MAYO CLINIC

Objective Assessment of Function:
Using Gait Analyses to Detect Objective Differences

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Motion Analysis Laboratory

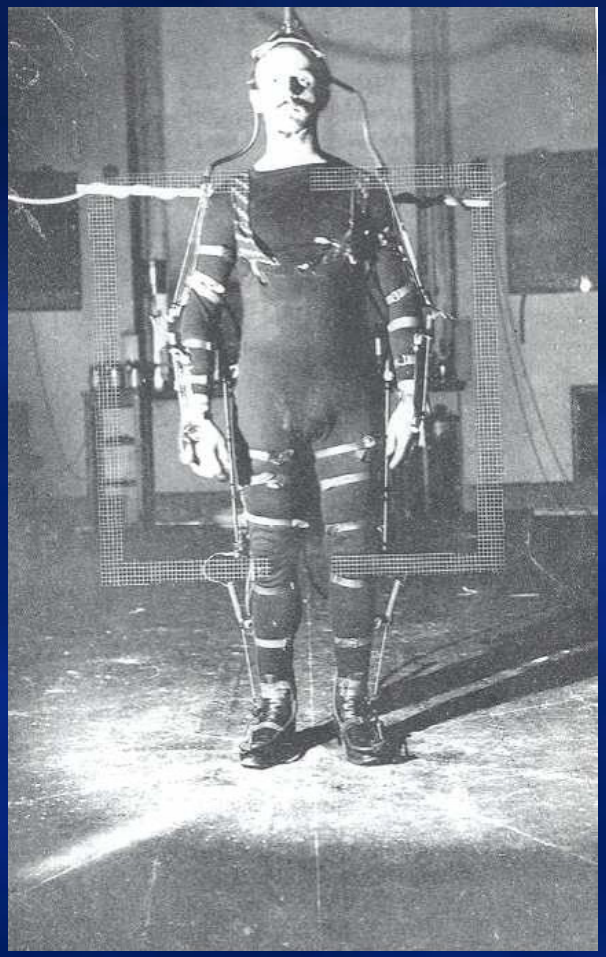
Mayo Clinic

Rochester, MN

Amputee Healthcare & Prosthetics Workshop

November 17 - 18, 2003

The Human Gait
Braune and Fischer, ~1895



U C – Berkeley
~ 1950

- Verne Inman, MD, PhD
  Orthopedic Surgeon & Anatomist
- Howard Eberhart, PhD
  Civil Engineer
- Charles Radcliffe, PhD
  Mechanical Engineer
- Henry Ralston, PhD
  Physiologist

Monumental Studies

Affected every area of gait analysis

Ford et al, 1995

- Prosthetic clinicians rating video footage of transtibial amputees
- Intentional misalignment in sagittal and coronal plane
- Between rater reliability
  - Coronal plane: k=0.36
  - Sagittal plane: k=0.08

Saleh & Murdoch, 1985

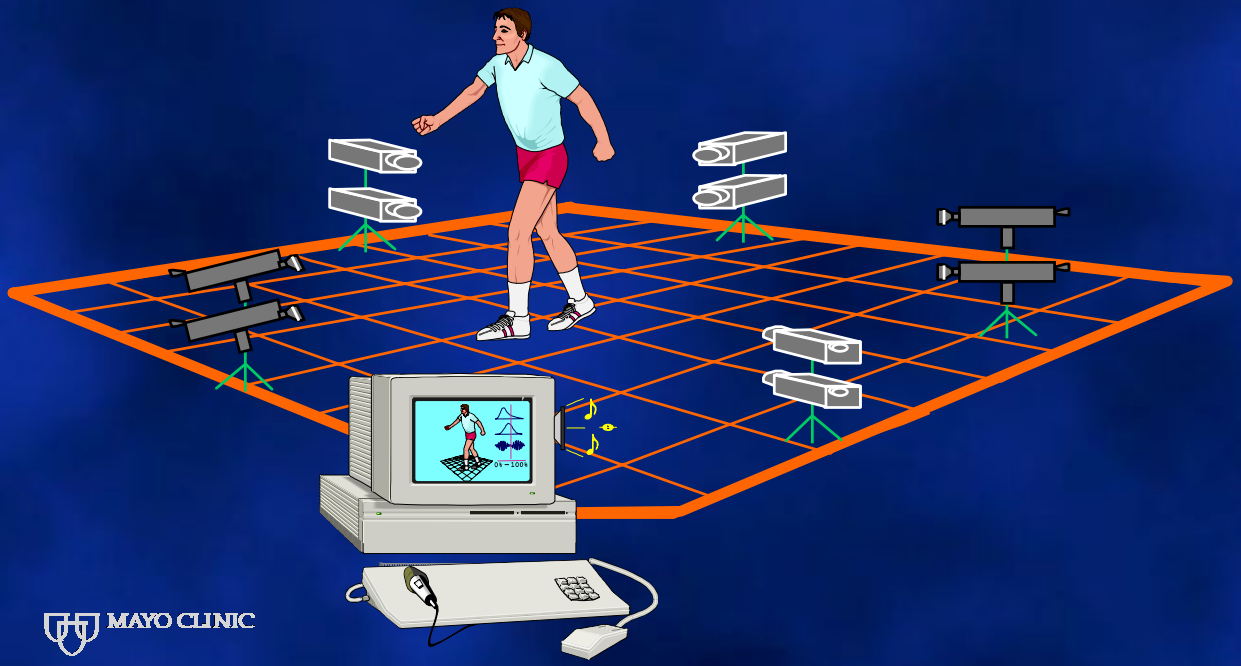
- Experienced observers
- Gait of transtibial amputees
- Prosthetic limbs intentionally misaligned in sagittal plane
- Agreement of observers with biomechanical model was 22%

C-LEG

SNS

Motion Measurement

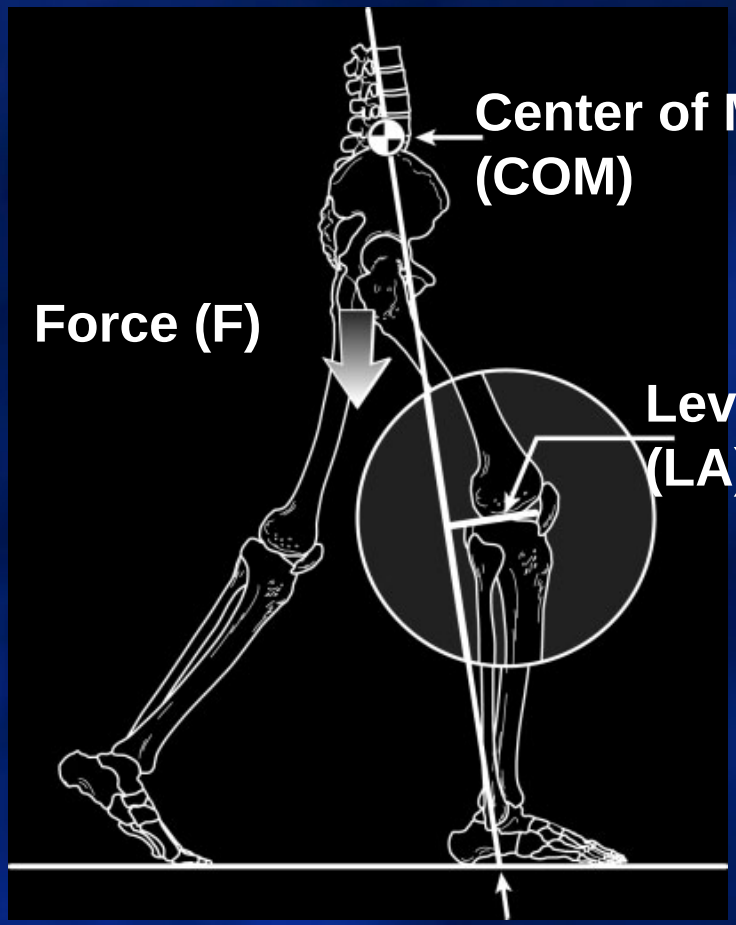
- Real-time analysis
- Digital cameras
  - Up to 300 Hz
  - Infrared strobe lighting

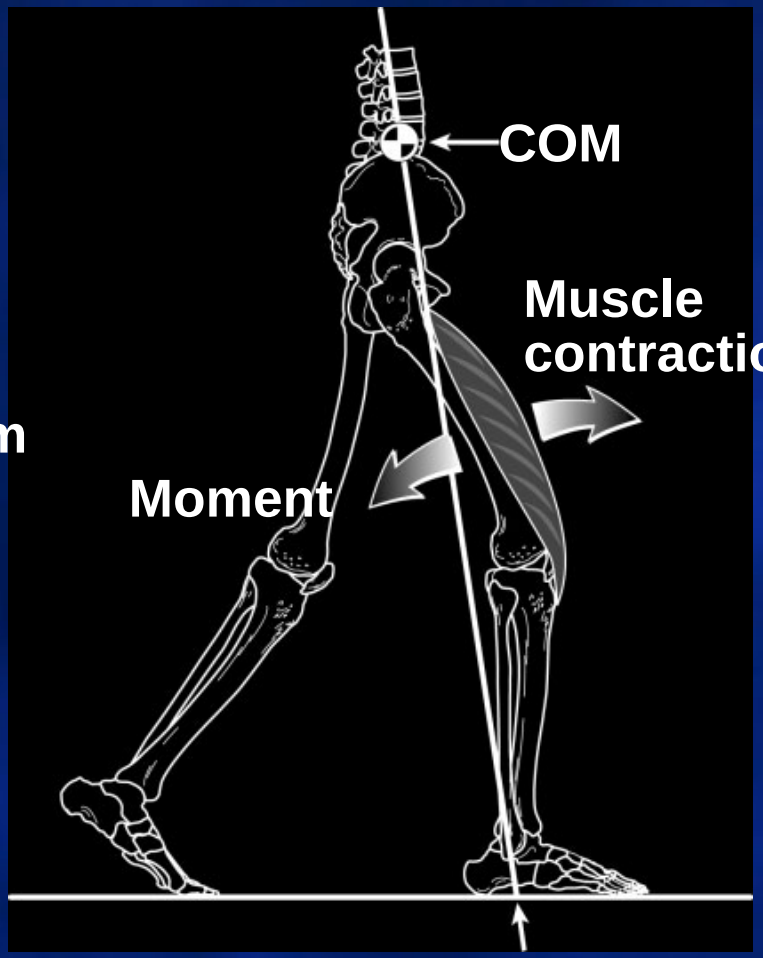


Knee Extensor Moment

External Demand

Internal Response





Ground Reaction Force (F)

