Sensor-based chair rise transfer analysis --- comparison of standardized assessments and daily life measurements.

Wei Zhang, M.Sc.
Philips Research Europe
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Introduction

Sensor-based sit-to-stand power analysis

Chair rise performance influenced by leg strength and power.
It is a useful parameter indicating mobility and fall risk in older people [1,2].

- Chair rise peak power measured with body-fixed sensors in the standardized tests

  -has good to excellent agreement with the peak power measured with the instrumented force-plate [3].

  -has good to excellent test-retest reliability [4,5].

  -is sensitive to detect the change in the leg power [6].

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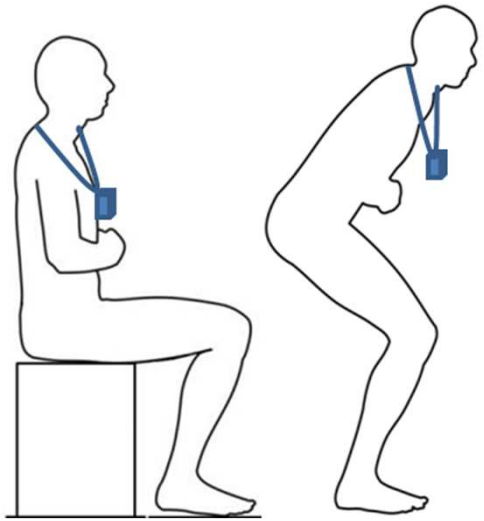
Algorithm

Chair rise detection and analysis with a pendant sensor [7]

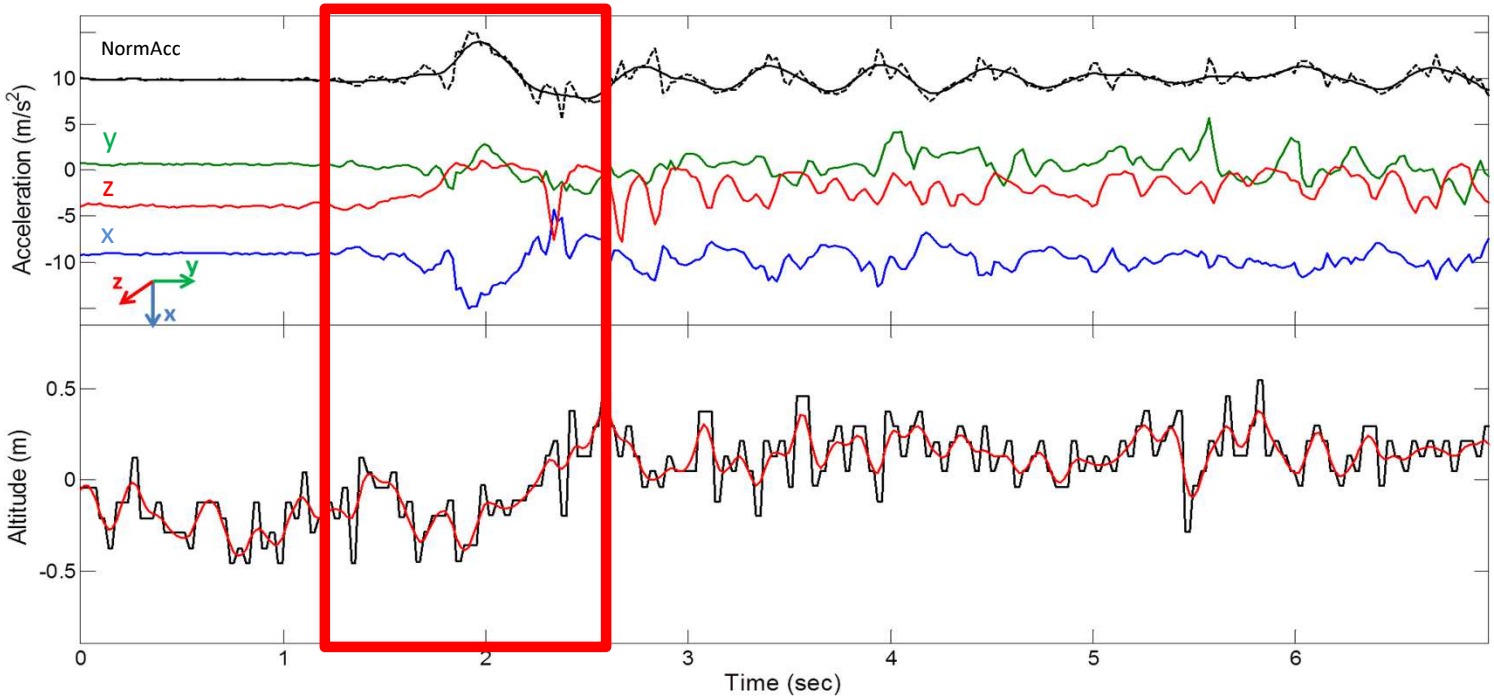
3D accelerometer (50Hz) and
an air pressure sensor (25Hz).



