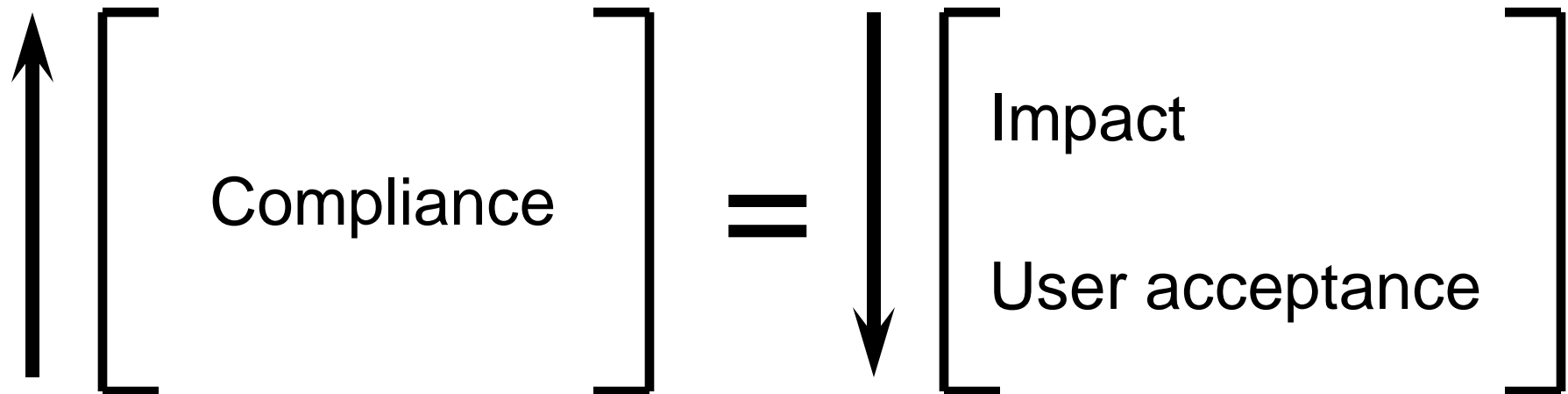


A compliant handrim can be used to reduce impact loading



Compliance
= (Spring constant)⁻¹
= Displacement / Force

We know from pilot studies that,



Therefore, need to optimize compliance such that,

- Impact is reduced
- User acceptance is preserved



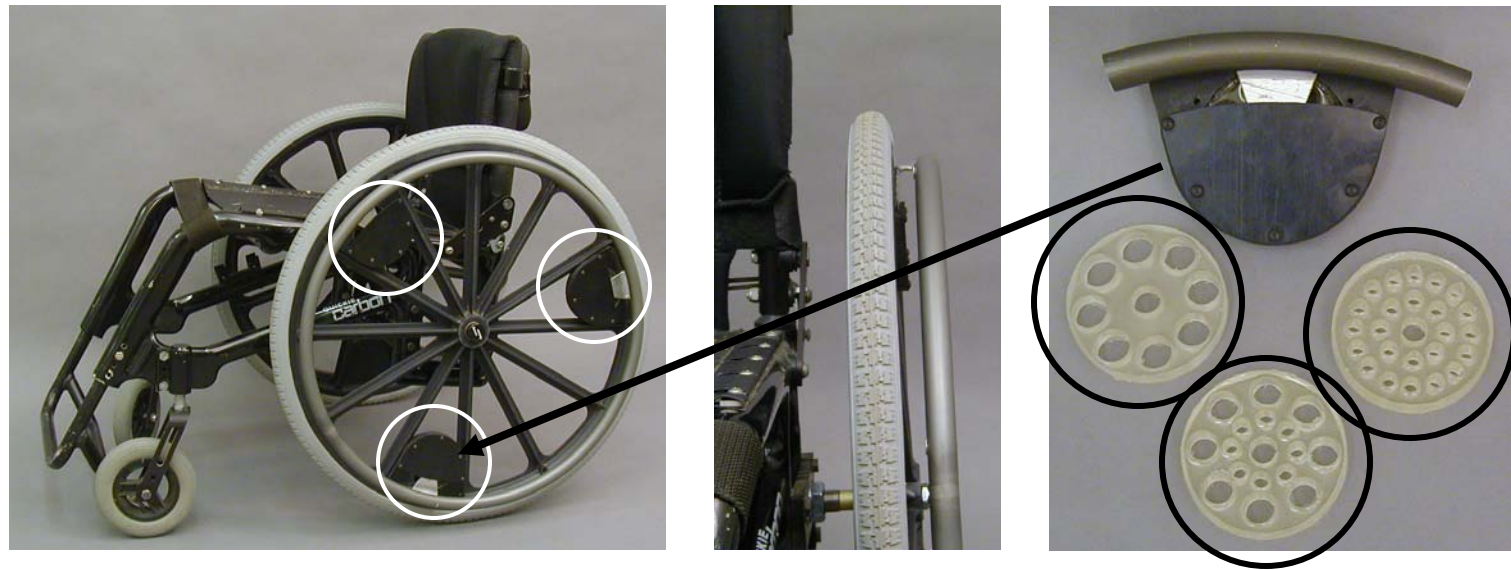
What we also know that,

Translational compliance is good for impact attenuation (Richter, 2000)

Rotational compliance may be good for preserving propulsion efficiency (Richter, 2001)

