VU university medical center

Rehabilitation technology and E-health:

Projects at VU University Medical Center Amsterdam

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Disclosures

Presenter has no conflict of interest to disclose.

Outline

* Role of Physical activity
* (Tele-) rehabilitation technology / selfmanagement in stroke
* Usefulness of ambulatory sensors for real-time monitoring and feedback for activity tracking
* Physical activity monitoring and feedback in tele-rehabilitation and e-health after stroke:
  * the care- program

Physical inactivity

* Assumed costs of major chronic or non-communicable diseases (NCDs) : $53.8 billion dollars.

* About 1.5% of these costs are preventable if physical inactivity leading to chronic diseases and co-morbidity is properly addressed. (Ding et al, Lancet 2016).

Disease Self-management

In the Chronic Care Model:

* *Self-management* involves engaging the person with chronic disease in activities that:

  * Protect and promote health behavior
  * Monitor the symptoms and signs of illness
  * Manage the impacts of illness on functioning, emotions and interpersonal relationships
  * Promote adherence to treatment regimes

Von Kroff et al., Ann Intern Med 1997;127(12):1097-1102.

* Early data on self-management strategies (Lorig KR et al., Medical Care 1999;37(1):5-14)
  * 1000 patients with chronic diseases
    * Heart disease, lung disease, *stroke*, arthritis
  * completed Chronic Disease Self Management Program
  * Followed-up for 3 years
  * Improvements :
    * Self-efficacy
    * Health status
    * Health care utilization
    * Self-management behaviors
    * Aerobic exercise (minutes per week)
    * Physical activity?
    * Mobility?

Self-report

	Baseline		Six-Month Change		
	Treatment Mean (SD) (n = 561)	Control Mean (SD) (n = 391)	Treatment Mean (SD of Δ)	Control Mean (SD of Δ)	Significance P^*
Health behaviors					
Stretching & strengthening	40	37	13	5	0.005
Exercise (minutes/week)	(54)	(54)	(56.7)	(54.6)	
Aerobic exercise	95	93	16	-2	0.0003
(minutes/week)	(97)	(83)	(94.5)	(87.0)	

(Tele-) rehabilitation applications and technology for mobility and physical activity

* Consultation / Education
* Diagnosis and Evaluation (i.e. Assessment)
* Training / Therapy: Motor Relearning (Robotics, biofeedback / Virtual Reality applications)
* Home and Activity monitoring
  * Body worn sensors
  * Smartphones

Robotics

Effects of Robot-Assisted Therapy for the Upper Limb After Stroke: A Systematic Review and Meta-analysis

Neurorehabilitation and
Neural Repair
1–15

DOI: 10.1177/1545968316666957
nnr.sagepub.com
SAGE

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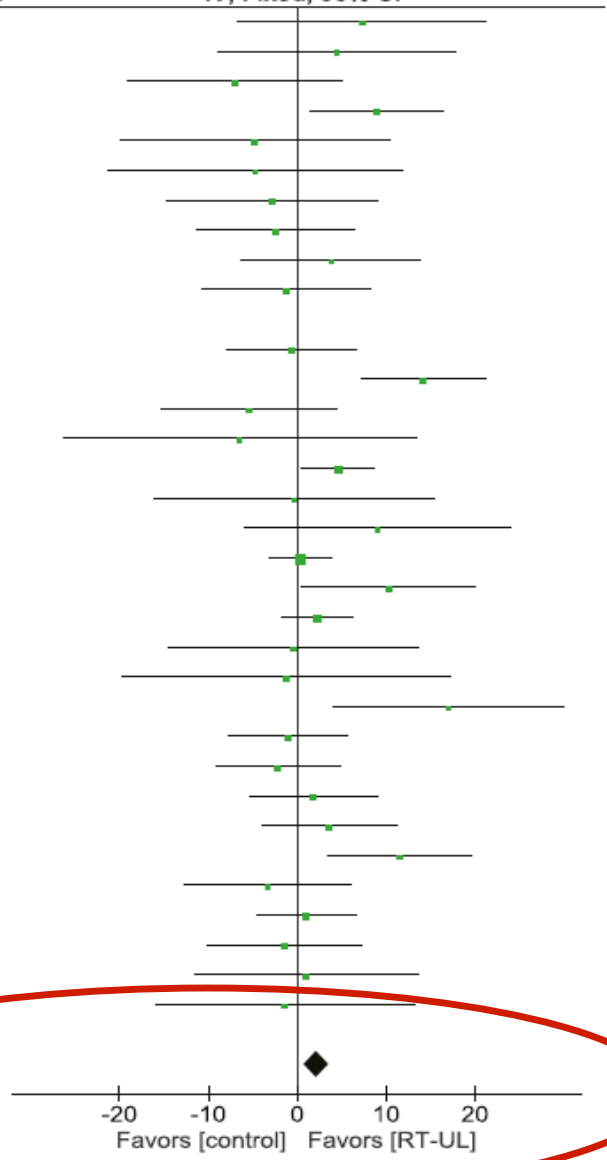
Effect on motor control (FMA, N=28)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Mean Difference IV, Fixed, 95% CI
Aisen, 1997	31.2	15.18	10	23.9	16.64	10	1.0%	7.30 [-6.66, 21.26]
Ang, 2014	32.8	11.5	8	28.3	14.5	7	1.0%	4.50 [-8.87, 17.87]
Araújo de, 2011	40.83	6.15	6	47.83	13.78	6	1.3%	-7.00 [-19.07, 5.07]
Brokaw, 2014	27.57	8.77	7	18.6	4.22	5	3.3%	8.97 [1.49, 16.45]
Burgar, 2011	33.4	15.26	17	38.2	20.36	9	0.8%	-4.80 [-19.95, 10.35]
Burgar, 2011	33.5	21.79	19	38.2	20.36	9	0.7%	-4.70 [-21.22, 11.82]
Byl, 2013	27.8	7.92	5	30.6	6.92	2	1.3%	-2.80 [-14.64, 9.04]
Byl, 2013	28.2	4.6	5	30.6	6.92	3	2.4%	-2.40 [-11.21, 6.41]
Conroy, 2011	23.24	14.7	20	19.39	12.5	10	1.8%	3.85 [-6.23, 13.93]
Conroy, 2011	18.2	10.6	18	19.39	12.5	9	2.0%	-1.19 [-10.71, 8.33]
Daly, 2005	30.5	6.38	0	32.5	7.06	6		Not estimable
Fasoli, 2004	15.7	10.95	30	16.3	15.81	26	3.5%	-0.60 [-7.83, 6.63]
Hesse, 2005	24.6	14.9	22	10.4	7.5	22	3.8%	14.20 [7.23, 21.17]
Hesse, 2014	25.7	16.5	25	31.1	19.1	25	1.9%	-5.40 [-15.29, 4.49]
Hollestein 2011	20.5	12.8	7	27	21.8	6	0.5%	-6.50 [-26.35, 13.35]
Housman, 2009	24.9	5.9	14	20.3	5	14	11.3%	4.60 [0.55, 8.65]
Hsieh, 2011	40	10.47	6	40.33	11.86	3	0.7%	-0.33 [-16.15, 15.49]
Hsieh, 2011	49.33	8.34	6	40.33	11.86	3	0.8%	9.00 [-5.99, 23.99]
Klamroth-Marganska, 2014	23.65	7.1	38	23.27	8.2	35	14.9%	0.38 [-3.15, 3.91]
Liao, 2012	51.2	8.82	10	40.9	13.14	10	1.9%	10.30 [0.49, 20.11]
Lo, 2010	23.57	10.7	47	21.31	8.4	46	12.2%	2.26 [-1.65, 6.17]
Lum, 2002	29.46	17.99	13	29.93	19.38	14	0.9%	-0.47 [-14.57, 13.63]
Masiero, 2011	42.66	15.79	11	43.87	25.72	10	0.5%	-1.21 [-19.68, 17.26]
Masiero, 2014	56	9.64	14	39	24.46	16	1.1%	17.00 [3.99, 30.01]
McCabe, 2015	31.3	6.2	6	32.3	7.9	12	4.2%	-1.00 [-7.68, 5.68]
McCabe, 2015	31.3	6.2	6	33.5	8.3	11	3.8%	-2.20 [-9.18, 4.78]
Page, 2013	22.86	7.01	8	21	7.54	8	3.6%	1.86 [-5.27, 8.99]
Reinkensmeyer, 2012	27.4	11.4	13	23.8	8	13	3.2%	3.60 [-3.97, 11.17]
Sale, 2014 (II)	35.46	12.24	26	23.96	17.51	27	2.8%	11.50 [3.39, 19.61]
Susanto, 2015	37	12.48	9	40.3	7.54	10	2.1%	-3.30 [-12.70, 6.10]
Timmermans, 2014	55	7.41	11	54	5.93	11	5.9%	1.00 [-4.61, 6.61]
Wu, 2012	47.14	10.97	14	48.57	12.32	14	2.5%	-1.43 [-10.07, 7.21]
Yang, 2012	47	8.4	7	46	11.1	4	1.2%	1.00 [-11.53, 13.53]
Yang, 2012	44.6	10	7	46	11.1	3	0.9%	-1.40 [-15.98, 13.18]
Total (95% CI)			**465**			**419**	**100.0%**	**2.23 [0.87, 3.59]**