F

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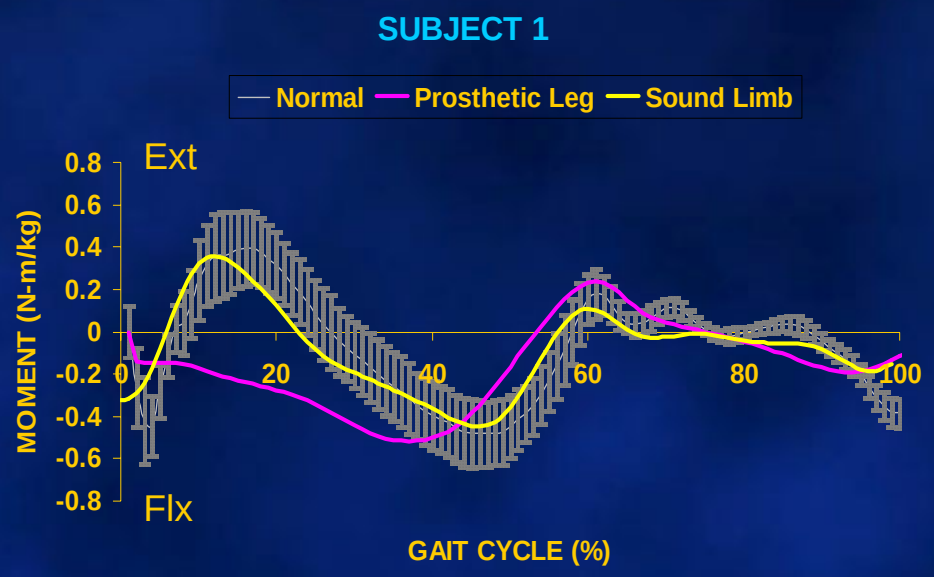
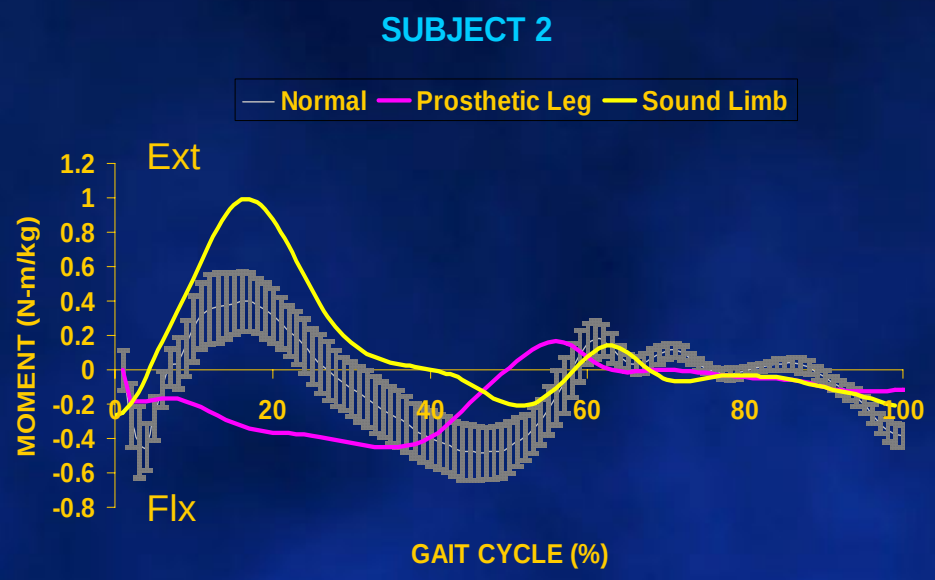
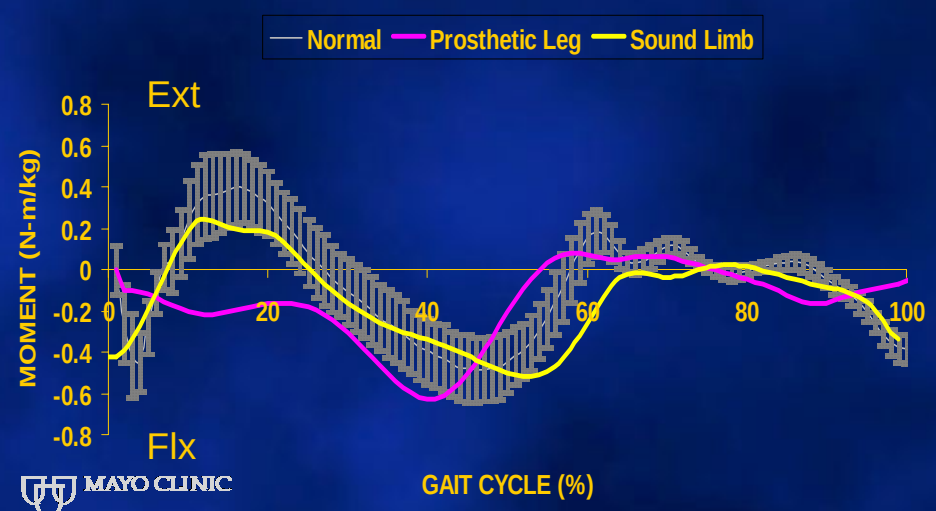
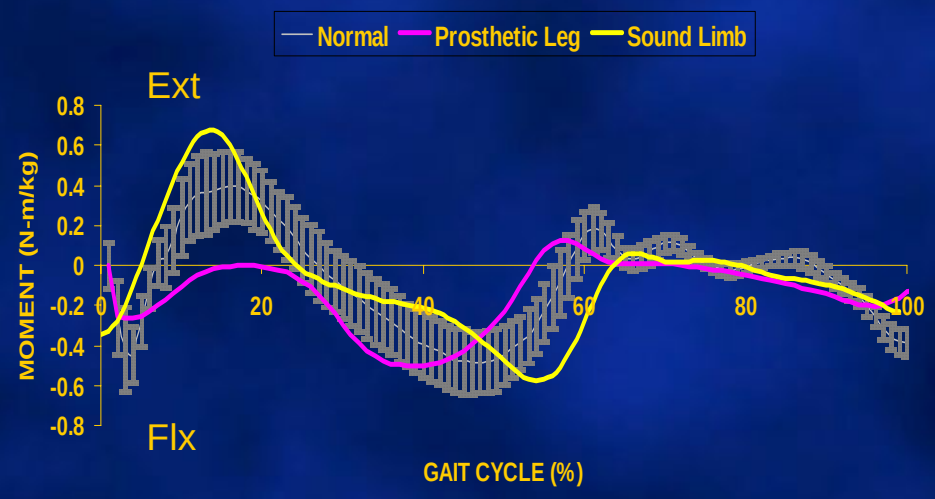
Mauch SNS Knee









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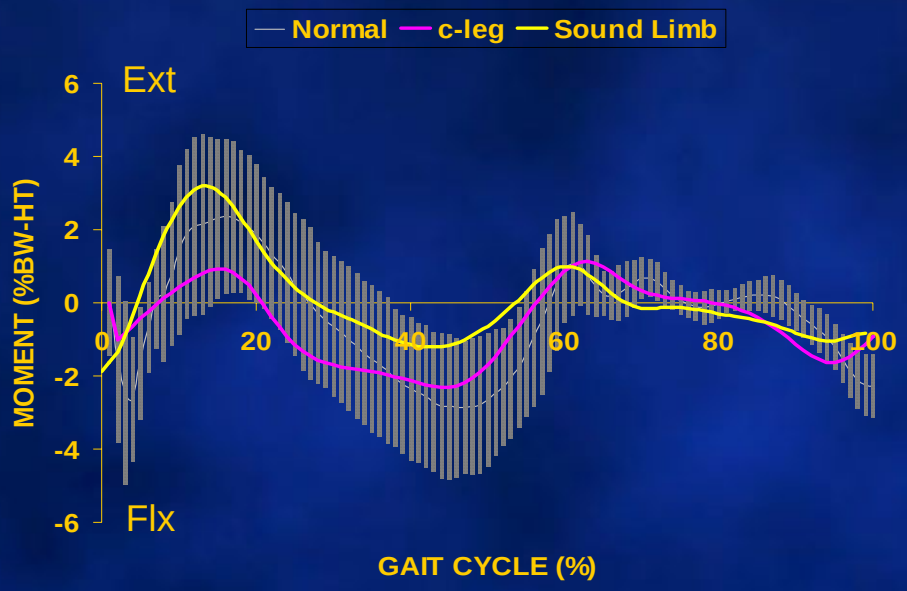
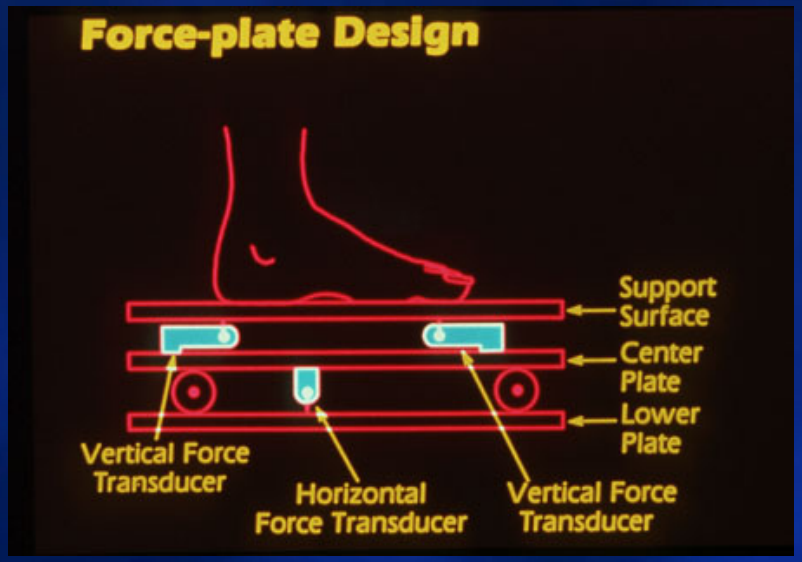
c-leg User


Normal
c-leg
Sound Limb
Ext
Flx
6
4
2
0
-2
-4
-6
MOMENT (%BW-HT)
0
20
40
60
80
100
GAIT CYCLE (%)

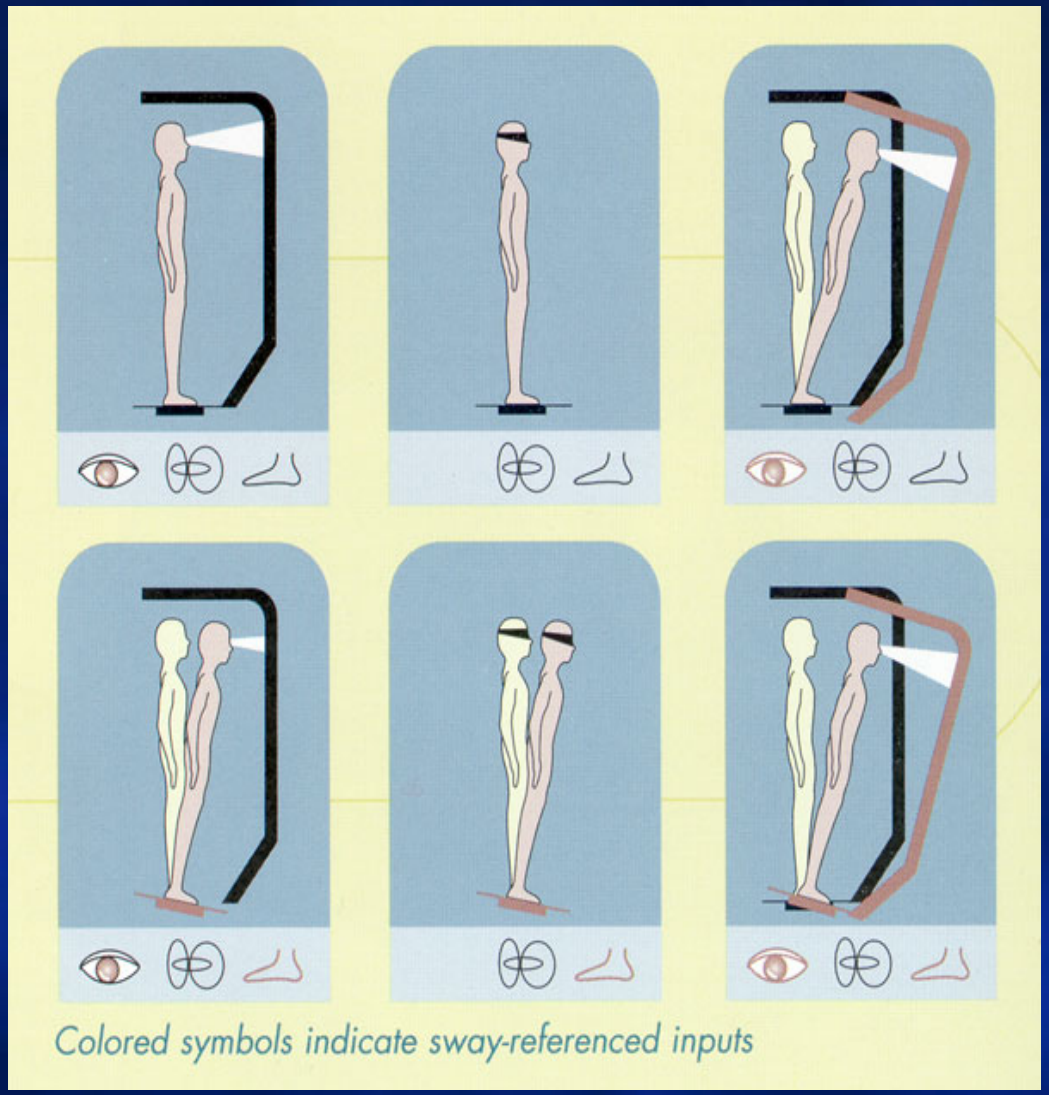
Balance
Computerized Dynamic Posturography



