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SPORT SCIENCE LABORATORY

Jacques Rogge

INHOUD

Deel 1

- Biomechanica
- Sportbiomechanica
- Locomotie

Deel 2

- Belasting / belastbaarheid
- Loopblessures
  - Incidentie
  - Risicofactoren
  - Preventie
    - Grounded running
    - Lower Impact Running

BIOMECHANICA

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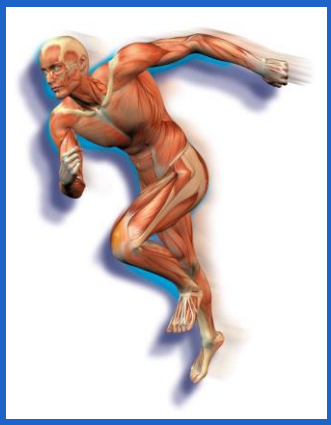

BIO MECHANICA

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BIOMECHANICA

Biomechanica is de studie van de structuur en de functie van **biologische** systemen d.m.v. methoden uit de **mechanica***

Biomechanica is de studie van de **krachten** inwerkend op een **biologisch** systeem (intern en extern) en van het effect dat ze teweeg brengen #

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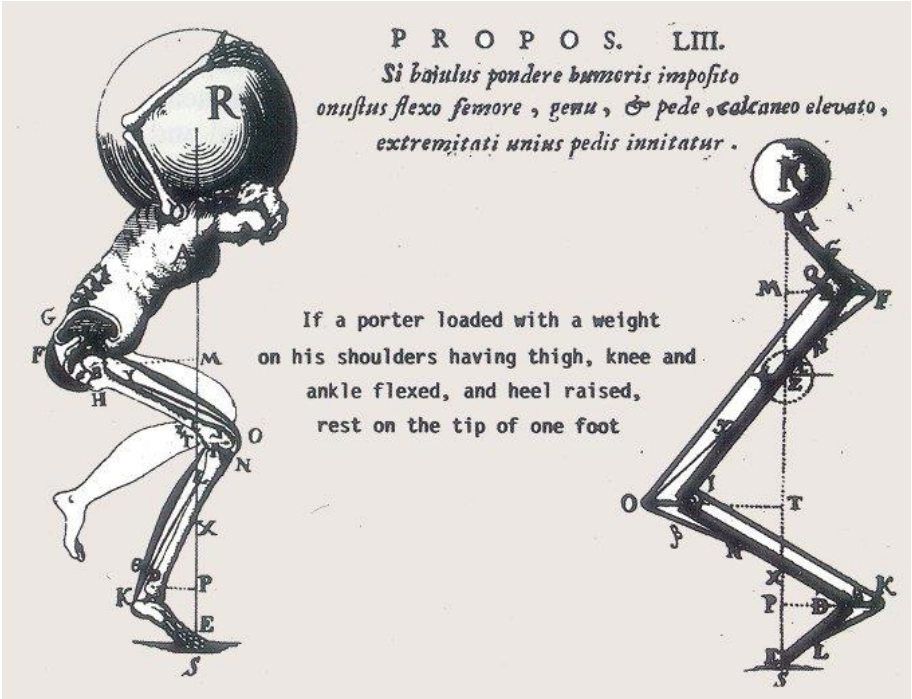
* *Hatze, Herbert (1974). "The meaning of the term biomechanics". Journal of Biomechanics. 7 (12): 189–190.*

Nigg, Biomechanics of the musculo-skeletal system, 1994; Hay, Biomechanics of Sports Techniques, 1973

- Lex I. Corpus omne perseverare in statu suo quiescendi vel movendi uniformiter in directum, nisi quatenus a viribus impressis cogitur statum illum mutare.
- Lex II. Mutationem motis proportionalem esse vi motrici impressae, et fieri secundum lineam rectam qua vis illa imprimitur.
- Lex III. Actioni contrariam semper et æqualem esse reactionem: sive corporum duorum actiones in se mutuo semper esse æquales et in partes contrarias dirigi.

- De eerste wet van Newton = de traagheidswet.
  Een voorwerp waarop geen resulterende kracht werkt, is in rust of beweegt zich rechtlijnig met constante snelheid voort.
- De tweede wet van Newton = kracht verandert de snelheid
  De verandering van de impuls is recht evenredig met de resulterende kracht en volgt de rechte lijn waarin de kracht werkt.
- De derde wet van Newton: actie ↔ reactie
  Als een voorwerp A een kracht op een voorwerp B uitoefent, gaat deze kracht gepaard met een even grote, maar tegengestelde gerichte kracht van B op A.



uit "De Motu Animalium"

1608-1679 G.Borelli

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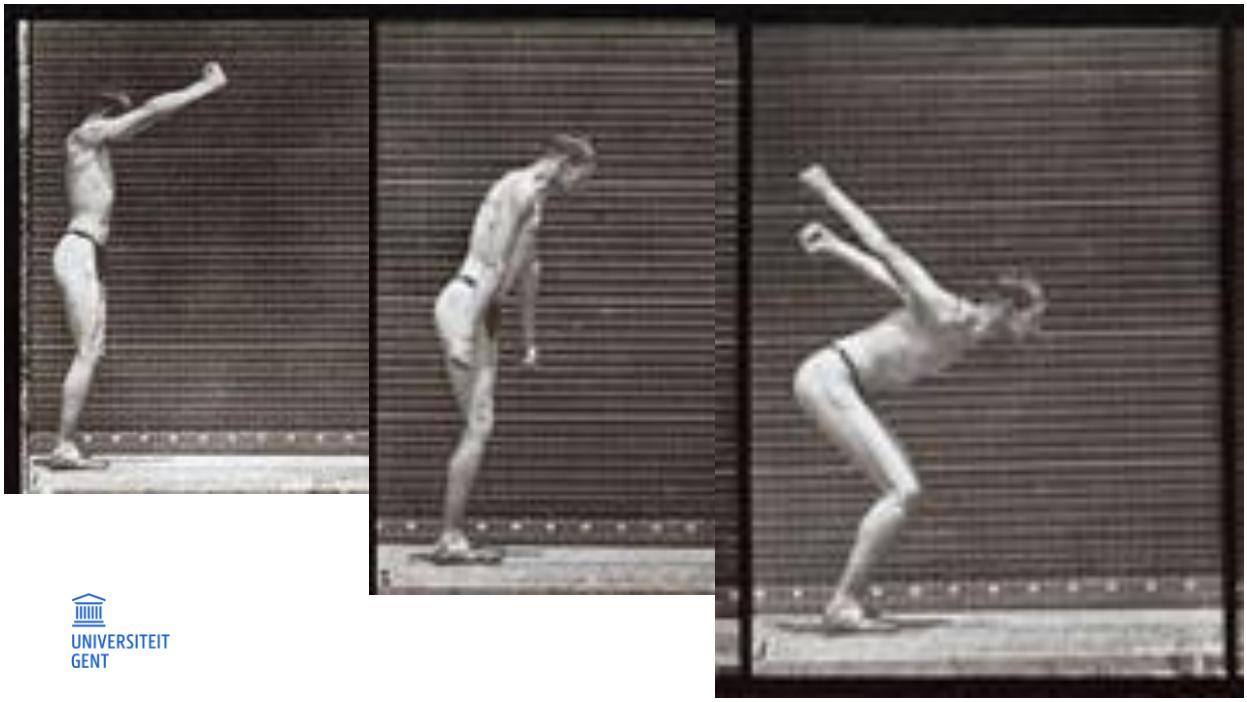

