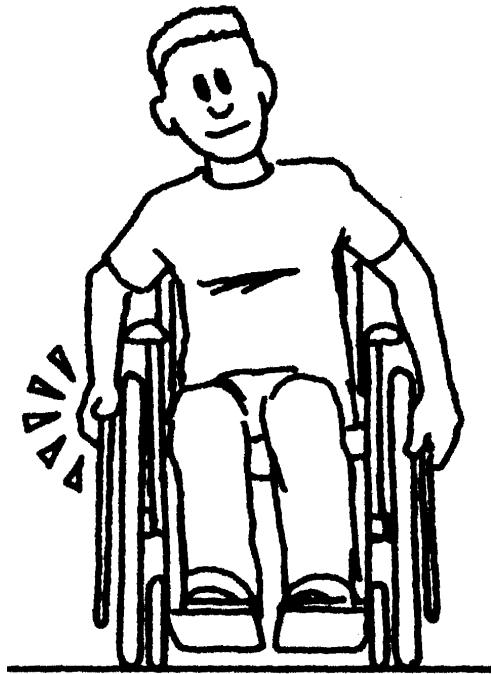


Vinyl-coated handrim biomechanics:

Balancing the ergonomic pros and cons



W Mark Richter, Russell Rodriguez,
Kevin R Woods and Peter W Axelson

Beneficial Designs, BioMobility Lab
Nashville TN, USA

Vinyl-coated handrim



Vinyl-Coating: *Pros*

Peak forces on the handrim were reduced by 10% during propulsion (Koontz, 1998)

Pushing on rollers that simulated a level surface, did not test on hills

Energy demand was reduced for pushing on a multi-grade treadmill (Richter, 2004)

Averaged over 2%, 4%, 6% and 8% grades

9% Reduction in oxygen consumption

Vinyl-Coating: *Cons*

Ahhhh, that ***BURNS!***

Braking can quickly burn the hands

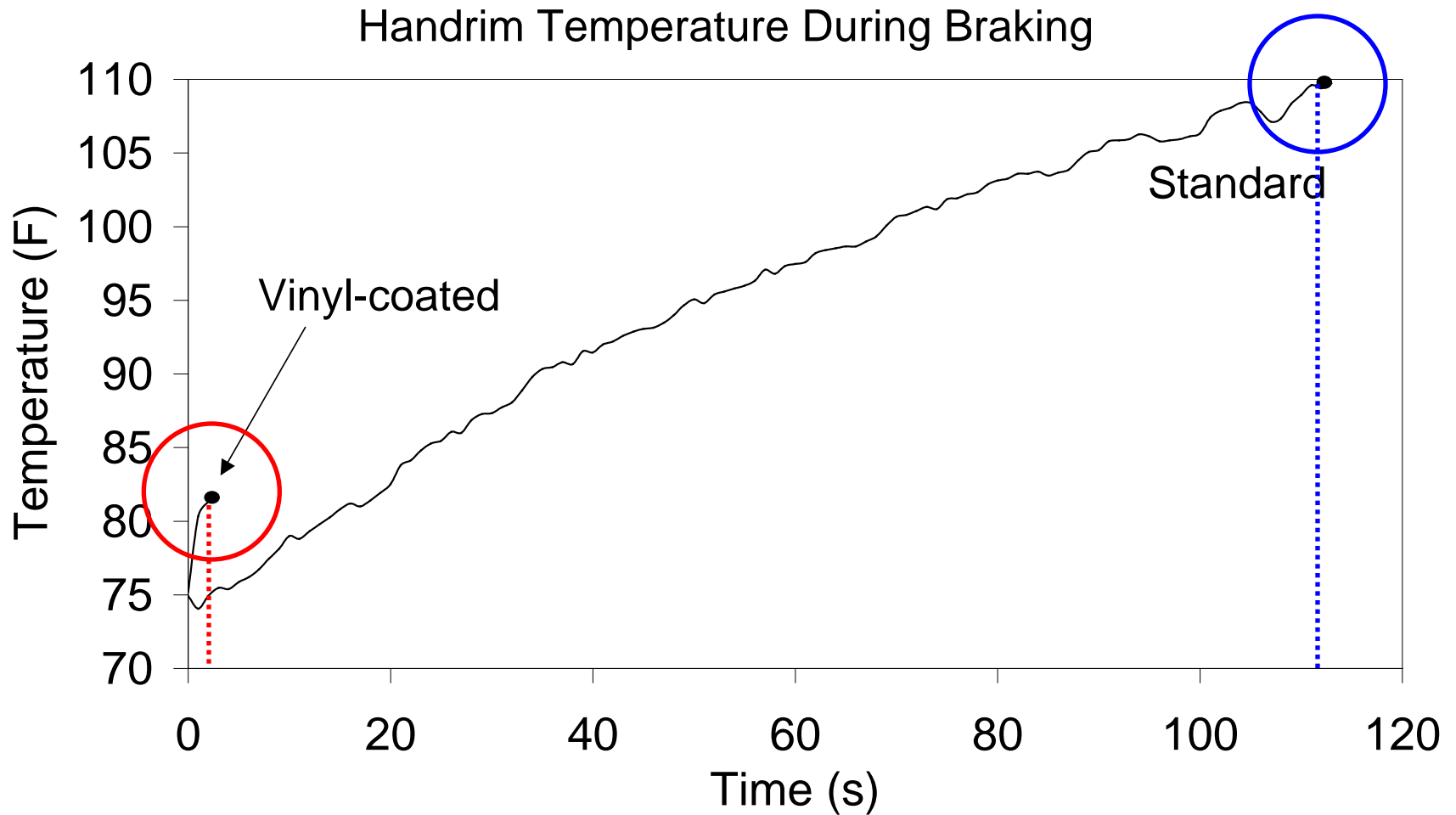
Like rubbing hands together, heat is generated as the handrim slides through the hands