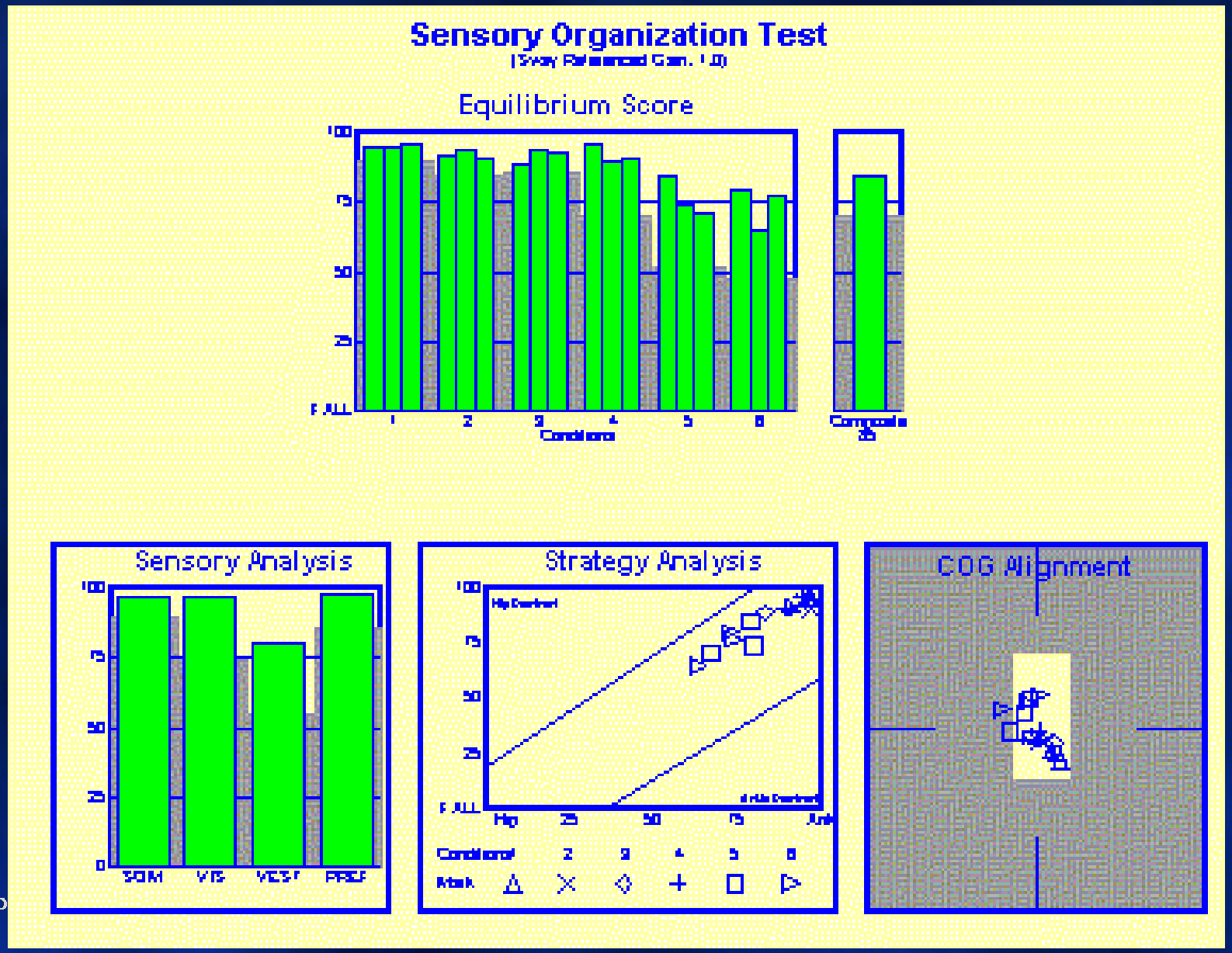
- Sensory Organization Test (SOT)
- Motor Coordination Test (MCT)

SOT

Visual and proprioceptive inputs are altered to evaluate their effect on balance.



C-leg User



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Mauch SNS Knee

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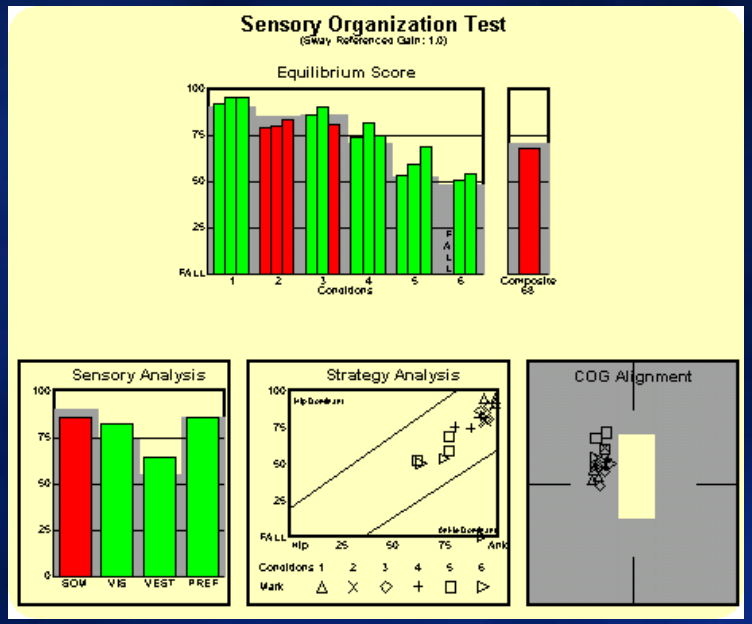

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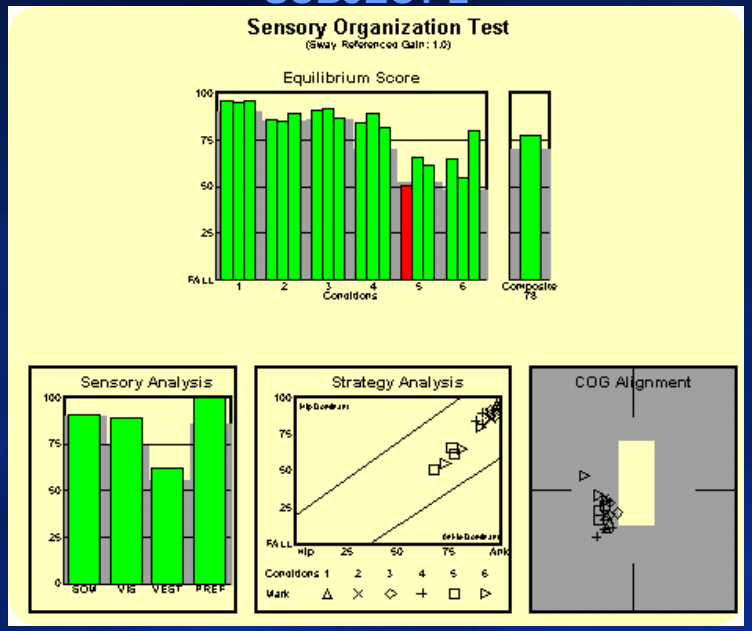

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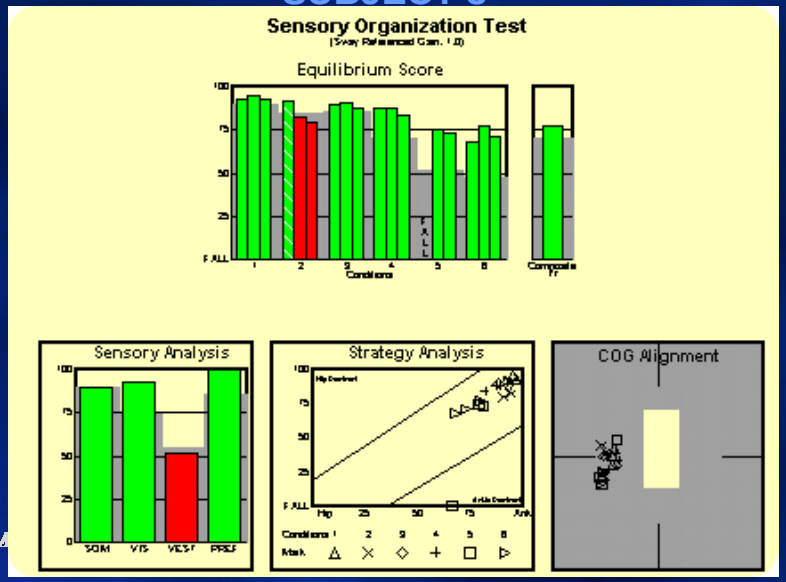