Heterogeneity: Chi² = 45.95, df = 32 (P = 0.05); I² = 30%

Test for overall effect: Z = 3.21 (P = 0.001)

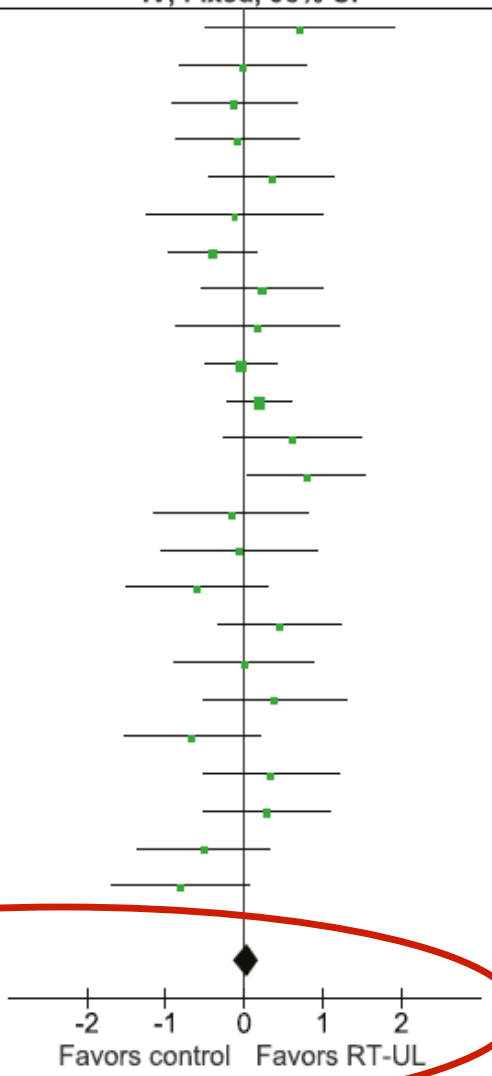


Effect on UL capacity (N=20)

Study or Subgroup	Experimental Mean	Experimental SD	Experimental Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Brokaw, 2014	26.71	12.6	7	19	3.32	5	1.7%	0.71 [-0.49, 1.91]
Burgar, 2011	-55.2	70.09	17	-53.6	76.37	9	3.7%	-0.02 [-0.83, 0.79]
Burgar, 2011	-64.2	82.82	19	-53.6	76.37	9	3.8%	-0.13 [-0.92, 0.67]
Conroy, 2011	-84.25	35.7	18	-81.09	33.3	10	4.0%	-0.09 [-0.86, 0.69]
Conroy, 2011	-67.12	40.2	20	-81.09	33.3	9	3.8%	0.35 [-0.44, 1.15]
Daly, 2005	-1,648	314.4	6	-1,593	496.7	6	1.9%	-0.12 [-1.26, 1.01]
Hesse, 2014	14.1	15.5	25	20.3	15.4	25	7.6%	-0.39 [-0.96, 0.17]
Hu, 2009	26	11.1	15	23.4	11.1	12	4.1%	0.23 [-0.53, 0.99]
Hwang, 2012	-76	87	9	-98.5	159.6	6	2.2%	0.18 [-0.86, 1.21]
Klamroth-Marganska, 2014	-60.5	23	38	-59.44	29	35	11.3%	-0.04 [-0.50, 0.42]
Lo, 2010	-62.44	37.7	47	-69.21	30.4	46	14.4%	0.20 [-0.21, 0.60]
Masiero, 2011	24.83	10.38	11	17.8	11.49	10	3.1%	0.62 [-0.26, 1.50]
Masiero, 2014	22	6.67	14	14	11.86	16	4.3%	0.79 [0.05, 1.54]
McCabe, 2015	-1,463	573	6	-1,367	566	12	2.5%	-0.16 [-1.14, 0.82]
McCabe, 2015	-1,463	573	6	-1,417	637	11	2.4%	-0.07 [-1.07, 0.92]
Rabadi, 2008	62.21	4.9	10	65.44	5.41	10	2.9%	-0.60 [-1.50, 0.30]
Reinkensmeyer, 2012	2	4.1	13	0.6	1.1	13	3.9%	0.45 [-0.33, 1.23]
Sale, 2014 (I)	9.09	13.5	11	9.11	12.02	9	3.1%	-0.00 [-0.88, 0.88]
Susanto, 2015	31.33	8.01	9	28.5	5.95	10	2.9%	0.39 [-0.52, 1.30]
Timmermans, 2014	34	11.86	11	43	14.08	11	3.2%	-0.67 [-1.53, 0.20]
Volpe, 2008	65	6.63	11	62.9	5.06	10	3.2%	0.34 [-0.52, 1.20]
Wu, 2013	-4.51	2.21	18	-5.26	3.26	9	3.7%	0.28 [-0.52, 1.08]
Wu, 2013	-8.79	7.57	18	-5.26	3.26	8	3.3%	-0.52 [-1.36, 0.33]
Yoo, 2013	-43.4	15.9	11	-33.3	6.3	11	3.1%	-0.80 [-1.68, 0.07]
Total (95% CI)			**370**			**312**	**100.0%**	**0.04 [-0.12, 0.19]**