Worn with a necklace belt.
No restriction in daily activity.

Algorithm

Chair rise transfer detection



Standardized assessments
- precision: 87.4%
- recall: 85.3%

Free movements
- precision: 88.6%
- recall: 60.9%

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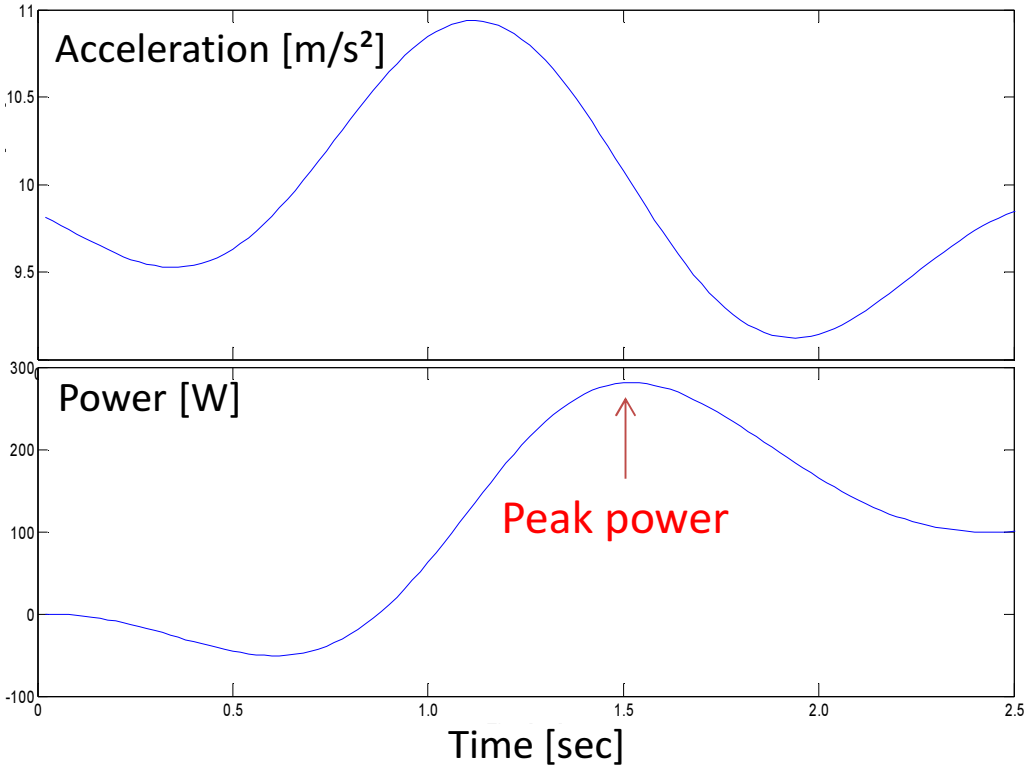
Algorithm

Chair rise transfer peak power analysis



Performance of the chair rise is measured by the peak power (PI):

$$V_{vert}(t) = V_{vert}(t_0) + \int_{t_0}^{t} [A_{norm}(t) - \mathrm{G}] \cdot dt$$

$$Power(t) = BodyMass \cdot A_{norm}(t) \cdot V_{vert}(t)$$

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Comparison study

Study protocol

- Participants:
  - 70 years or older
  - community-dwelling or living in an older adult home
  - able to walk 10m themselves with or without an assistive devices (cane or walker)

- Assessments:
  - Mobility (Timed-up-and-go (TUG))
  - Limitation in activities (Groningen Activity Restriction Scale (GARS))
  - Frailty (Groningen Frailty Indicator (GFI))
  - Fear of falling (Fall Efficacy Scale-International (FES-I))

  with pendant-sensor
  - Standardized tests: 5 repetitions of STS and 3 repetitions of STW
  - Free movements: 30 minutes self chosen activities in and around home
  - Daily living: 1-week continuous measurements in daily life.

- Analysis:
  - Pearson correlation among transfer peak powers in different tests
  - Spearman correlation between transfer peak powers measured in different tests and the clinical assessments
  - ANOVA analysis of significant differences in transfer peak powers between groups of older people using and not using assistive devices.