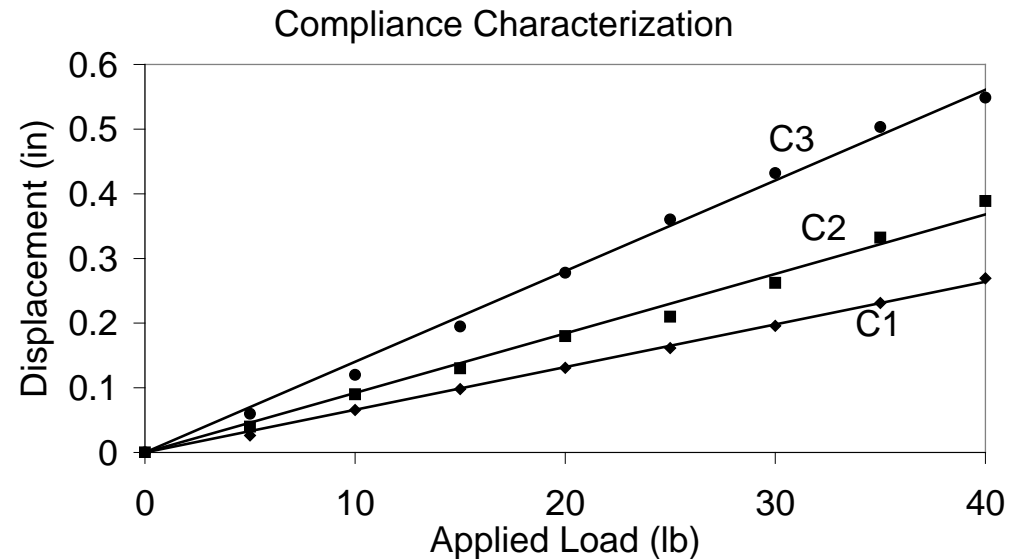
Use of an ***isotropic compliance*** would allow the benefits of both translational and rotational compliance to be utilized.

Compliance optimization



The Variable Compliance Handrim Prototype (VCHP)

3 levels of linear compliance developed and characterized



How to measure propulsion outcomes

The **VCHP** wheel mounts are inside the plane of the wheel

Commercially available **SMART^{Wheel}** would not accommodate the VHRP

Developed a specialized instrumented wheel specifically for this optimization study

Based on a 6 DOF load cell

“Propulsiometer”

VCHP



Load cell

Treadmill is a controlled and realistic propulsion environment



Propulsion velocity and grade are controlled



Optimization study

- 1) Compliance tolerance – How soft is too soft?
- 2) Propulsion performance – How soft is soft enough?

Compliance tolerance testing setup – 7 typical activities



Was that too soft?



Propulsion performance setup – BD BioMobility Lab

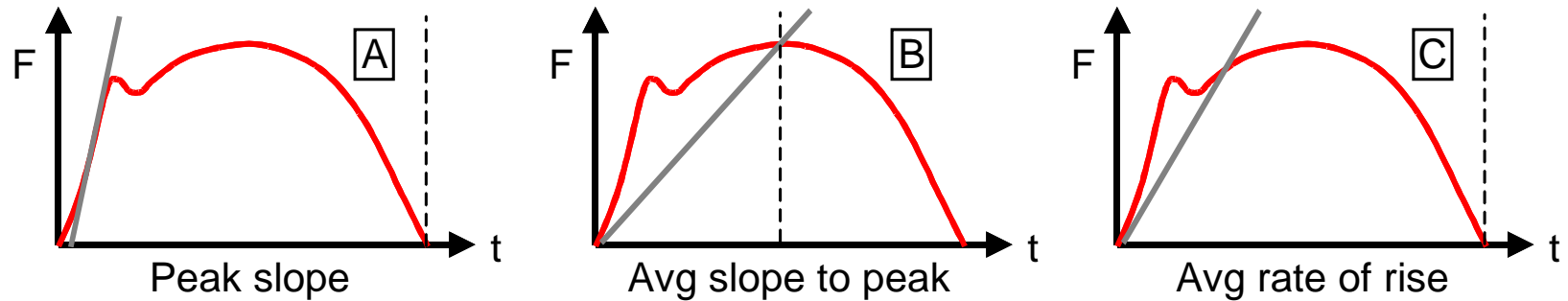
How soft is soft enough?

8% grade @ 0.22 m/s

2% grade @ 0.94 m/s



Analysis – new metric introduced to quantify impact



A - Peak rate of rise of the force commonly used but does not necessarily imply impact has occurred (pROR)

B – Average slope option is path independent, so can not capture impact characteristics

C - Average rate of rise of the force captures impact characteristics (aROR)