Heterogeneity: Chi² = 23.40, df = 23 (P = 0.44); I² = 2%

Test for overall effect: Z = 0.47 (P = 0.64)



Telerehab: Cochrane review 2013

Telerehabilitation services for stroke (Review)

Laver KE, Schoene D, Crotty M, George S, Lannin NA, Sherrington C

10 trials, N= 933

* No effects on primary outcome ADL (4 trials)
* (or any other outcome)

* Only 1 trial targeted mobility, assessed with TUG!
* No physical activity monitoring

Result from Cochrane recently comfirmed by a systematic review Chen et al , 2015

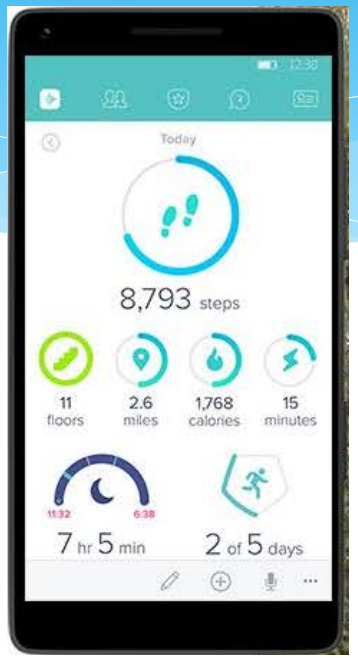
Applications for Monitoring in (tele-) rehabilitation

* General Activity Recording (Stepcounts/Energy expenditure/ …)
* Used in research as descriptors / outcome measures
  * Problems:
    * reactivity effects
    * avoidance effects
* **Delayed feedback** on free-living performance (i.e. daily activity/ stepcounts to promote increased activity levels)
  * Fitbit, jawbone, Nike fuelband, Apple watch etc etc.

* **Instantaneous / direct feedback** on free-living performance
  * posture correction in Parkinson's disease
  * walking and balance instability in stroke

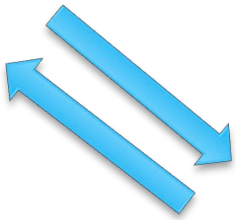
Delayed feedback on physical activity

* Fitbit
* Parkinson specific:
  * FoxInsight



Sensor Assisted Self management

BEHAVIOR/FUNCTIONING



sensing

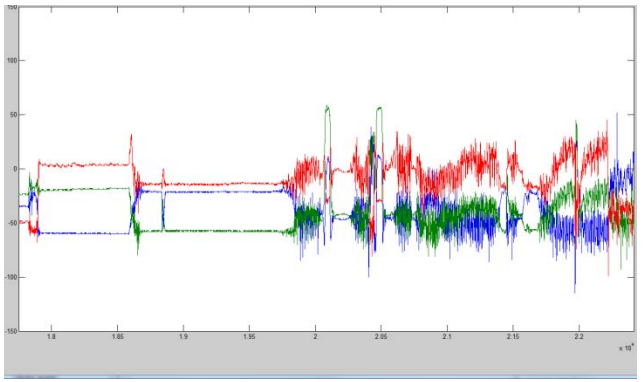
recording

delayed feedback

Client Dashboard
(optional)

PC - Smartphone - Tablet

direct feedback

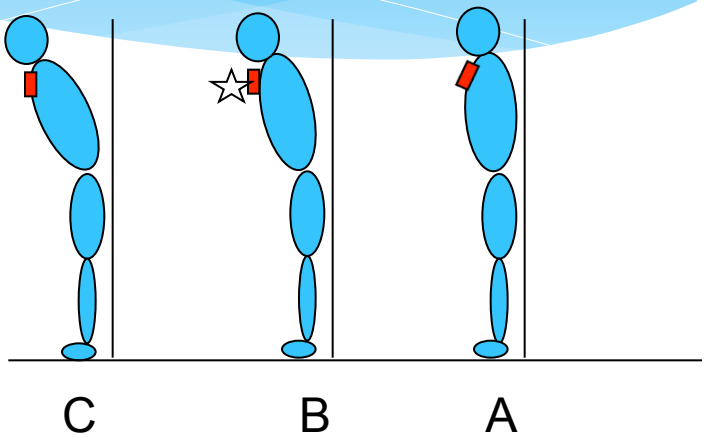


metrics

2M Engineering

Sensor Assisted Self management

UPRIGHT



A = correct posture
B = threshold 10 º
C = stooped posture

Sensor Assisted Self-management

Parkinson's disease: stooped posture

- Placed on sternum
- Measures trunk angle in saggital and frontale plane
- Feedback signal when x-sing threshold
- Setting threshold with therapist
- Data can be recorded, downloadable for therapist to monitor adherence