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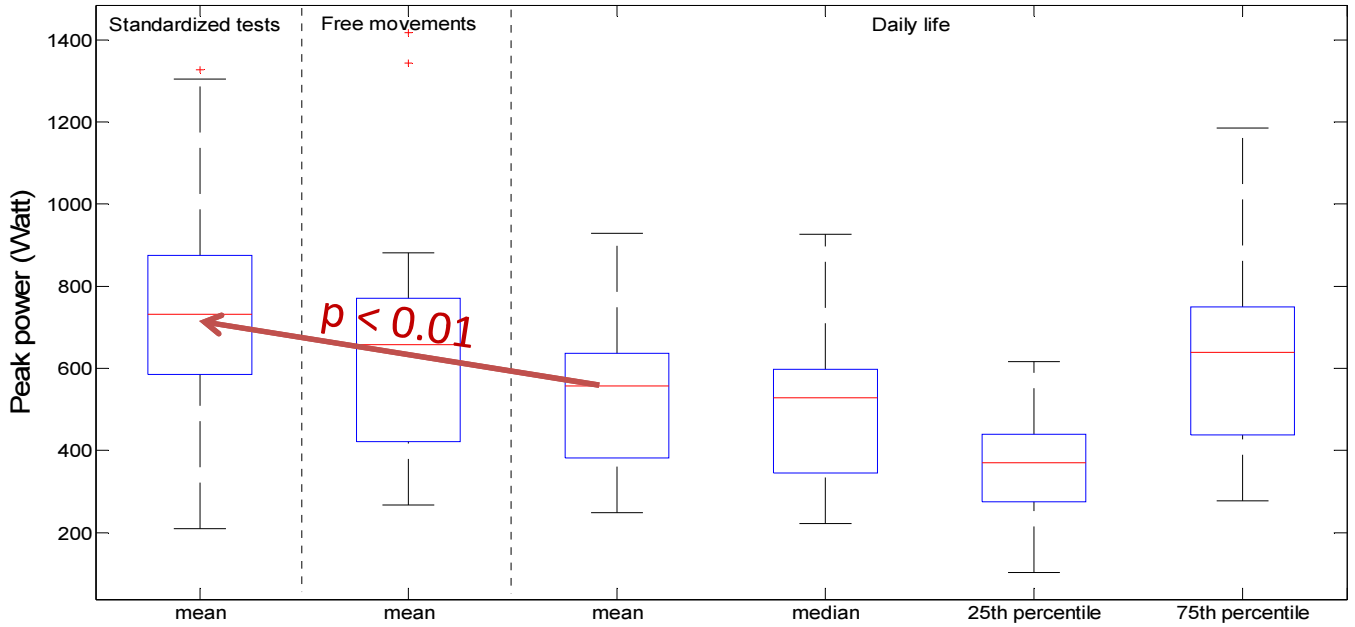
Results

Transfer peak power measured in different tests

Tests	Nr. Subjects	Nr. Transfer (mean±SD)	Peak power (Watt)
Standardized tests (mean)	21	7.7±1.7	763.1±315.2
Free movements (mean)	23	2.3±1.2	664.1±318.6
Daily life (mean)	23	138.8±101.6	531.0±169.1
Daily life (median)			496.9±176.7
Daily life (25percentile)			366.5±136.6
Daily life (75percentile)			641.5±216.9



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Results

Pearson correlation of transfer peak power measured in different tests

Spearman correlation of transfer peak power with clinical measurements

	Chair rise peak power (mean)		TUG (normal)	TUG (fast)	GARS	GFI	FESI
	Standardized tests	Free movements					
Standardized tests (mean)	/	/	-0.67_s^{**}	-0.62_s^{**}	-0.32_s	-0.16_s	0.03_s
Free movements (mean)	0.86_p^{**}	/	-0.59_s^{**}	-0.62_s^{**}	-0.50_s^{*}	-0.20_s	-0.07_s
Daily life (mean)	0.74_p^{**}	0.61_p^{**}	-0.66_s^{**}	-0.61_s^{**}	-0.48_s^{*}	-0.43_s^{*}	-0.42_s^{*}
Daily life (median)	0.70_p^{**}	0.62_p^{**}	-0.69_s^{**}	-0.64_s^{**}	-0.53_s^{**}	-0.45_s^{*}	-0.42_s^{*}
Daily life (25percentile)	0.66_p^{**}	0.66_p^{**}	-0.71_s^{**}	-0.62_s^{**}	-0.62_s^{**}	-0.52_s^{*}	-0.48_s^{*}
Daily life (75percentile)	0.69_p^{**}	0.59_p^{*}	-0.64_s^{**}	-0.58_s^{**}	-0.49_s^{*}	-0.37_s	-0.39

$_p$: Pearson correlation coefficient.
$_s$: Spearman correlation coefficient.
*: $p < 0.05$.
**: $p < 0.01$.

