가상 현실 기술로 모터 제어 트리거

Triggering Motor Control with Virtual Reality Technology

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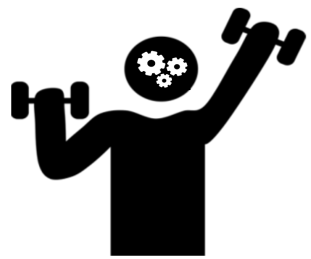
Swiss Federal Institute of Technology Zurich

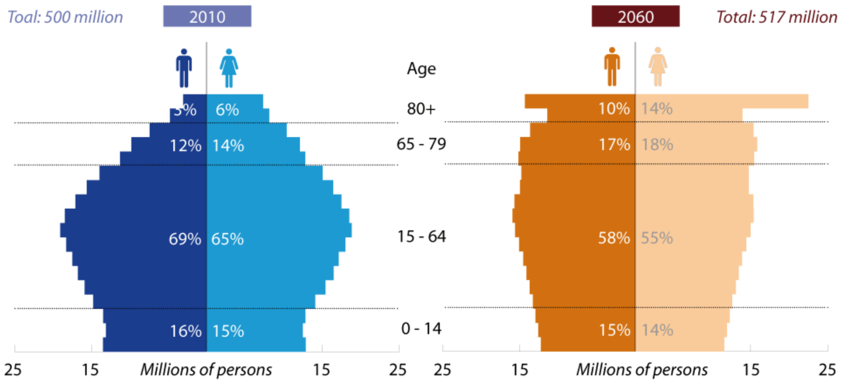
- [1] Background «why would we care for motor control in an ageing society?»
  - *Focus on walking & falls*

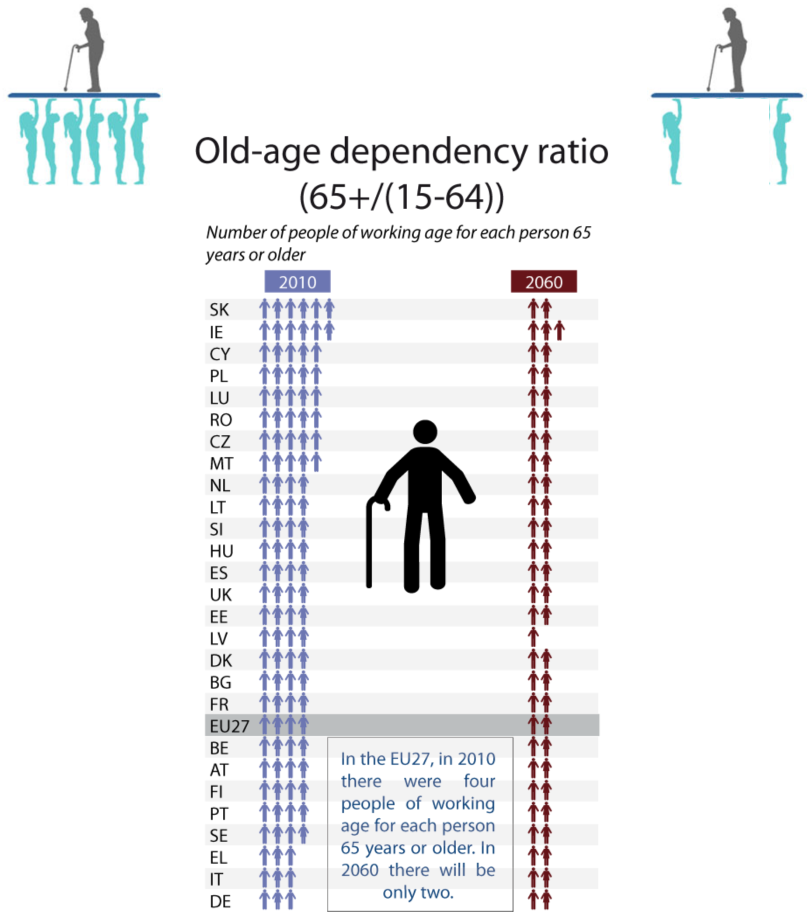

- [2] Important mobility components of ageing populations
  - *Speed & Variability*


- [3] How should/could interventions be designed?

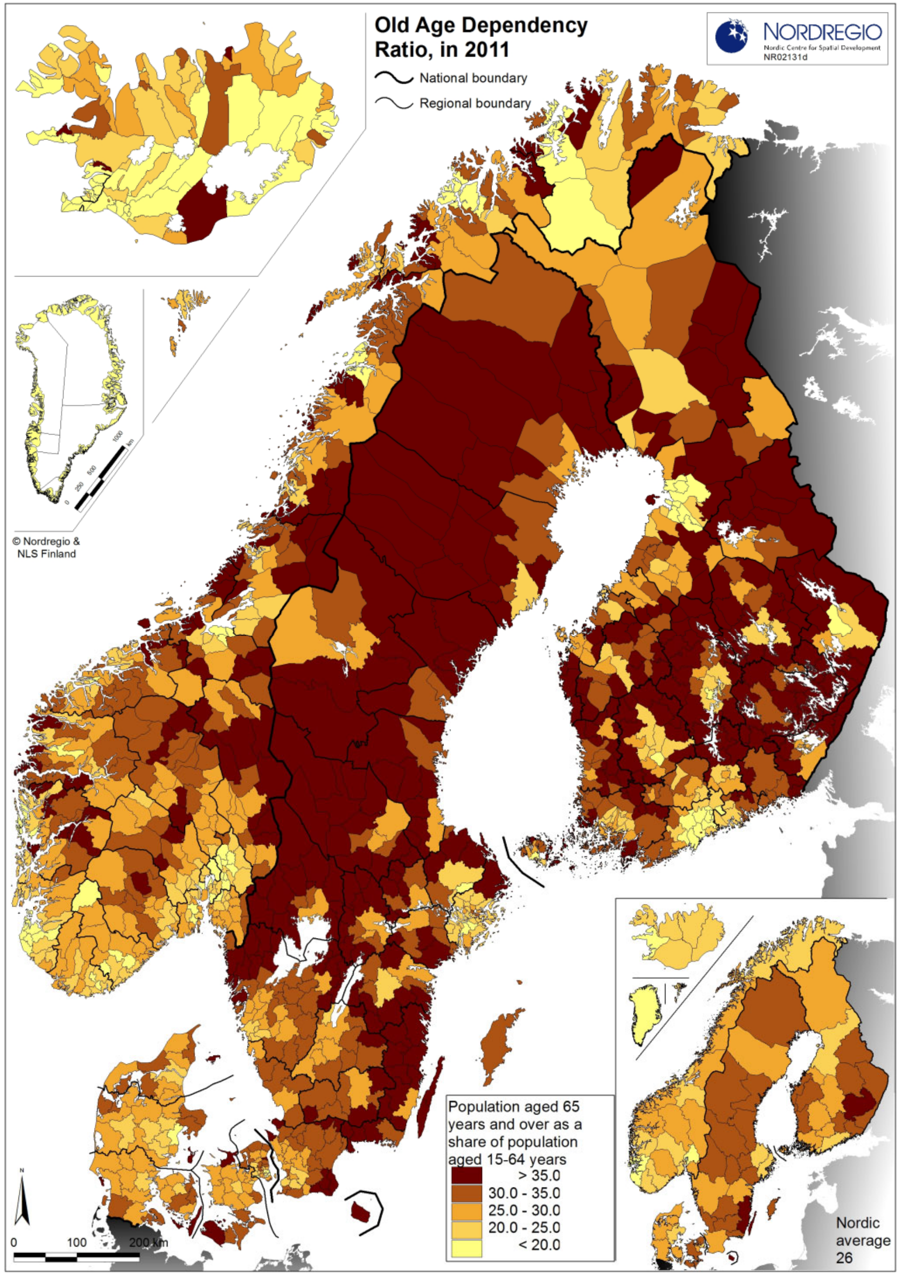
- [4] Practical examples VR driven innovations







https://epthinktank.eu/2013/12/19/ageing-population-projections-2010-2060-for-the-eu27/