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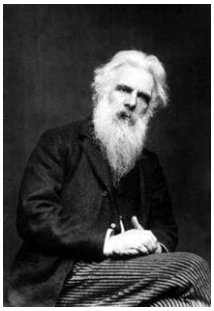
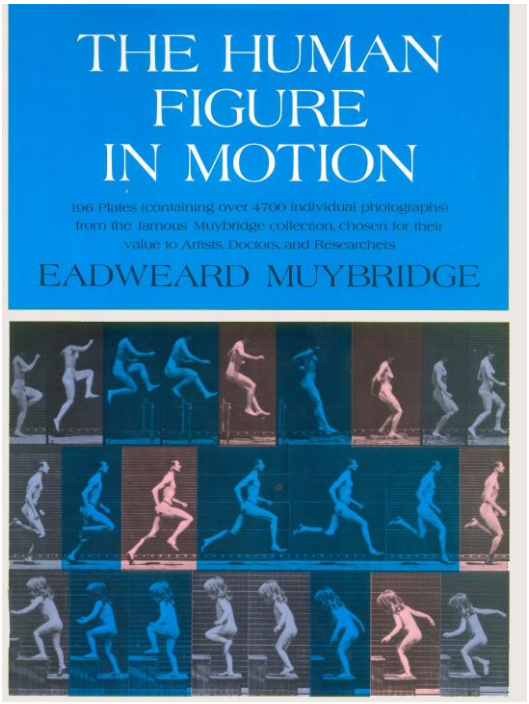


Eadweard Muybridge, England 1830 -1904



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SPORTBIOMECHANICA

Sportbiomechanica is de wetenschappelijke discipline die de "sport"beweging beschrijft en verklaart op basis van begrippen, methoden en wetten uit de mechanica.

- Labo en/of veld
- Prestatiesport en/of bewegen als fysieke activiteit
- Geïndividualiseerd en/of brede populatie

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** Ballreich, R. & Baumann, W. (1988). Grundlagen der Biomechanik des Sports (Foundations of sports biomechanics). Stuttgart: Enke.*

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LABO --- VELD

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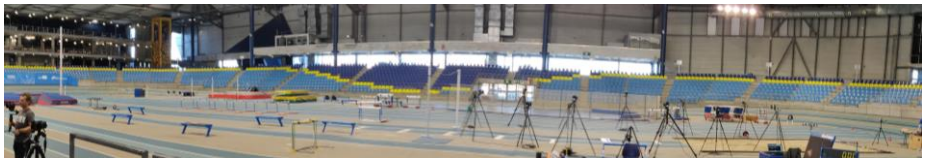

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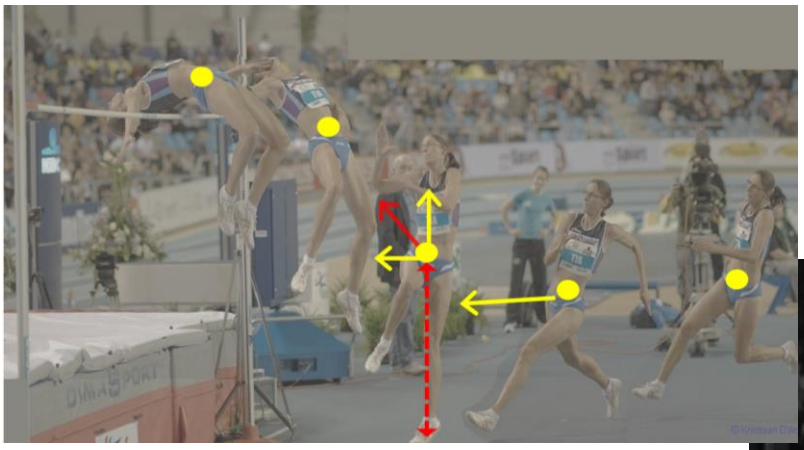
ALTIUS --- CITIUS ?



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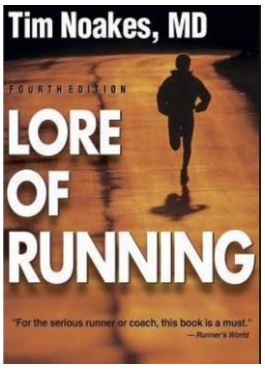
BEWEGEN FYSIEKE ACTIVITEIT --- BREEDTE SPORT

BEWEGEN FYSIEKE ACTIVITEIT --- BREEDTE SPORT

- 64 Mio USA (2016)
- 12% van de 15-80j in EU (2015)
- 19% van de volwassenen in VL

*Jeroen Schreerder "Vandaag zijn er in Vlaanderen ongeveer **1,2 miljoen mensen** die minstens één keer per jaar de loopschoenen aantrekken", zegt Scheerder in **De Morgen**. Het aantal lopers (goed voor 19% van de Vlamingen tussen de 12 en 75 jaar) is daarmee groter geworden dan het aantal Vlamingen dat aan sport doet in competitieverband (16%). Vlaanderen staat daarmee op drie in Europa, na **Denemarken** (31%) en **Duitsland** (25%), en doet ruim beter dan het Europees gemiddelde (12%).*



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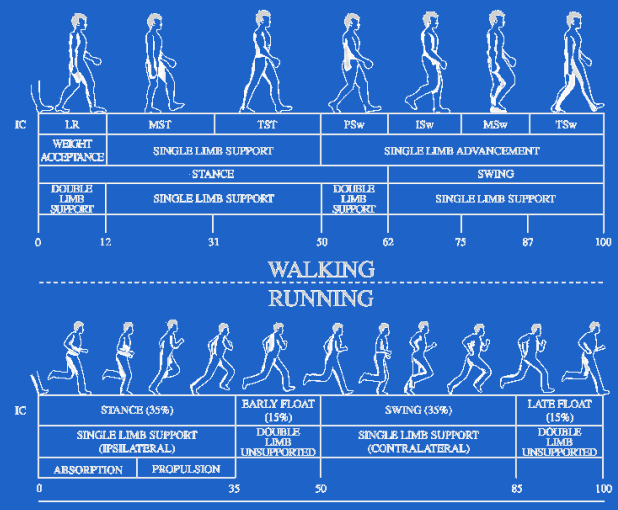
LOCOMOTIE



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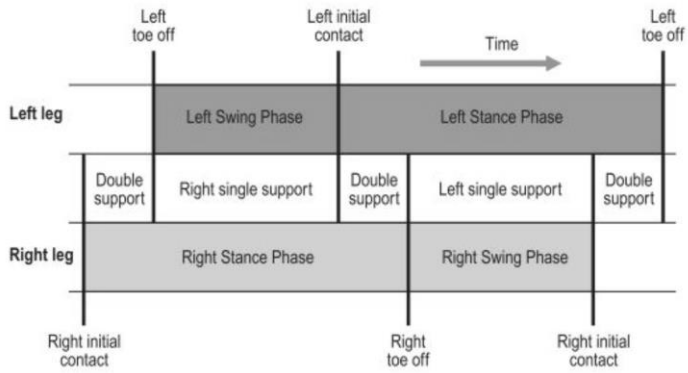
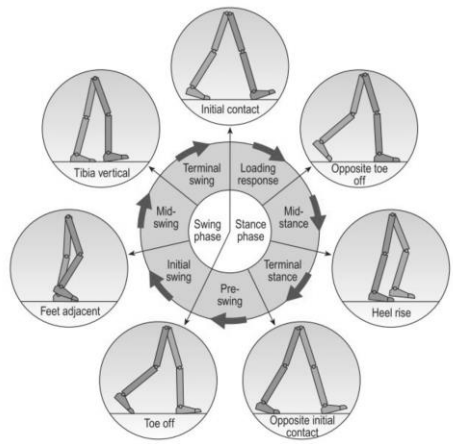
WANDELEN - GAAN