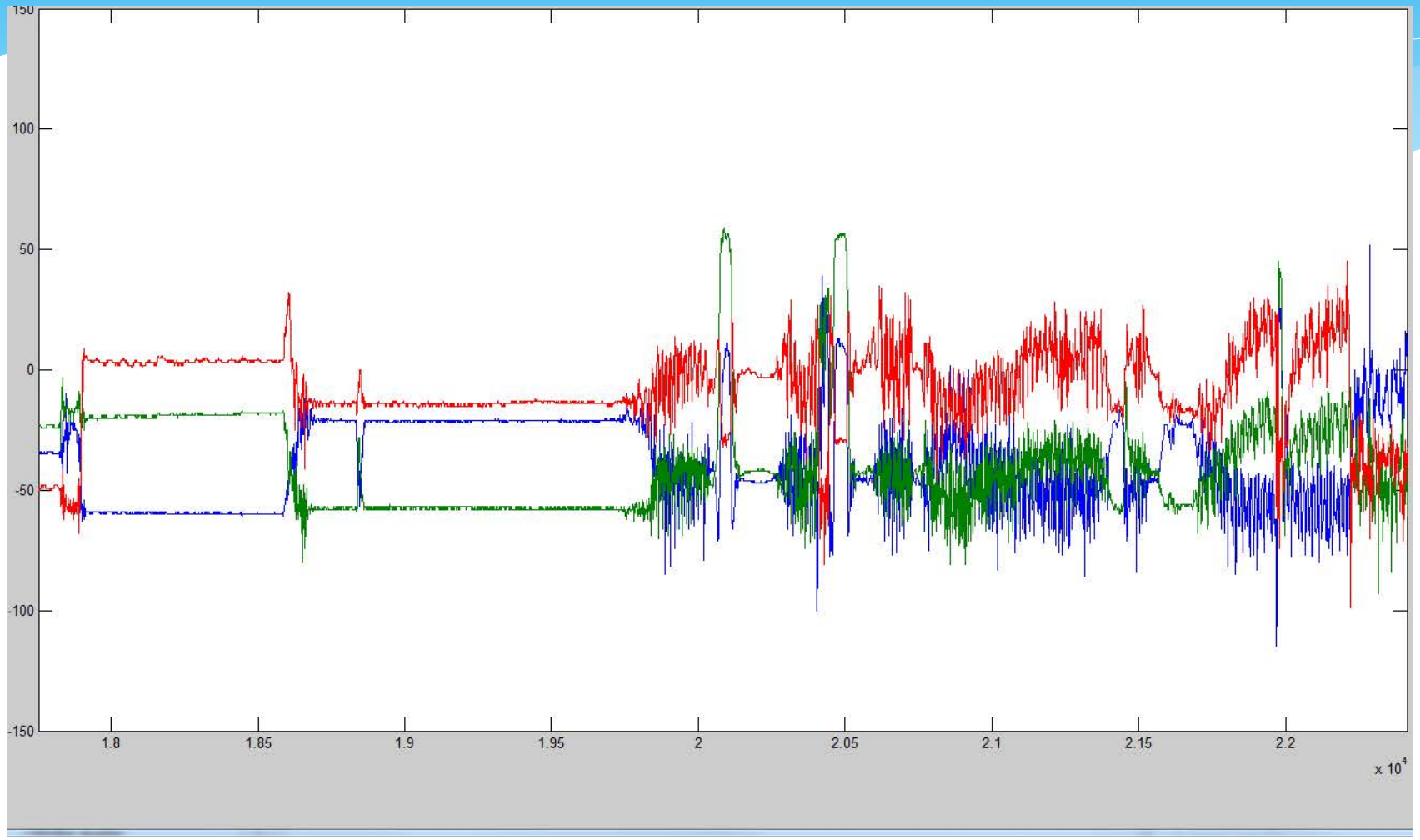
(Also built in metronome for cueing during walking)

2M Engineering

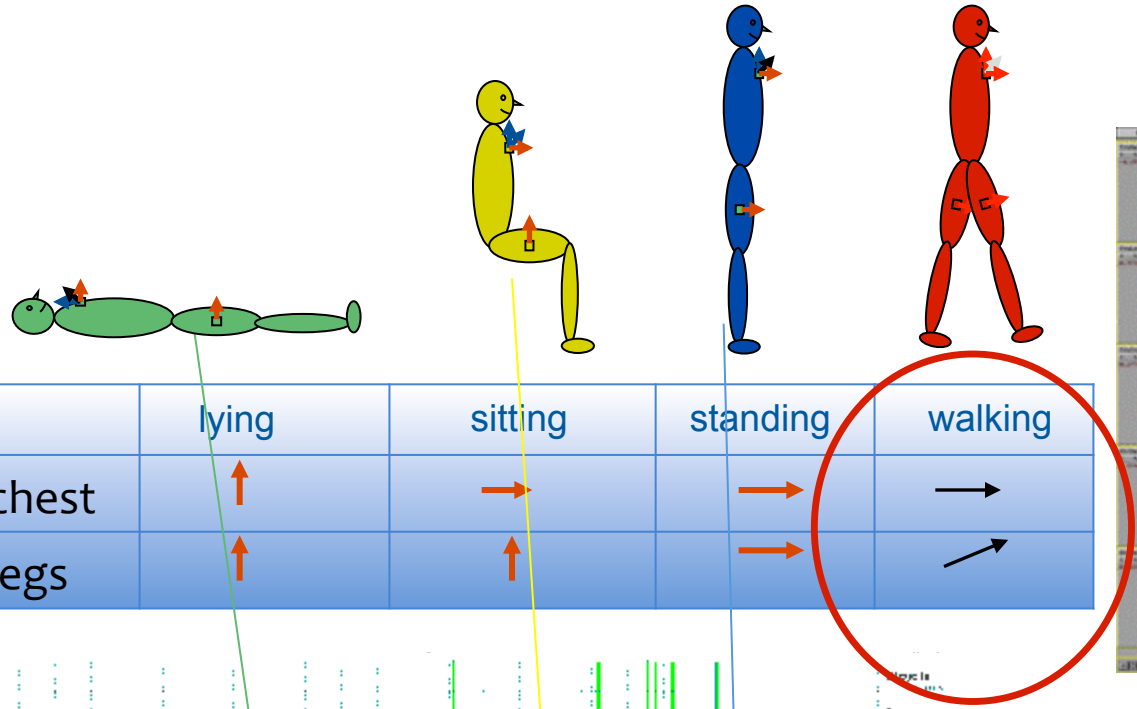
Activ8

* Activity Tracker w/ bluetooth capability
* Pilot validated in healthy subjects
* Suitable for use in stroke research?
* Validation of **Posture and Motion Detection** at Erasmus MC, Rotterdam
* Validation of **Stepcounts / Step detection** at VUmc