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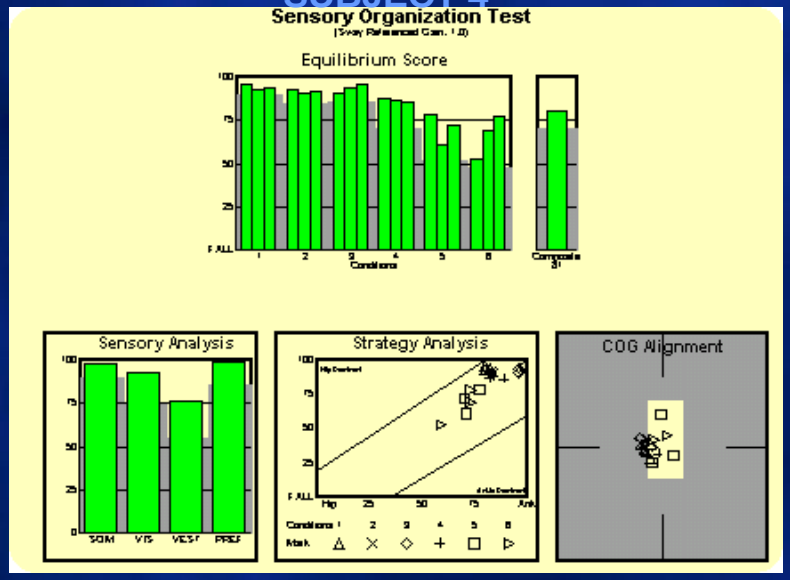
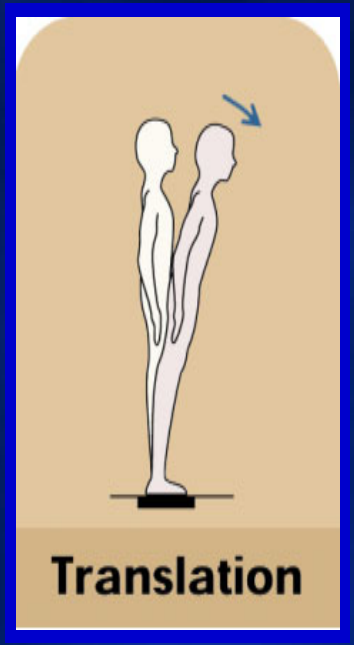
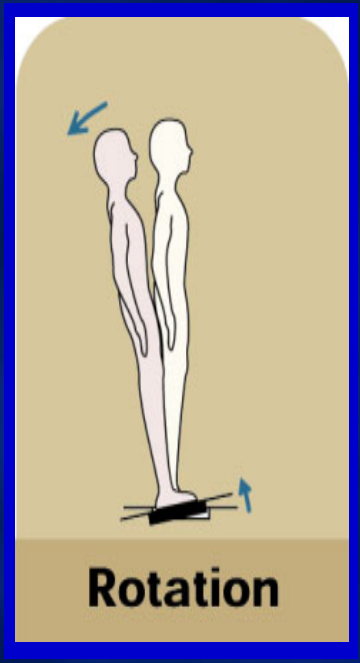


Motor Coordination Tests

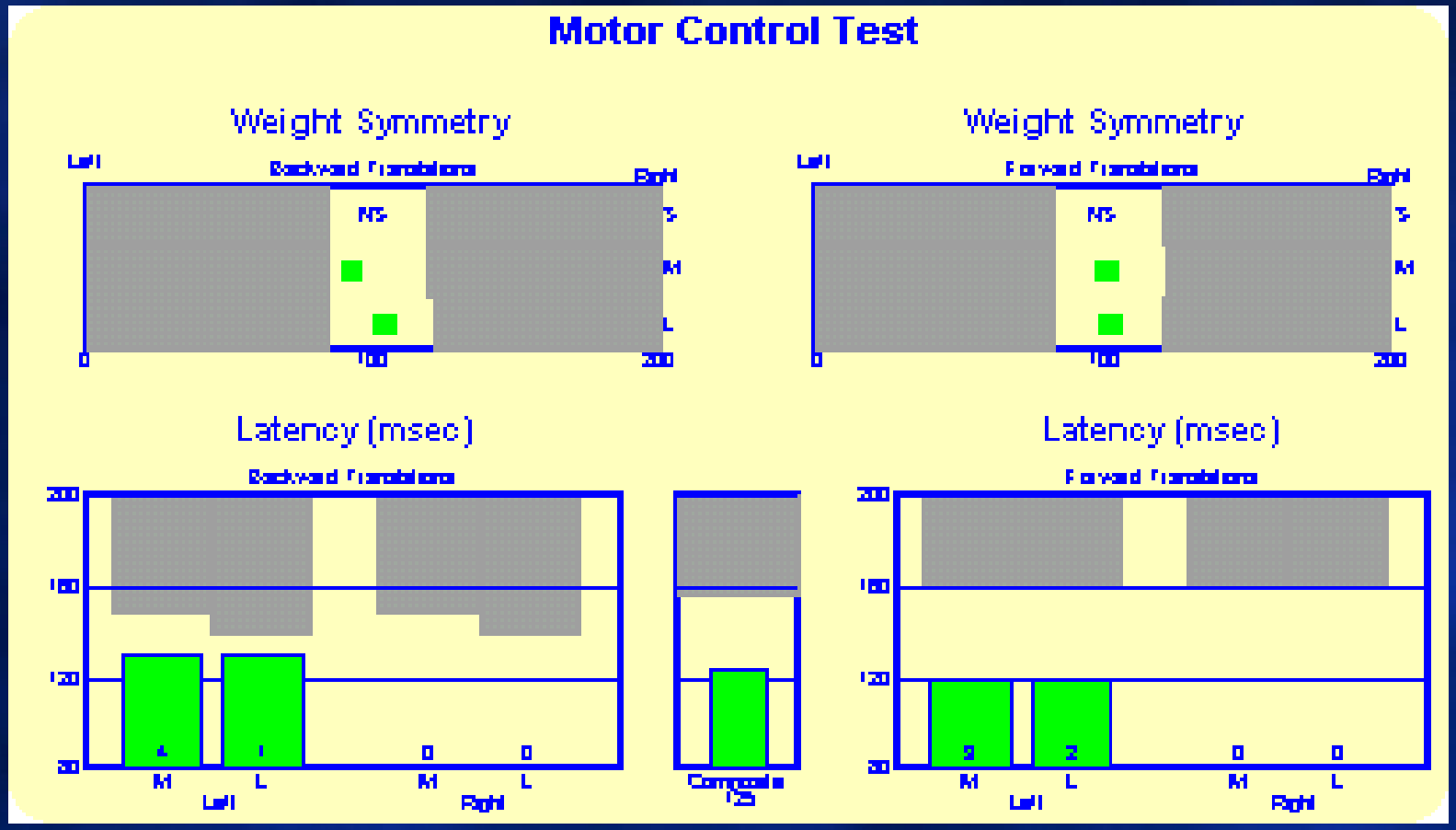
Motor Control Test



Adaptation Test



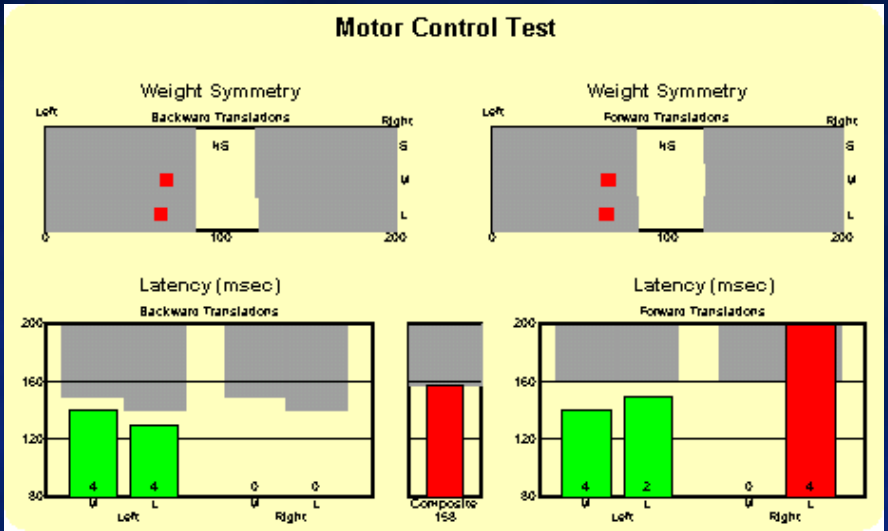
c-leg User



Motor Control Test
Weight Symmetry
Backward Translations
Left
Right
NS
S
M
L
0
100
200
Weight Symmetry
Forward Translations
Left
Right
NS
S
M
L
0
100
200
Latency (msec)
Backward Translations
200
160
120
80
4
1
0
0
M
L
M
L
Left
Right
Composite
125
Latency (msec)
Forward Translations
200
160
120
80
2
2
0
0
M
L
M
L
Left
Right

Mauch SNS Knee

SUBJECT 1



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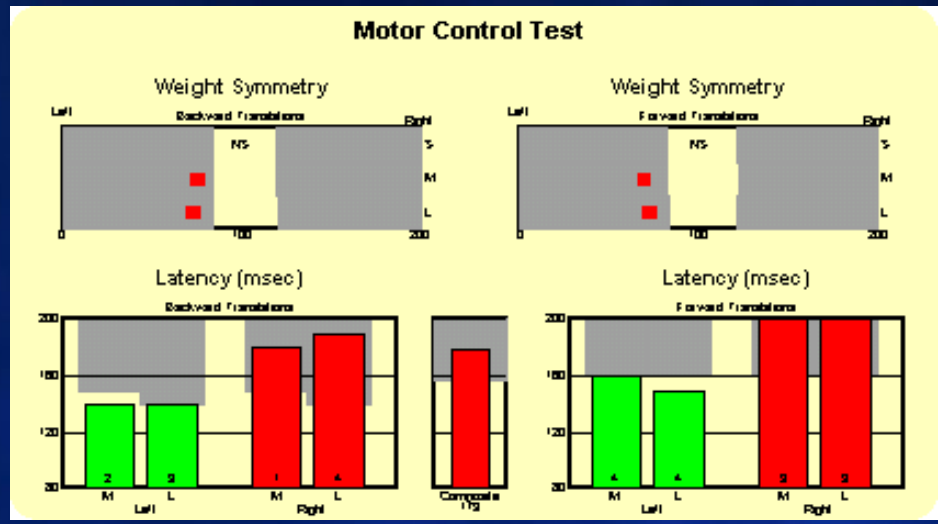

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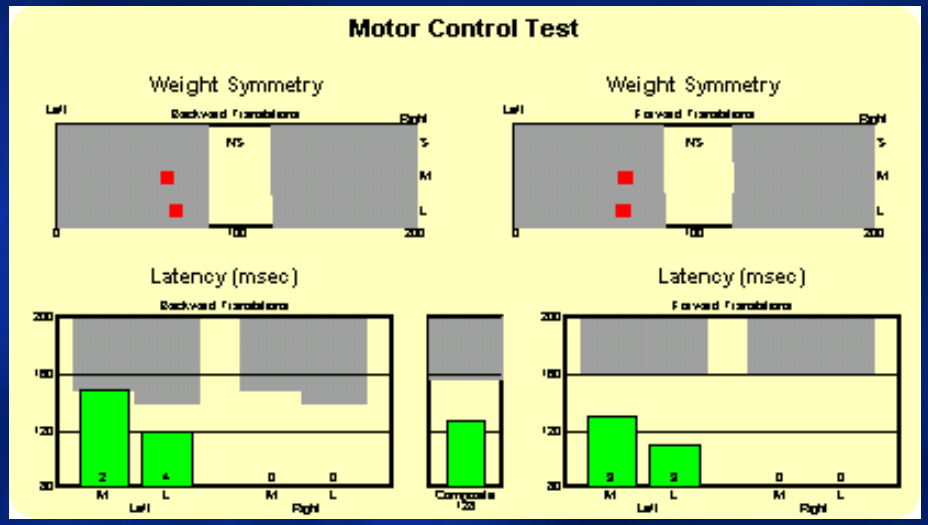

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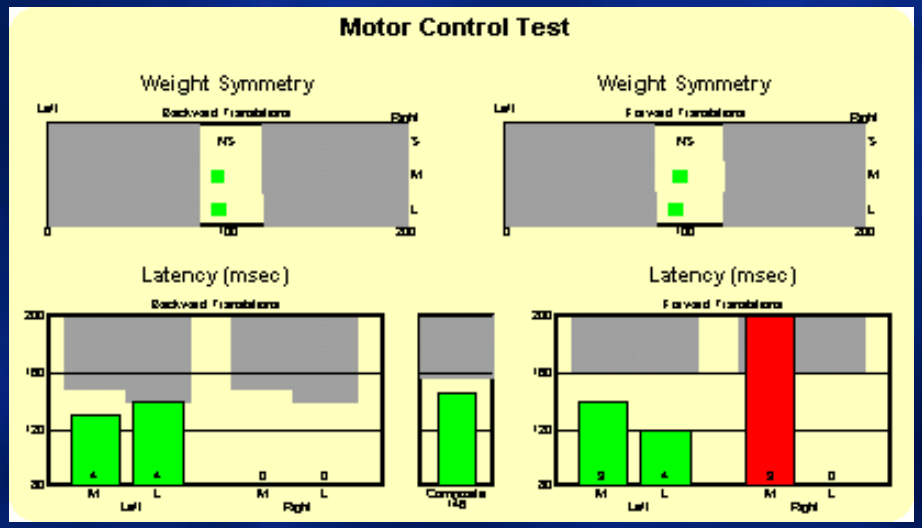