Aluminum is a heat conductor

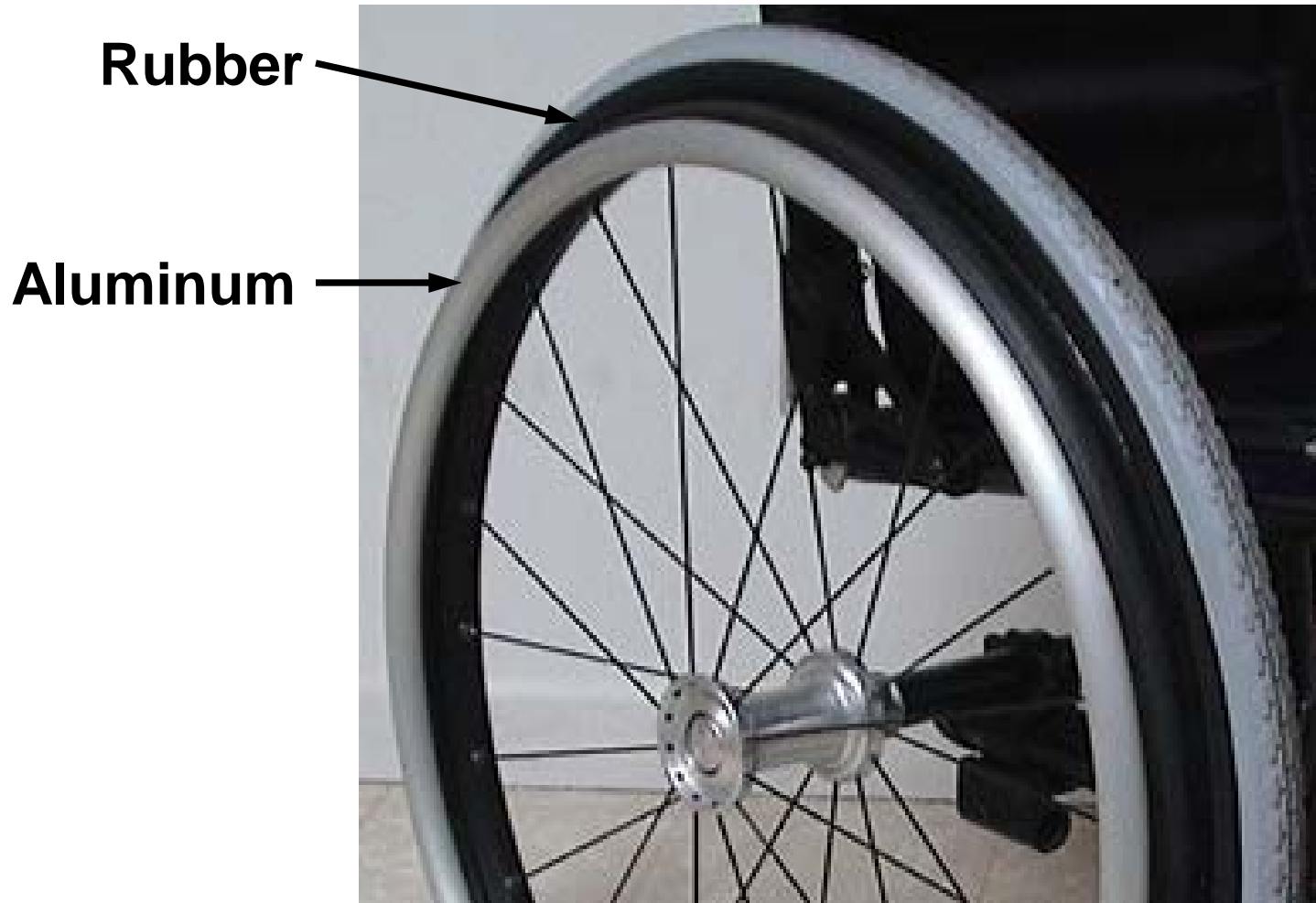
Vinyl is a heat insulator

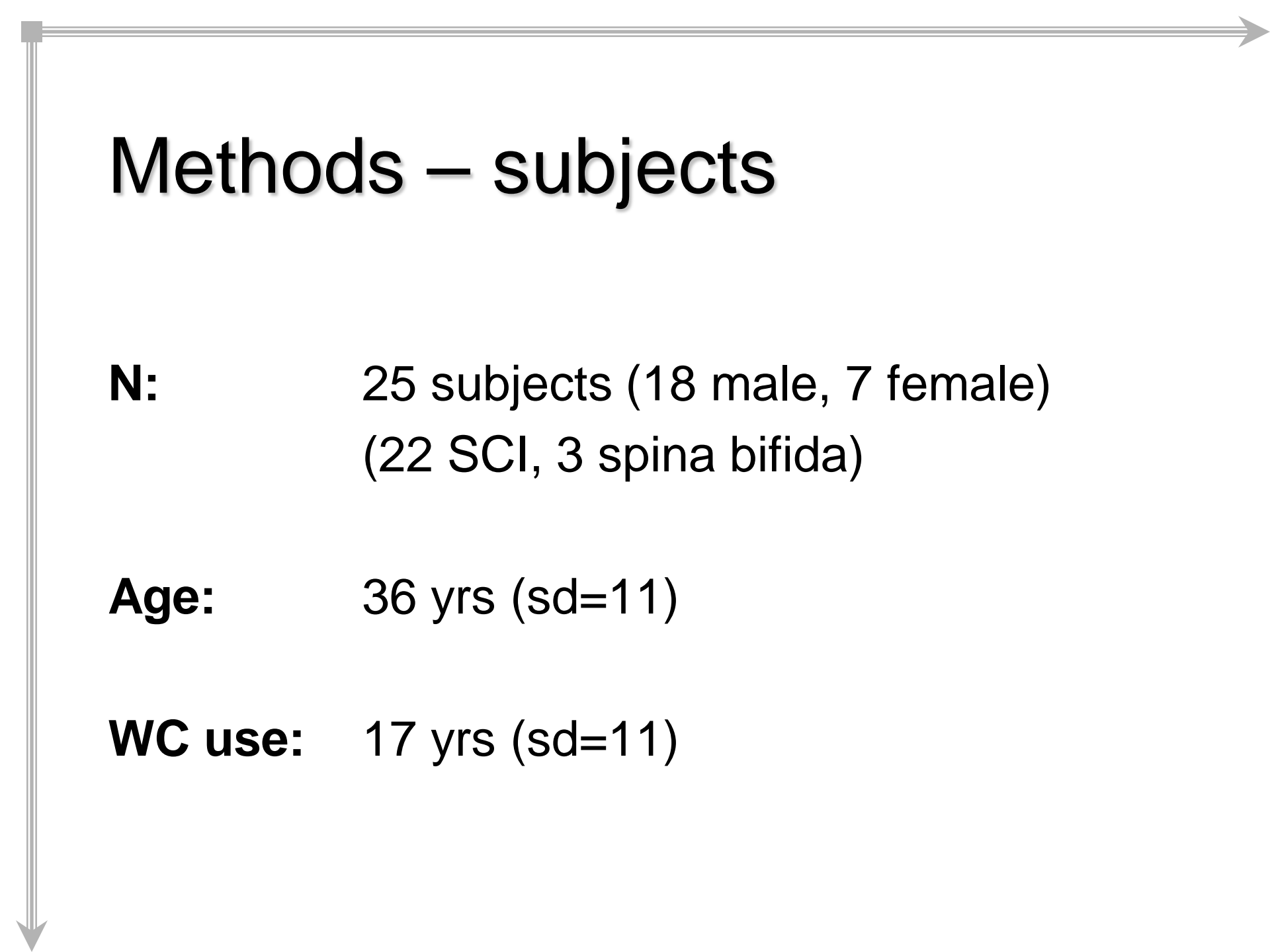
Average braking tolerance was found to be reduced from 103s with a standard handrim to only 9s with vinyl-coating (Richter, 2004)

Braking tolerance



New ergonomic handdrims





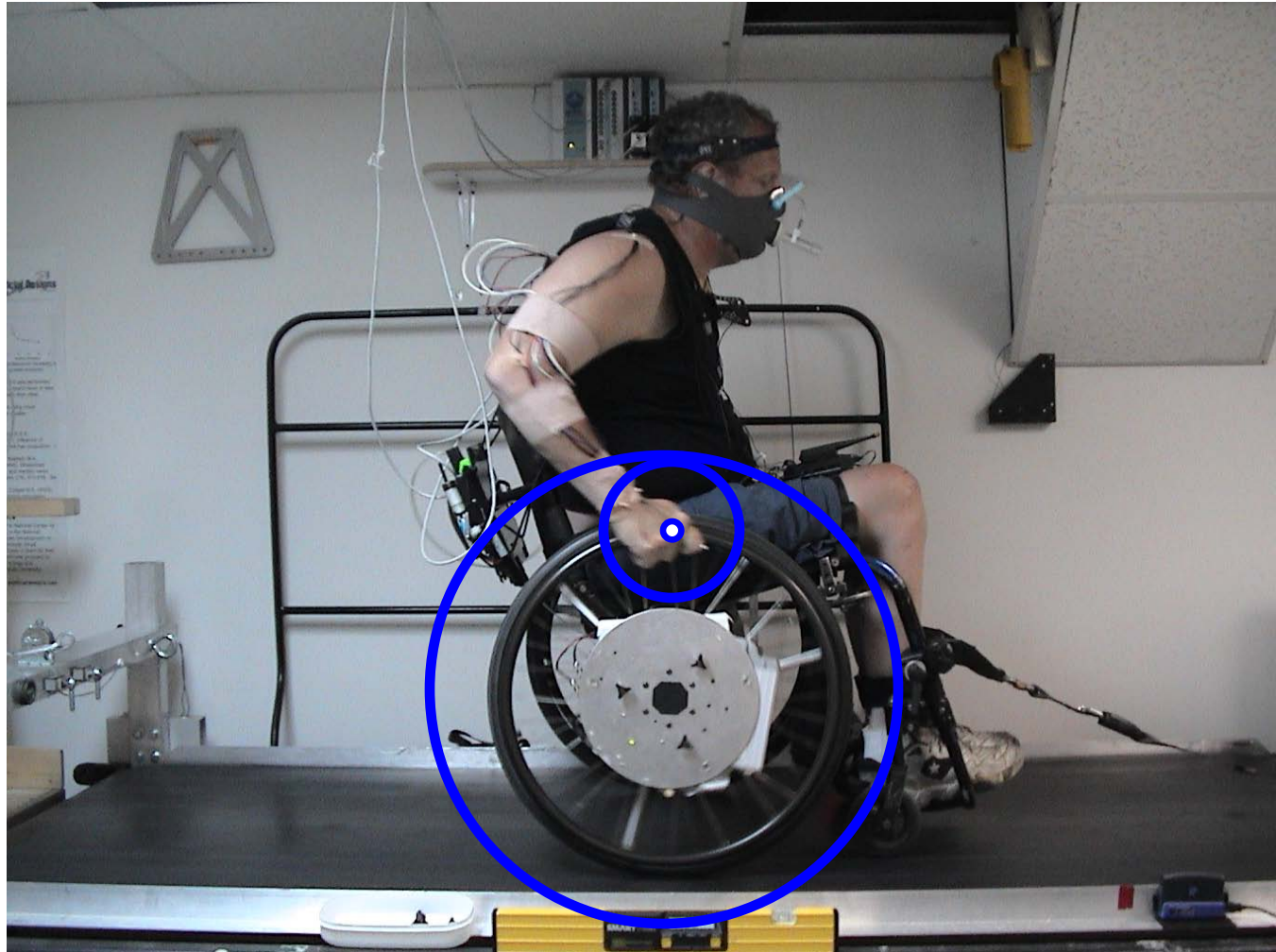
Methods – subjects

N: 25 subjects (18 male, 7 female)
(22 SCI, 3 spina bifida)

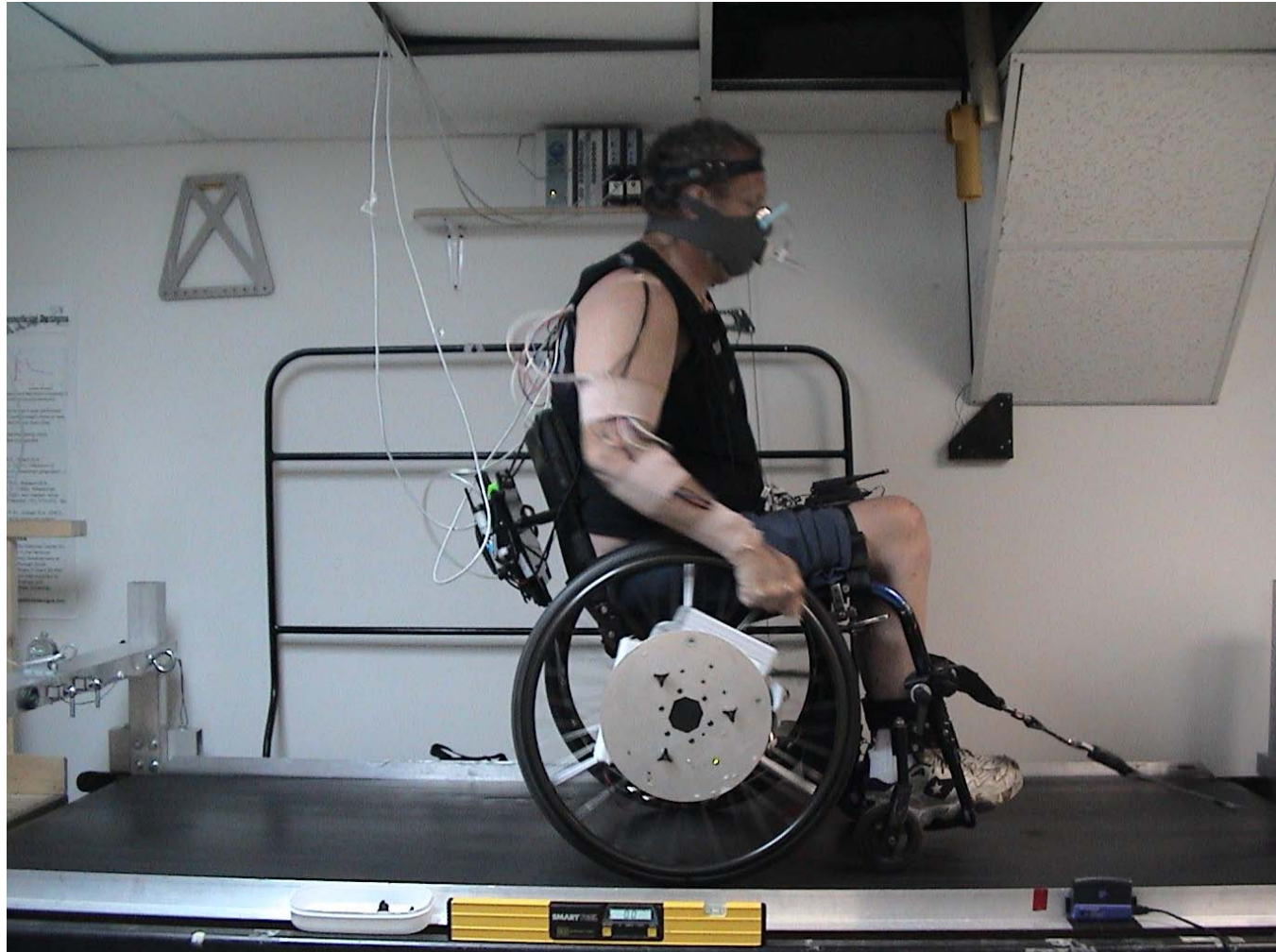
Age: 36 yrs (sd=11)