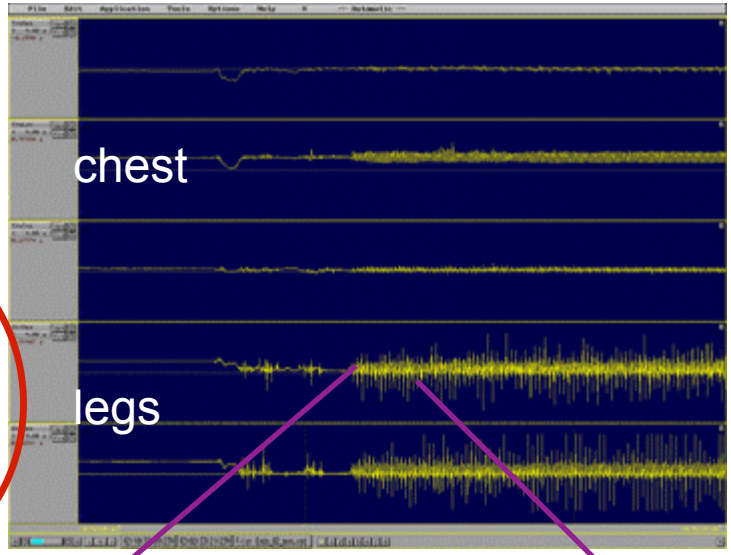
Raw 3D Activ8 data of stroke patient

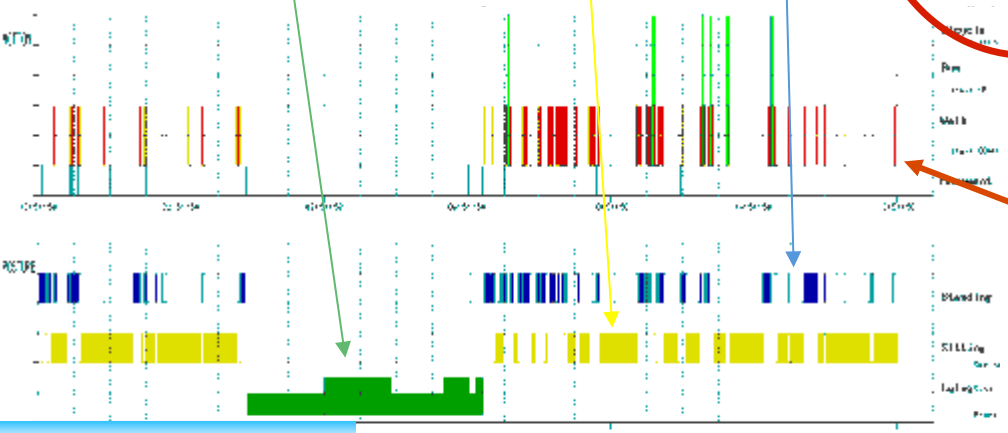


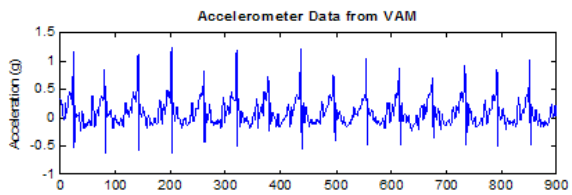
Classification of movements



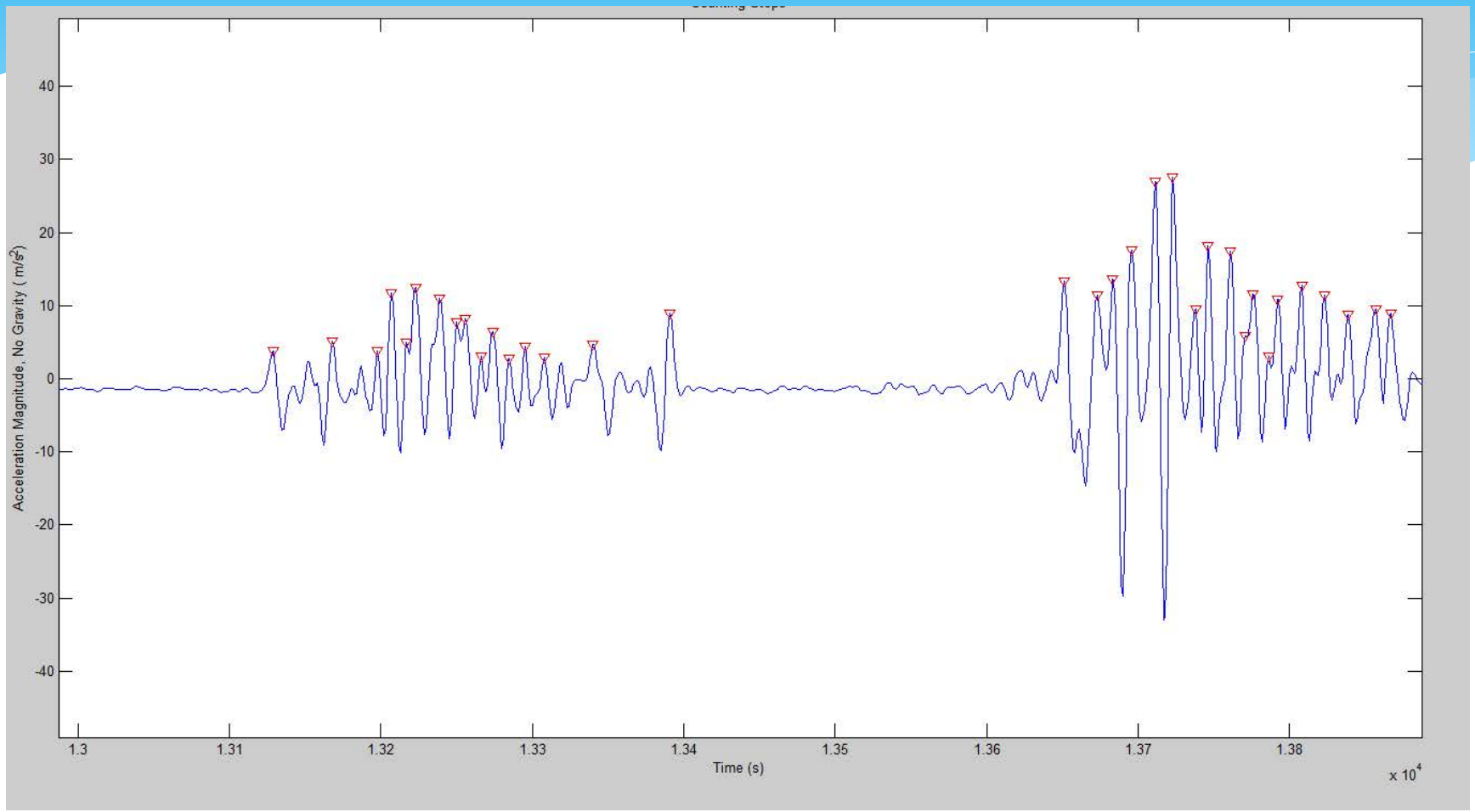
	lying	sitting	standing	walking
chest	↑	→	→	→
legs	↑	↑	→	↗