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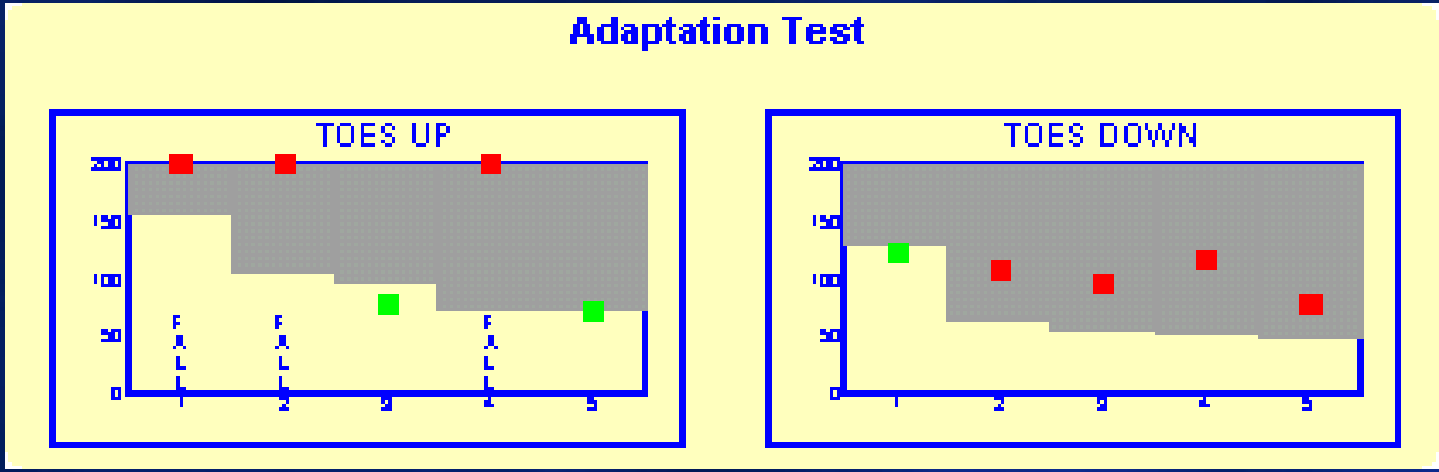

Mauch SNS Knee

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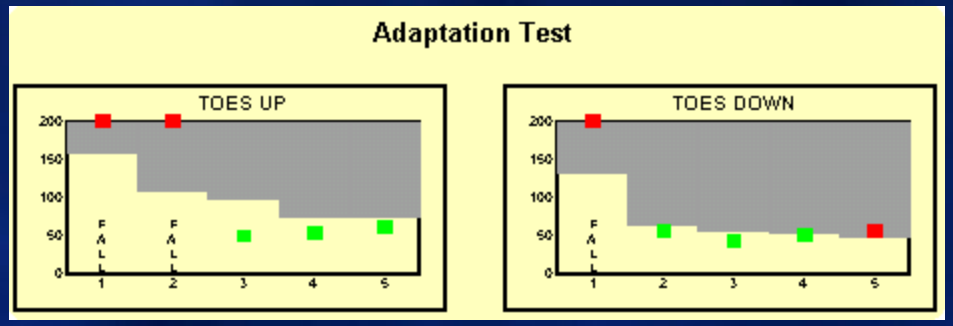

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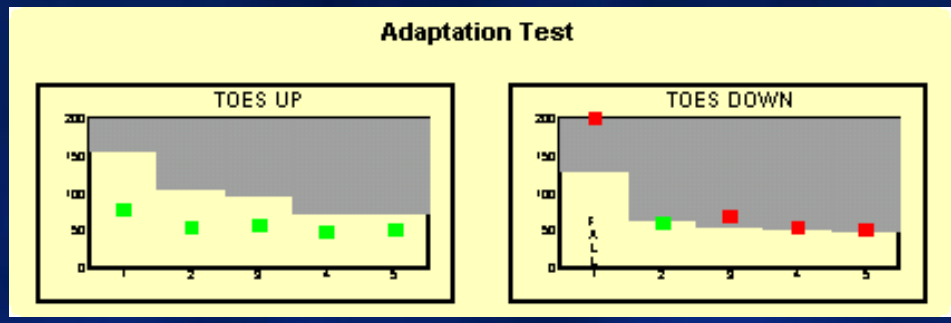

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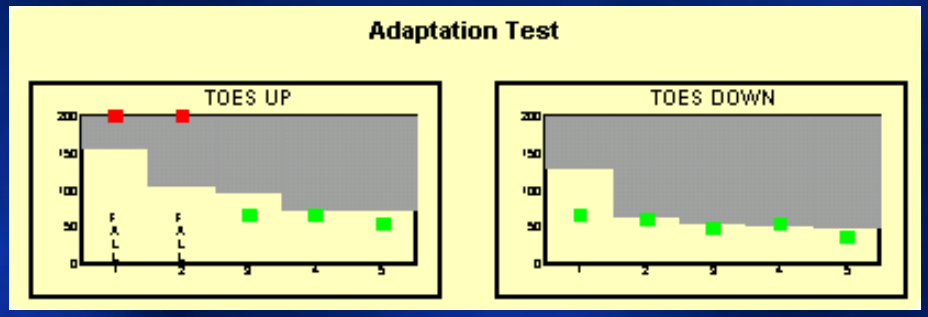

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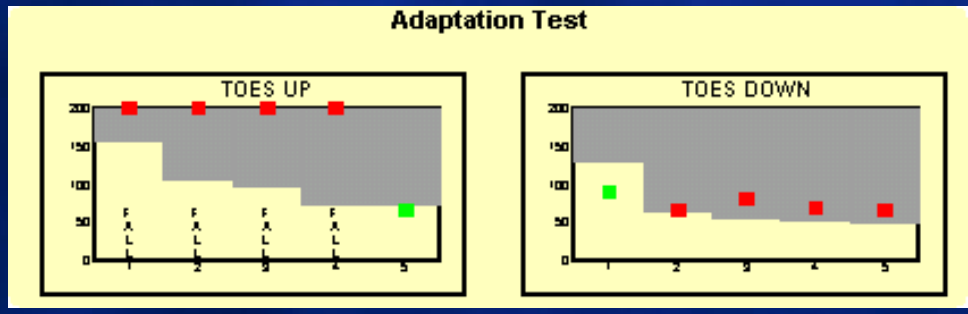
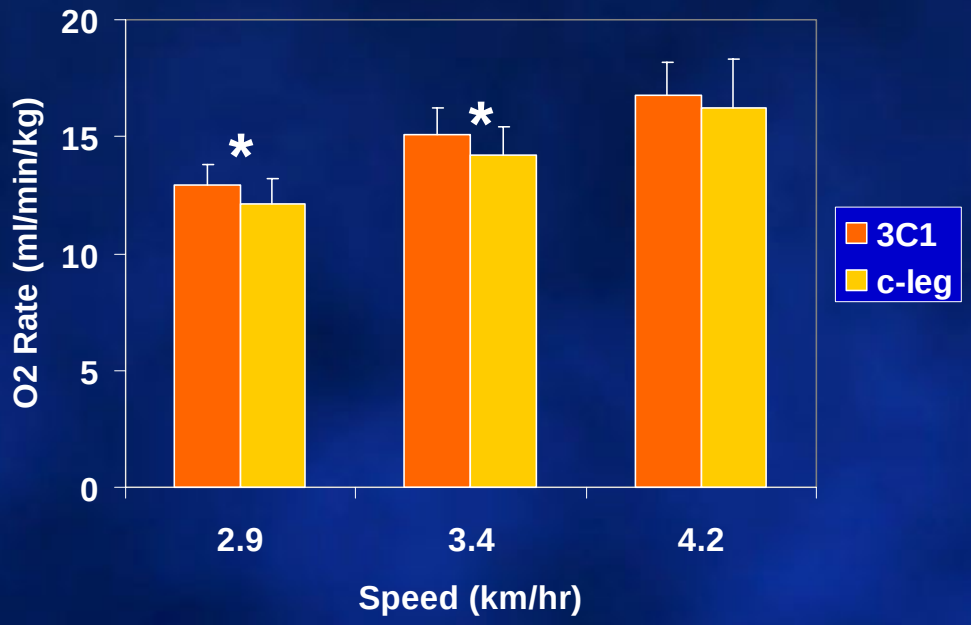