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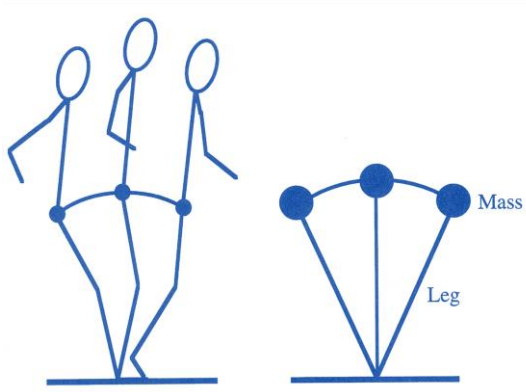
WANDELEN - GAAN



MAXIMALE KRACHT voorkeurssnelheid = 1,2 LG

ENERGIEVERBRUIK = 3-4 MET

MODELLEREN MET OMGEKEERDE PENDULUM

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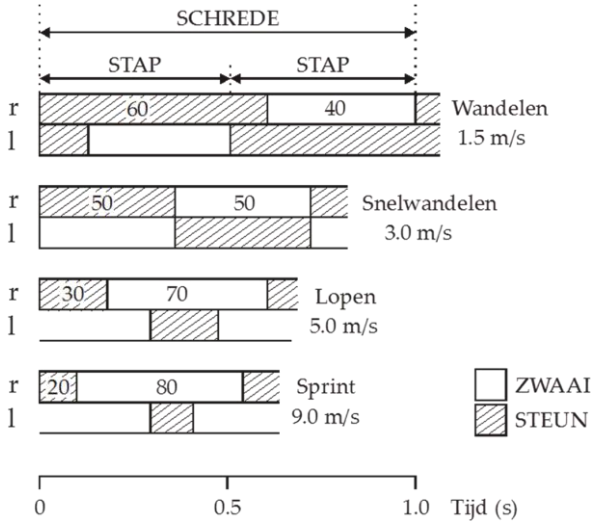
Farley et al., 1998

LOCOMOTIE – TEMPORELE PARAMETERS



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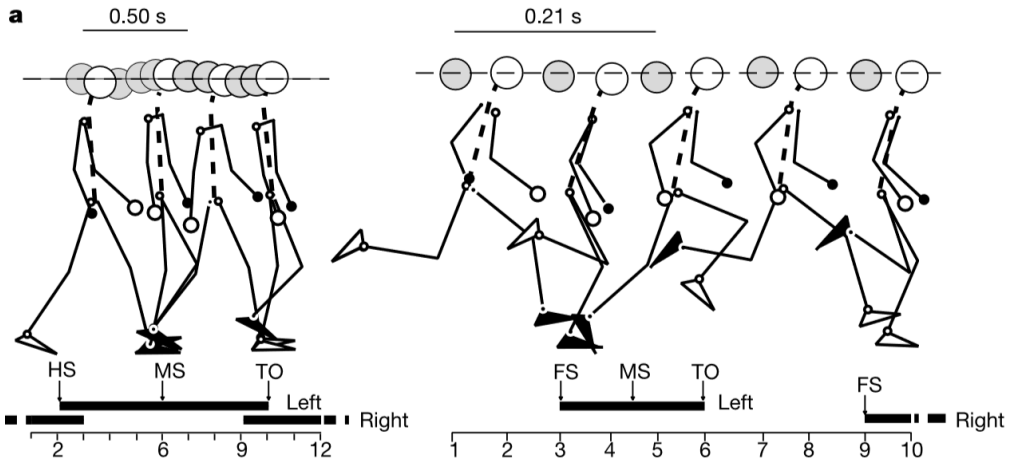
Zatsiorsky VM, Werner SL, Kaimin MA. 1994.
Basic kinematics of walking. Step length and step frequency. A review. J Sports Med Phys Fitness 34

LOPEN - RENNEN



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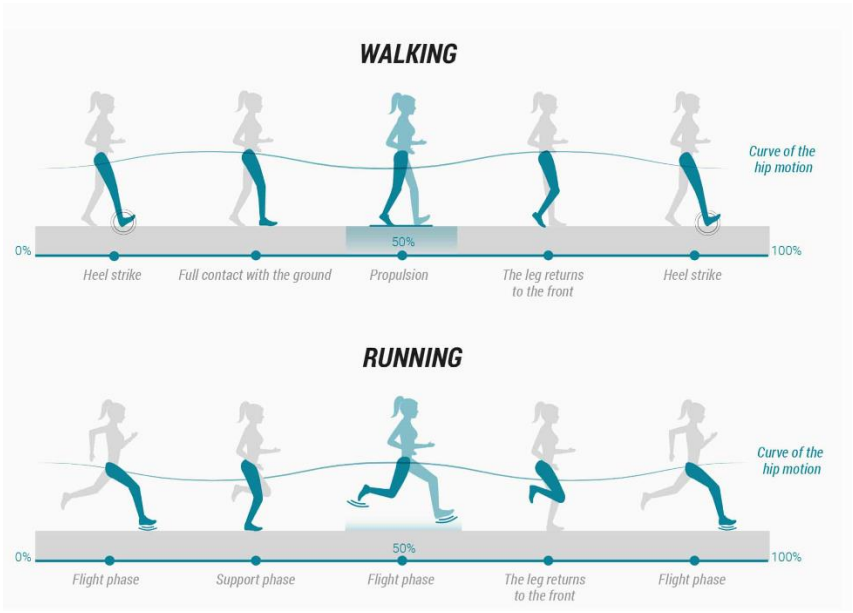
Bramble and Lieberman, 2004



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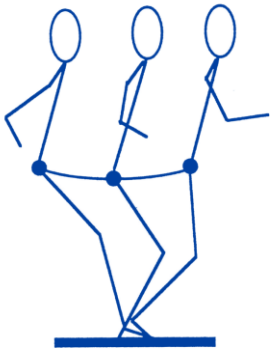
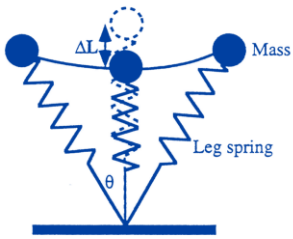
LOPEN - RENNEN





MAXIMALE KRACHT voorkeurssnelheid = 2-3 LG

ENERGIEVERBRUIK = 5-6 MET

MODELLEREN MET MASSA-VEER SYSTEEM

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GEWRICHTSSYSTEMEN

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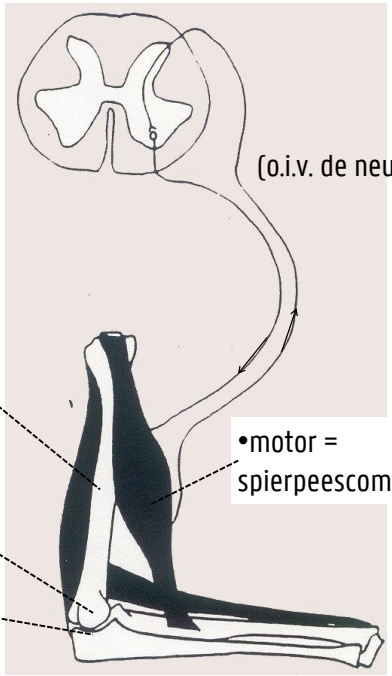
GEWRICHTSSYSTEMEN ALS FUNCTIONELE EENHEID