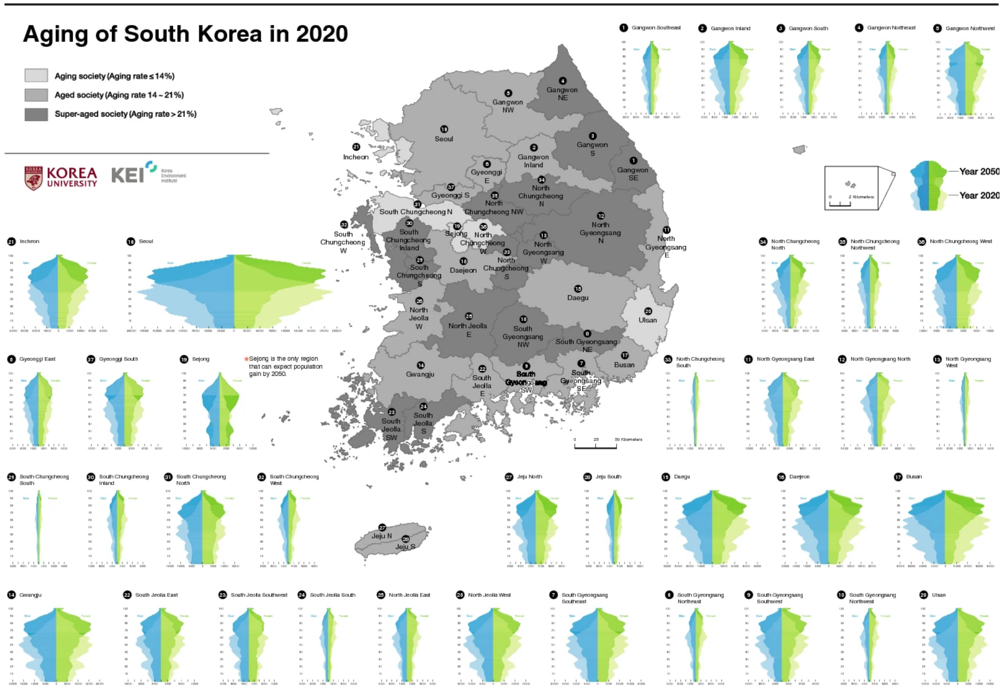


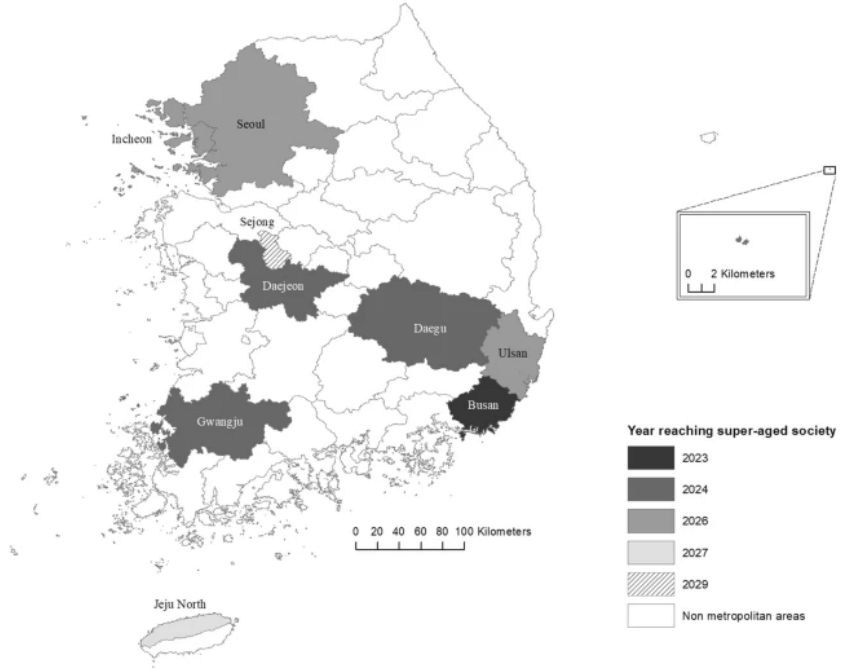
http://www.nordregio.se/en/Metameny/Nordregio-News/2013/Nordic-Population-Ageing--Challenge-and-Opportunity/Context/

Super Aging in South Korea Unstoppable but Mitigatable: A Sub-National Scale Population Projection for Best Policy Planning

Kee Whan Kim[1] · Oh Seok Kim[2,3,4]

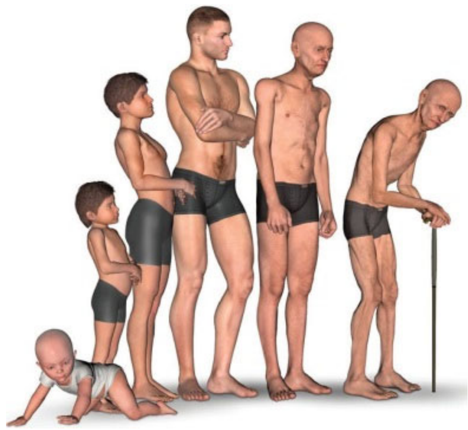
Spatial Demography (2020) 8:155–173
https://doi.org/10.1007/s40980-020-00061-8





Degenerative changes in aging

Physiological changes
↓ sensory functions
↓ muscle mass and strength
↓ bones density
↓ tissue elasticity



Cognitive changes
↓ information processing speed
↓ attentional functions
- selective attention
- divided attention

↓ executive functions
- inhibition
- switching/shifting
- updating, control, monitoring

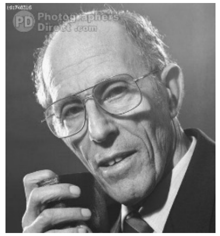
↓ memory functions

Structural/functional changes in the brain
↓ grey and white matter
↓ cerebral blood flow

especially in specific brain regions
(e.g. prefrontal lobe and Hippocampus)

Lustig, C., Shah, P., Seidler, R., & Reuter-Lorenz, P. A. (2009). Aging, Training, and the Brain: A Review and Future Directions. *Neuropsychology review, 19*(4), 504-522. doi: 10.1007/s11065-009-9119-9
Singh, M. A. F. (2002). Exercise comes of age: Rationale and recommendations for a geriatric exercise prescription. *Journals of Gerontology Series a-Biological Sciences and Medical Sciences, 57*(5), M262-M282.

Definitions:



- Bernard Isaacs coined the term ***geriatric giants*** (1965)
  - *immobility, instability, incontinence, and impaired intellect/memory*[1]

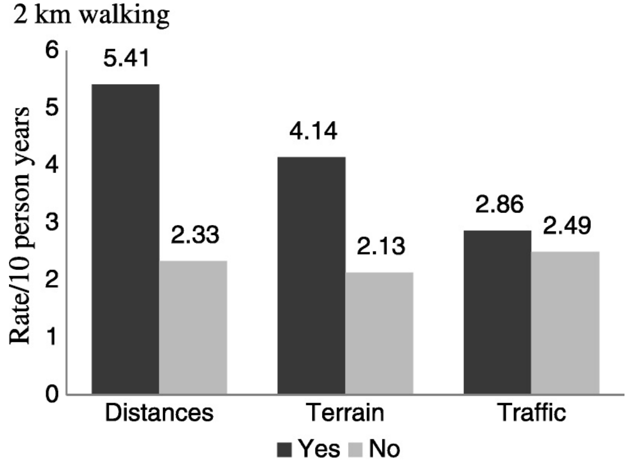
- the modern "geriatric giants" contain four new syndroms ***frailty***,[2] ***sarcopenia***,[3] the ***anorexia of aging***,[4] and ***cognitive impairment***.[5]

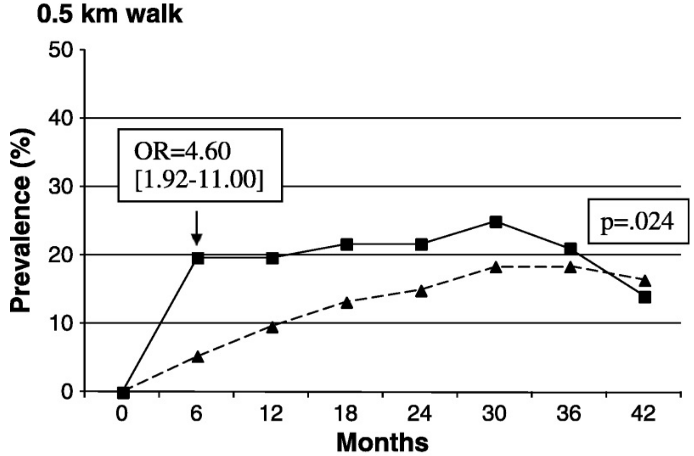
[1]J Gerontol A Biol Sci Med Sci. 2004; 59: 1132–1152
[2]J Cachexia Sarcopenia Muscle. 2014; 5: 5–8
[3]J Am Med Dir Assoc. 2016; 17: 471–472
[4]Curr Opin Clin Nutr Metab Care. 2013; 16: 27–32
[5]J Am Med Dir Assoc. 2015; 16: 731–739

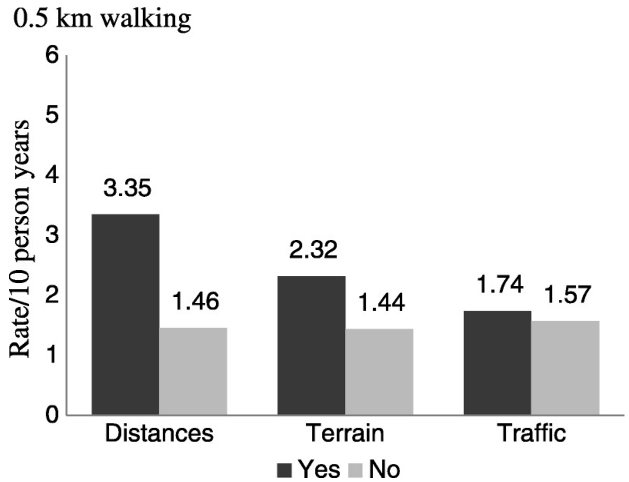
Mobility Decline in Old Age

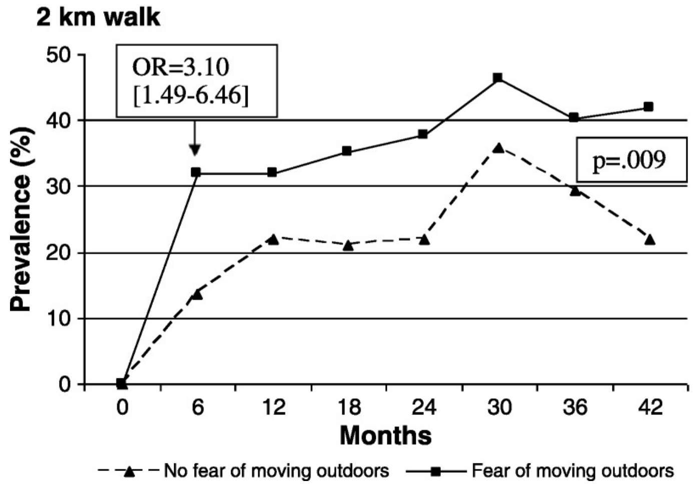
Exerc. Sport Sci. Rev., Vol. 41, No. 1, pp. 19–25, 2013.

