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# Objective measurement of physical behaviour in rehabilitation research and clinical practice



#### Hans Bussmann

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#### Short Curriculum Vitae



	<ul> <li>Physical therapy &amp; Human Movement Sciencies</li> </ul>	Hans Bussmann
1998	PhD thesis: "Ambulatory monitoring of mobility- related activities in Debabilitation Medicine"	
2008	<ul> <li>first ICAMPAM (International Conference on</li> </ul>	
	Ambulatory Monitoring of Physical Activity and	F
	Movement	Ambulatory monitoring
2015 -	<ul> <li>(Vice-) president of ISMPB (International Society</li> </ul>	in rehabilitation medicine
	on Measurement of Physical Behaviour)	
2007 - 2017	<ul> <li>Board member of the Society of Ambulatory</li> </ul>	ICMDD
	Assessment	International Society for the Measurement of Physical Beha

senior researcher / associate professor Erasmus MC research theme *"Physical behaviour and fitness of people with chronic conditions"* 

- in collaboration with Rijndam Rehabilitation



#### Presentation



- 1. Rehabilitation Medicine
- 2. Physical Activity & Physical Behaviour
- 3. Measurement
- 4. Application in clinical research & practice
- 5. Considerations & conclusions



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#### **Rehabilitation Medicine**

- medical specialty
- people with (chronic) disabling conditions
- multidisciplinary treatment
- focus on the consequences of diseases and optimizing patient functioning
  - e.g. spasticity treatment, exercise, mobility aids, adjustments to home, psychological treatment,..









## International Classification of Functioning, Disability, and Health (ICF, WHO)



Functional diagnosis Treatment Assessment & research



## International Classification of Functioning, Disability, and Health (ICF, WHO): example



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#### $\rightarrow$ Physical activity

**Physical activity** 

"any bodily movement produced by skeletal muscles that requires energy expenditure"

> **Physical** Health  $\downarrow$ activity  $\downarrow$









### Physical activity and prevention of health problems



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## Physical activity treatment and effects on health



E.g. positive effects of physical activity programs on:

- blood pressure
- body fat mass
- blood sugar markers (HbA1)
- prognosis angina pectoris
- dyspneu in COPD
- anxiety and stress
- depression





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## Physical activity & physical behaviour

- HOWEVER: not only health in terms mortality, morbidity, health markers important target for physical activity
- Other targets e.g.
  - fatigue
  - independent living
  - pain
  - fall risk
  - being able to perform activities more easily
  - post-surgery complications
  - •







## Physical activity & physical behaviour

AND: not (only) levels of physical activity and/or EE important

but (also):

- sedentary behaviour
  - amount and distribution of "sitting"
- body postures and movements
  - e.g. upright position
- use of the arm in daily life
  - e.g. reaching movements in daily life
- quality of performance
  - e.g. stasbility of gait, speed of gait
- sleep







#### Physical activity & physical behaviour



#### → Physical Behaviour

"the body postures, movements and physical activities people perform in their daily life"



## Physical activity and prevention of health problems



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#### A bit of history....







Early Step Counter, 1667

Museum of the History of Science (Oxford University)



#### A bit of history....



















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## **Basic principle**





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#### Accelerometry: working principle





#### Not only levels of physical activity

#### Orientation Physical sensor / body activity segment **Movement** patterns **Movement** (quality) Levels of Accelerometer **Accelerations** physical activity (counts) Gyro's, MFS Energy expenditure



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## Technological developments (Rotterdam)





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## Application of wearables in clinical research & practice



- descriptive & explorative studies
- insight in determinants and effects
- PB monitoring in treatment
- evaluation of interventions
- improved interpretation other (non PB) data



#### **Descriptive & explorative studies**



About questions such as:

- "Is there any Physical Behaviour issue?"
- "What is the course / recovery of Physical Behaviour?"



## Objectively measured levels of PA in chronic conditions



Berg-Emons HJG van den, Bussmann JB, Stam HJ. Accelerometry-based activity spectrum in persons with chronic physical conditions. Arch Phys Med Rehabil 2010;91:1856-61.



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## Recovery of physical activity after spinal cord injury



Van den Berg et al. A prospective study on physical activity levels after spinal cord injury during inpatient rehabilitation and the year after discharge. Arch Phys Med Rehabil. 2008 Nov;89(11):2094-101.

*Vissers et al. Barriers to and facilitators of everyday physical activity in persons with a spinal cord injury after discharge from the rehabilitation centre. J Rehabil Med. 2008 Jun;40(6):461-7.* 



## Daily life arm-hand use in people with chronic stroke







Michielsen ME, Selles RW, Stam HJ, Ribbers GM, Bussmann JB. Quantifying Nonuse in Chronic Stroke Patients: A Study Into Paretic, Nonparetic, and Bimanual Upper-Limb Use in Daily Life. Arch Phys Med Rehabil. 2012;93:1975-81



#### Insight in determinants and effects



About questions such as:

- "Which factors contribute to (changes in) physical behaviour outcomes?"
  - e.g. result fitness programs in higher levels of physical activity?
- "Where does (changes in) physical behaviour result in?"