Results – subjects

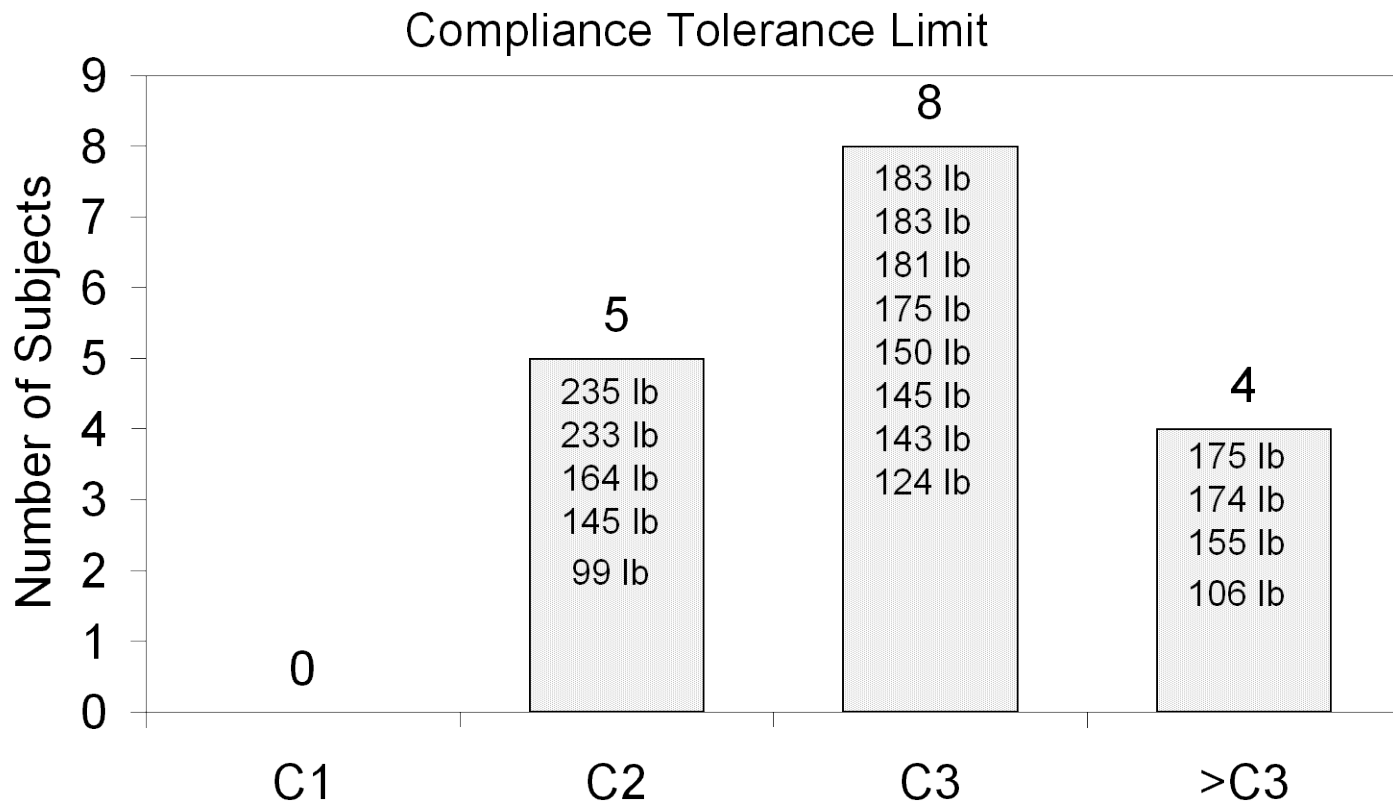
N: 17 subjects (10 male, 7 female)
(16 SCI, 1 spina bifida)

Age: 37 yrs (sd=12)

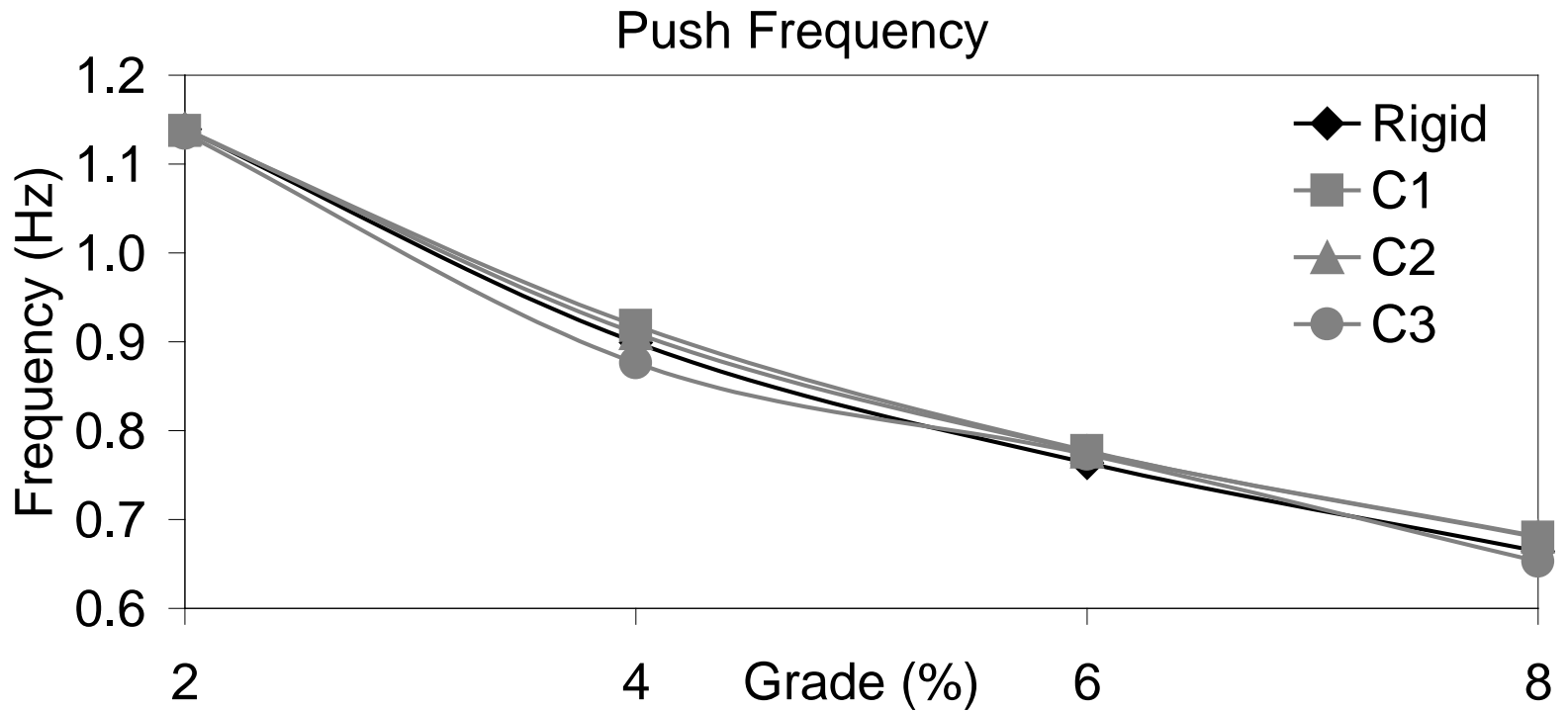
WC use: 14 yrs (sd=10)