WC use: 17 yrs (sd=11)

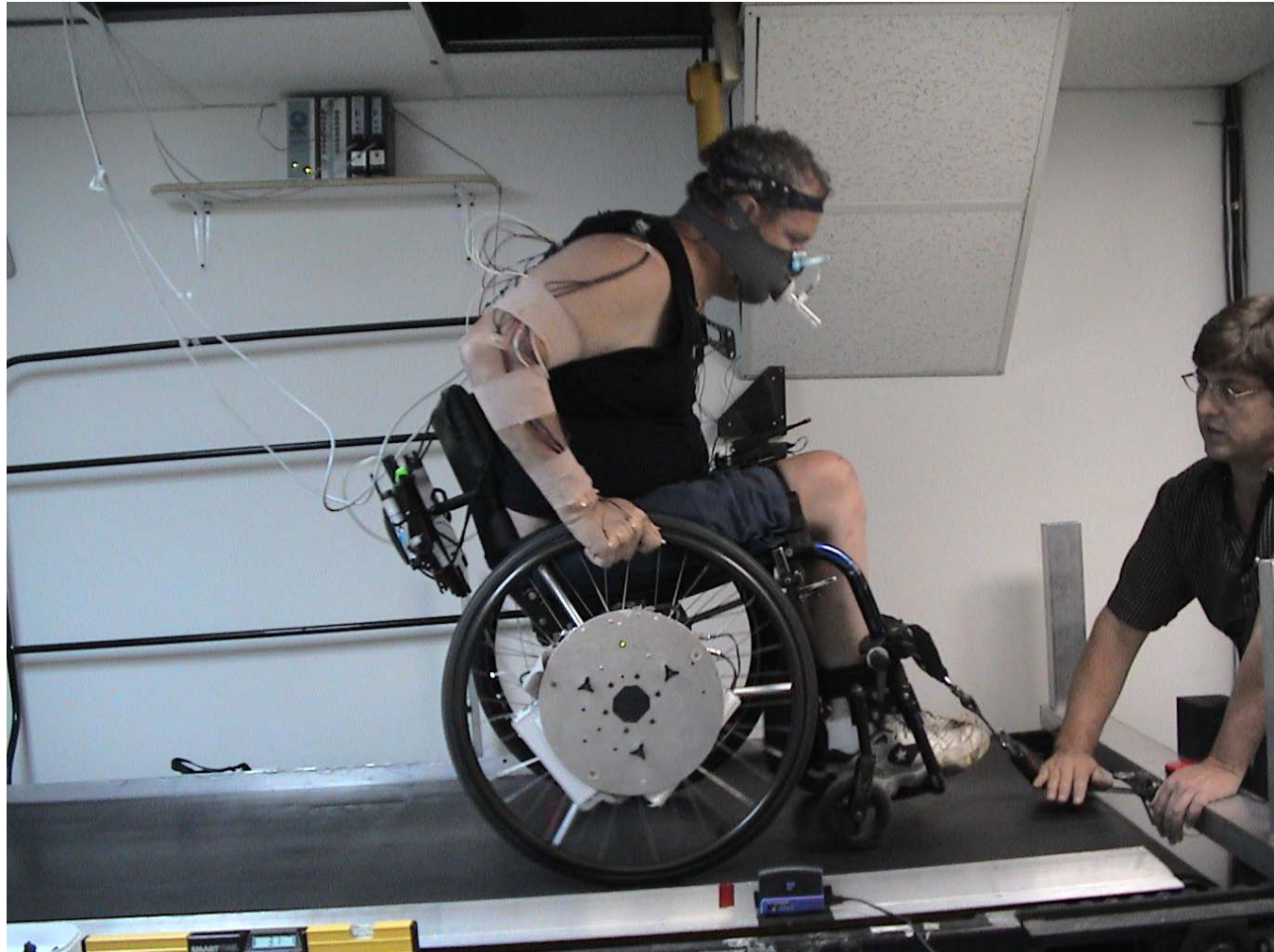
Methods: instrumentation



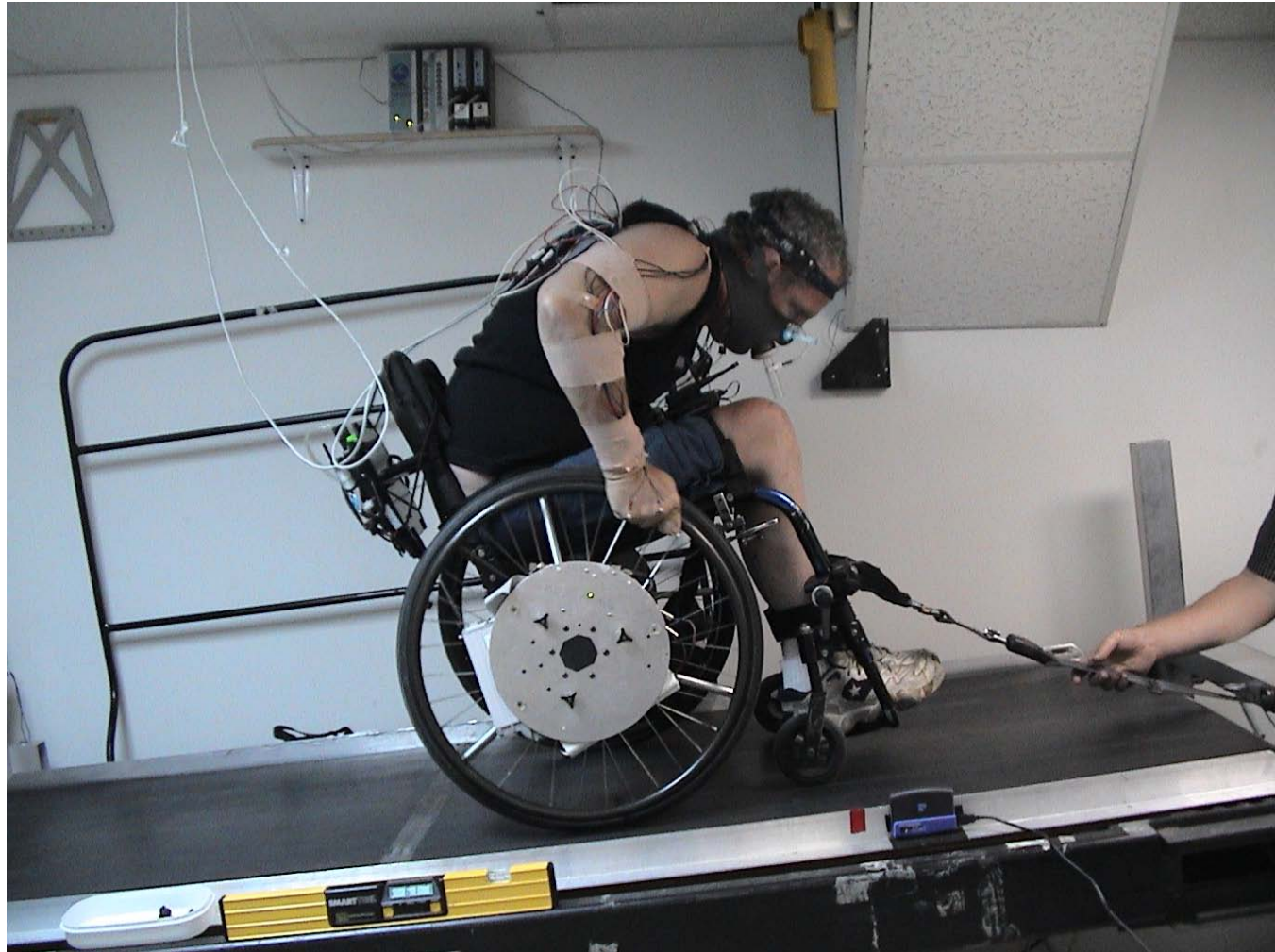
Methods: level propulsion



Methods: 3-degree grade



Methods: 6-degree grade



Methods: handrim testing

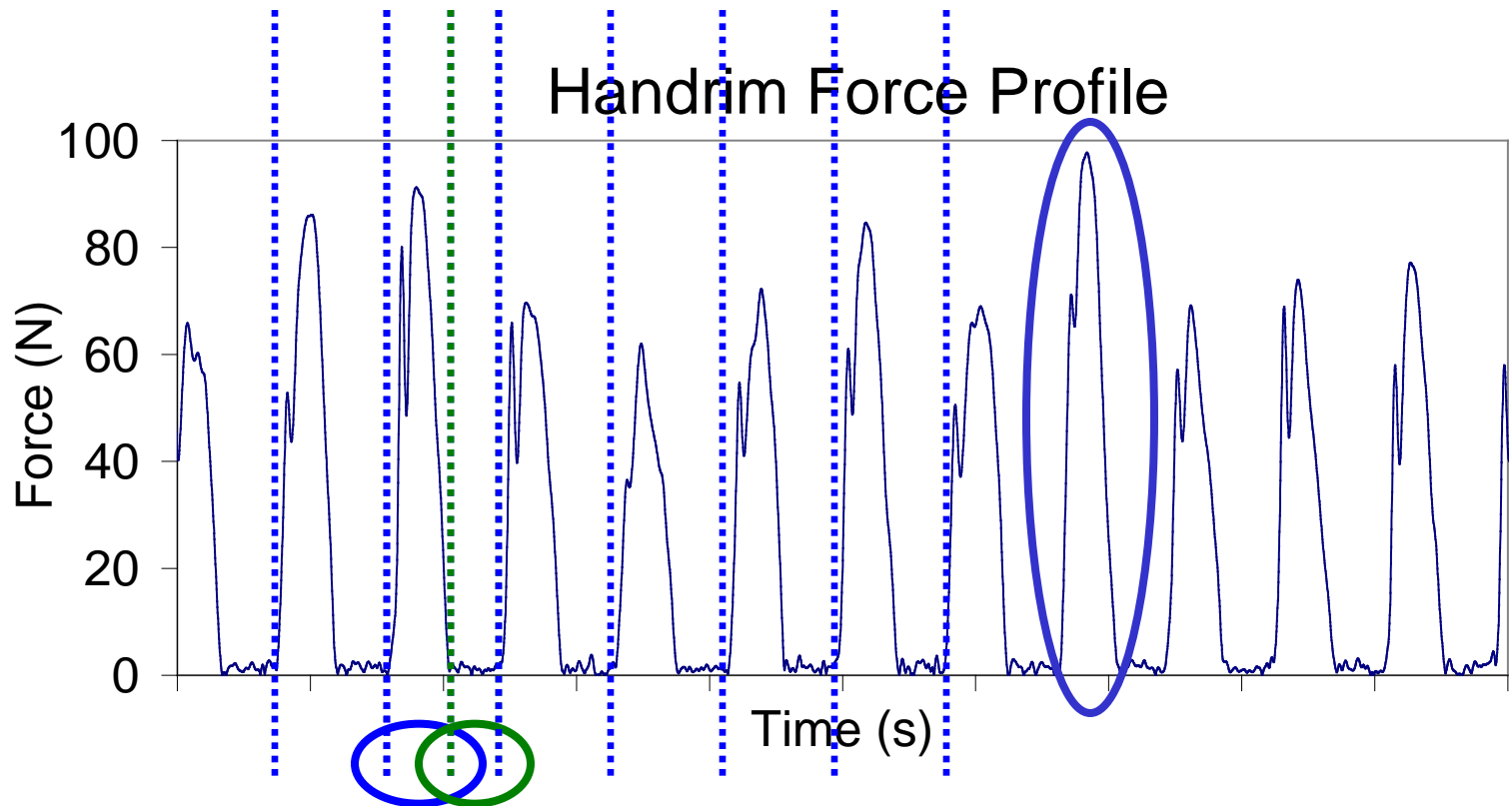
Handrim order is randomized