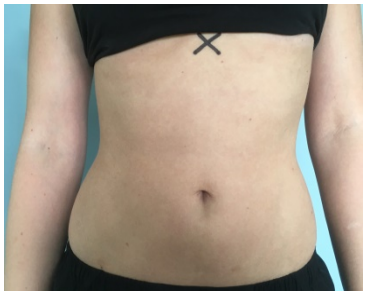




Scalar composite of filtered data



Criterion/Concurrent validity



Criterion validity

	Video (Spearman correlation)		
Activ8	**Total**	**Paretic side**	**non-paretic side**
Walking on normal surface	0.99	0.82	0.88
Walking on a treadmill	0.99	0.92	1.00
Walking stairs	0.87	0.94	0.65
Actigraph			
Walking on normal surface	0.52		
Walking on a treadmill	0.93		
Walking stairs	0.92		
Stepwatch			
Walking on normal surface	0.88		
Walking on a treadmill	0.95		
Walking stairs	0.74		

Telerehabilitation / selfmanagement in stroke patients?

* Intensive rehabilitation can improve functional recovery
* However, demand exceeds supply
  * Stroke patients are receiving less therapy than needed and are going home sooner
  * Transition from inpatient to home setting is troublesome
* Focus on self-management strategies by legislature
* By now, technologies are becoming available to maintain, improve and/or monitor recovery AT HOME

The Care-programme:

CARegiver mediated exercises with E-health support for early supported discharge after stroke.

Dr. Erwin van Wegen

Drs. Judith Vloothuis
Drs. Marijn Mulder
Dr. Rinske Nijland
Prof. Dr. M. Crotty
Dr. M. van den Berg
Prof. Dr. Gert Kwakkel

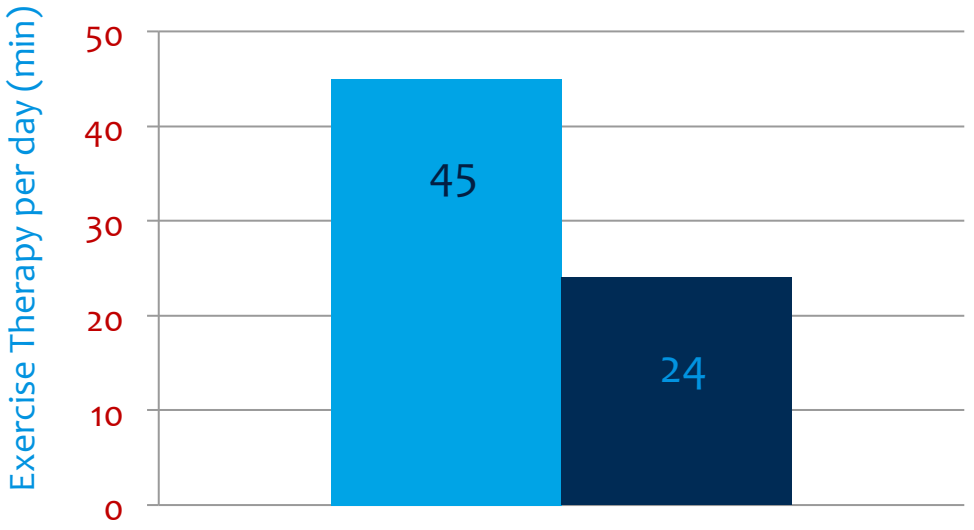
(Vloothuis et al. 2015)

Care:

Training with caregiver

4 Concepts

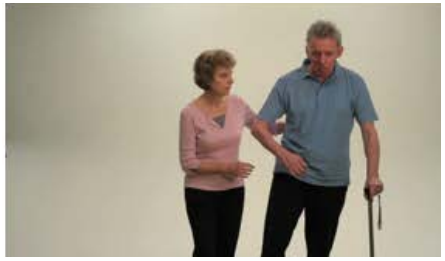
- 1. More training = better functional outcome (Veerbeek et al, 2014)
  - Stroke patients are very inactive, especially in weekends (see also pres. Dr. Chastin)
  - Guidelines recommend 45 minutes therapy per day (Veerbeek et al, 2014)
  - Is in fact only 24 minutes / day (Otterman 2012, 91 Hospital Stroke Units NL)



Care program:
caregiver mediated exercises

Concepts

- 2. Involving a caregiver in exercise therapy
  - Demand exceeds supply in rehabilitation settings
  - Focus on “novel” methods to increase duration/intensty of exercise therapy with minimal use of resources
  - Possibility for additional training in absence of therapist
  - + effect on functional outcome of patient
  - + effect on caregiver burden



Galvin 2011, Foster 2012, Vloothuis 2015

Care program:
Caregiver mediated exercises

Concepts

- 3. 'Early Supported Discharge' (Fischer 2011, Fearon 2012)

  - Rehabilitation explicitly directed at early discharge, with rehabilitation continuing in the home setting
  - Is strongly dependent on mobility of the patient

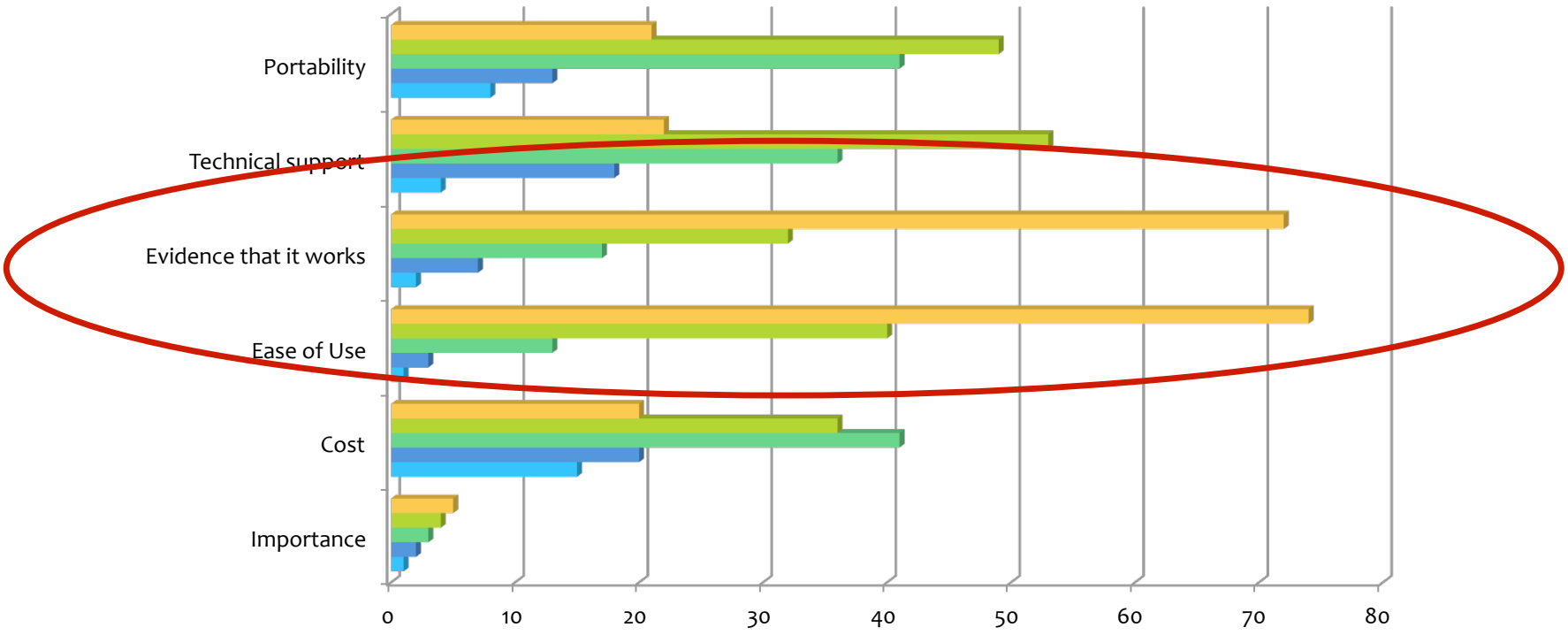
  - + reduced length of stay: cost-effective..
  - + increased independence
  - + reduced admission to nursing homes