Weight: 76 kg (sd=17)

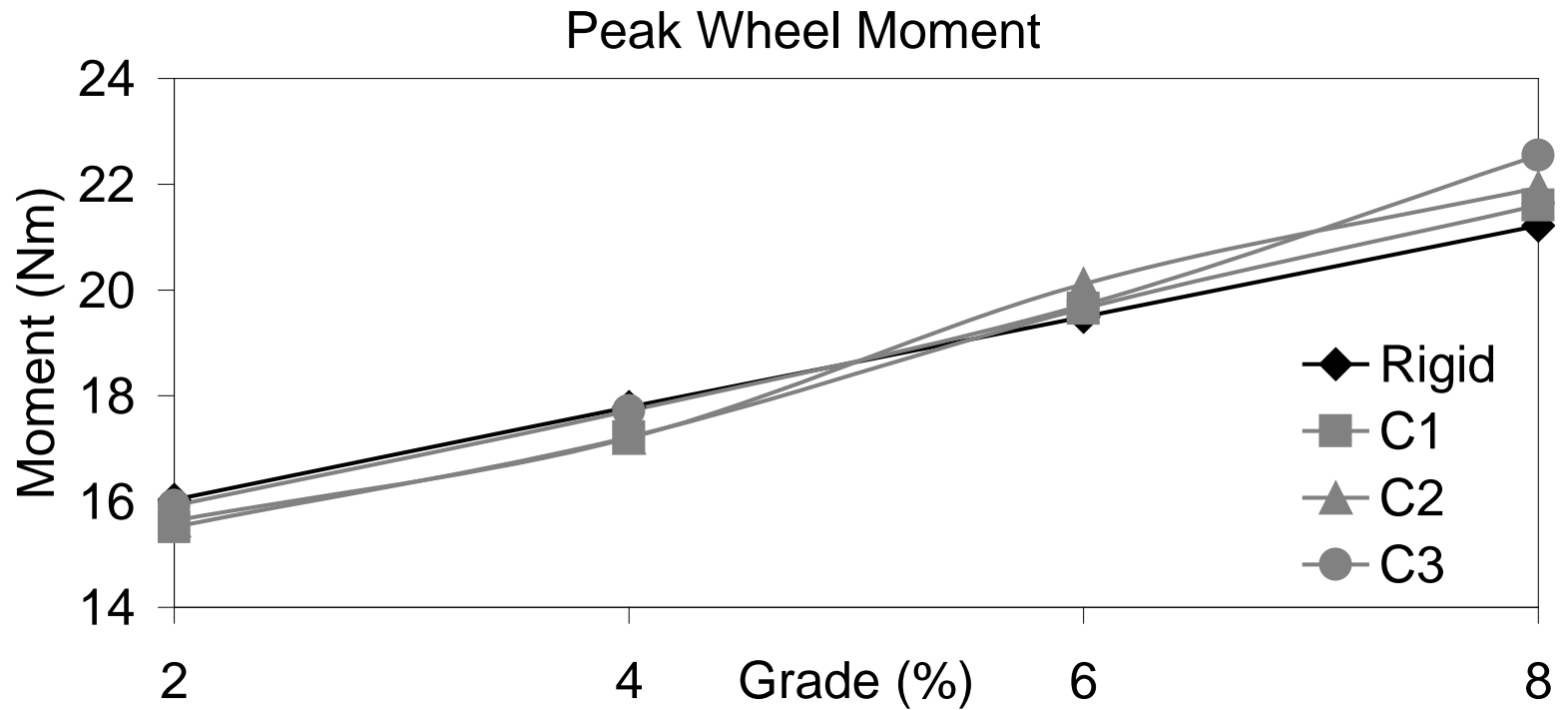
Compliance acceptance