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#### Recovery after stroke: performance vs. capacity



#### Physical Behaviour and Fatigue in MS patients



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- monitoring
- feedback
- exercise





#### Application in treatment: Monitoring





## Recovery arm-hand use after stroke Profits study





Fanchamps et al. submitted

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#### Application in treatment: Feedback





#### Systematic review



• "objective PB feedback contributes to changing PB"

Experimental			C	Control			Std. Mean Difference	Std. Mean Difference		
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% Cl	IV, Fixed, 95% Cl	
Dorsch 2015	16.6	14.3	78	15.1	13.1	73	11.0%	0.11 [-0.21, 0.43]		
Frederix 2015	11,205	894	32	7,551	652	34		Not estimable		
Guiraud 2012	137.2	87.5	19	45.7	43.4	10	1.6%	1.17 [0.34, 2.01]		
Hornikx 2015	2,628	1,980	12	2,570	1,297	12	1.7%	0.03 [-0.77, 0.83]		
Kaminsky 2015	8,005	1,874	10	5,906	1,877	8	1.1%	1.07 [0.06, 2.08]		
Kawagoshi 2015	93.6	31.5	15	42.3	84.9	12	1.8%	0.81 [0.02, 1.61]		
Mansfield 2014	6,195	4,112	29	4,435	4,347	28	4.1%	0.41 [-0.11, 0.94]	+	
McMurdo 2010	143,127	61,453	68	121,270	61,453	68	9.7%	0.35 [0.01, 0.69]		
Moy 2015	3,922	2,491	133	3,200	2,489	68	13.0%	0.29 [-0.00, 0.58]		
Nimwegen 2013	584	256	273	483	181	267	38.3%	0.45 [0.28, 0.62]		
Nolan 2016	82	74	63	90	94	59	8.9%	-0.09 [-0.45, 0.26]		
Peel 2017	24.58	1.46	128	17.53	1.5	177		Not estimable		
Shoemaker 2017a	2.7	0.6	6	3.3	0.27	4	0.6%	-1.08 [-2.48, 0.32]		
van der Weegen 2015	48.16	23.8	52	39.61	19.5	65	8.3%	0.39 [0.03, 0.76]		
Total (95% CI) 758				674	100.0%	0.34 [0.23, 0.44]	•			
Heterogeneity: $Chi^2 = 21.46$ df = 11 (P = 0.03); $l^2 = 49\%$										
Test for overall effect: $7 = 6.27$ (P < 0.00001)										
Control group Experimental group									Control group Experimental group	



Braakhuis et al. submitted.

## Rotterdam: physical behaviour feedback devices

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#### **OPTICARE (OPTImal CArdiac REhabilitation**



*Ter Hoeve et al. Changes in phyiscal activity and sedentary behavior during cardiac rehabilitation. Arch Phys Med Rehabil 2017.* 



## Upper limb use feedback monitor: Attractif project



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#### Application in treatment: (at home) exercise



#### Voorkom & Herstel project



- body fixed wearables to be used in virtual reality
  - e.g. training of reaching movements in stroke











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#### **OPTICARE** results





- Mainly effective for outcome on which patient received feedback (steps)
- Aftercare suboptimal: exclusive focus on physical behaviour needed?
- General information on sedentary behaviour insufficient



*Ter Hoeve et al. Changes in phyiscal activity and sedentary behavior during cardiac rehabilitation. Arch Phys Med Rehabil 2017.* 

Spinal cord injury: regular care + lifestyle intervention + Erasmus MC exercise vs. regular care





Nooijen CF et al. A behavioral intervention leads to a more active lifestyle in persons with subacute spinal cord injury: a randomized controlled trial. Journal of Physiotherapy. 2016



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Improved measurement & interpretation of other (non PB) data ------



## Amputees: physical behaviour & physiological strain



Bussmann JBJ, Schrauwen H. Stam HJ. Daily physical activity and heart rate response in people with a unilateral traumatic transtibial amputation. Arch Phys Med Rehabil 2008;89:430-4.



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## Stroke: stress and mental workload

- Measurement of stress/mental workload:
  - Imec sensors & analysis
  - electronic diaries (EMA)
- Physical behaviour
  - Activ8 (body postures & movements)

- Development and validation of stress models that include the posture & movement data
- linking physical behaviour data to reported stress levels

Brands et al. submitted; Bussmann et al. to be submitted









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## Many significant future technological developments

- Increased application in rehabilitation
  - remote "monitoring" ("health check")
  - application of wearables in large cohort/ surveillance studies
  - big data

advanced statistical analyses and modelling



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## Objectively measured PB is a unique domain of functioning



- ightarrow include PB measurements in research and clinical care
- ightarrow consider carefully the component of PB you're interested in



## Physical Behaviour really is "behaviour"



- still the case when measured with wearables!
  - variability
  - difficult to change



 $\rightarrow$  challenge: how to change physical behaviour most effectively



#### Still much unknown about determinants & effects

- Example: sedentary behaviour
  - Is sitting really an additional risk factor?
    - for what?

. . . . .

- for which sitting outcome?
- what are the underlying mechanisms?
- what are the dose-response relationships?



→ importance of basic/fundamental research





#### Measurement issues



...

Fanchamps et al. Gait & Posture

- Results in: no pooling of data; problems in interpreting results; no comparison between studies
- $\rightarrow$  importance of standardization



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#### Design of research

- Changes of / improvements in designs, e.g.
  - context information
  - within-subject vs. between-subject approaches







#### Implementation & application in care



- is a difficult process
  - requires specific (implementation) expertise
  - use of technology: "believers vs. non-believers"
  - other patient problems important too (or more important)
  - problems patient specific (tailored approach required)
  - between-therapist differences
  - PB outcomes: sometimes too much and/or too difficult to interpret
  - context info is missing