Objective Analyses of Gait Efficacy

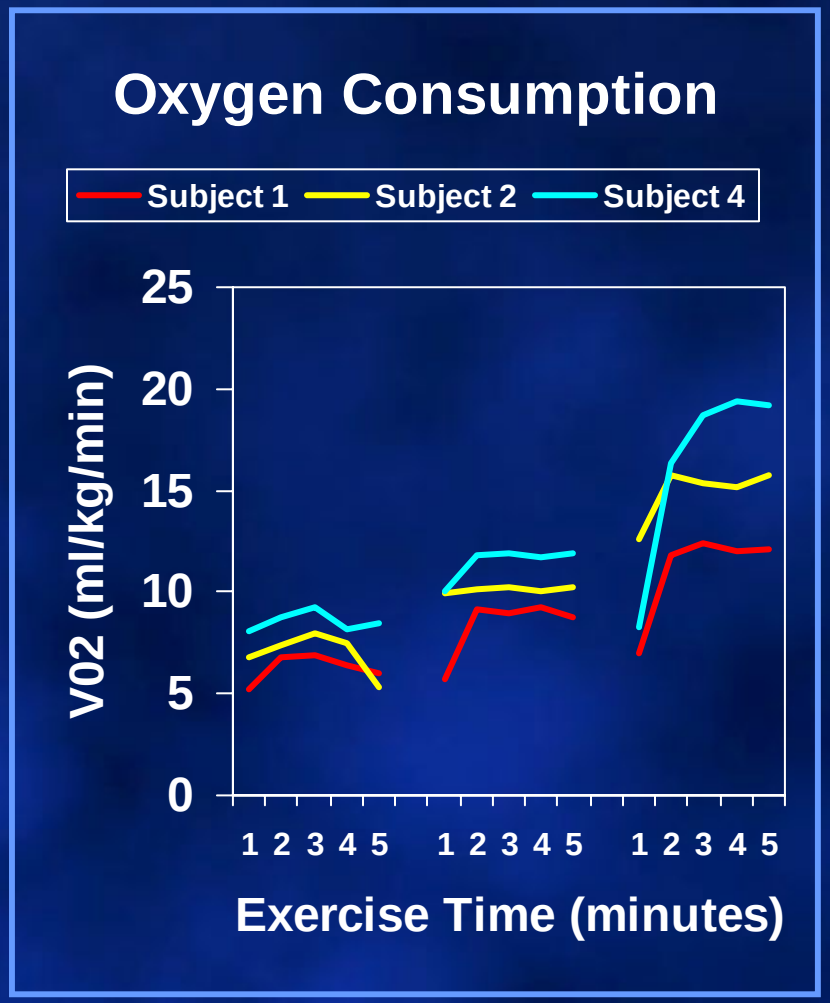


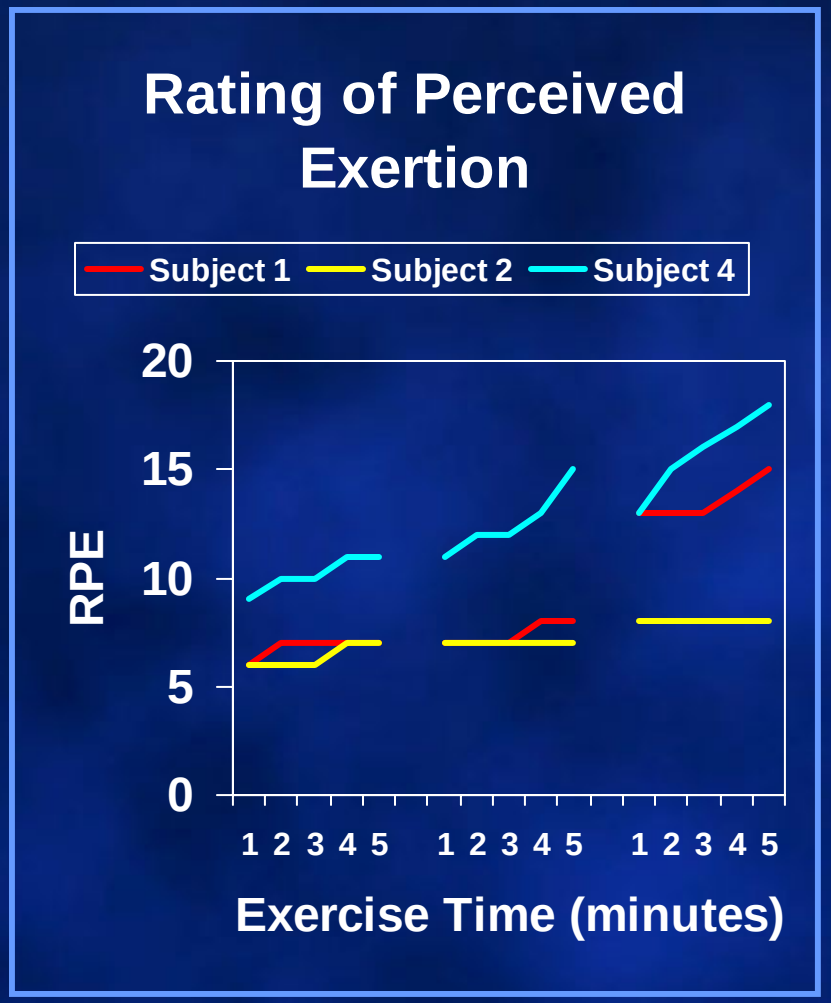
n = 6

Schmalz et al, 2002

- Oxygen consumption measurements
- Evaluate metabolic efficiencies

Energy Consumption





Total Activity

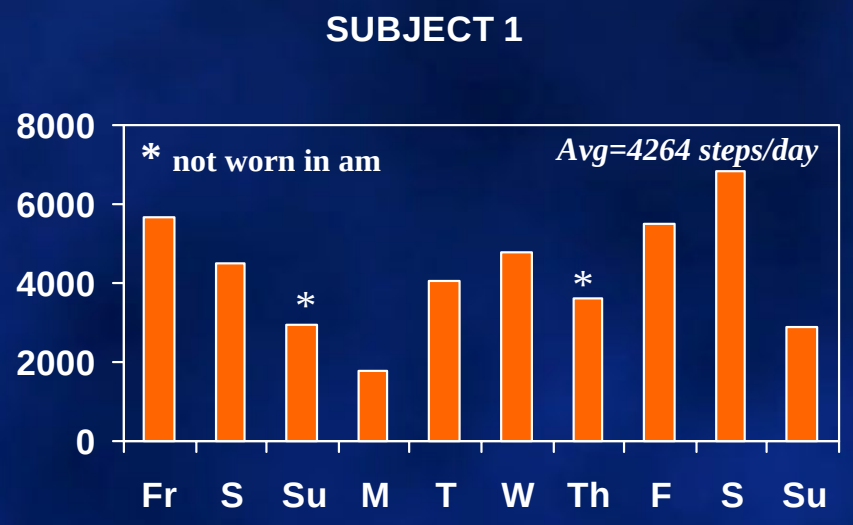
- Doubly-labeled Water

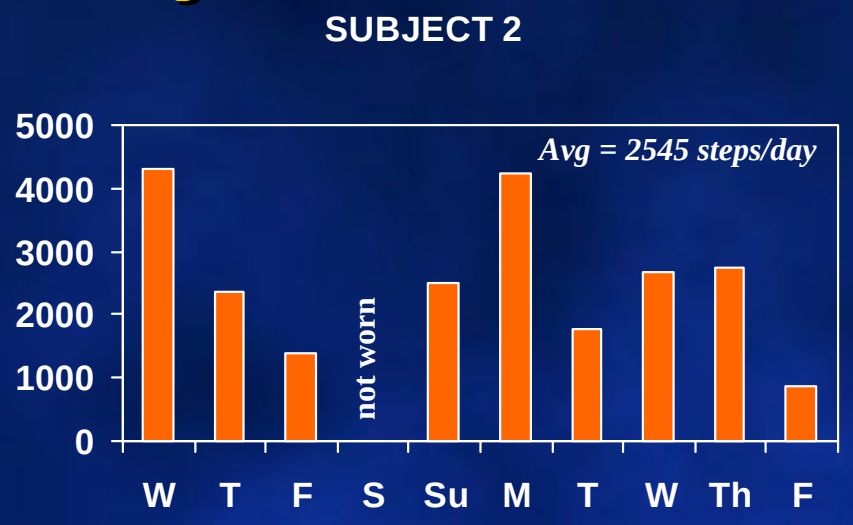
- Step Counter

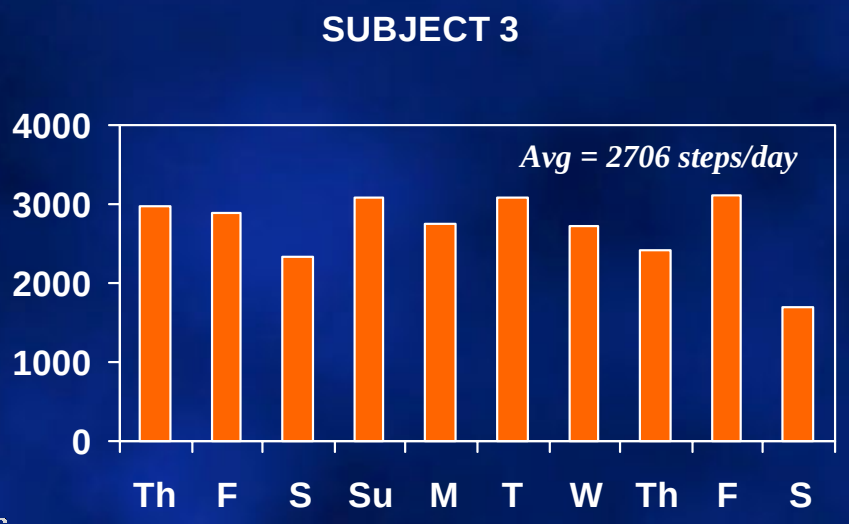
StepWatch™

- Pager-size molded urethane case worn on ankle
- Continuously records number of steps extended monitoring periods
- Time-sequenced data allow patterns of activity and rest to be visualized

Mauch SNS Knee
Steps/Day







1 millions steps/yr =
2700 steps/day

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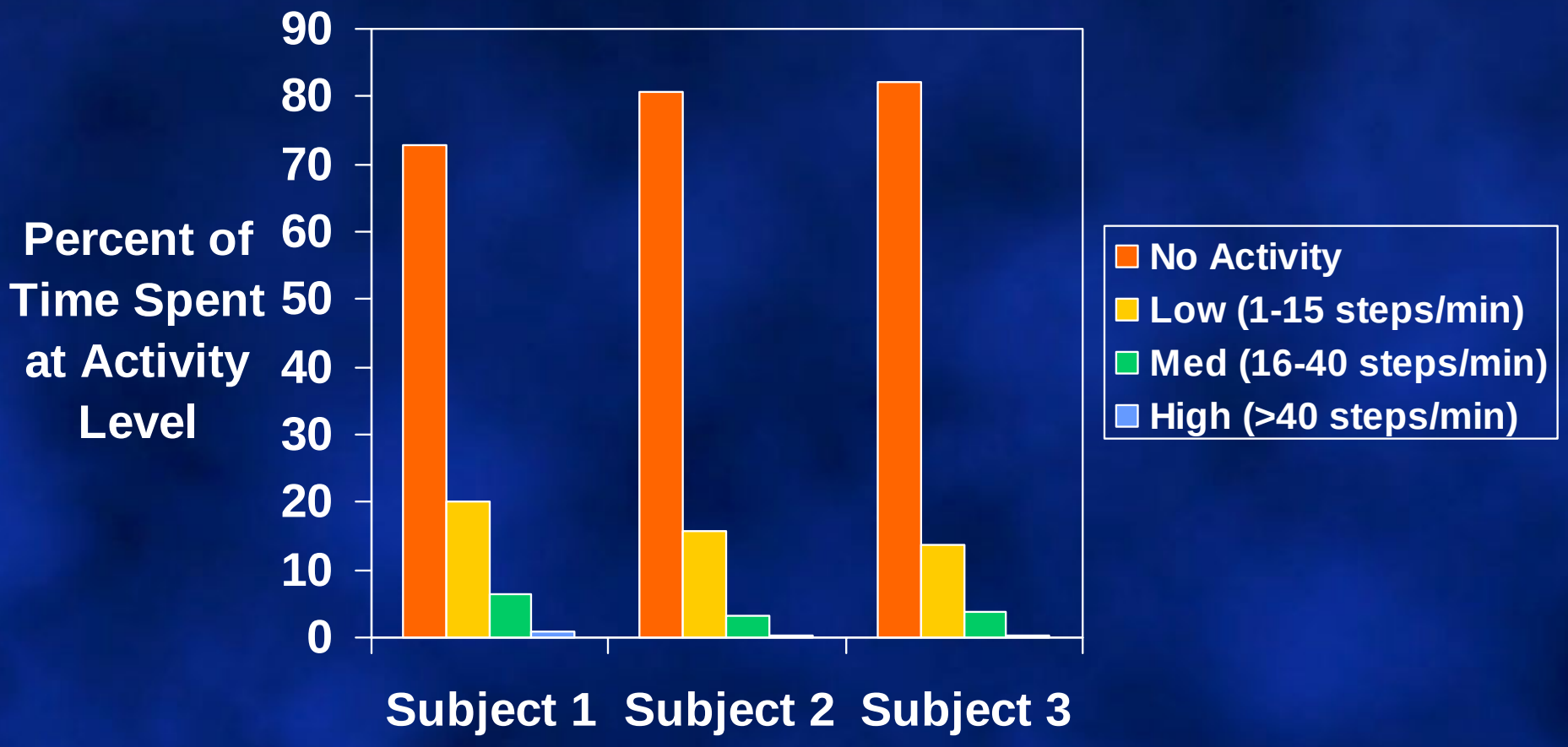
Activity Level