Subjects push continuously for 35 pushes on level,
30 on 3 degrees and 25 on 6 degrees

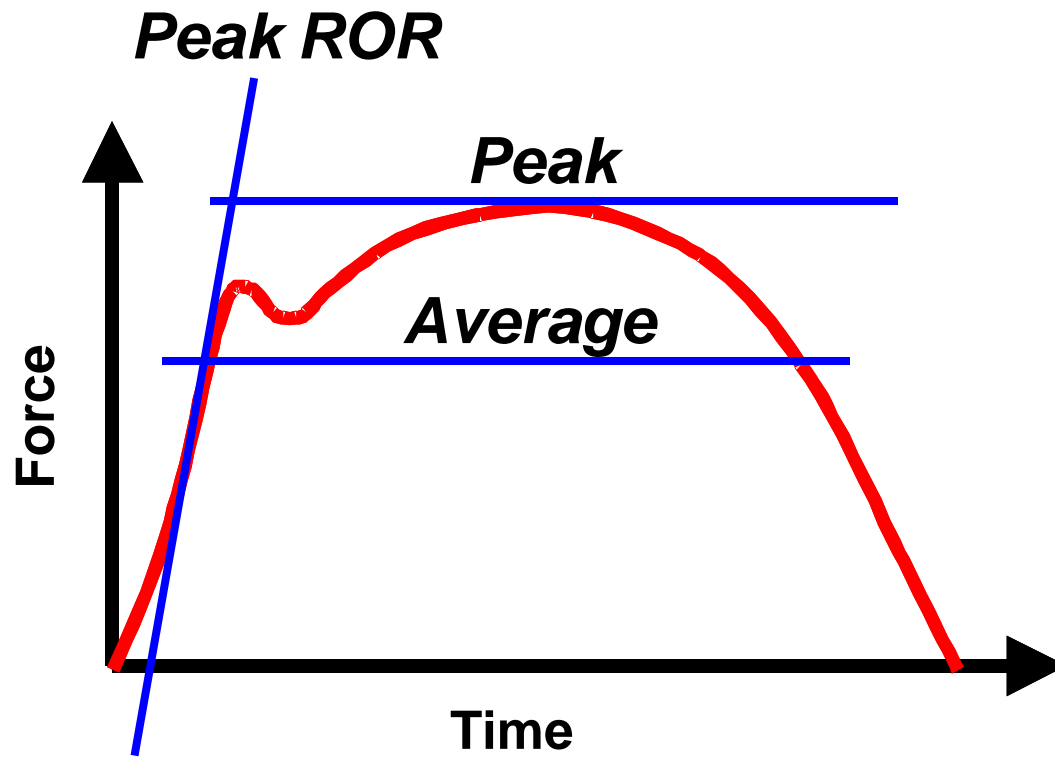
The last 20 pushes on each grade were analyzed

All propulsion is at predetermined comfortable
speeds

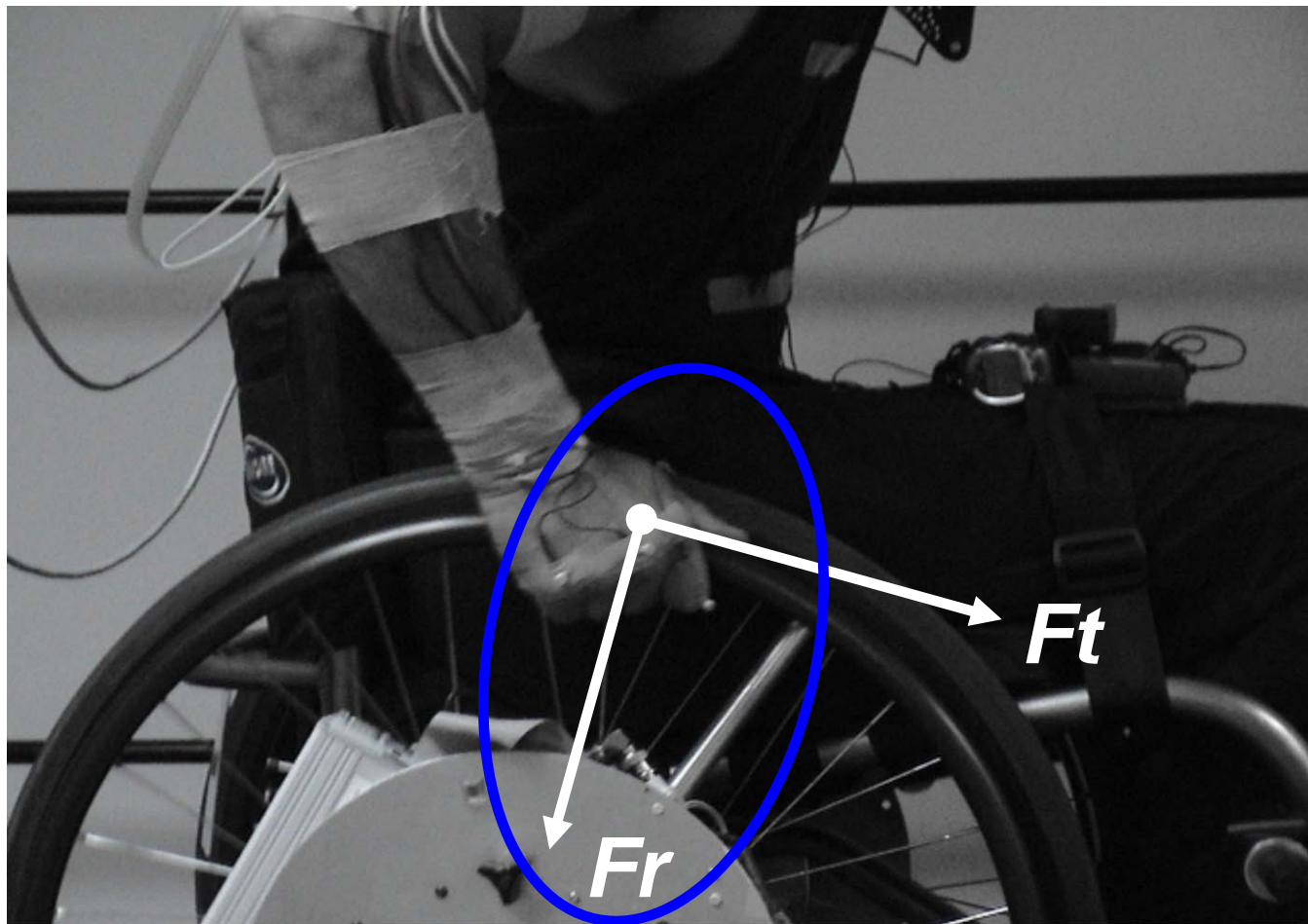
Force applied to the handrim during propulsion