(o.i.v. de neuromotoriek)

starre beenderen

Gewrichten: scharnieren
= hefbomen

Kraakbeen, kapsel en ligamenten

•motor = spierpeescomplexen

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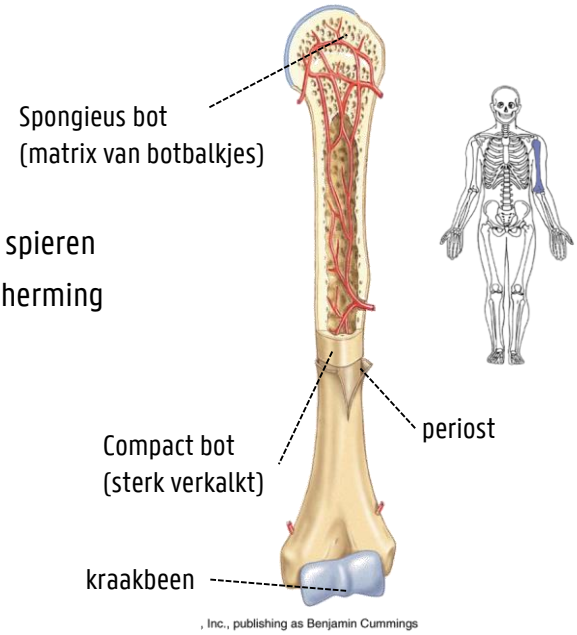
BEENDERSTELSEL



Spongieus bot
(matrix van botbalkjes)

periost

Compact bot
(sterk verkalkt)

kraakbeen

, Inc., publishing as Benjamin Cummings

Steunfunctie:

- Hefboomwerking voor de spieren
- Aanhechting voor en bescherming van weke weefsels

Andere functies:

- Opslag van calcium
- Vorming van bloedcellen

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WOLFF'S WET VAN FUNCTIONELE ADAPTATIE

"De inwendige structuur en de uitwendige vorm van levend bot wordt in belangrijke mate bepaald door de overheersende mechanische belasting en volgt fysische wetmatigheden, waarbij het bot met een minimum aan materiaal zijn functie kan vervullen"

→ de vorm van de dwarsdoorsnede
→ de structuur van het spongieus bot
→ de uitwendige (gebogen) vorm van beenderen.

MECHANISCHE BELASTING IS DUS ESSENTIEEL OM BOT « IN VORM » TE HOUDEN !

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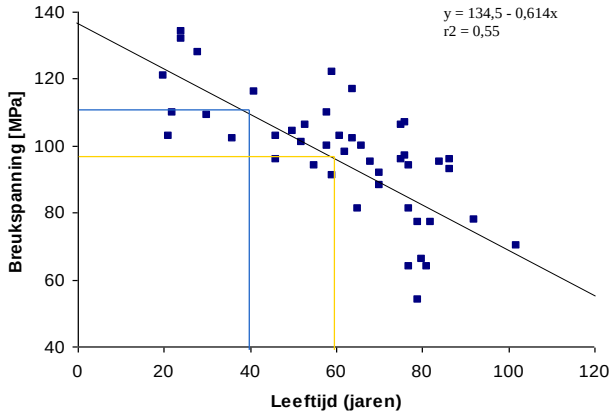
STERKTE VAN BEENDEREN – LEEFTIJD

vanaf 30 à 40 jaar; per 10 jaar : σ_{breuk} – 5 % en ε_{breuk} – 9 %



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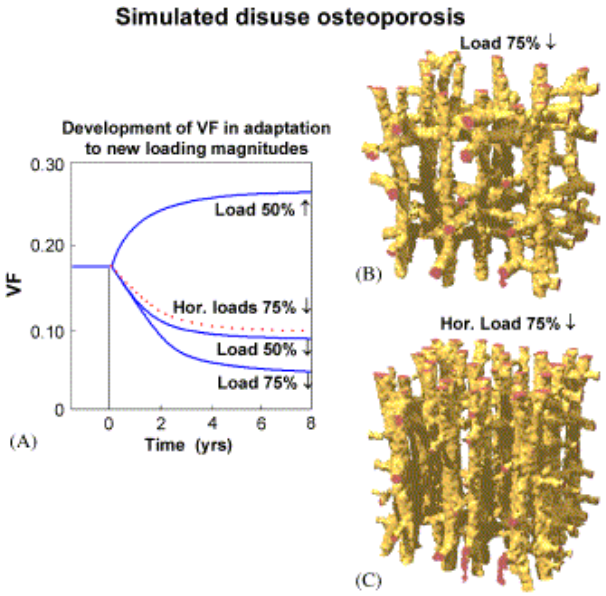
vrouwen: problematiek van osteoporose

Stimuleren van verhogen van botdensiteit door mechanische belasting → fysieke activiteit

Simulatie van osteoporose door een tekort aan mechanische belasting



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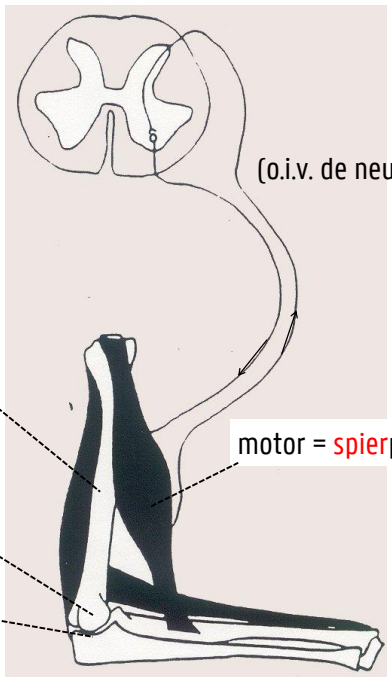
GEWRICHTSSYSTEMEN ALS FUNCTIONELE EENHEID



(o.i.v. de neuromotoriek)

starre beenderen

Gewrichten: scharnieren = hefbomen

motor = spierpeescomplexen

Kraakbeen, kapsel en ligamenten

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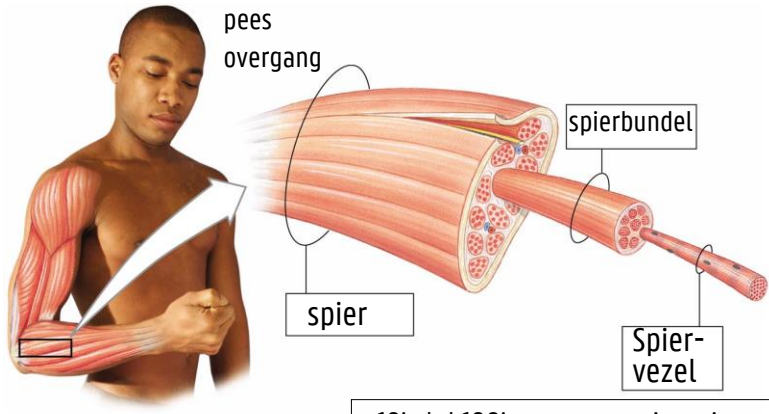
SPIEREN

- Leveren de actieve kracht op het skelet ifv houding of beweging
- Ondersteunen weke delen



= 10'n tot 100'n **sarcomeren** in serie

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SPIERKRACHT EN LEEFTIJD

Sarcopenie

- # spiervezels daalt → ↓ Kracht
- Vanaf 20 jaar
- Vanaf 50 jaar : daling 1-1,5% per jaar
- Vanaf 65 jaar : daling 3% per jaar

75 jaar = verlies 30%

https://www.sport.vlaanderen/nieuws/spierkracht-senioren

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https://faber.kuleuven.be/nl/portaal/krachttraining

www.ugent.be
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INHOUD

Deel 1

- Biomechanica
- Sportbiomechanica
- Locomotie
- Gewrichtssystemen

Deel 2

- Belasting / belastbaarheid
- Loopblessures
  - Incidentie
  - Risicofactoren
  - Preventie
    - Grounded running
    - Lower Impact Running

Belasting belastbaarheid

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LIFE TIME RUNNING

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Waarom levenslang lopen?