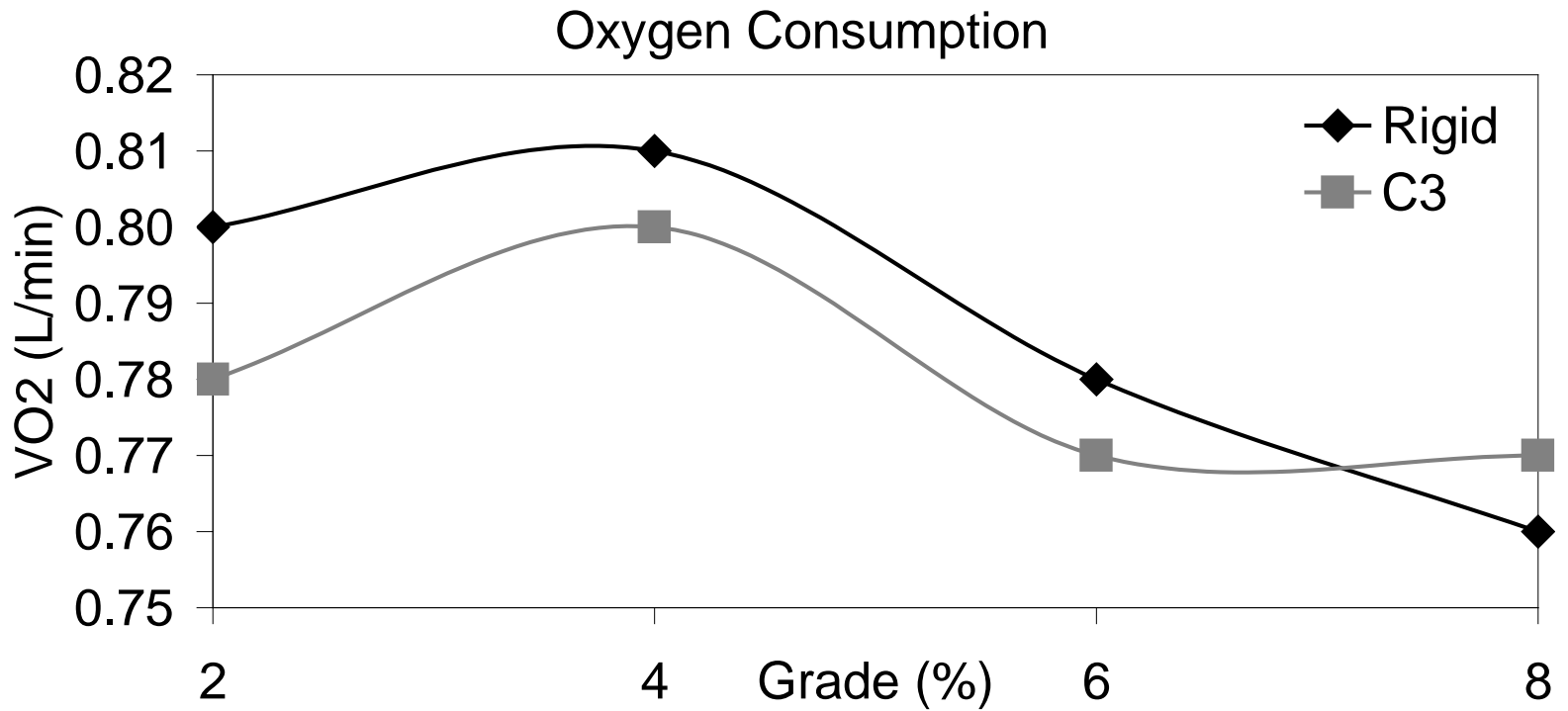
Push frequency



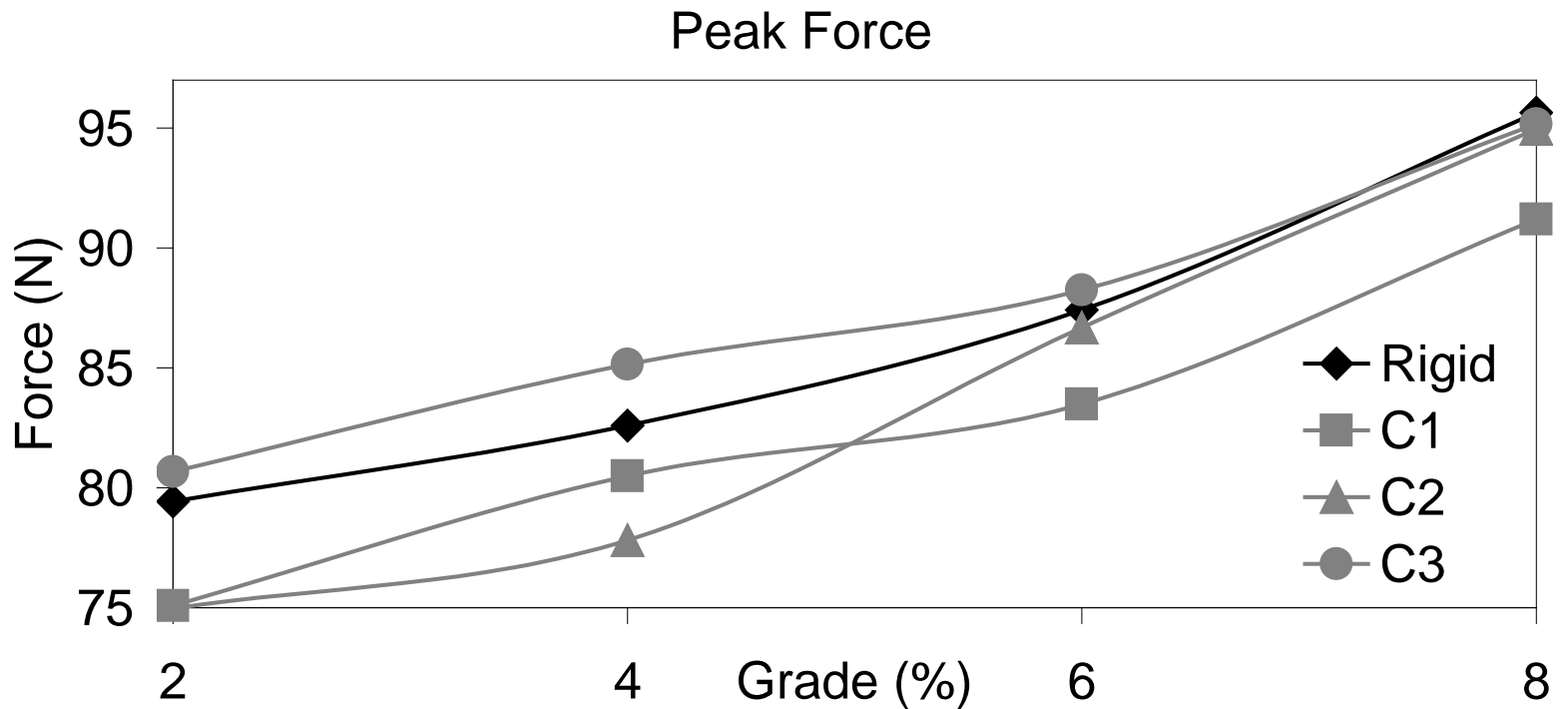
Peak wheel moment