Merja Rantakokko[1], Minna Mänty[2], and Taina Rantanen[1]





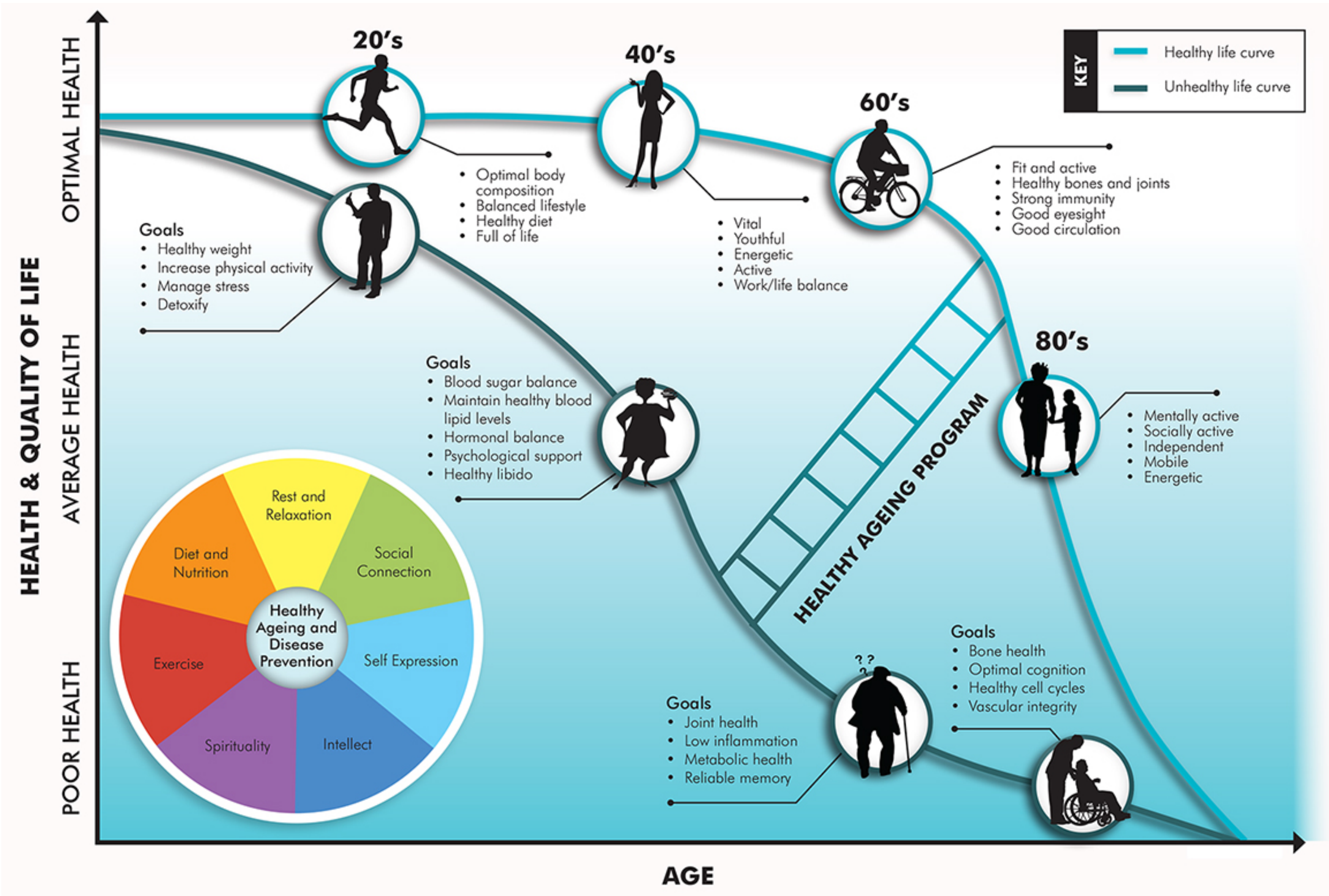




"Attention should be paid to preventive interventions seeking to minimize the individual risk factors for mobility decline, such as obesity, sensory impairments, falls, or physical inactivity."

Healthy aging: [1] avoidance of disease and disability, ***[2]*** maintenance of high physical and cognitive function, ***[3]*** sustained engagement in social and productive activities

Gerontologist, 1997. ***37****(4): p. 433-40*



HEALTHY AGING (WHO)

"*the process of developing and maintaining functional ability that enables well-being in older age*."[1]

TWO MAIN CONCEPTS[2]

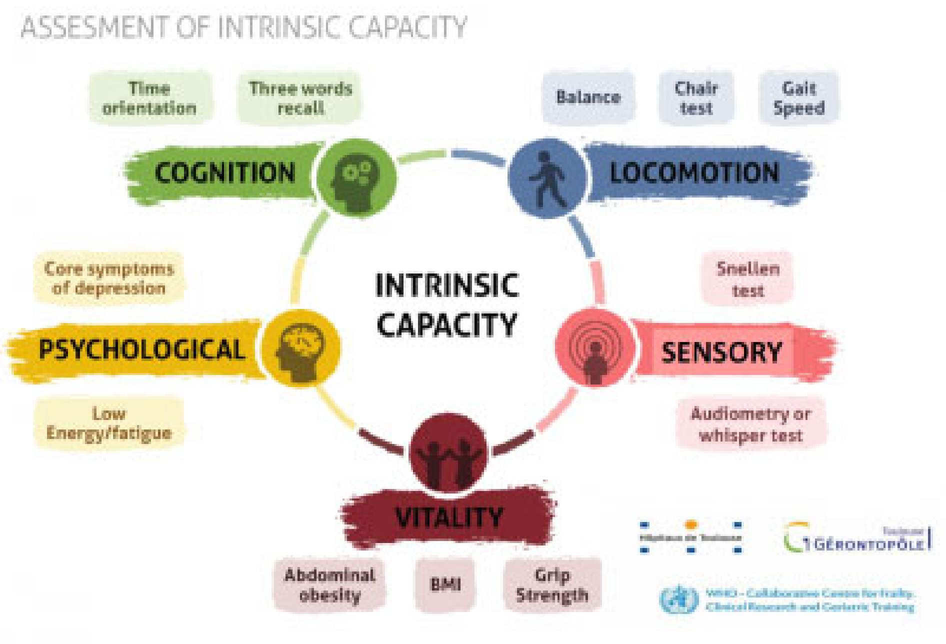
Intrinsic Capacity: "*the combination of the individual's physical and mental – including psychosocial – capacities*"

- *Mobility*, *Cognition*, *Vitality* (*Psycho-social*, neuro-sensorial), V*ision, Hearing*

Functional Ability: "*having the capabilities that enable all people to be and do what they have reason to value.*"

[1] WHO Clinical Consortium on *Healthy Ageing* 2017 – report of consortium meeting 21 and 22 November 2017 in Geneva, Switzerland. Geneva: World Health Organization; 2018. Licence: CC BY-NC-SA 3.0 IGO. [2] http://www.aging-news.net/w-h-o-world-health-organization-program-on-maintaining-intrinsic-capacities-with-aging/

INTRINSIC CAPACITY VS. (PHYSICAL) FITNESS



- Health related
  - Cardio-respiratory & muscle endurance, muscle strength, body composiotion, flexibility
- Skill related
  - Agility, balance, coordination, speed, power, reaction time

http://www.aging-news.net/w-h-o-world-health-organization-program-on-maintaining-intrinsic-capacities-with-aging/

Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. Public Health Rep. **1985**;100(2):126-31.

Video capture of the circumstances of falls in elderly people residing in long-term care: an observational study

Stephen N Robinovitch*, Fabio Feldman*, Yijian Yang, Rebecca Schonnop, Pet Ming Lueng, Thiago Sarraf, Joanie Sims-Gould, Marie Loughin

www.thelancet.com Published online October 17, 2012 http://dx.doi.org/10.1016/S0140-6736(12)61263-X

	Frequency*		Participants falling due to this cause†		Number of falls per participant†	
	Number	Percentage of falls captured	Estimated proportion, % (SE)	95% CI	Estimated count, n (SE)	95% CI
Incorrect transfer or shift of bodyweight	93	41%	51·2% (4·5)	42·5–59·8	0·72 (0·078)	0·59–0·90
Trip or stumble	48	21%	26·0% (3·9)	19·1–34·3	0·35 (0·054)	0·26–0·47
Hit or bump	25	11%	17·3% (3·4)	11·7–25·0	0·19 (0·040)	0·13–0·28
Loss of support with external object	25	11%	18·9% (3·5)	13·0–26·7	0·20 (0·041)	0·13–0·30
Collapse or loss of consciousness	24	11%	16·5% (3·3)	11·0–24·1	0·17 (0·039)	0·11–0·27
Slip	6	3%	4·7% (1·9)	2·1–10·2	0·047 (0·020)	0·021–0·11
Could not tell	6	3%	..	..	..	..

In descending order of frequency. *Of 227 total falls captured. †Of 215 falls analysed, after exclusion of cases for which the faller could not be identified (six), and cases for which the team could not identify the cause of the fall (six).

Table 2: **Estimated proportion of participants falling at least once, and average number of falls per participant, attributable to various causes of falling**

	Frequency*		Participants falling while undertaking activity†		Number of falls per participant†	
	Number	Percentage of falls captured	Estimated proportion, % (SE)	95% CI	Estimated count, n (SE)	95% CI
Walking forward	54	24%	28·1% (4·0)	21·0–36·6	0·39 (0·06)	0·29–0·53
Standing quietly	29	13%	20·3% (3·6)	14·2–28·2	0·22 (0·04)	0·15–0·33
Sitting down or lowering	28	13%	18·8% (3·5)	12·9–26·5	0·21 (0·04)	0·14–0·32
Initiation of walking	24	11%	15·6% (3·2)	10·3–23·0	0·19 (0·04)	0·12–0·29
Getting up or rising	20	9%	14·5% (3·2)	9·6–22·1	0·15 (0·04)	0·10–0·25
Walking backward or sideways	16	7%	11·7% (2·8)	7·1–18·6	0·13 (0·03)	0·07–0·21
Walking and turning	16	7%	11·7% (2·8)	7·1–18·6	0·13 (0·03)	0·07–0·21
Standing and turning	14	6%	8·6% (2·5)	4·8–14·9	0·10 (0·03)	0·06–0·18
Seated or wheeling in wheelchair	12	5%	8·6% (2·5)	4·8–14·9	0·08 (0·03)	0·05–0·16
Standing and reaching	11	5%	7·8% (2·4)	4·2–13·9	0·09 (0·03)	0·05–0·16
Could not tell	3	1%	..	..	..	..