Uit literatuur blijkt dat lopen het ideale preventieve geneesmiddel is om gezond ouder te worden. Maar is een hoge prevalentie van loop gerelateerde blessures (RRI – running related injuries) zeker bij beginnende lopers.

Biomechanische inzichten kunnen mogelijks helpen in het vermijden van een RRI en misschien "lopen op doktersvoorschrift" mogelijk maken?

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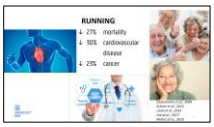
INTRODUCTIE – LANGE AFSTAND LOPEN



- Een van de meest populaire sporten bij recreatieve sporters
- Gezondheidsvoordelen
- Goedkoop en toegankelijk

MAAR hoge prevalentie van loopblessures

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LOPEN

↓ 27% mortaliteit

↓ 30% cardiovasculaire aandoeningen

↓ 23% kanker

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Chakravarty et al., 2008
Schnor et al., 2015
Lavie et al., 2015
Lee at al., 2017
Pedisic et al., 2019

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British Journal of Sports Medicine

2019

Is running associated with a lower risk of all-cause, cardiovascular and cancer mortality, and is the more the better? A systematic review and meta-analysis

Zeljko Pedisic,[1] Nipun Shrestha,[1] Stephanie Kovalchik,[1] Emmanuel Stamatakis,[2,3] Nucharapon Liangruenrom,[1,4] Jozo Grgic,[1] Sylvia Titze,[5] Stuart JH Biddle,[6] Adrian E Bauman,[3] Pekka Oja[7]

14 studies from six prospective cohorts with a pooled sample of 232 149 participants were included. In total, 25 951 deaths were recorded during 5.5–35 year follow-ups.

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What are the new findings?

- Running participation is associated with 27%, 30% and 23% reduced risk of all-cause, cardiovascular and cancer mortality, respectively.
- Significant reductions in mortality risk can be expected for any dose of running, even just once a week or 50 min a week.
- We found no evidence that mortality benefits increase with higher amounts of running.

Even the smallest doses of running that were examined in the available studies were found to confer significant all-cause mortality benefits

i.e. 1 time a week, <50 min a week, <6 mph = 9,6km/h and <500 MET.min/week

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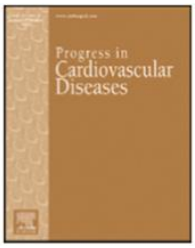
Pedisic at al, 2019



Lee et al., 2017

Running as a Key Lifestyle Medicine for Longevity

Duck-chul Lee[a,], Angelique G. Brellenthin[a], Paul D. Thompson[b], Xuemei Sui[c], I-Min Lee[d], Carl J. Lavie[e]*

[a]Department of Kinesiology, College of Human Sciences, Iowa State University, Ames, IA
[b]Department of Cardiology, Hartford Hospital, Hartford, CT
[c]Department of Exercise Science, Arnold School of Public Health, University of South Carolina, Columbia, SC
[d]Brigham and Women's Hospital, Harvard Medical School, Boston, MA
[e]Department of Cardiovascular Diseases, John Ochsner Heart and Vascular Institute, Ochsner Clinical School, University of Queensland School of Medicine, New Orleans, LA

Running is a popular and convenient leisure-time physical activity (PA) with a significant impact on longevity. In general, runners have a 25%–40% reduced risk of premature mortality and live approximately 3 years longer than non-runners.

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Gemiddelde loper	Gemiddelde	SD
Leeftijd (jaren)	37,2	12,3
Gewicht (kg)	75,8	18,1
Lengte (cm)	173	10,0
BMI	25,4 *	5,0
Loopafstand (km/week)	20,60	12,6
Snelheid (km/h)	9,5	2,8
Based on 2,5 Million Runners (Shorten and Priscotta, 2017)		

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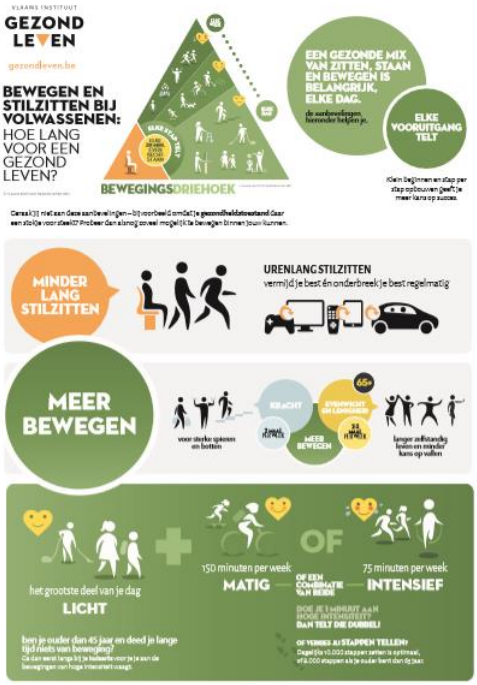
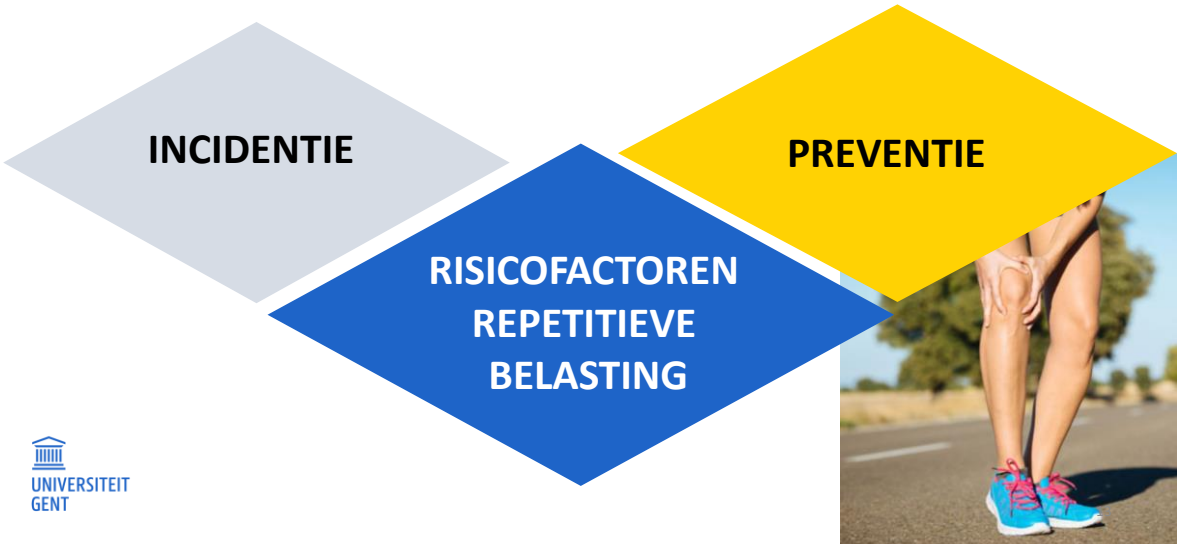


> 6 MET @ 75 min/week ≋500 MET.min/wk

RUNNING RELATED INJURIES – RRI'S



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RUNNING RELATED INJURIES

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RUNNING RELATED INJURIES - INCIDENTIE

- 2,5 tot 12,1 blessures per 1000 uur lopen
- Voornamelijk blessures aan het onderbeen
- 50-75% overbelastingskwetsuren
- Herval 20-70%
- Risicofactoren:
  - vorige blessures
  - te weinig loopervaring
  - te veel te snel
- Preventie belangrijk