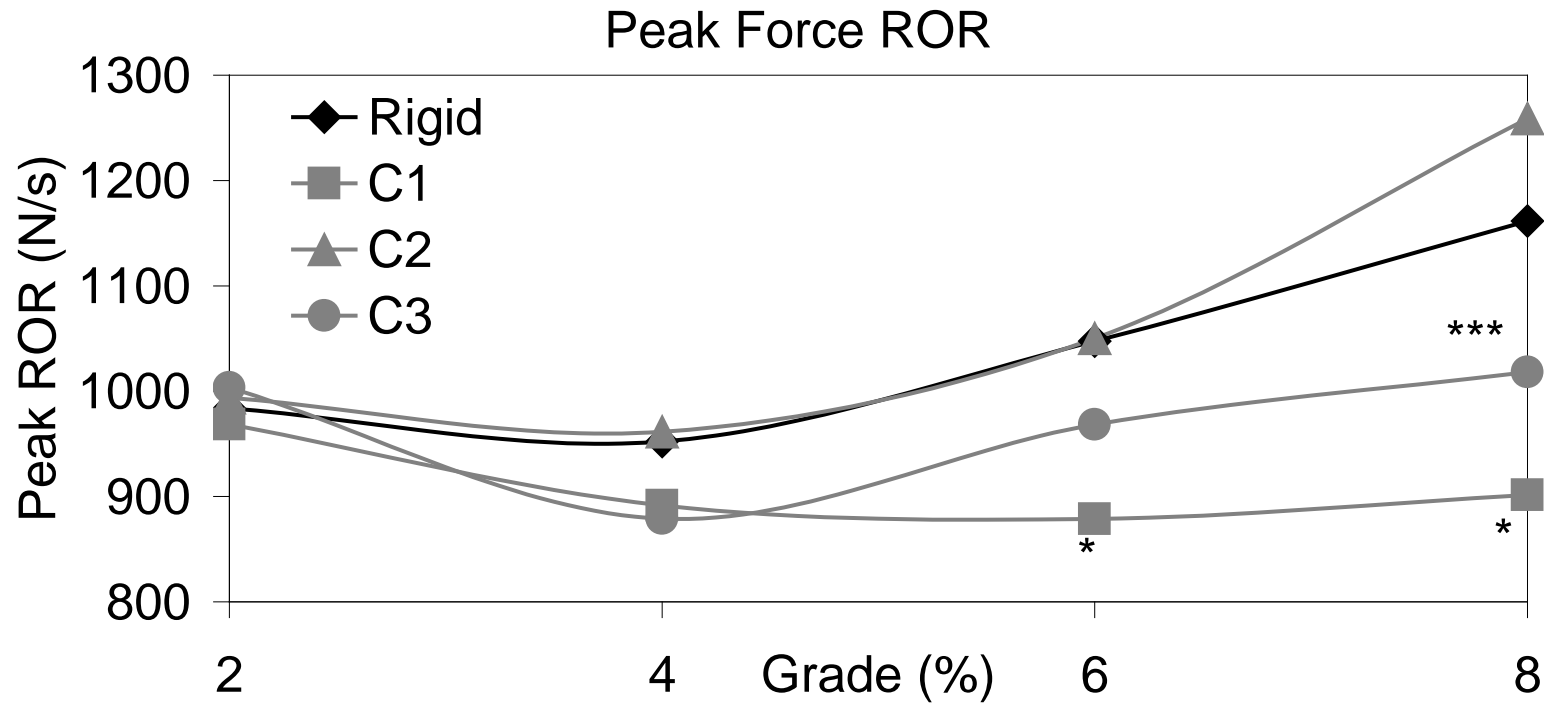
Oxygen consumption



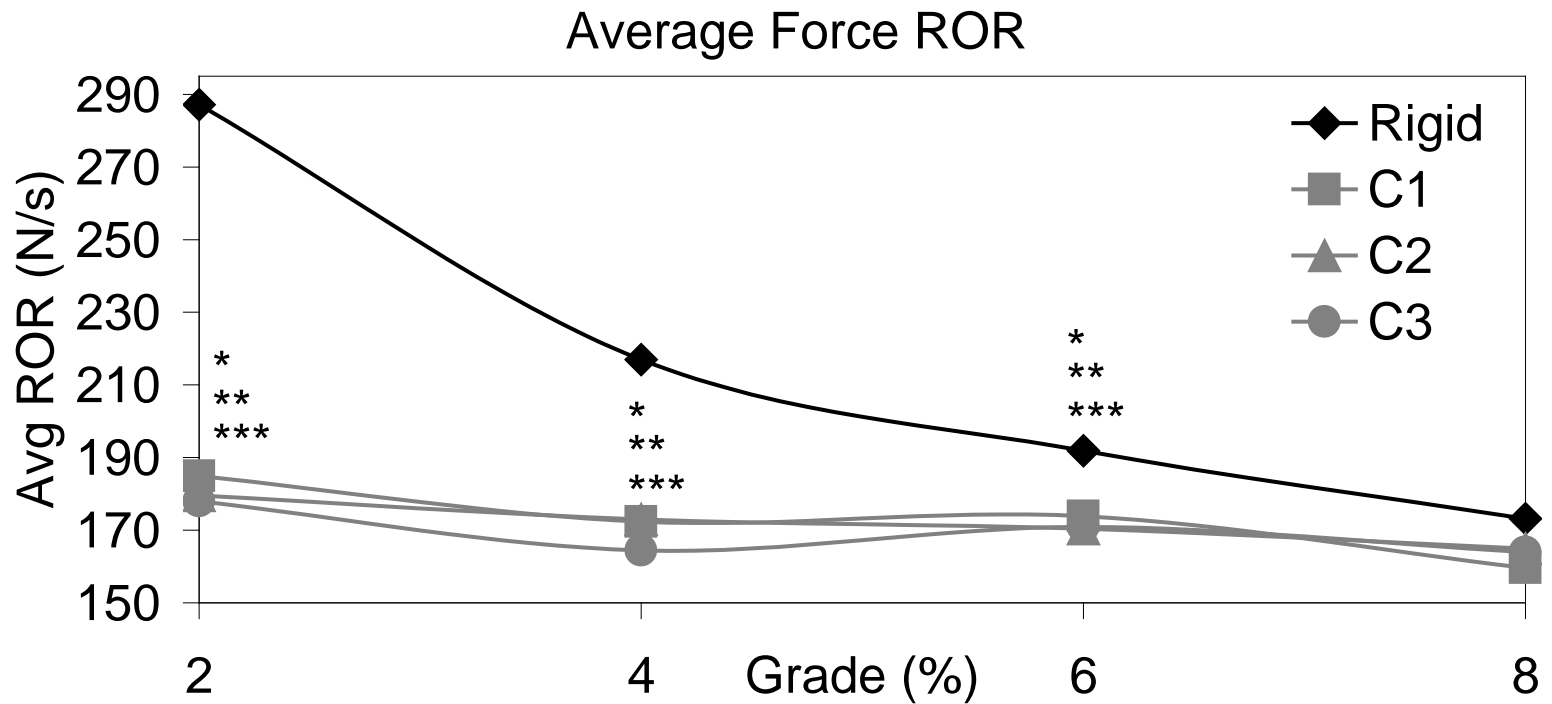