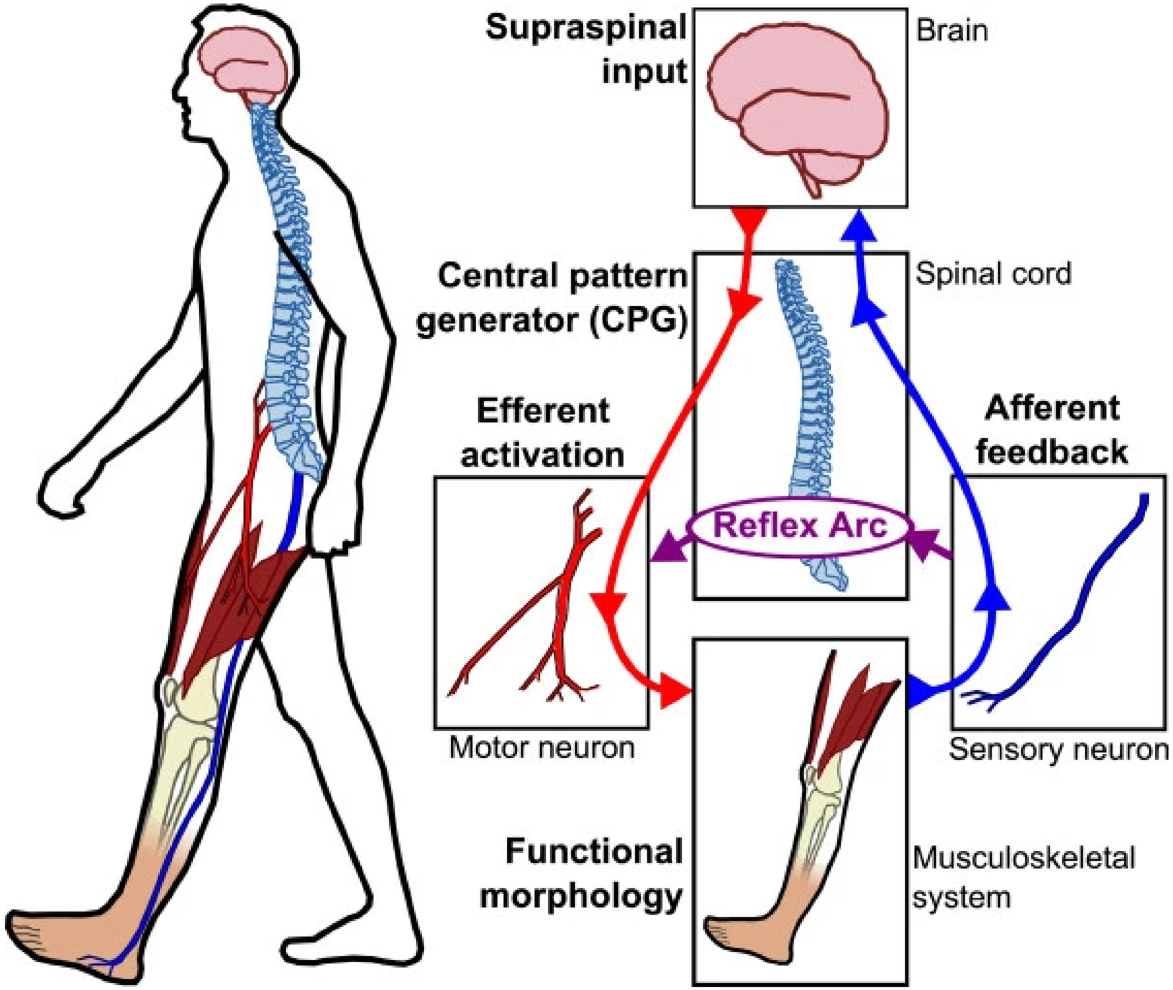
In descending order of frequency. *Of 227 total falls captured. †Of 218 falls analysed; after exclusion of cases for which the faller could not be identified (six) and cases for which the team could not identify the activity at time of falling (three).

Table 4: **Estimated proportion of participants falling at least once, and average number of falls per participant, for each activity at time of falling**

Video capture of the circumstances of falls in elderly people residing in long-term care: an observational study

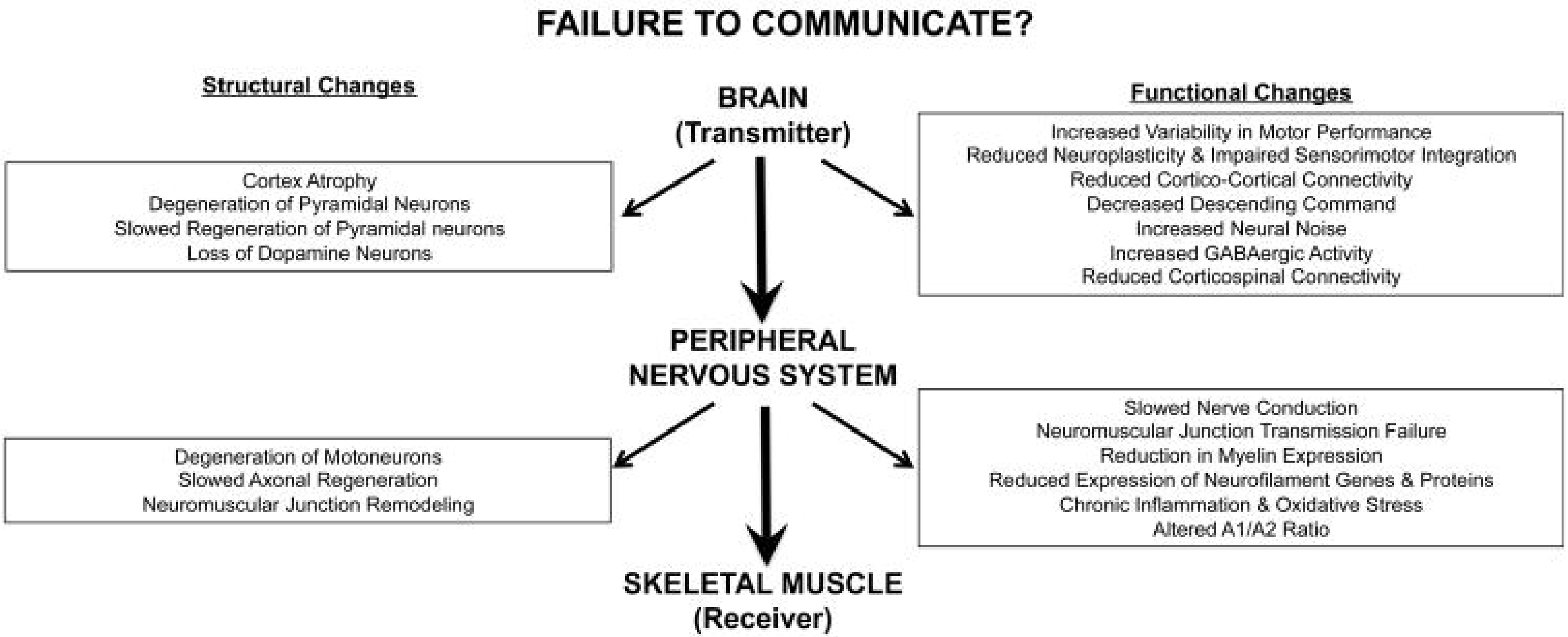
Stephen N Robinovitch*, Fabio Feldman*, Yijian Yang, Rebecca Schonnop, Pet Ming Lueng, Thiago Sarraf, Joanie Sims-Gould, Marie Loughin

www.thelancet.com **Published online October 17, 2012 http://dx.doi.org/10.1016/S0140-6736(12)61263-X**



J NeuroEngineering Rehabil **12,** 1 (2015)

FEHLER EFFIZIENTER HIRN-MUSKEL-KOMMUNIKATION IN DYNAPENIA: EIN NEUROGEN GETRIEBENES-SYNDROM**?**



Current Opinion in Clinical Nutrition and Metabolic Care

TM Manini, 2013

Age-Related Changes in Motor Cortical Properties and Voluntary Activation of Skeletal Muscle

Author(s): Brian C. Clark, Janet L. Taylor

Journal Name: Current Aging Science

Volume 4 , Issue 3 , 2011

- *«Deficits in the neural drive can contribute to much of the muscle weakness observed in the very elderly – at least in the knee extensor muscles»*
- *«Clinically meaningful deficits in voluntary activation do exist in the knee extensors when a population of older adults is considered»*
- *«There is also evidence for a deficit in activation of the knee extensors, which are clinically important as the level of muscle strength has been linked to disability development and functional capacity»*

Loss of white matter integrity is associated with gait disorders in cerebral small vessel disease

Karlijn F. de Laat,[1,*] Anil M. Tuladhar,[1,*] Anouk G. W. van Norden,[1] David G. Norris,[2] Marcel P. Zwiers[2,3] and Frank-Erik de Leeuw[1]

Brain 2011: 134; 73–83

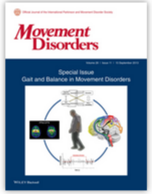
- *«.. in elderly subjects with small vessel disease, widespread disruption of white matter integrity, predominantly in the normal-appearing white matter, is involved in gait disturbances.*
- *In particular, loss of fibres interconnecting bilateral cortical regions, especially the prefrontal cortex that is involved in cognitive control on motor performance, may be important ..»*

J Am Geriatr Soc. 2010 February ; 58(2): 275–281. doi:10.1111/j.1532-5415.2009.02699.x.

White Matter Hyperintensities Predict Functional Decline in Voiding, Mobility and Cognition in Older Persons

Dorothy B. Wakefield, MS[1], **Nicola Moscufo, PhD**[3], **Charles R. Guttmann, MD**[3], **George A. Kuchel, MD**[4], **Richard F. Kaplan, PhD**[2], **Godfrey Pearlson, MD**[5], and **Leslie Wolfson, MD**[1]

Movement Disorders
Official Journal of the International Parkinson and Movement Disorder Society