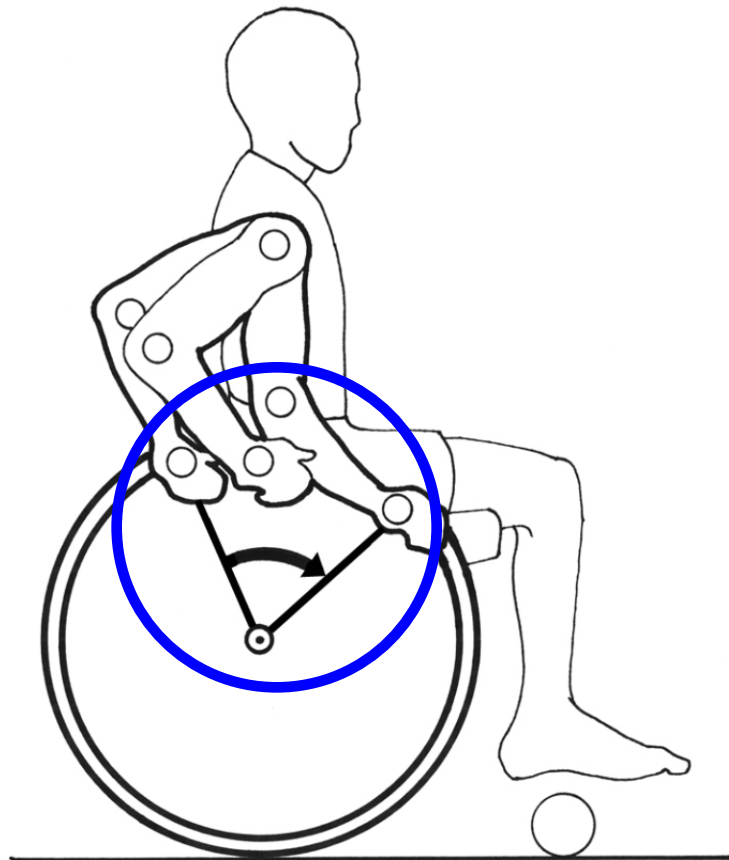
Force characteristics



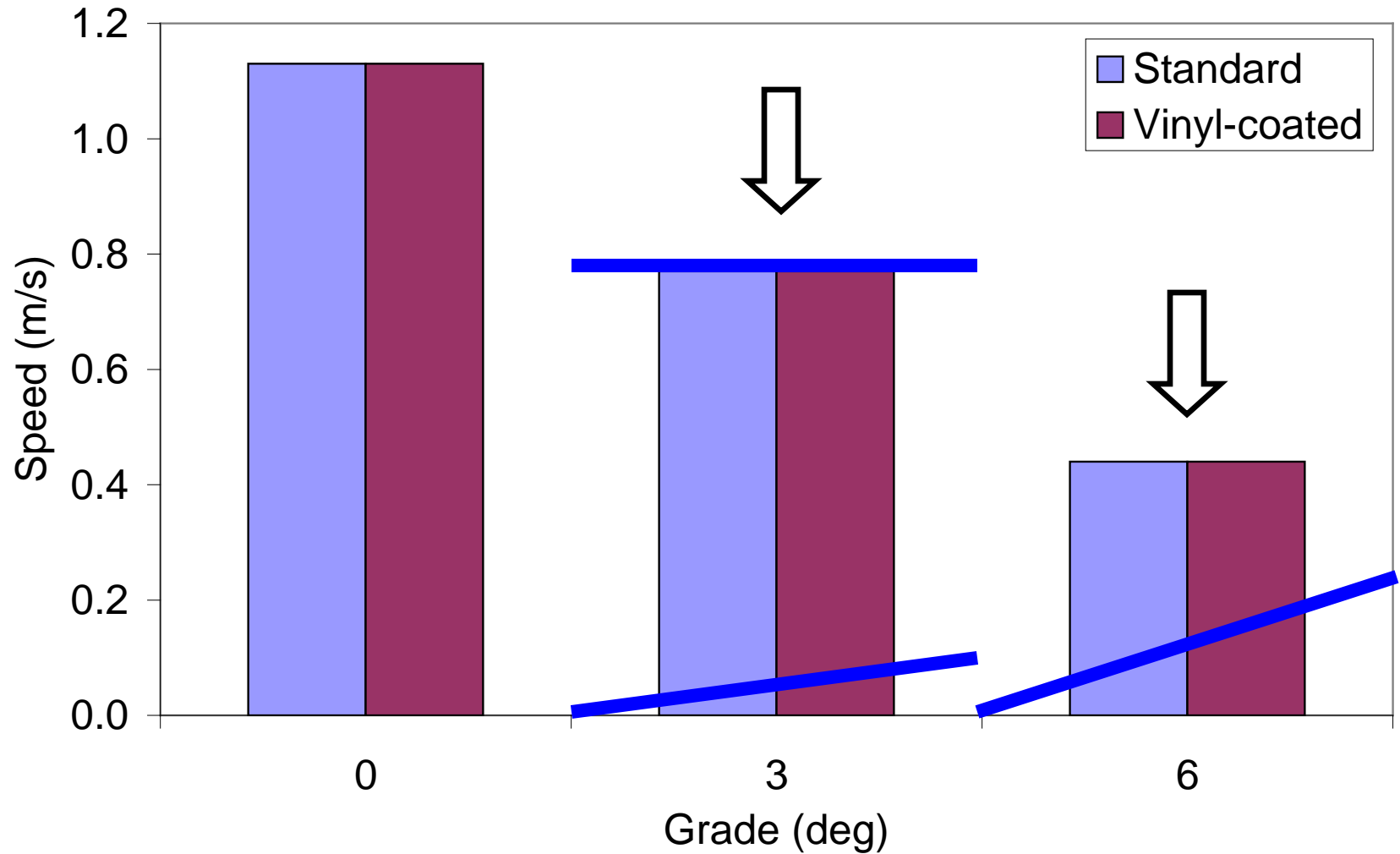
Tangential and radial components of force