Peak force

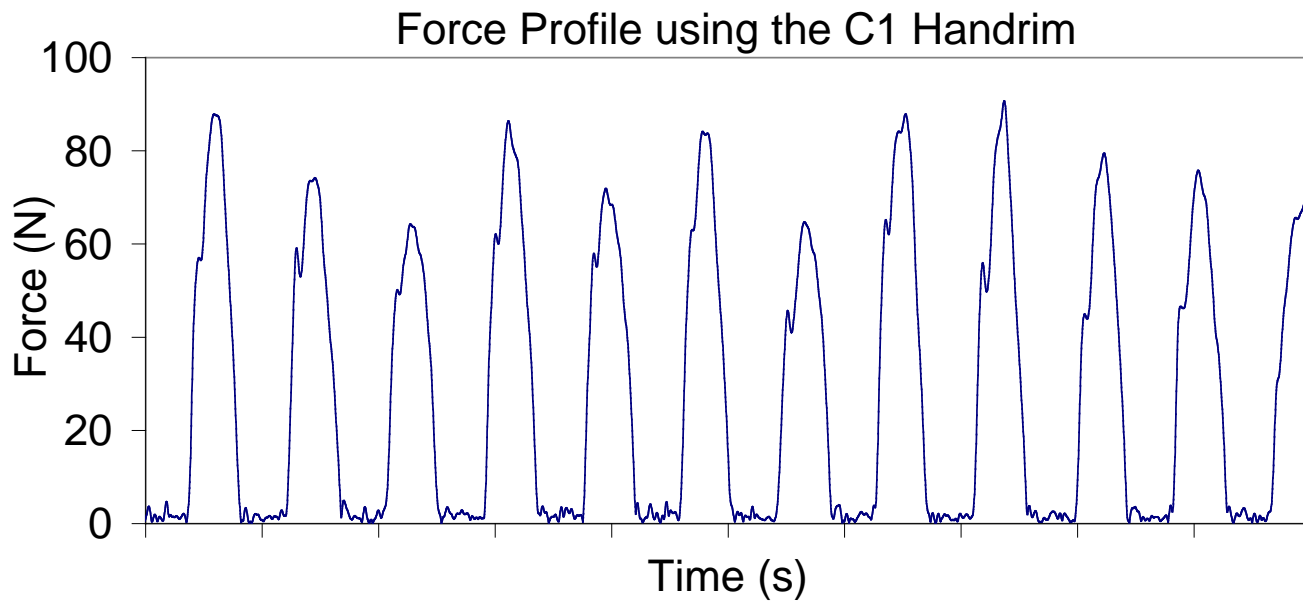
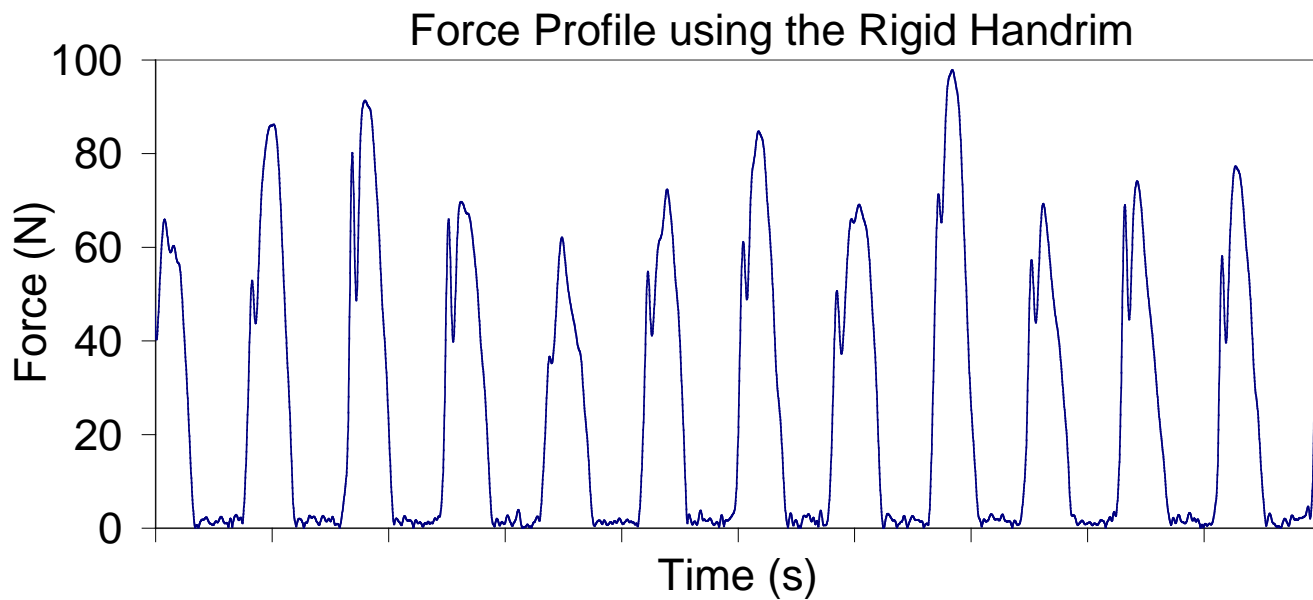