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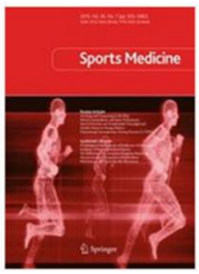
van Mechelen W., 1992



1992, Vol 14

2.5 to 12.1 injuries per 1000h running

2015, Vol 45

7.7 to 17.8 injuries per 1000h running

Drop Out

RUNNING RELATED INJURIES

RISICOFACTOREN
REPETITIEVE
BELASTING

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BELASTING

BELASTBAARHEID

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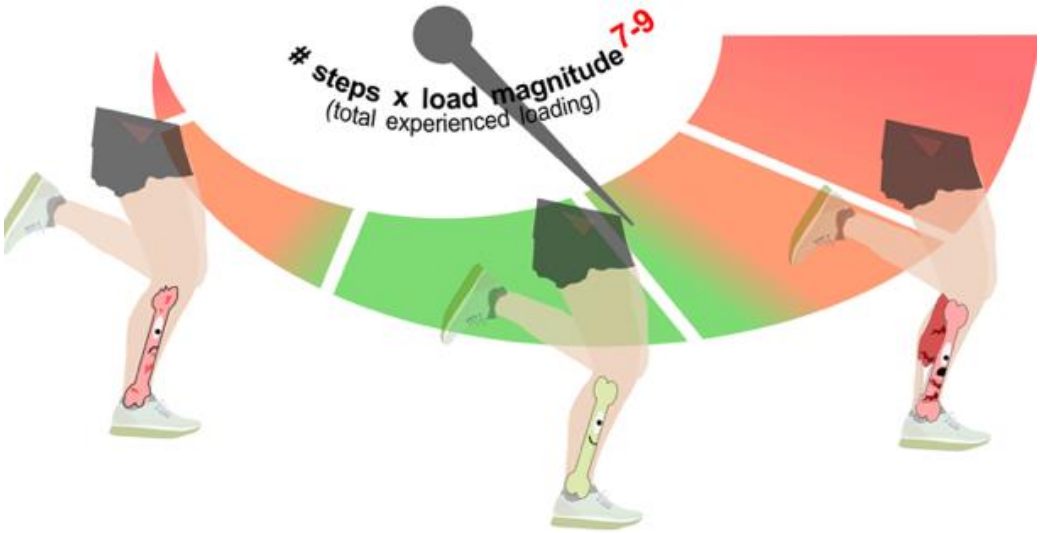

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BIONEGATIEF EFFECT OP BMD

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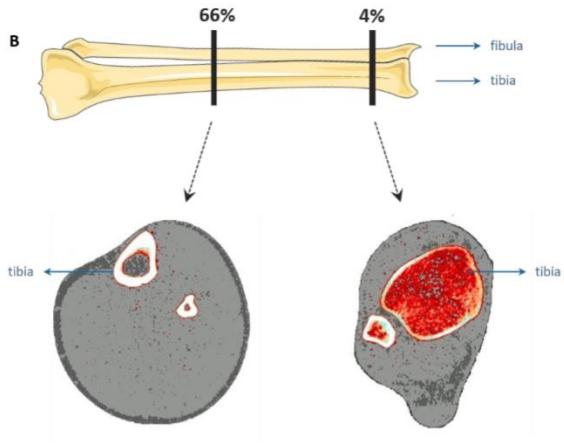
BIOPOSITIEF EFFECT OP BMD

BMD =
Bone Mineral Density
maat voor stevigheid van het bot

BMD Lopers > niet lopers



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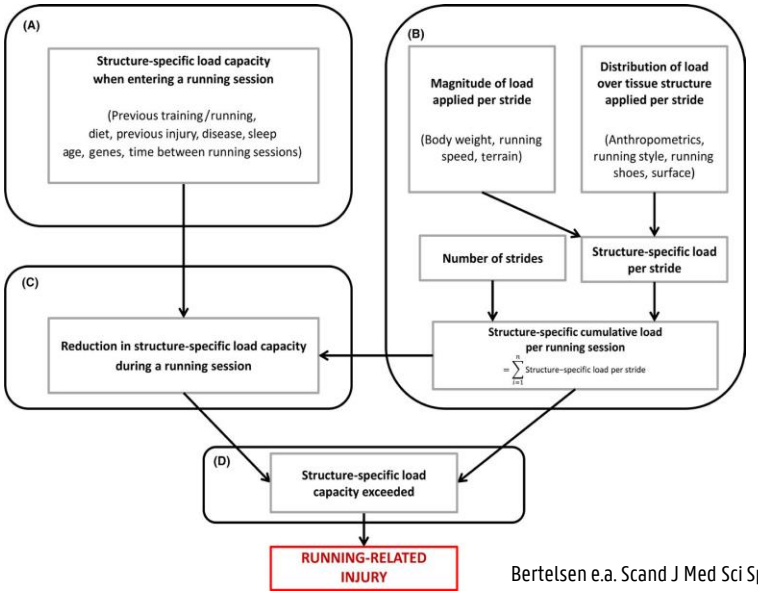
A FRAMEWORK FOR THE ETIOLOGY OF RUNNING-RELATED INJURIES



Bertelsen e.a. Scand J Med Sci Sports,2017

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BELASTBAARHEID

- Niet echt meetbaar
- Verschillende weefsels
- Beïnvloed door veel factoren zoals o.a.
  - vermoeidheid
  - voorgeschiedenis in sport
  - training status
  - leeftijd
  - gewicht

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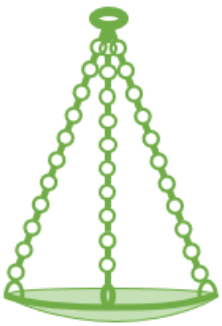
BELASTBAARHEID RISICOFACTOREN RRI



- Beperkte loopervaring
- Eerdere blessure

Fokkema et al., 2019
Videbaeck et al., 2015
Van Mechelen et al., 1992

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BELASTING

- Meetbaar
- Combinatie van
  - Grootte van de belasting
  - Aantal herhalingen

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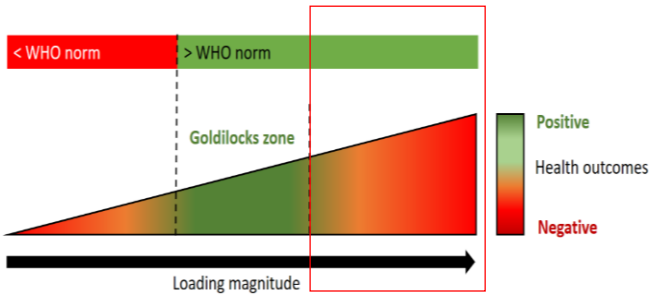
BELASTING RISICOFACTOREN RRI

- Speed too high
- Too much too soon



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OVERBELASTINGBLESSURES
MECHANISCHE VERMOEIDHEID

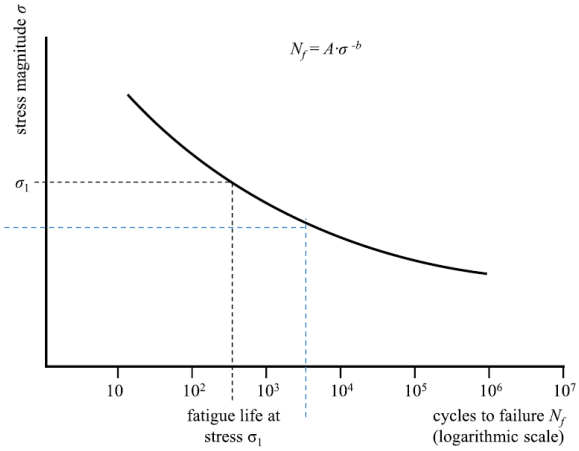

Figure 1. Theoretical stressed-life plot, or S-N curve, for a material subjected to cyclic loading. Fatigue life is defined as the number of cycles to failure N_f at a particular stress magnitude σ.