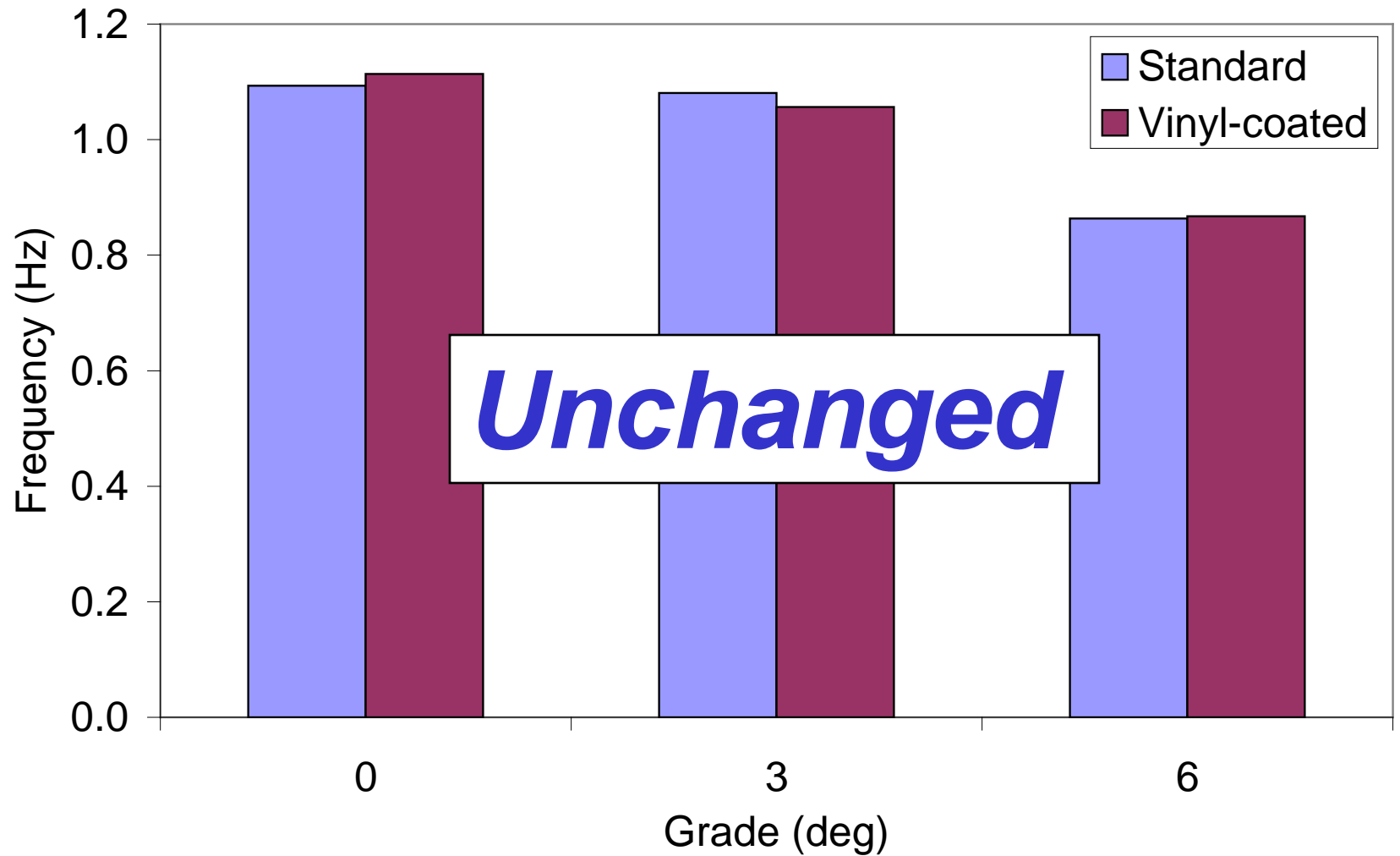
Push angle



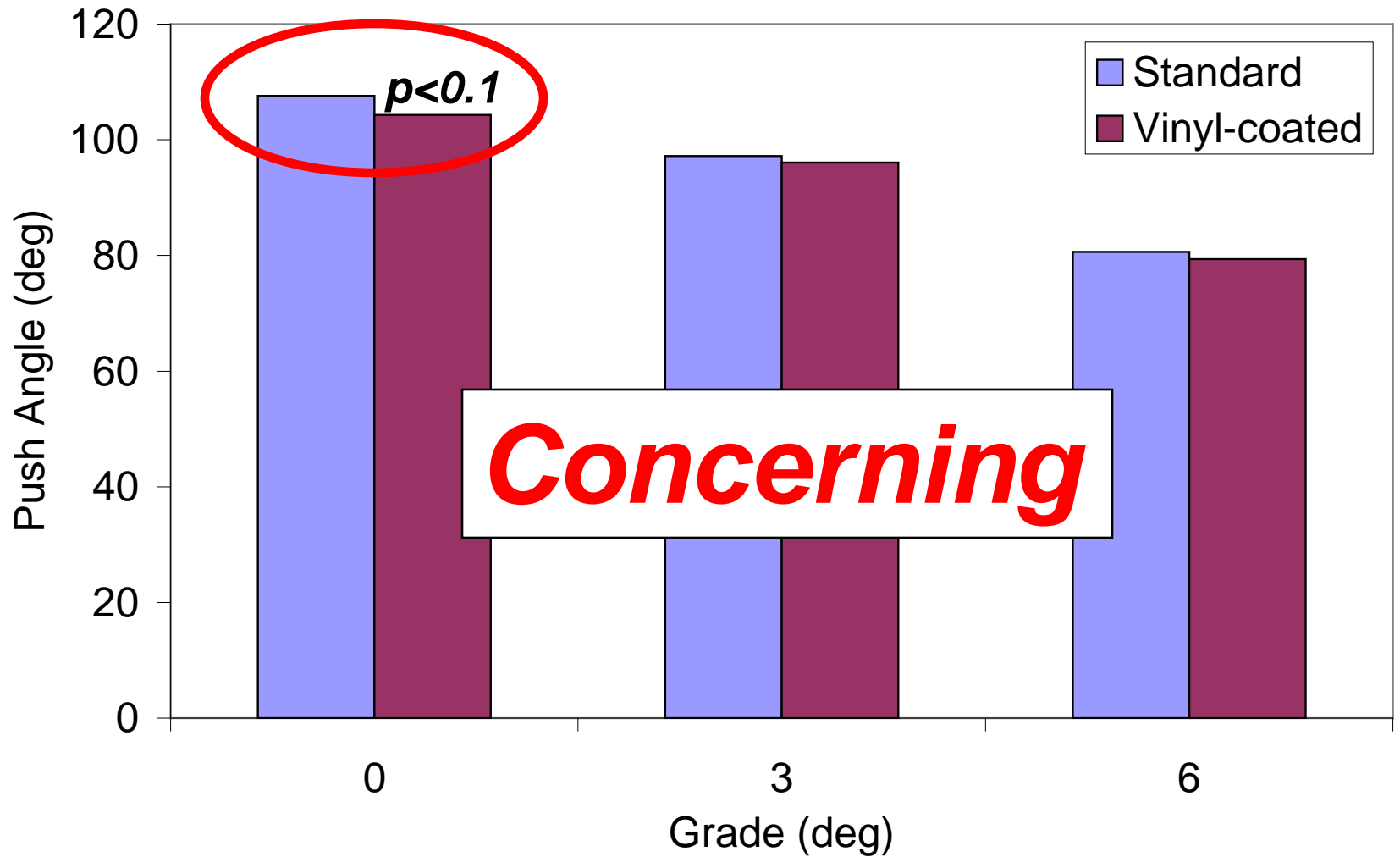
Speed



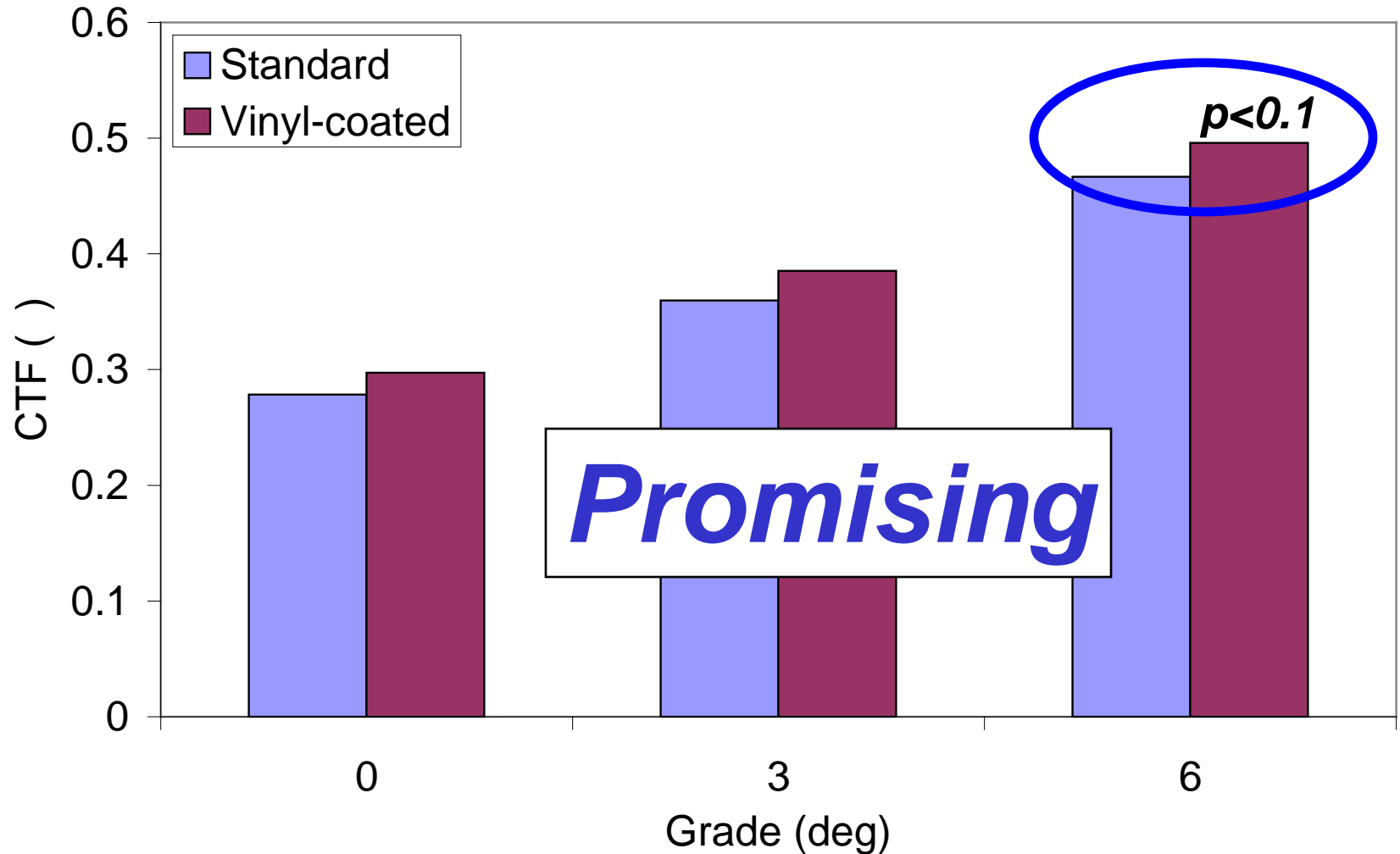