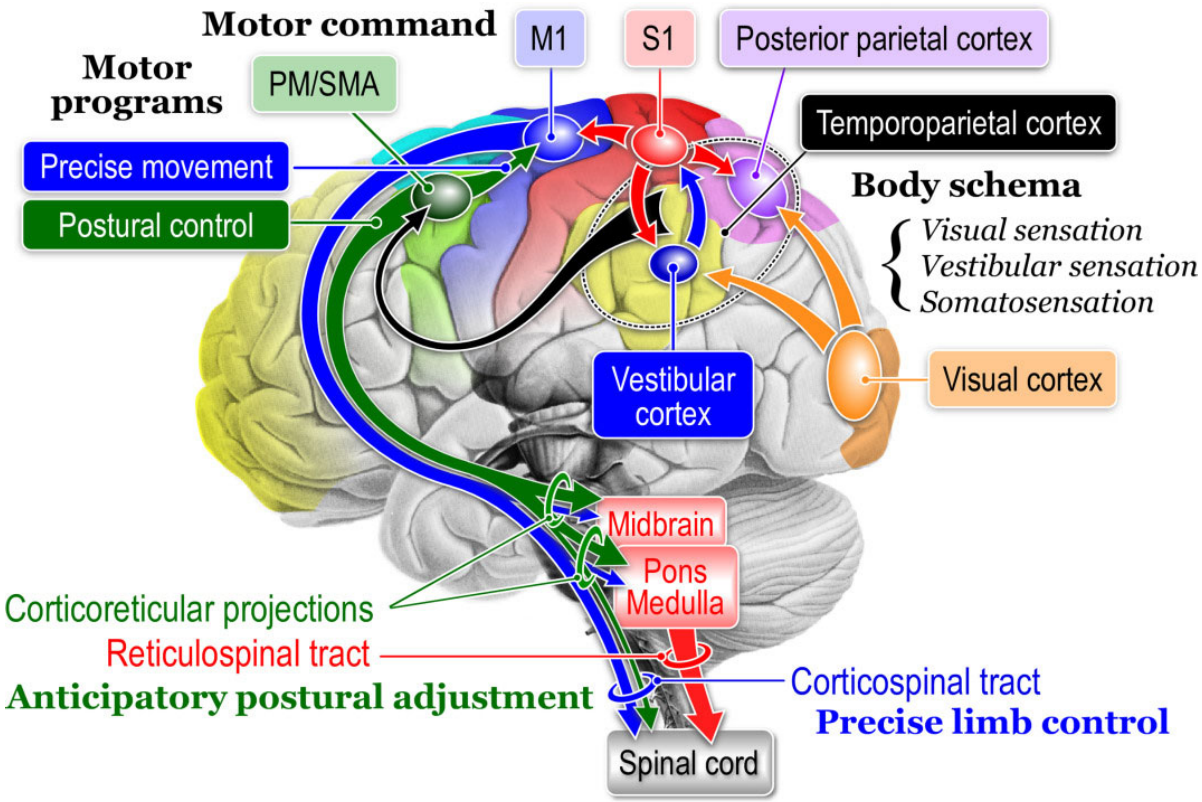
Volume 28, Issue 11
Special Issue: Gait and Balance in Movement Disorders
15 September 2013
Pages 1483-1491

Review | Full Access

Neurophysiology of gait: From the spinal cord to the frontal lobe

Kaoru Takakusaki MD, PhD

Neurophysiology of gait: From the spinal cord to the frontal lobe



Movement Disorders, Volume: 28, Issue: 11, Pages: 1483-1491, First published: 16 October 2013, DOI: (10.1002/mds.25669)

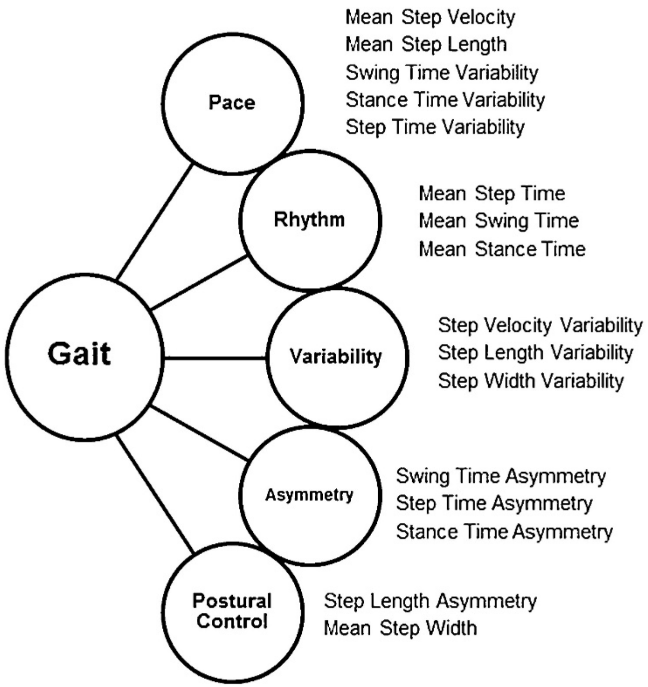
ELSEVIER

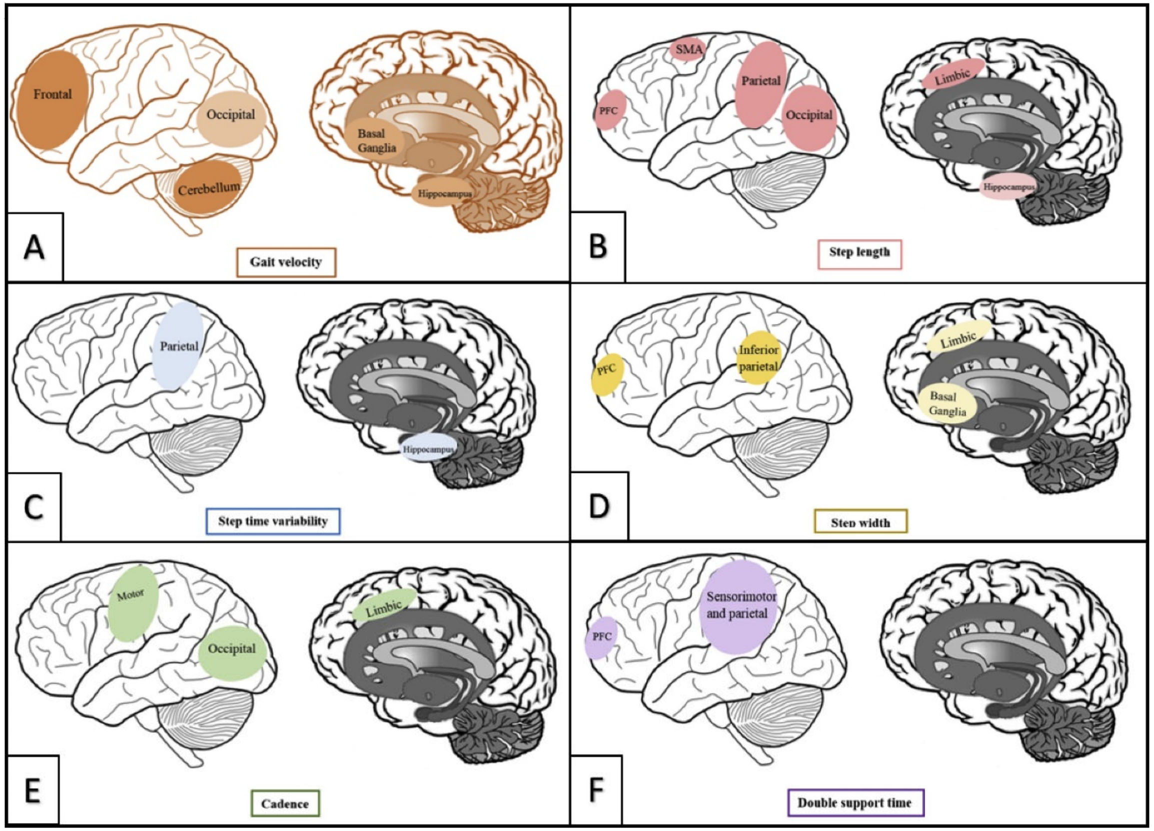
Neuroscience & Biobehavioral Reviews
Volume 100, May 2019, Pages 344-369

Review article

The neural correlates of discrete gait characteristics in ageing: A structured review

Joanna Wilson [a], Liesl Allcock [b], Ríona Mc Ardle [a], John-Paul Taylor [a], Lynn Rochester [a, c]





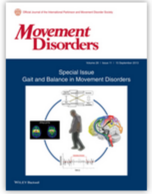
Regional associations between GM volume and gait characteristics; gait velocity (A), step length (B), step time variability (C), step width (D), cadence (E) and double support time (F).

Movement Disorders
Official Journal of the International Parkinson and Movement Disorder Society

Review | Full Access

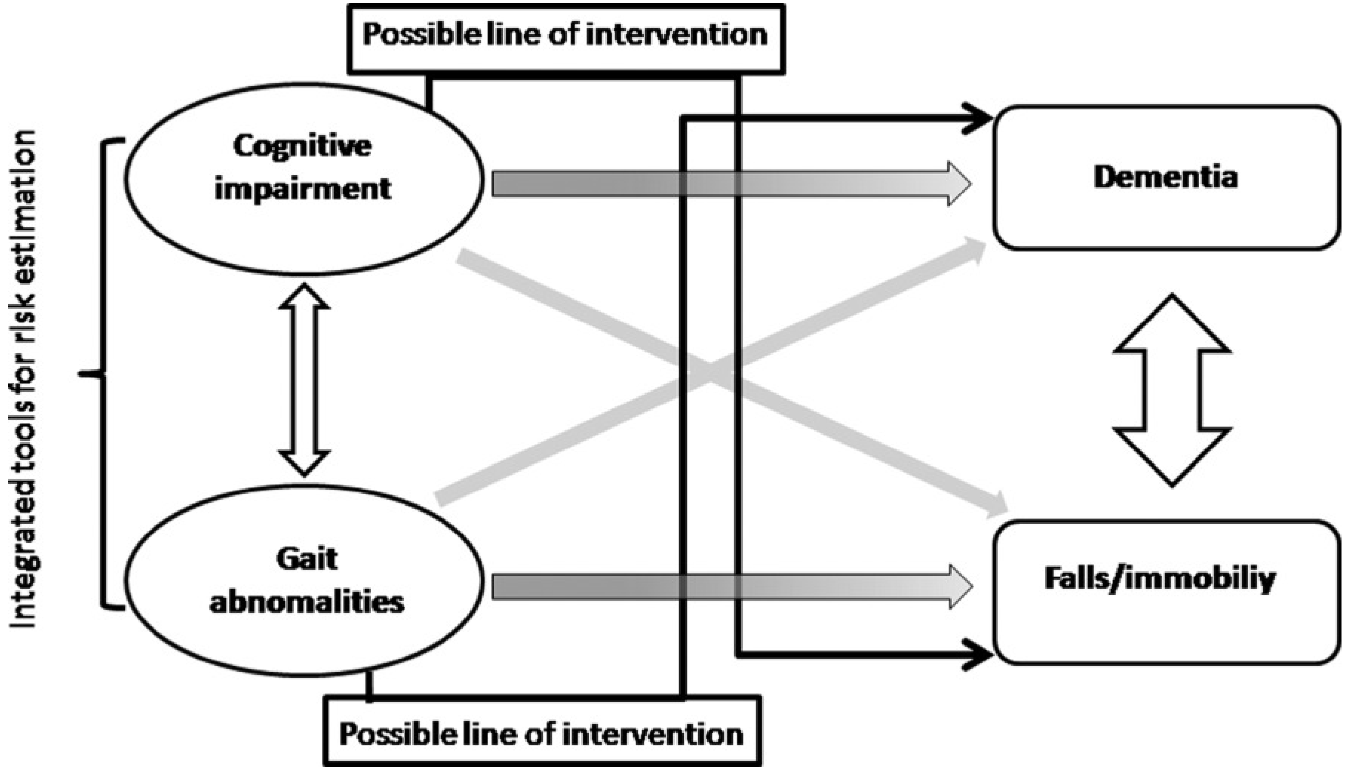
Cognitive contributions to gait and falls: Evidence and implications

Marianna Amboni MD, PhD, Paolo Barone MD, PhD, Jeffrey M. Hausdorff PhD



Volume 28, Issue 11
Special Issue: Gait and Balance in Movement Disorders
15 September 2013
Pages 1520-1533

Cognitive contributions to gait and falls: Evidence and implications



Movement Disorders, Volume: 28, Issue: 11, Pages: 1520-1533, First published: 16 October 2013, DOI: (10.1002/mds.25674)

New Technologies & Neuroplasticity: VR / Exergames

NZZ, 9.5.2016

«*Use dependent plasticity*»:
Practicing movements results in improvement in performance and in plasticity of the motor cortex. Non-practicing gives the opposite effect!