StepWatch™ Data

10 day Average



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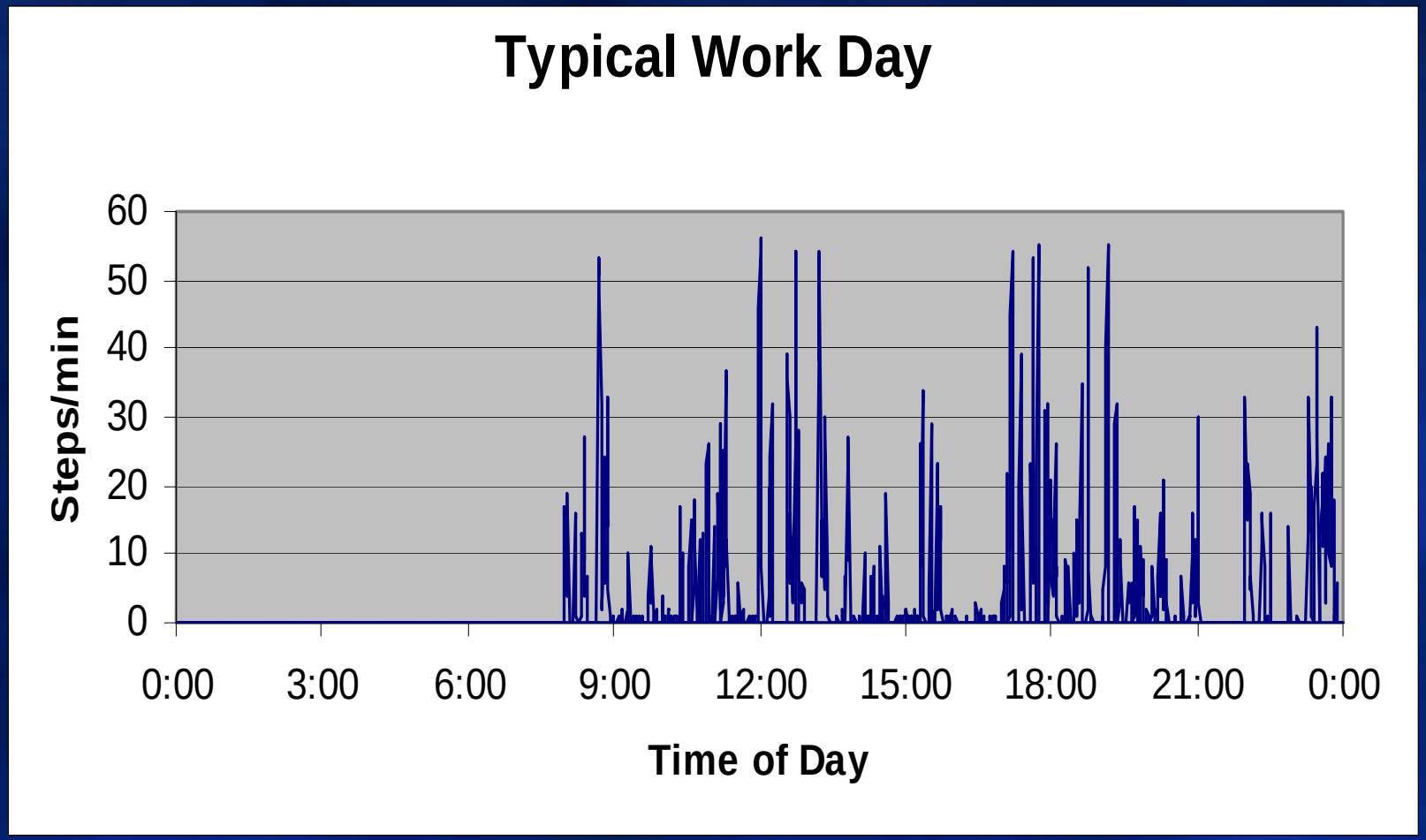
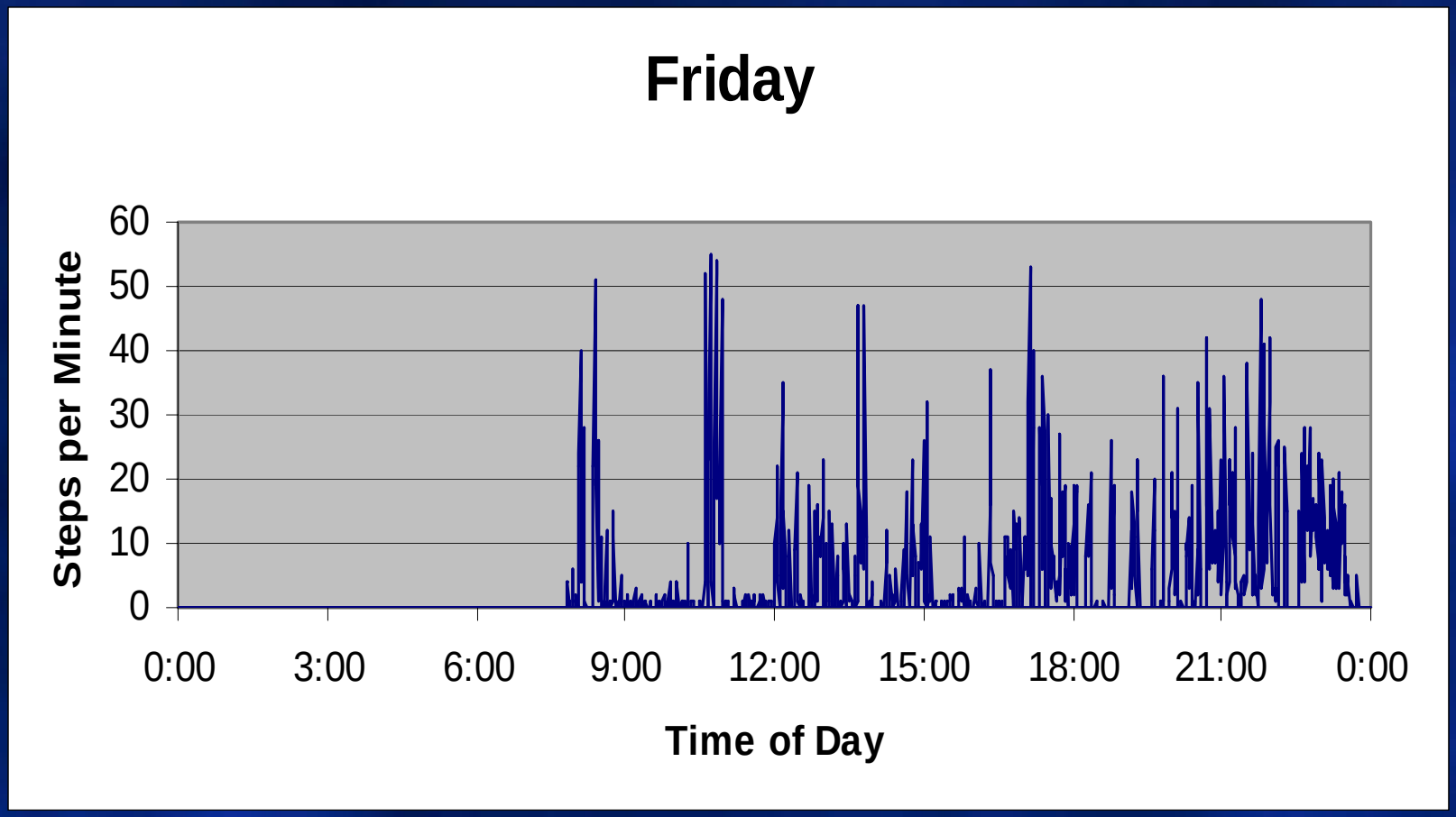
StepWatch Data™