Peak rate of rise of the force



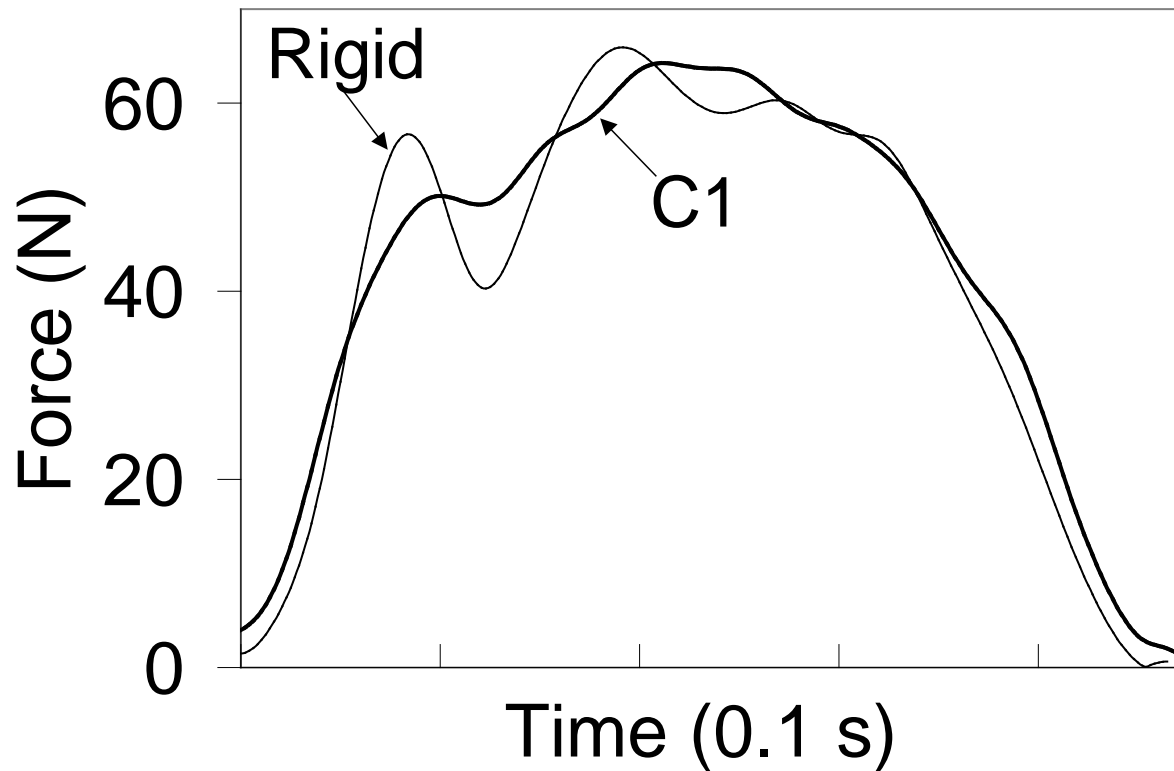
Average rate of rise of the force





Compliant handrim attenuates the impact

Profile Comparison





Study conclusions

Impact can be attenuated with minimal compliance, while user acceptance is preserved

There are no adverse 'side effects' from minimal handrim compliance



Current and future directions

Compliant mechanism was adapted to a standard wheel design to maximize availability and use

“FlexRim” ergonomic wheelchair wheel should be commercially available in the next year



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NIH SBIR Phase II Grant #2 R44 HD36533-02A2

Northern Michigan University for donating the treadmill

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