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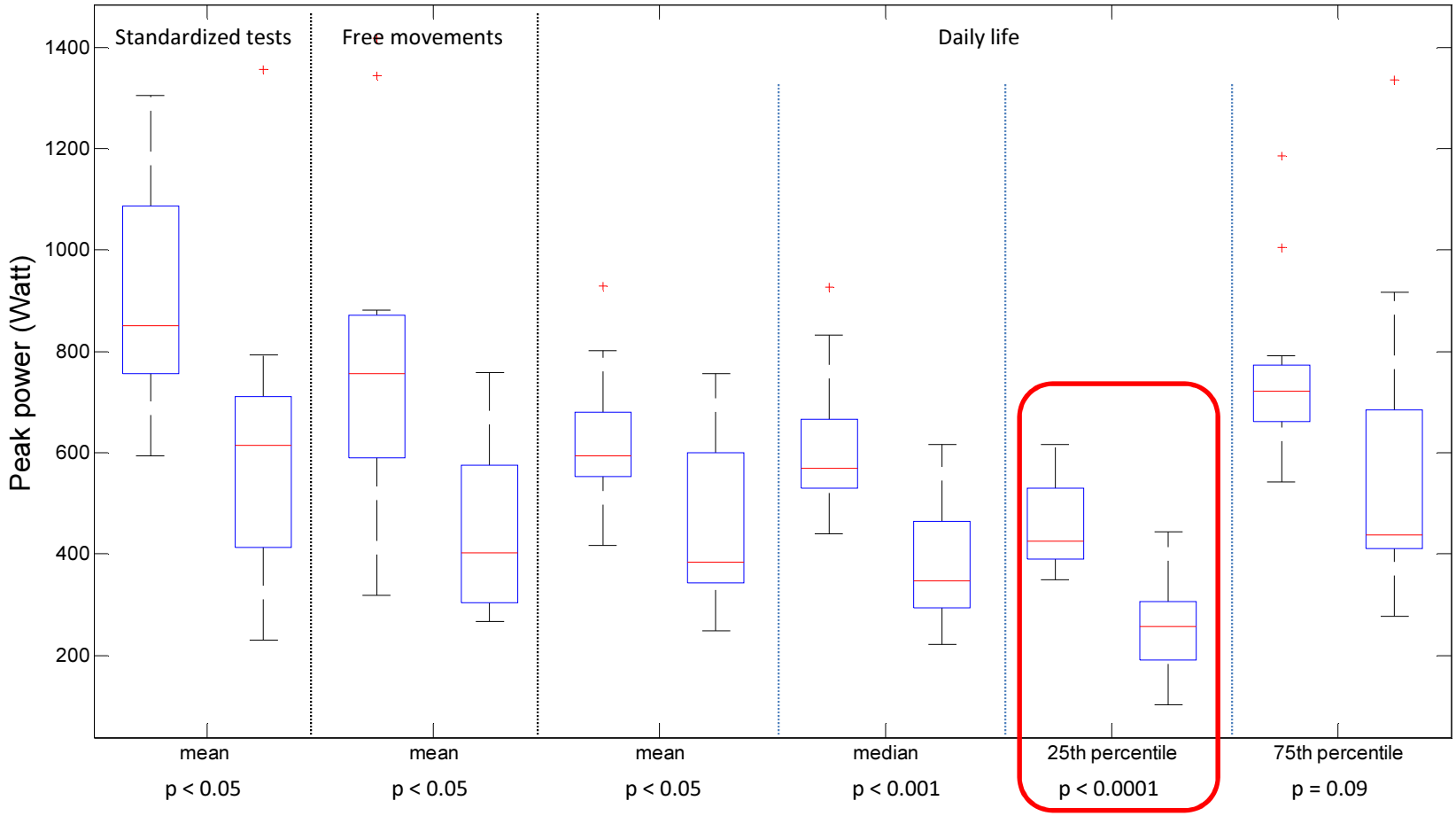
Results

Significant difference in peak powers measured between groups of older people using and without using assistive devices



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Conclusion

- Pendant-sensor is feasible for chair rise transfer peak power analysis in standardized tests and in daily life.

- Pendant-sensor-based peak power analysis has significant moderate to strong correlation to the clinical mobility test outcome. The correlation is slightly stronger with the measurements in daily life than in the standardized tests.

- Reliable measurement statistics can be obtained from large number of chair rise transfers acquired in daily life, which can better reflect the functional performance compared to the standardized tests.

- To certain extent, sensor-based movement analysis in daily life can replicate the measurement of clinical tests e.g. physical aspect, but cannot reproduce measurement in other aspects e.g. psychological aspect.

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