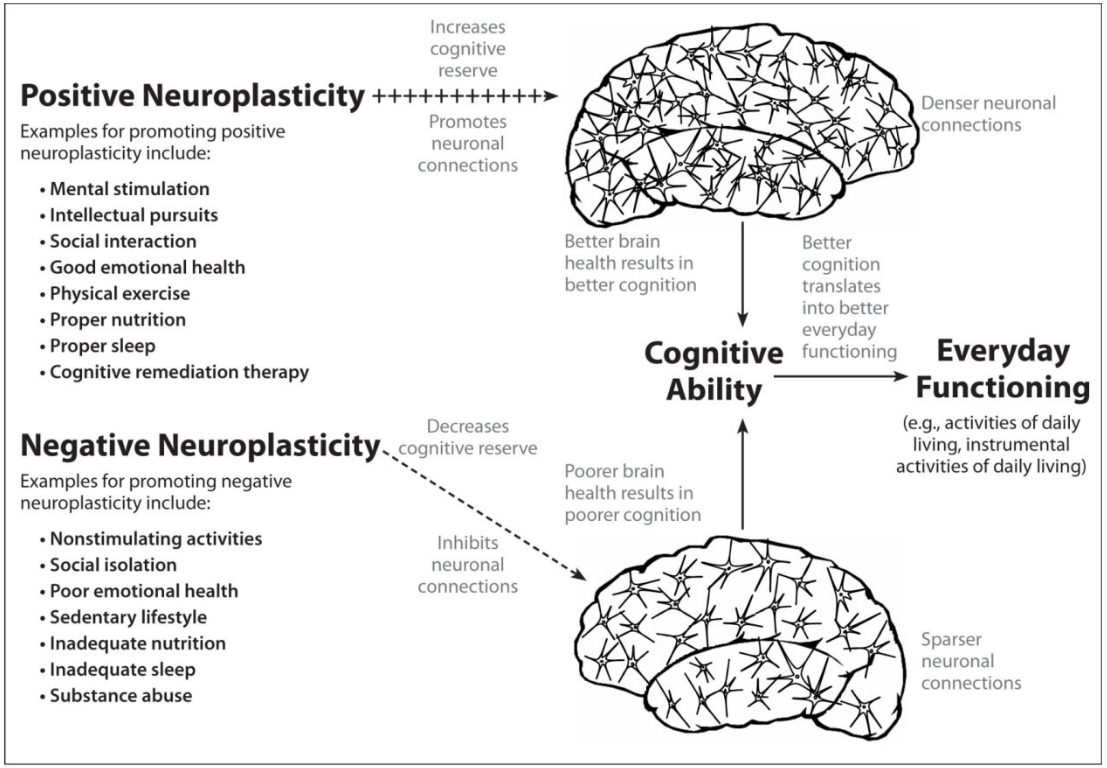
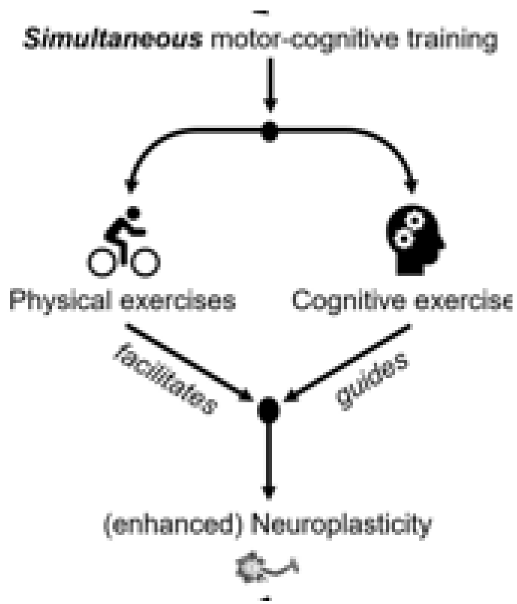
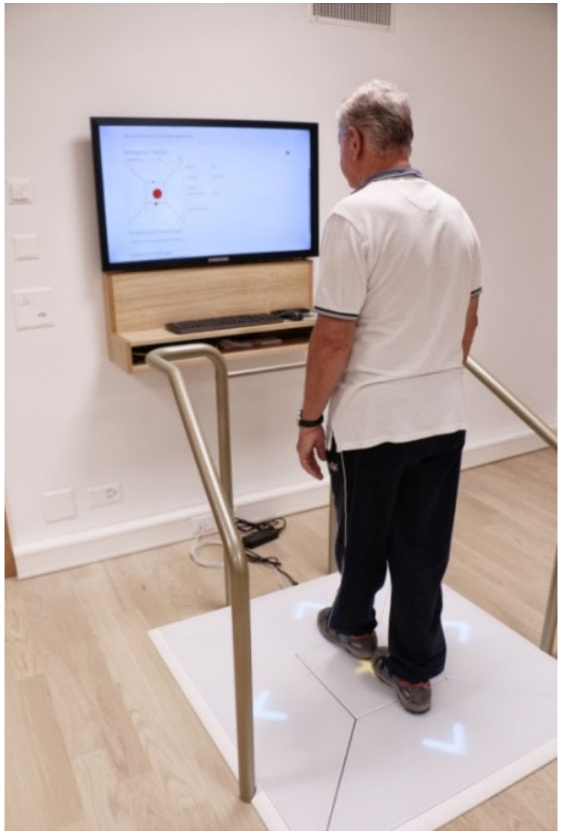


Figure. Methods of promoting positive and negative neuroplasticity.

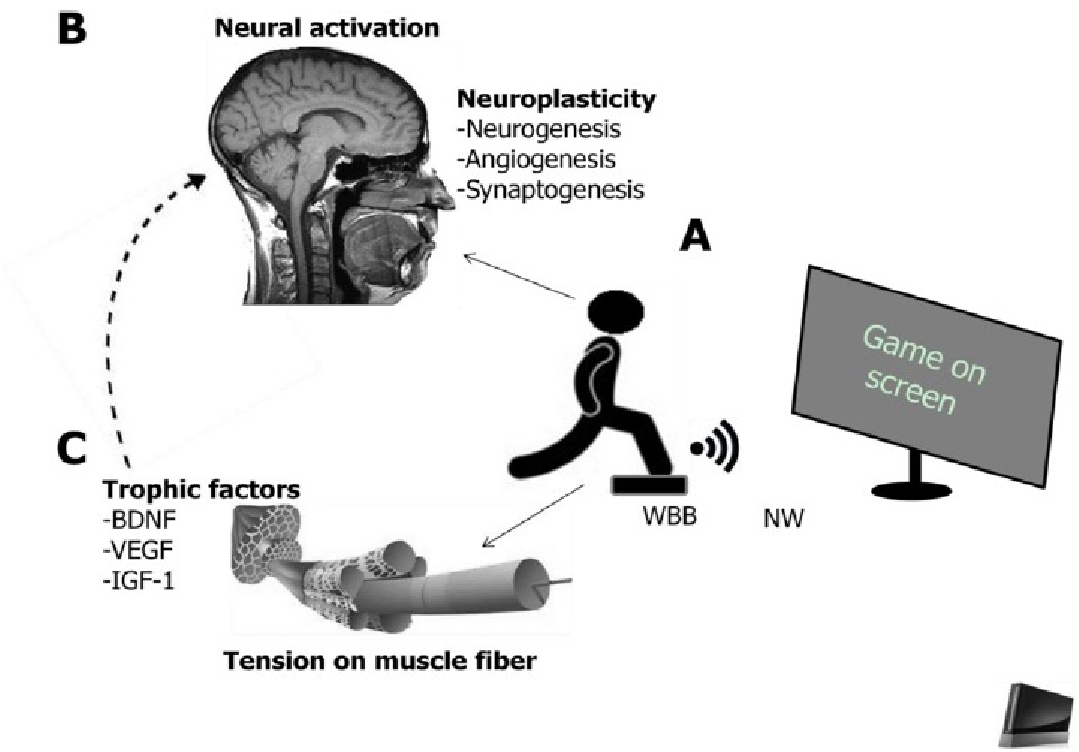
Exergaming?