Push frequency



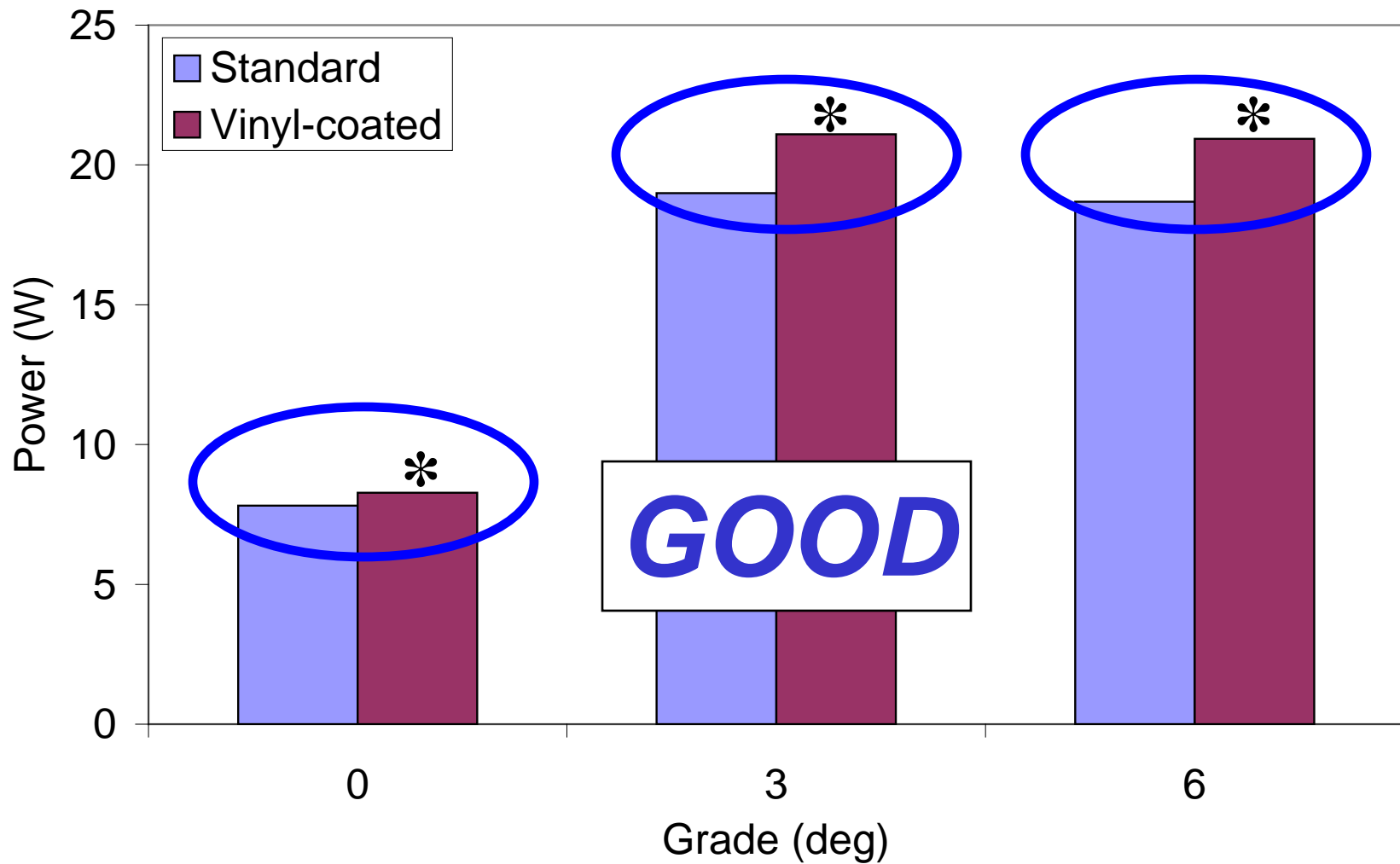
Push Angle



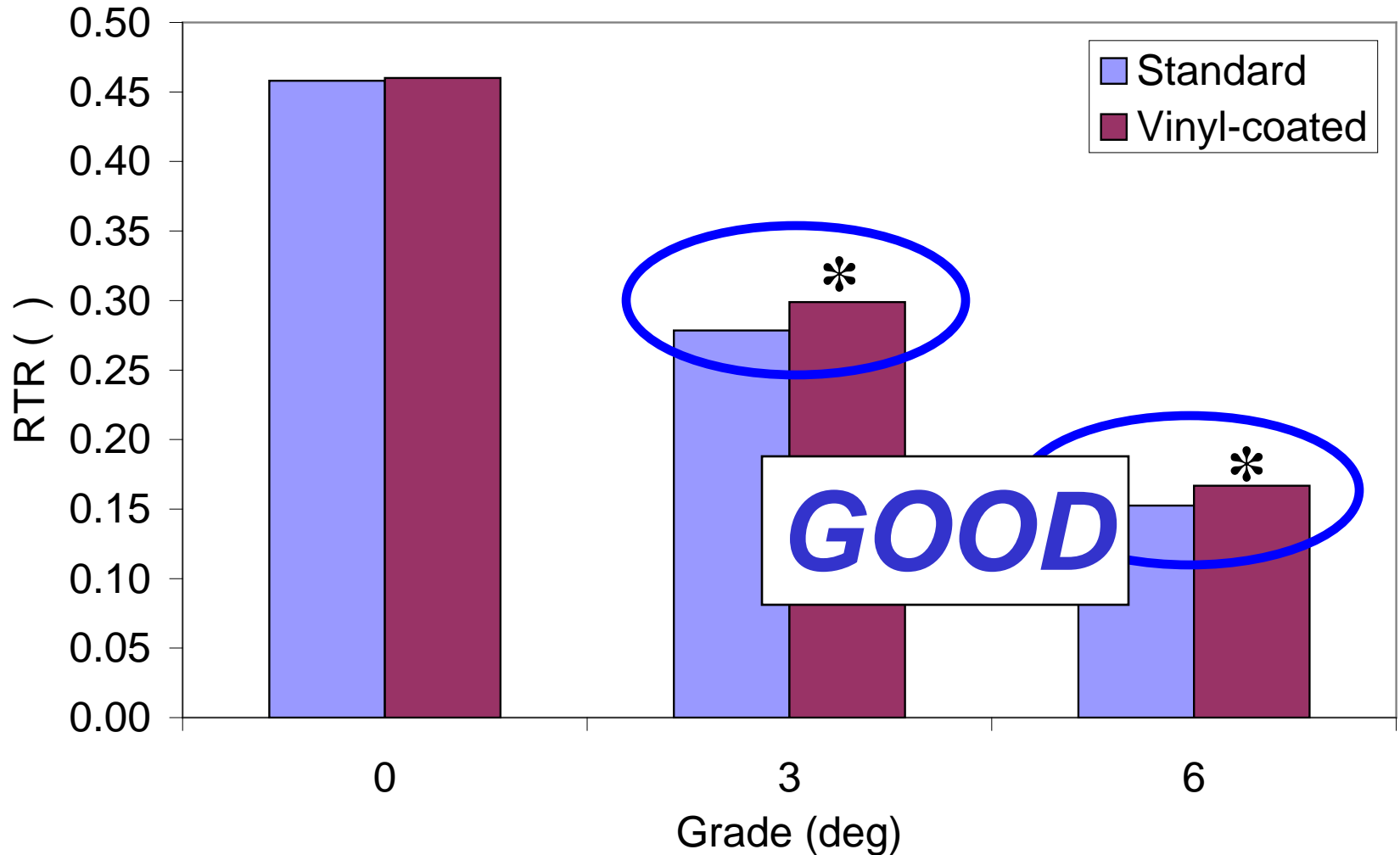
Mechanical efficiency (CTF)