Care program
Caregiver mediated exercises

Concepts

- 4. E-Health / Tele-rehabilitation for self management
  - Care at distance using ICT, care-provider not physically present
  - Tele-rehabilitation, remote monitoring and consulting by therapist
  - Promotion of physical activity with technology
  - + functioning of patient and informal caregiver ?

Survey workshop



Care program

* Combination of these 4 concepts:
  * Additional practice with caregiver without therapist:
    * Caregiver Mediated Exercises (CME)
  * Therapist, caregiver and patiënt compile exercise program in App
  * Start in rehab. Setting
  * Program continues after discharge home
  * Therapist coaches caregiver and patient at distance and monitors progress with e-health en tele-rehabilitation tools:
    * Smartphone / tablet App: exercise program, reminders, diary etc.
    * Tele-consultation: phone / email / Video conferencing
  * Clinimetrics test battery to assess effect of intervention
  * Adelaide branch:
    * FITNESS tracker to promote physical activity (FitBit Zip)
    * ActivPal to assess effect of intervention

Pilot project

* Financing pilot: Reade/VUmc
* Compiling pool of exercise in script (n=33) : guidelines
* Record images and video's with patient-carer diads
* Recording of voice-over and editing of videos
* Authoring into App (and exercise book)
* PILOT (n=4) successful: feasible and safe

Care intervention

- 35 Exercises for MOBILITY
  - Balance
  - Walking
  - Transfers
  - Physical Condition
  - ..

- Training program for <u>8 weeks</u>
  - 5 x per week 30 min practice (30 min may be split up)
  - 1x per week review/update exercises with therapist
  - Diad supported with telerehab. tools (phone/videoconferencing)
  - Adelaide: Fitbit Zip for daily promotion of activity

- Goals
  - Facilitate the transistion to home setting
  - Improve mobility and function
  - Shorten length of stay
  - Increase quality of life
  - Lower caregiver burden

●●●○○ T-Mobile NL 10:55 85%

My Exercises

Exercises

- Standing up with a handrail
- Low transfer bed-wheelchair
- Dynamic balance
- Picking up while standing
- Squatting
- Walking up stairs

Notifications

Completion Chart

About

My Exercises | Practitioner Section

●●●○○ T-Mobile NL 11:21 82%

My Exercises | Exercise

Picking up while standing

Number of repetitions: 5

Instructions:

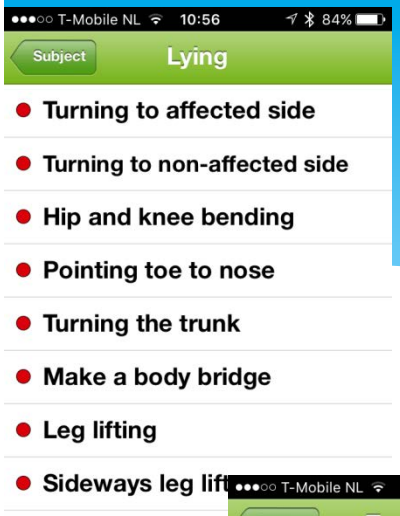
To make more difficult place object further