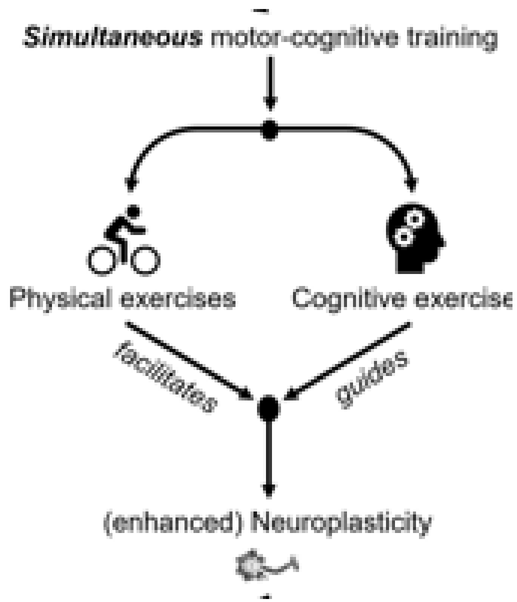


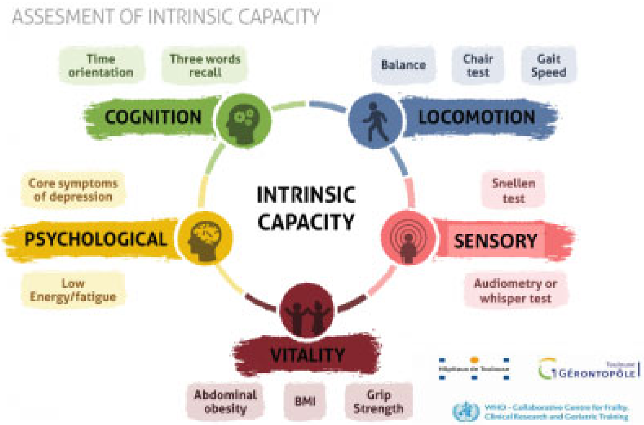


AMERICAN COLLEGE of SPORTS MEDICINE®
LEADING THE WAY

is defined as technology-driven physical activities, such as video game play, that requires participants to be physically active or exercise in order to play the game.







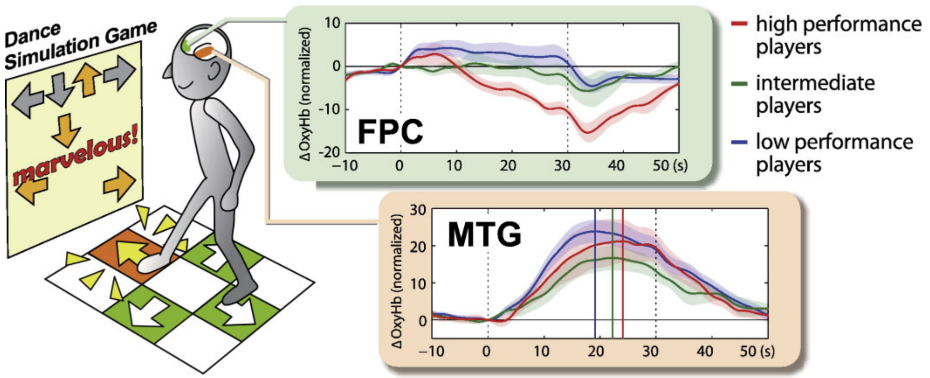
*(**A**) An individual playing exergame; (**B**) increases neural activation; (**C**) promotes a muscle fiber tension.*

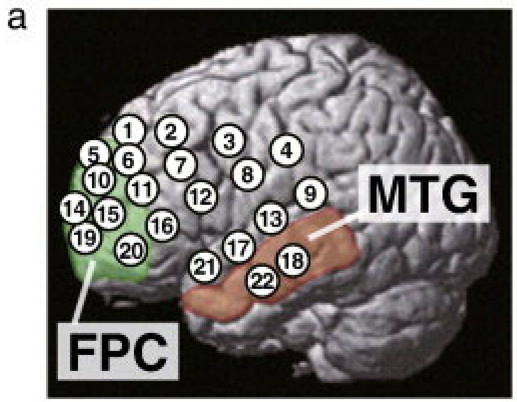
Monteiro-Junior, R. S., Vaghetti, C. A., Nascimento, O. J., Laks, J., & Deslandes, A. C. (2016). Exergames: neuroplastic hypothesis about cognitive improvement and biological effects on physical function of institutionalized older persons. *Neural regeneration research*, *11*(2), 201–204.

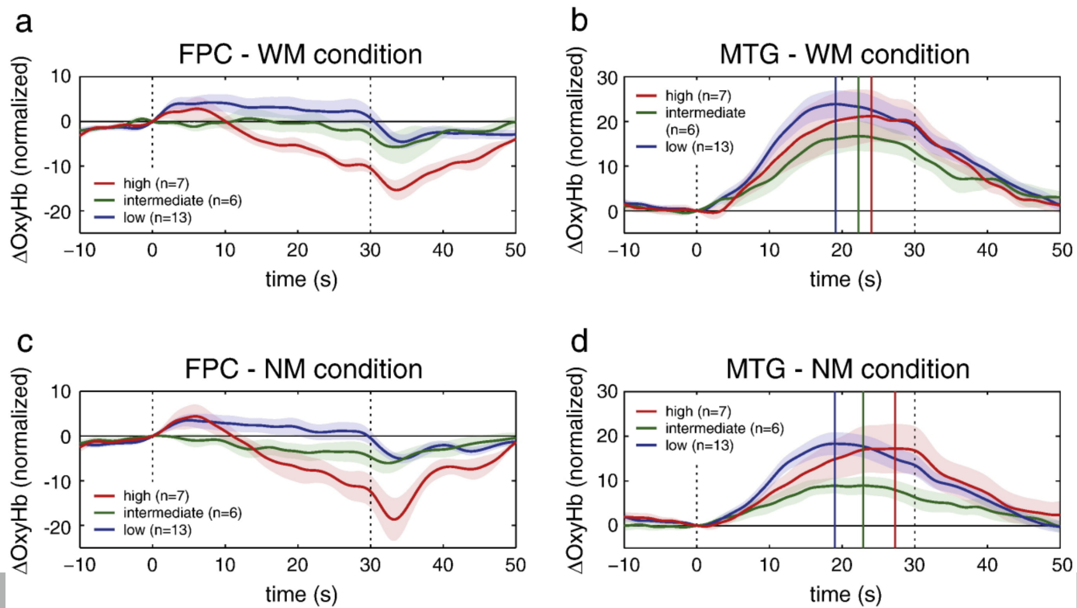
NeuroImage
Volume 85, Part 1, 15 January 2014, Pages 461–470
Celebrating 20 Years of Functional Near Infrared Spectroscopy (fNIRS)

Frontotemporal oxyhemoglobin dynamics predict performance accuracy of dance simulation gameplay: Temporal characteristics of top-down and bottom-up cortical activities

Yumie Ono[a], Yasunori Nomoto[a], Shohei Tanaka[a], Keisuke Sato[a], Sotaro Shimada[a], Atsumichi Tachibana[b], Shaw Bronner[c], J. Adam Noah[d]



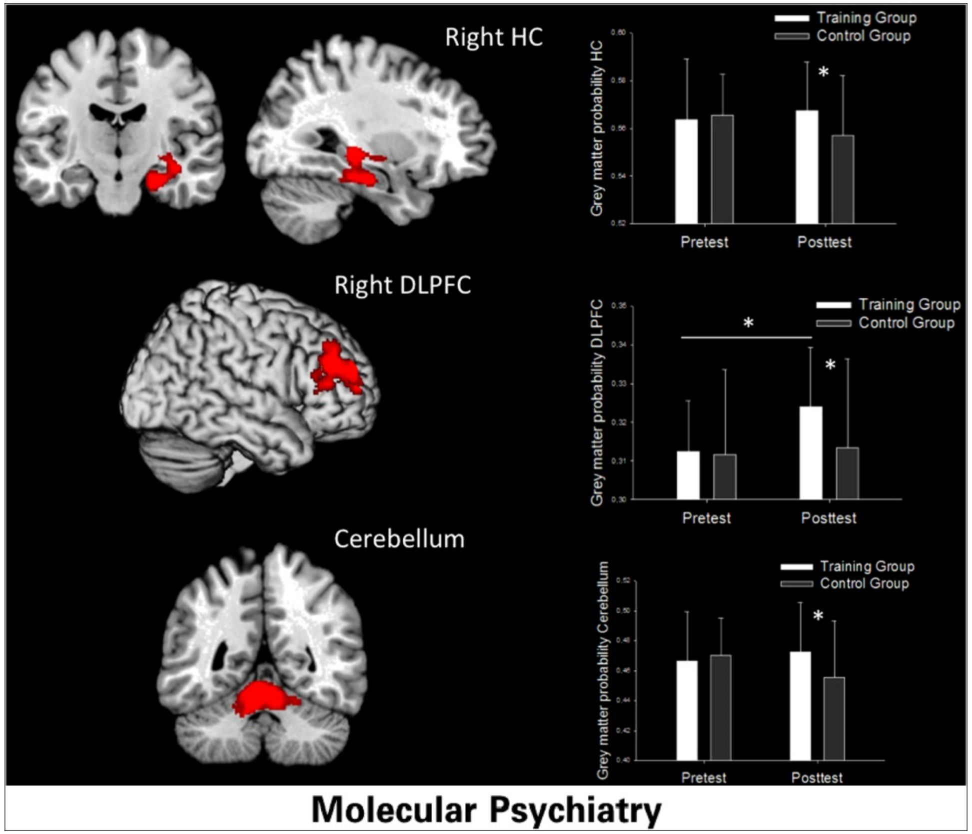




Playing Super Mario induces structural brain plasticity: gray matter changes resulting from training with a commercial video game

Molecular Psychiatry (2014) **19**, 265-271;
doi:10.1038/mp.2013.120

S Kühn[1], T Gleich[2], RC Lorenz[2,3], U Lindenberger[1] and J Gallinat[2]



Front. Aging Neurosci., 12 April 2016 | https://doi.org/10.3389/fnagi.2016.00066

Exergame and Balance Training Modulate Prefrontal Brain Activity during Walking and Enhance Executive Function in Older Adults

Patrick Eggenberger[1*], Martin Wolf[2], Martina Schumann[1] and Eling D. de Bruin[1,3,4]

Front. Aging Neurosci., 23 November 2016 | https://doi.org/10.3389/fnagi.2016.00278

Adaptations of Prefrontal Brain Activity, Executive Functions, and Gait in Healthy Elderly Following Exergame and Balance Training: A Randomized-Controlled Study