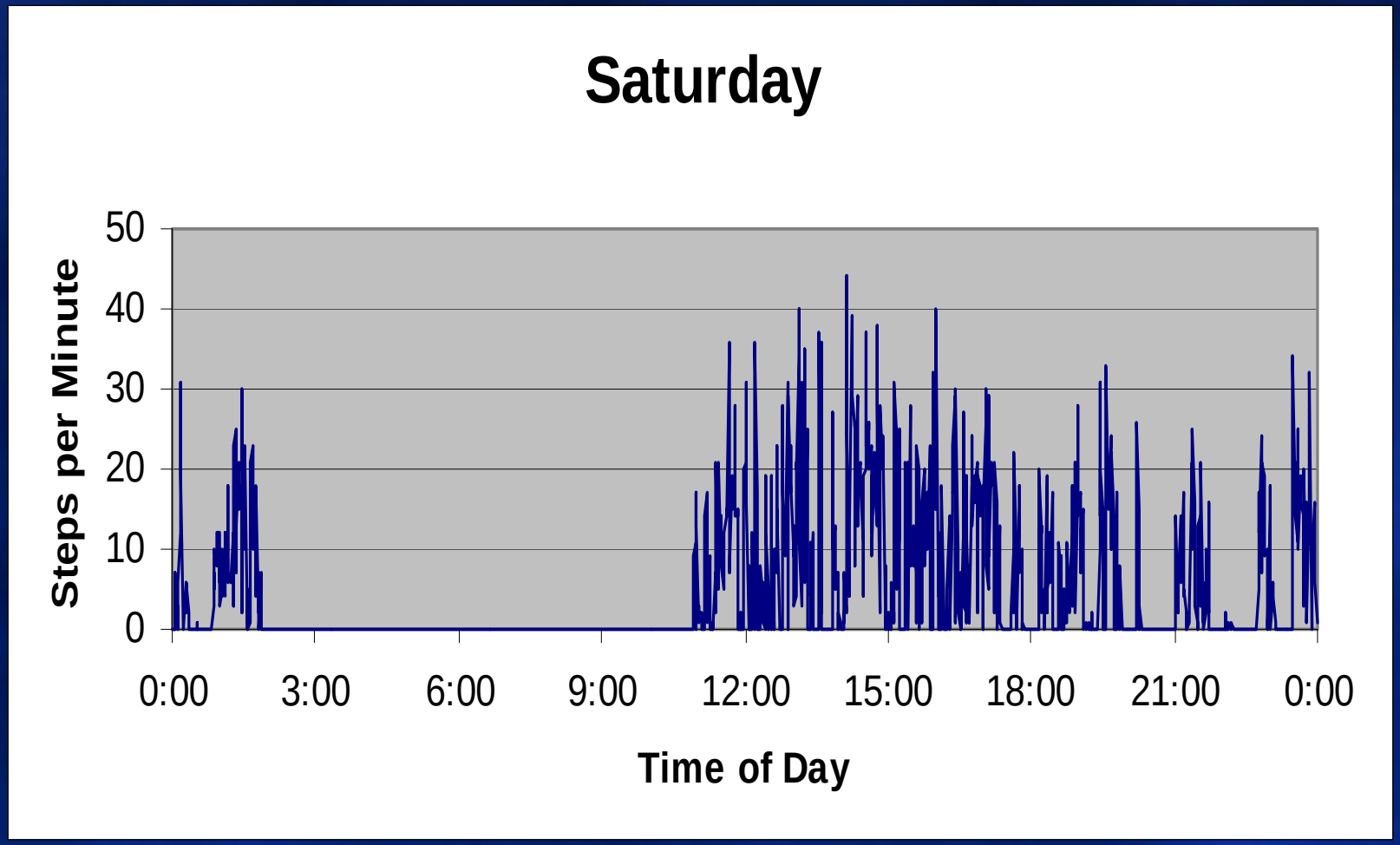


StepWatch™ Data

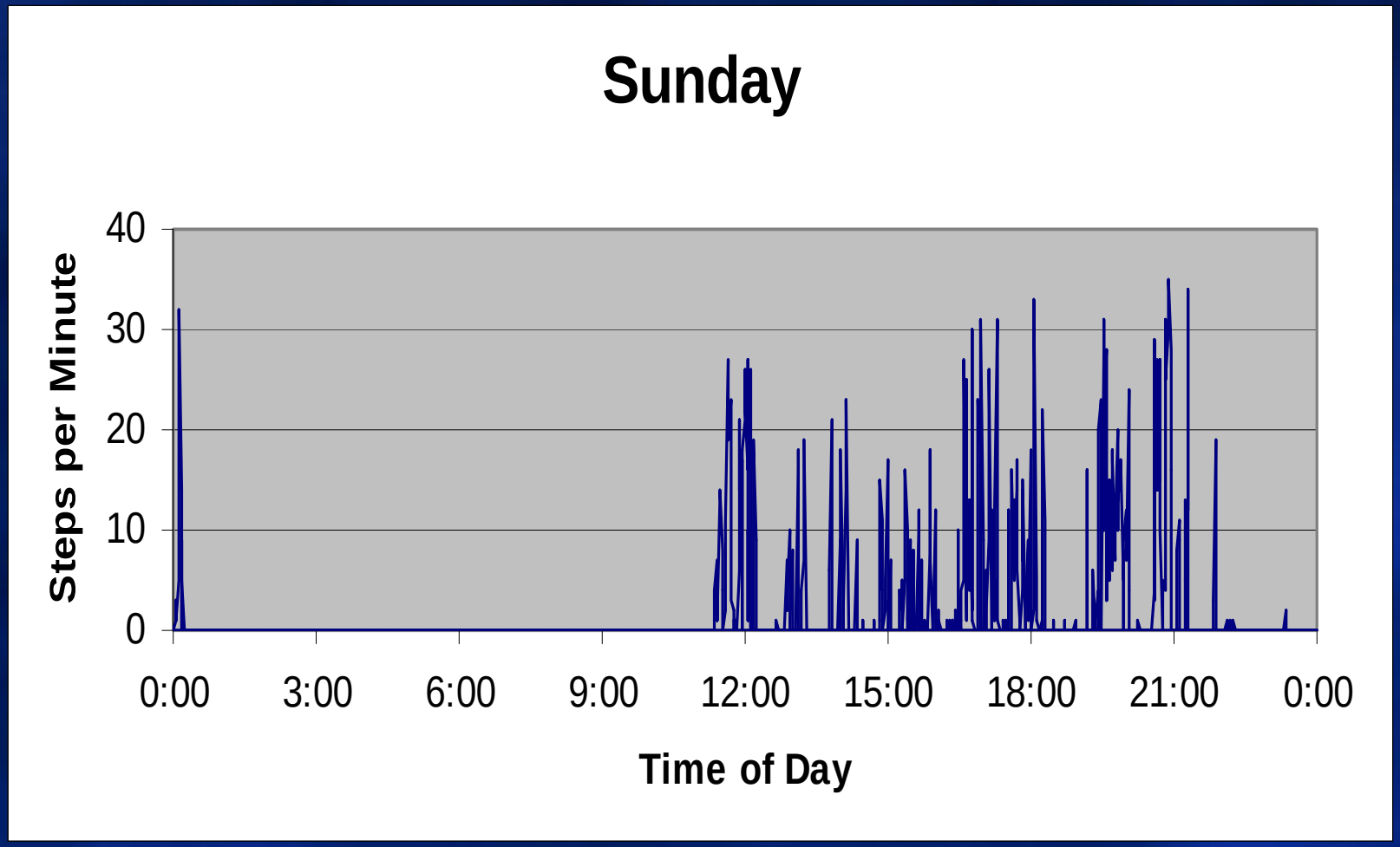
Typical weekend?

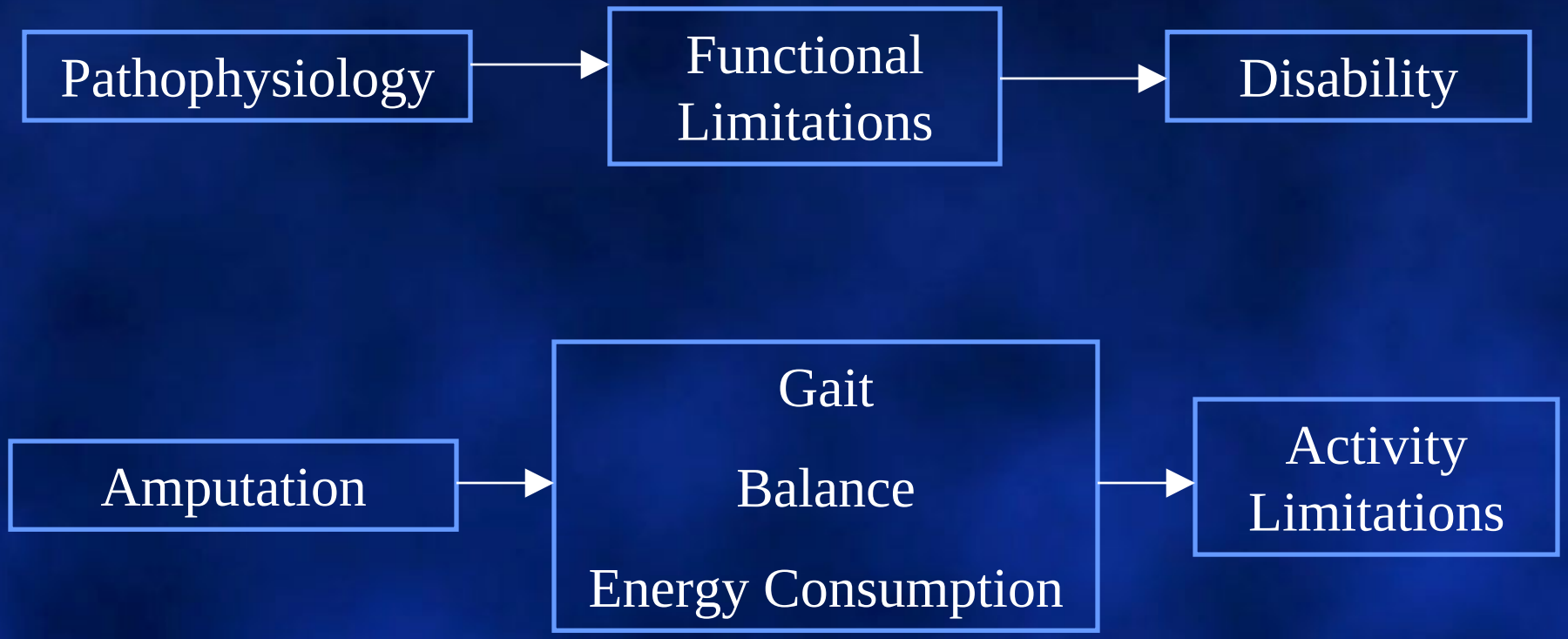


StepWatch™ Data

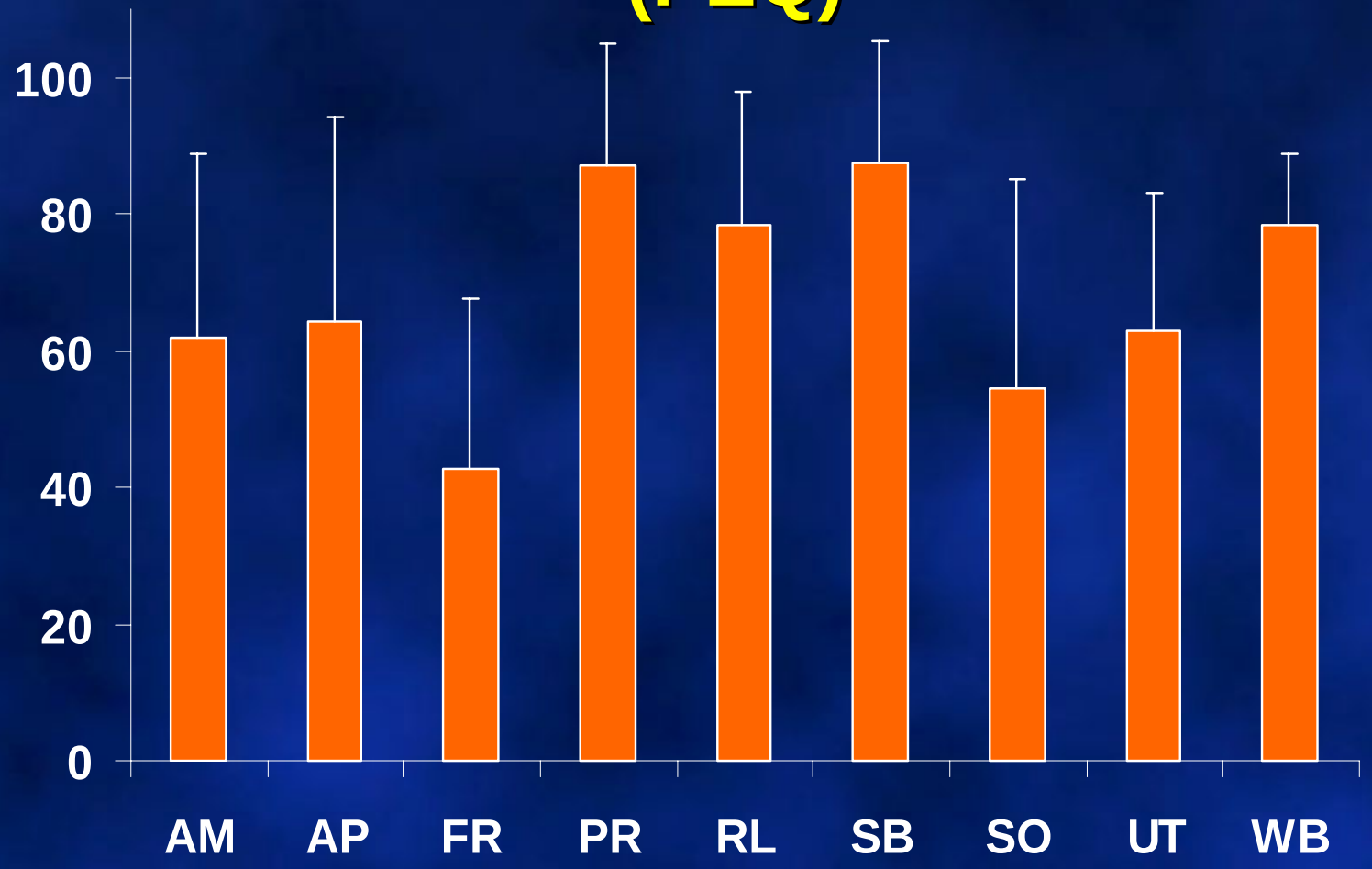


StepWatch™ Data




Pathophysiology
Functional Limitations
Disability
Amputation
Gait
Balance
Energy Consumption
Activity Limitations

Prosthetic Evaluation Questionnaire (PEQ)



Ambulation (AM), Appearance (AP), Frustration (FR), Perceived Response (PR), Residual Limb Health (RL), Social Burden (SB), Sounds (SO), Utility (UT), Well Being (WB)

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Outcome Assessment
RECOMMENDATIONS

Mechanistic

- Questionaire
  - SF-36
  - Prosthesis Evaluation Questionaire
- Instrumented Measures
  - Gait
  - Balance

Metabolic

- Energy Expenditure
- Total Activity

Thank you!