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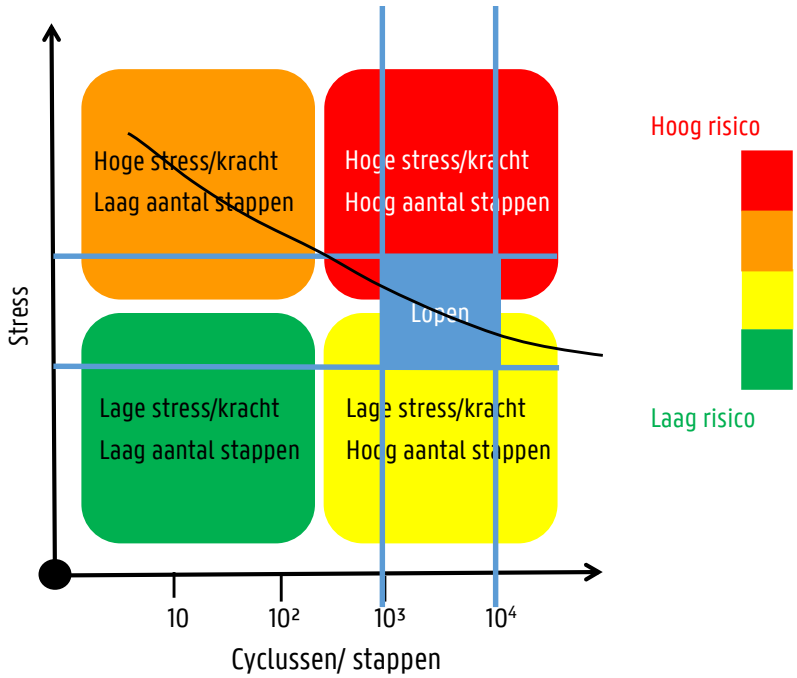
W.B.Edwards 2018

Lopen =
1,000-10,000 stappen

Lopen = medium kracht



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W.B. Edwards 2018

What is important to recognize is that small changes in σ often will result in large changes in N_f. For the loading magnitudes relevant to running, a 10% reduction in stress generally is associated with a corresponding 100% increase, or more, in the number of cycles to failure (11–13).

- Kleine verandering in stress → grote veranderingen in aantal schredes

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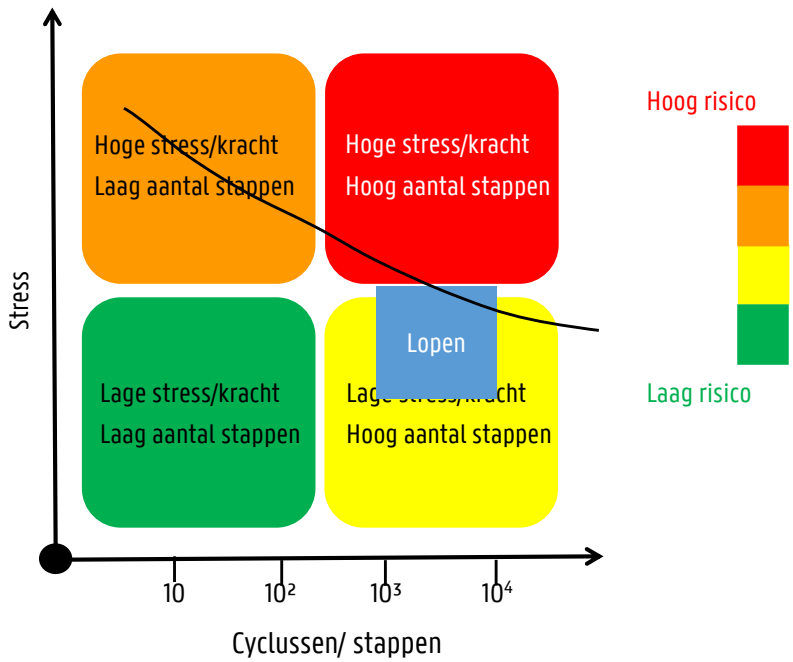
W.B.Edwards 2018

Lopen =
1,000-10,000 stappen

Lopen = medium kracht



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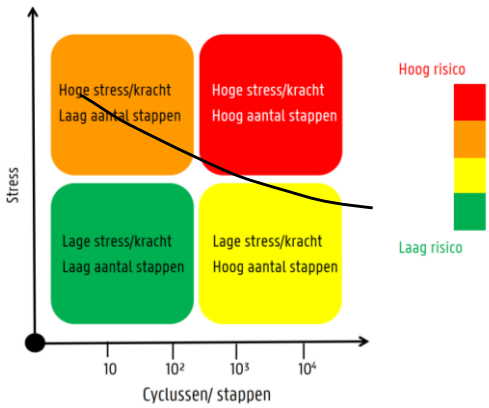
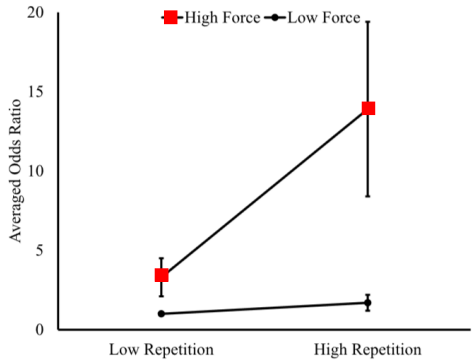
W.B. Edwards 2018





Odds Ratio = kans op letsel

Hoe hoger --- hoe meer kans

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RUNNING RELATED INJURIES

PREVENTIE

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INTERVENTIES VANDAAG

- Meestal op een graduele toename
- Met focus op het aantal stappen
- Meestal weinig succesvol

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JOSPT Journal of Orthopaedic & Sports Physical Therapy

2014; Vol 44(10):739-747

STUDY DESIGN: An explorative, 1-year prospective cohort study.

	Lopers
Volume + 30%	26 blessures/ 183 lopers 14%
Volume + 10%	32 blessures/ 401 lopers 8%

RASMUS ØSTERGAARD NIELSEN, PT, MHSc[1,2] • ERIK THORLUND PARNER, PhD[3] • ELLEN AAGAARD NOHR, PhD[4,5]
HENRIK SØRENSEN, PhD[1] • MARTIN LIND, PhD[6] • STEN RASMUSSEN, MD[2,7]

Excessive Progression in Weekly Running Distance and Risk of Running-Related Injuries: An Association Which Varies According to Type of Injury

RESULTS: A total of 202 runners sustained a running-related injury. Using Cox regression analysis, no statistically significant differences in injury rates were found across the 3 exposure groups. An increased rate of distance-related injuries (patellofemoral pain, iliotibial band syndrome, medial tibial stress syndrome, gluteus medius injury, greater trochanteric bursitis, injury to the tensor fascia latae, and patellar tendinopathy) existed in those who progressed their weekly running distance by more than 30% compared with those who progressed less than 10% (hazard ratio = 1.59; 95% confidence interval: 0.96, 2.66; $P = .07$).