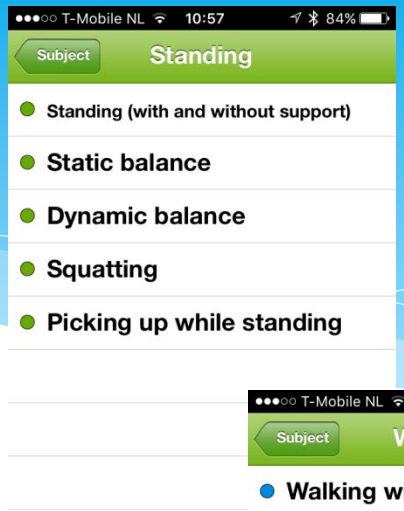
My Exercises | Practitioner Section

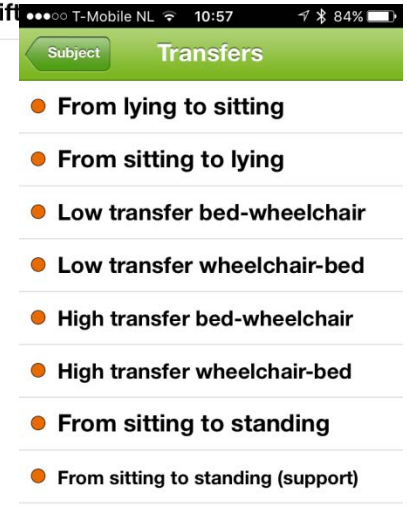
●●●○○ T-Mobile NL 10:52 85%

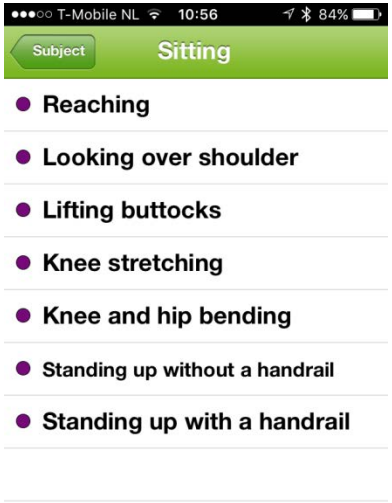
Exercise Scheme | Done

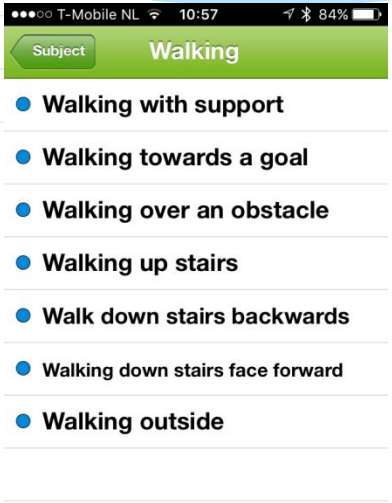
Day 1	To Do	Done
Day 2	To Do	Done
Day 3	To Do	Done
Day 4	To Do	Done
Day 5	To Do	Done


T-Mobile NL 10:56 84%
Subject
Lying
Turning to affected side
Turning to non-affected side
Hip and knee bending
Pointing toe to nose
Turning the trunk
Make a body bridge
Leg lifting
Sideways leg lift

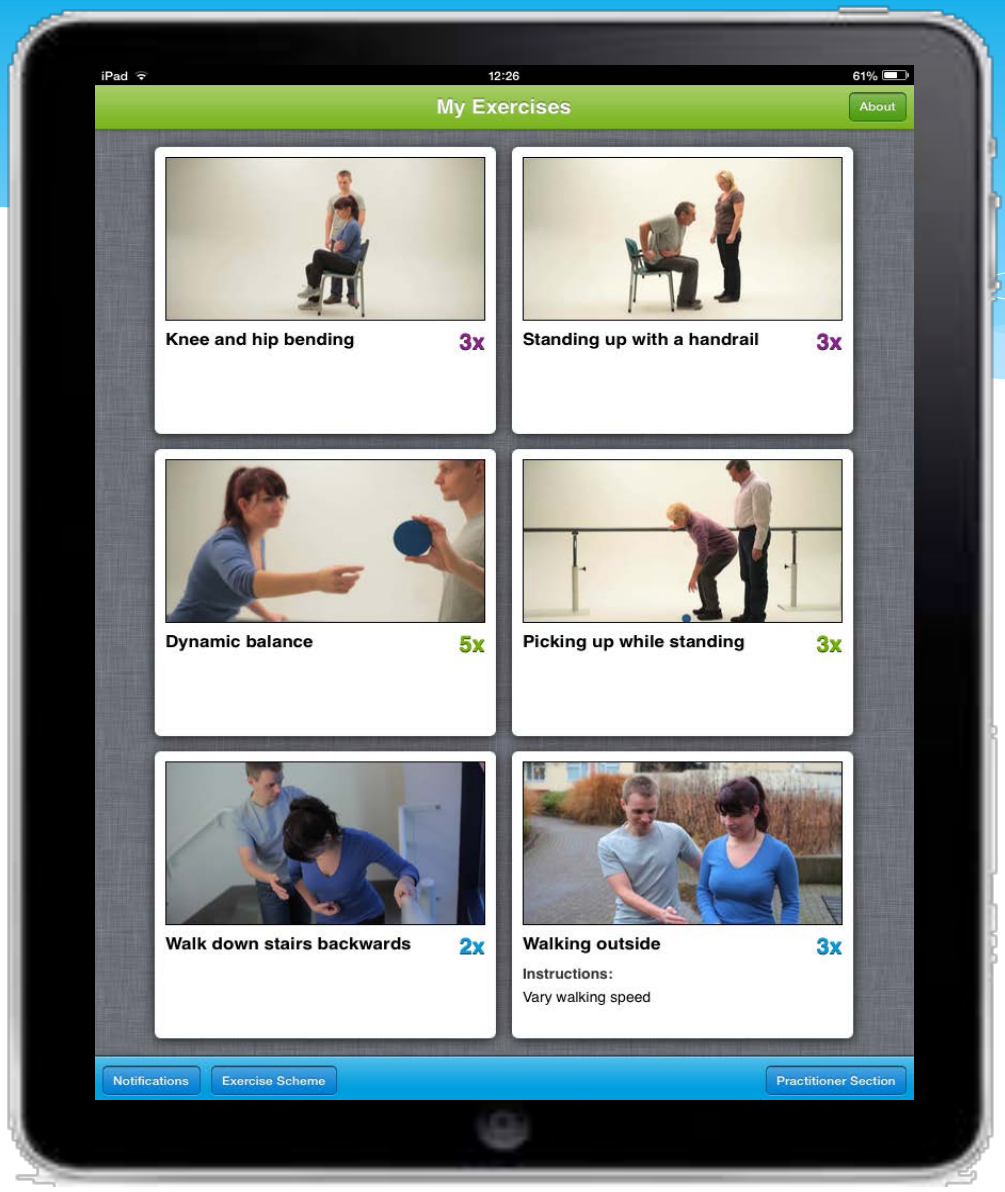

T-Mobile NL 10:57 84%
Subject
Standing
Standing (with and without support)
Static balance
Dynamic balance
Squatting
Picking up while standing


T-Mobile NL 10:57 84%
Subject
Transfers
From lying to sitting
From sitting to lying
Low transfer bed-wheelchair
Low transfer wheelchair-bed
High transfer bed-wheelchair
High transfer wheelchair-bed
From sitting to standing
From sitting to standing (support)


T-Mobile NL 10:56 84%
Subject
Sitting
Reaching
Looking over shoulder
Lifting buttocks
Knee stretching
Knee and hip bending
Standing up without a handrail
Standing up with a handrail


T-Mobile NL 10:57 84%
Subject
Walking
Walking with support
Walking towards a goal
Walking over an obstacle
Walking up stairs
Walk down stairs backwards
Walking down stairs face forward
Walking outside

iPad App


iPad
12:26
61%
My Exercises
About
Knee and hip bending
3x
Standing up with a handrail
3x
Dynamic balance
5x
Picking up while standing
3x
Walk down stairs backwards
2x
Walking outside
3x
Instructions:
Vary walking speed
Notifications
Exercise Scheme
Practitioner Section

Thank you for your attention

Judith Vloothuis
Rinske Nijland
Marijn Mulder
Maria Crotty
Maayken van den Berg
Enwu Liu
Gert Kwakkel

Hans Bussmann
Carel Meskers

Mark your calendar!

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STW connecting innovators

ZonMw