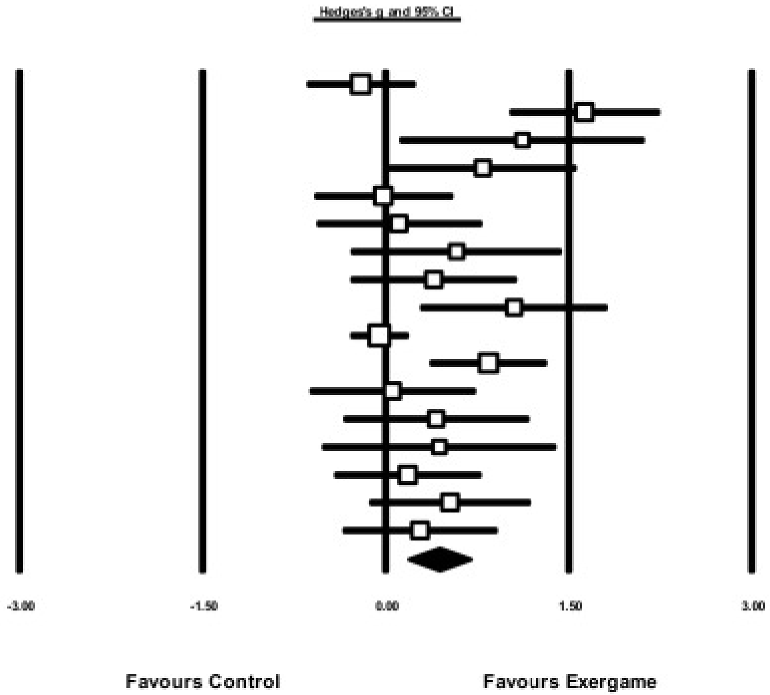
Alexandra Schättin[*], Rendel Arner, Federico Gennaro and Eling D. de Bruin

Review article

The effect of active video games on cognitive functioning in clinical and non-clinical populations: a meta-analysis of randomized controlled trials

Emma Stanmore[a,] , Brendon Stubbs[b, c], Davy Vancampfort[d, e], Eling D. de Bruin[f], Joseph Firth[g]

Study name	Statistics for each study							Sample size	
	Hedges's g	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Exergame	Control
Ackerman 2010	-0.202	0.226	0.051	-0.645	0.240	-0.896	0.370	39	39
Anderson-Hanley 2012	1.628	0.312	0.098	1.016	2.240	5.214	0.000	38	41
Barcelos 2015	1.118	0.509	0.259	0.119	2.116	2.194	0.028	8	9
Chan 2010	0.794	0.391	0.153	0.028	1.560	2.033	0.042	12	15
Eggenberger 2015	-0.019	0.288	0.083	-0.583	0.545	-0.065	0.948	24	24
Eggenberger 2016	0.109	0.344	0.118	-0.565	0.783	0.316	0.752	19	14
Hughes 2014	0.580	0.438	0.192	-0.278	1.439	1.324	0.185	10	10
Kimhy 2015	0.393	0.343	0.118	-0.279	1.066	1.146	0.252	16	17
Maillot 2012	1.050	0.389	0.151	0.288	1.812	2.700	0.007	15	15
Mirelman 2016	-0.051	0.119	0.014	-0.284	0.182	-0.425	0.671	146	136
Park 2015	0.841	0.243	0.059	0.364	1.318	3.454	0.001	36	36
Pompeu 2012	0.055	0.345	0.119	-0.620	0.731	0.160	0.873	16	16
Schattin 2016	0.413	0.384	0.148	-0.340	1.166	1.076	0.282	13	14
Schoene 2013	0.439	0.486	0.236	-0.514	1.392	0.904	0.366	15	17
Simsek 2015	0.181	0.304	0.092	-0.414	0.777	0.597	0.550	20	22
Staiano 2012	0.526	0.333	0.111	-0.127	1.179	1.579	0.114	18	18
Zimmermann 2014	0.281	0.320	0.103	-0.346	0.909	0.879	0.379	19	20
	0.436	0.129	0.017	0.184	0.688	3.391	0.001	464	462



Meta-Analyse von Exergames Auswirkungen auf globale Kognition im Vergleich zu Kontrollbedingungen.

Neuroscience & Biobehavioral Reviews, 2017, Available online 23 April 2017; http://dx.doi.org/10.1016/j.neubiorev.2017.04.011

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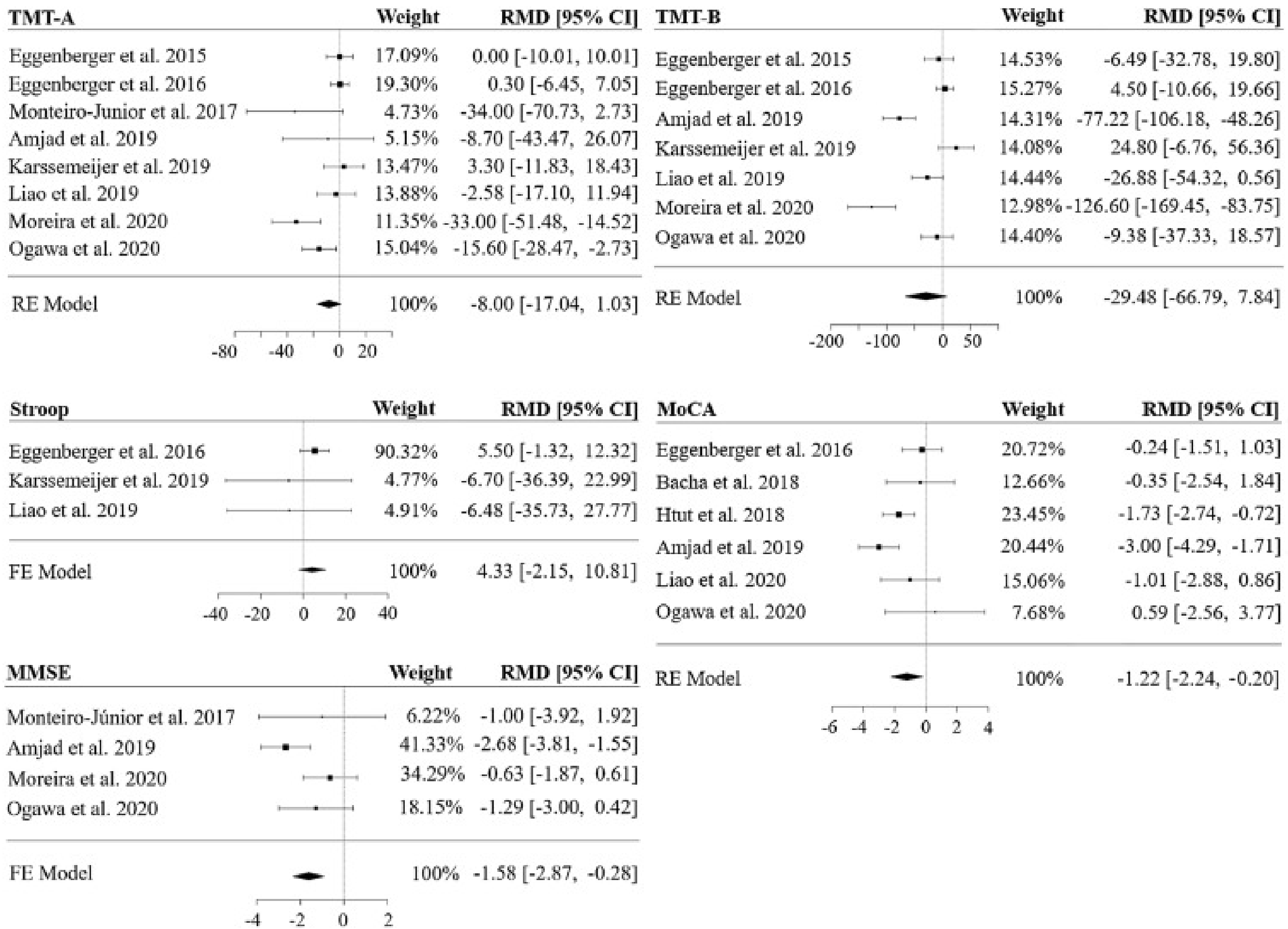
Archives of Gerontology and Geriatrics
Volume 97, November–December 2021, 104485

Review

Comparison of exergames versus conventional exercises on the cognitive skills of older adults: a systematic review with meta-analysis

Highlights

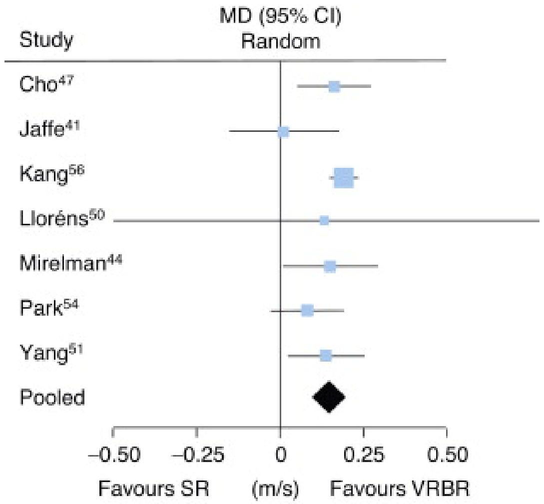
- Exergames and conventional physical exercises improve cognitive performance in older adults.
- Exergames appear to be more effective on global cognitive performance than conventional physical training.
- The differences seem to decrease when conventional exercise has high cognitive demand.
- Individual studies found neurophysiological benefits in favor of exergames.



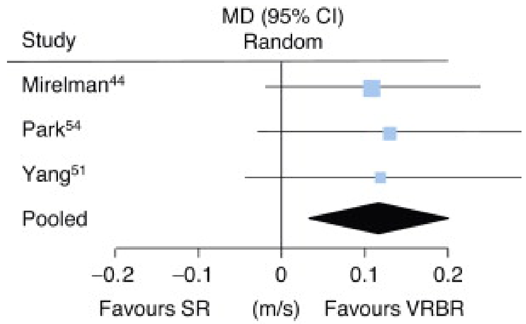
Rehabilitation that incorporates virtual reality is more effective than standard rehabilitation for improving walking speed, balance and mobility after stroke: a systematic review

Davide Corbetta [a], Federico Imeri [b], Roberto Gatti [c]

Journal of Physiotherapy 61 (2015) 117–124



Weighted mean differences (95% CI) of the effect immediately after intervention of substituting some or all of standard rehabilitation (SR) with virtual reality based rehabilitation (VRBR) on **walking speed**, pooling data from seven trials (n = 138).



Weighted mean differences (95% CI) of the effect beyond the end of the intervention period of substituting some or all of standard rehabilitation (SR) with virtual reality based rehabilitation (VRBR) on **walking speed**, pooling data from three trials.

http://dx.doi.org/10.1016/j.jphys.2015.05.017

관심을 가져주셔서 감사합니다.