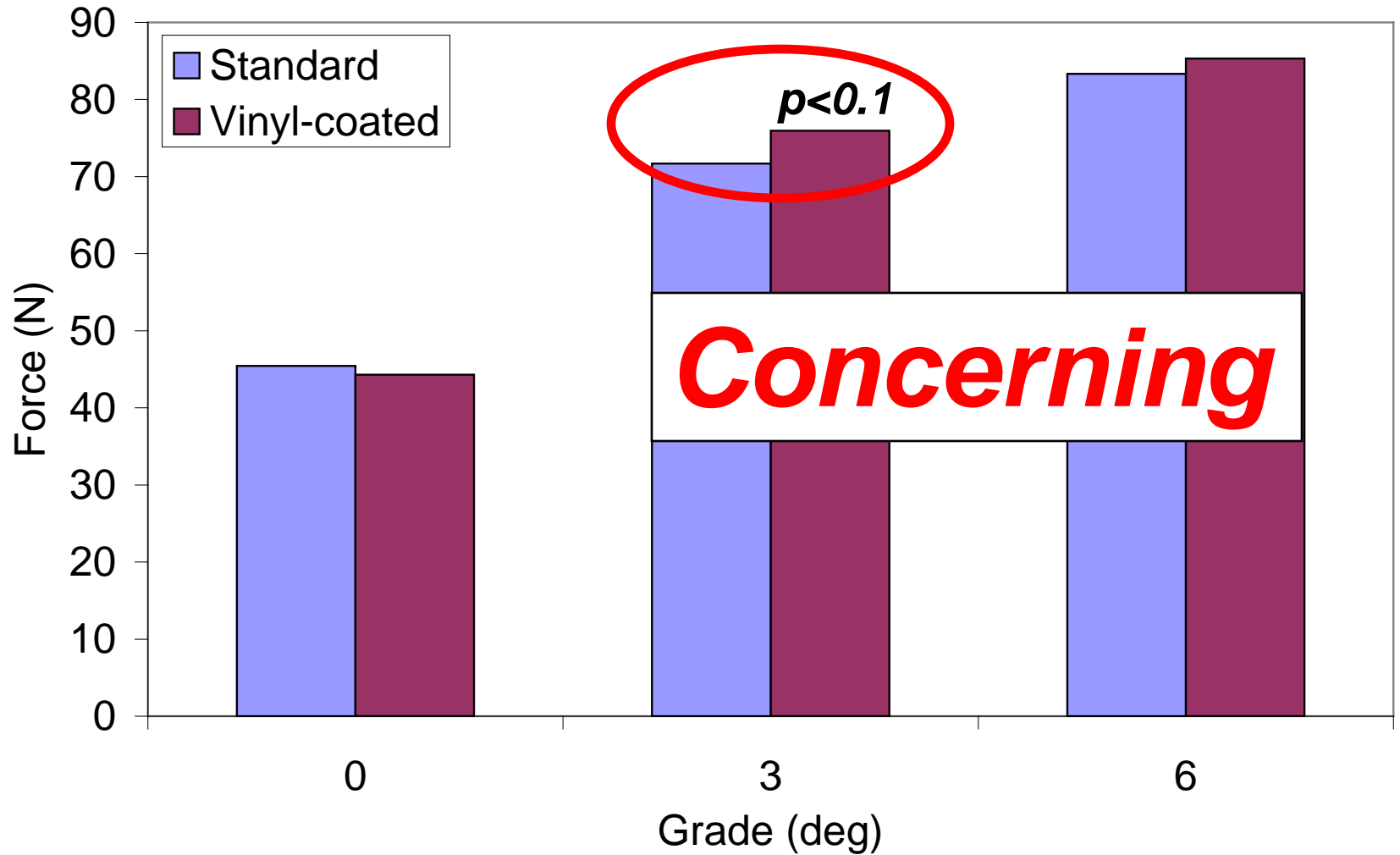
Power



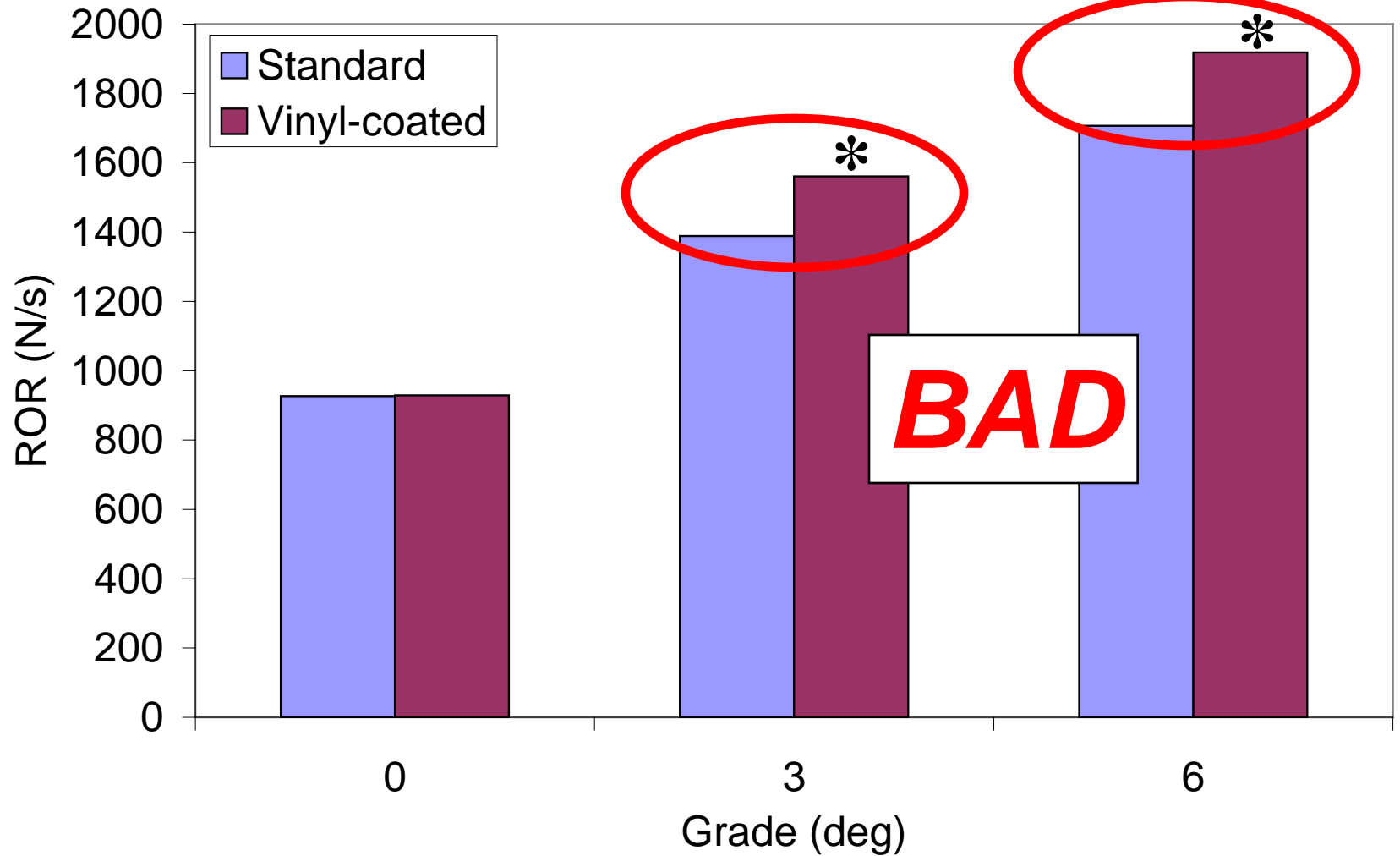
Recovery Time Ratio (RTR)



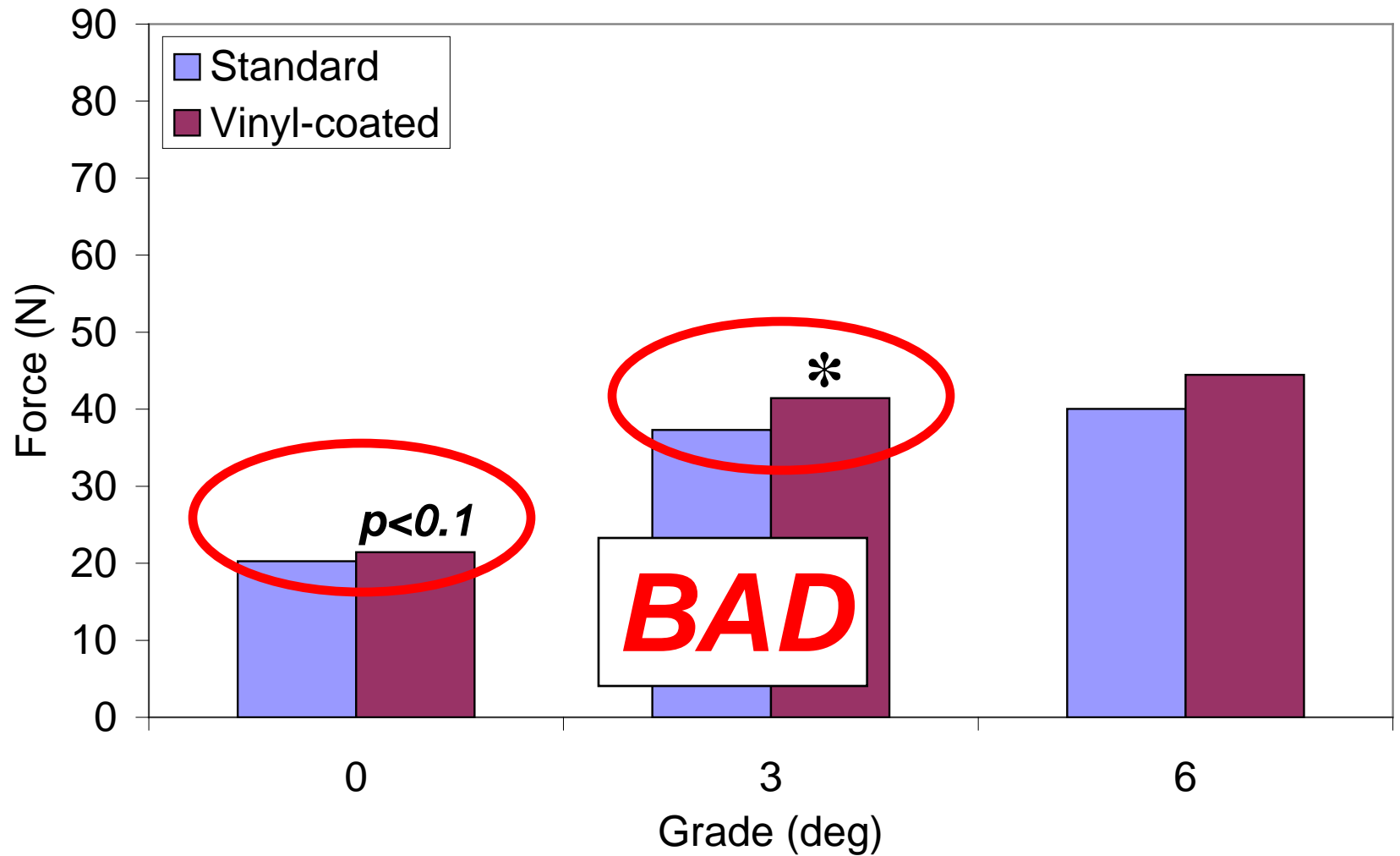
Peak Fr



Peak Fr ROR



Average Fr





Conclusions: *Pros*

More power generated during the push
6% to 12% for increasing grades

User is able to coast more between pushes
Especially important on steep grades when recovery
time is limited



Conclusions: *Cons*

Increased average handrim forces

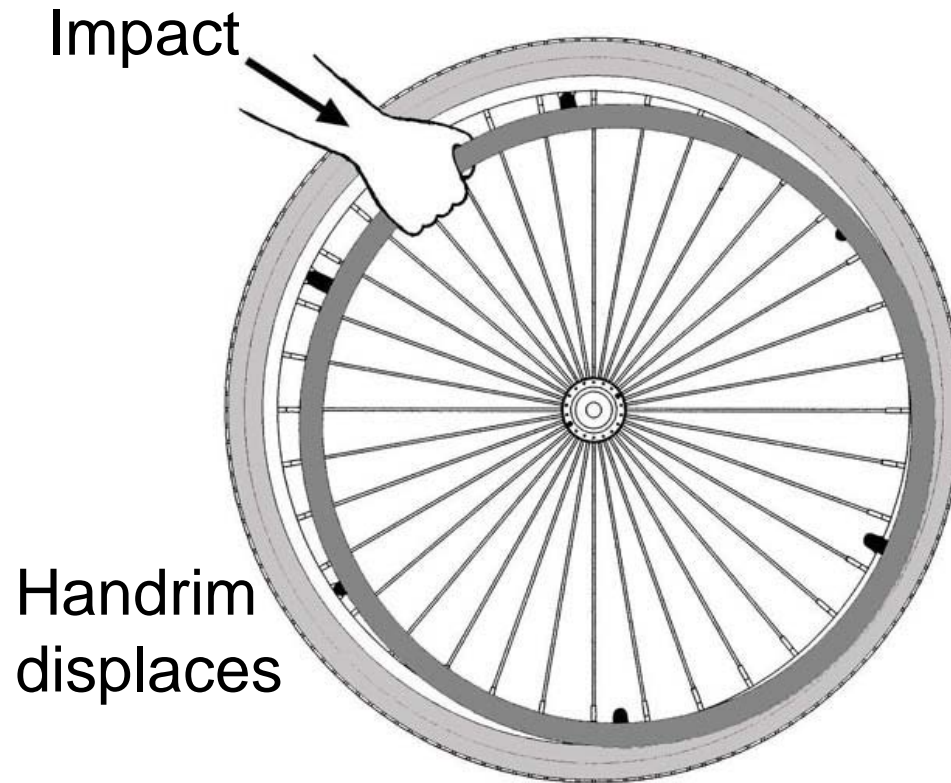
Most notable on hills

Increased Fr ROR

Found on hills, no change on level

Especially important since it has been found to be associated with incidence of RSI (Boninger, 1999)

Handrim compliance can be used to reduce ROR (Richter, 2001)





Final remarks

Use of increased handrim friction can have very beneficial ergonomic outcomes

However, adverse 'side effects' may counter those benefits

It is important that ergonomic handrims be thoroughly tested to ensure that similar side effects do not exist

Found differences were more apparent when pushing uphill, when demand is greatest

Handrim testing should include uphill conditions

A decorative graphic consisting of a horizontal arrow pointing right at the top and a vertical arrow pointing down on the left side, both with a double-line border and a grey arrowhead.

Acknowledgements

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