Owing to the exploratory nature of the present study, randomized controlled trials are needed to

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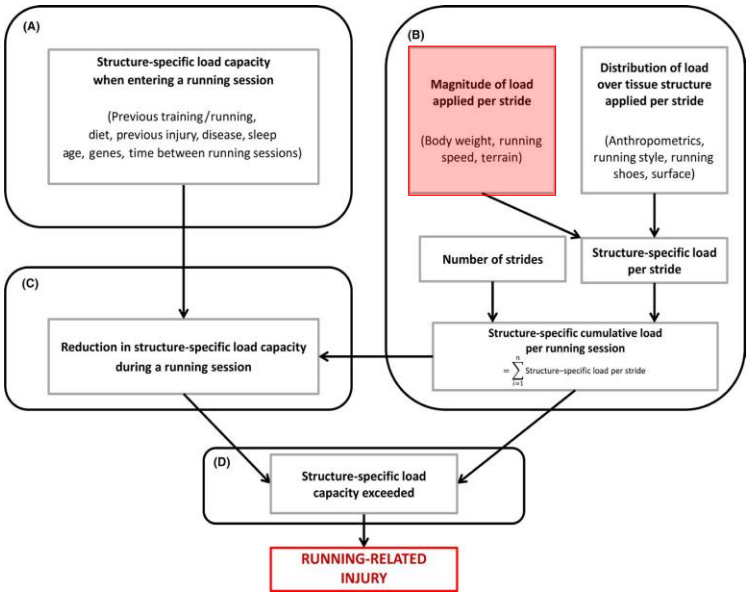
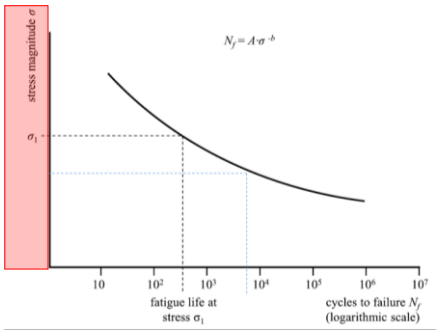
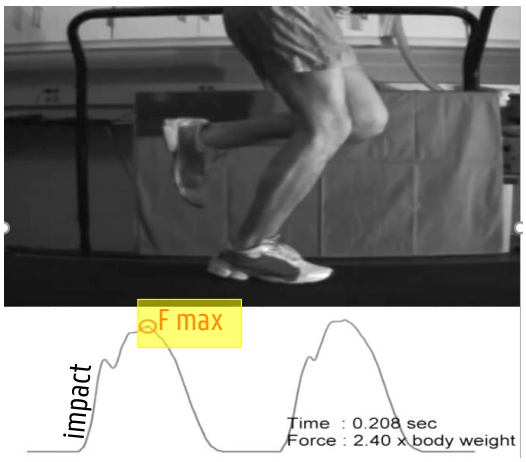
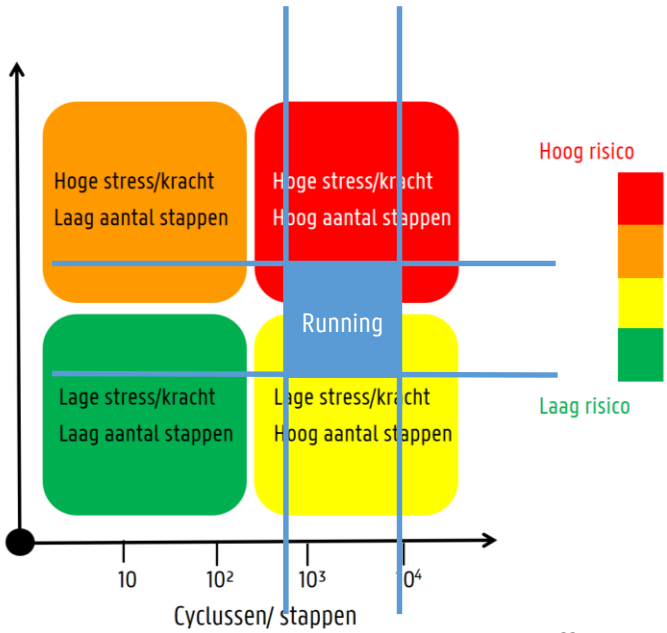
A framework for the etiology of running-related injuries





Bertelsen e.a. ,2017





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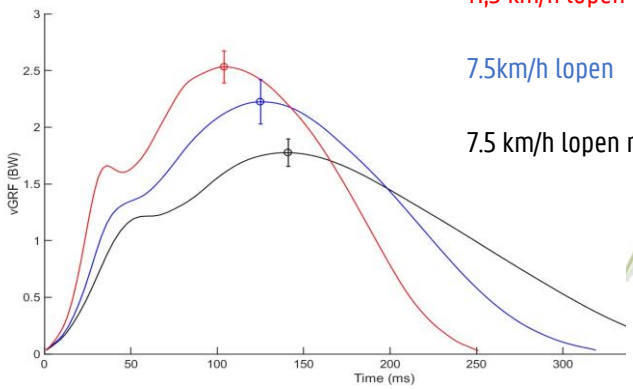
GROOTTE VAN DE BELASTING

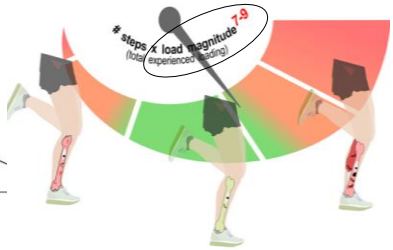
SNELHEID LOOPSTIJL

11,5 km/h lopen

7.5km/h lopen

7.5 km/h lopen met loopstijlaanpassing





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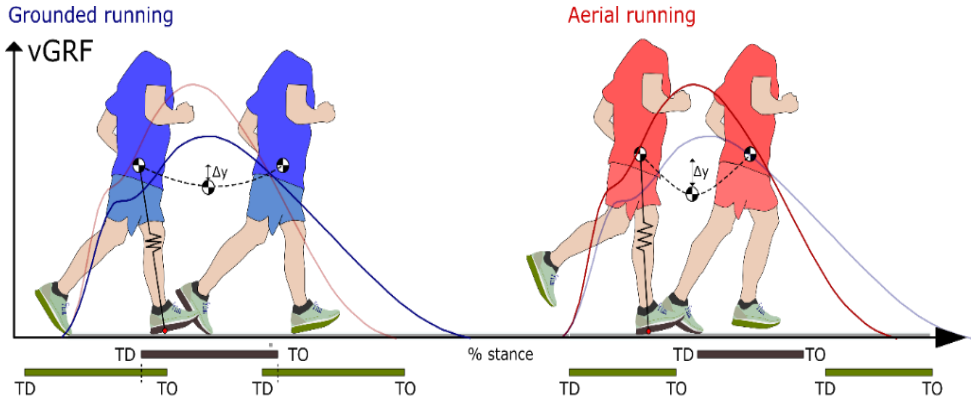
LOOPSTIJL AANPASSING



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SNELHEID – LOOPSTIJL

5,2 km Running Event Sept 2017 Ghent
HS video analysis - 97 lopers

SNELHEID	Runners (GR) (%)	DF (%)	BMI (kg.m^{-2})	Age (years)	♀ (%)
< 8,6 km.h^{-1}	16 (33)	50.90 ± 3.21	24.55 ± 3.67	45.73 ± 11.00	80,00
8,6 - 10,4 km.h^{-1}	39 (8)	45.75 ± 3.21	23.64 ± 3.47	39.84 ± 8.81	73,68
10,4 -12,1 km.h^{-1}	31 (0)	41.65 ± 2.60	22.45 ± 2.20	36.67 ± 9.54	60,00
12,1 - 13,9 km.h^{-1}	7 (0)	38.47 ± 4.83	22.66 ± 1.56	37.91 ± 10.56	0,00
> 13,9 km.h^{-1}	7 (0)	36.55 ± 1.20	21.81 ± 1.59	37.43 ± 4.39	0,00

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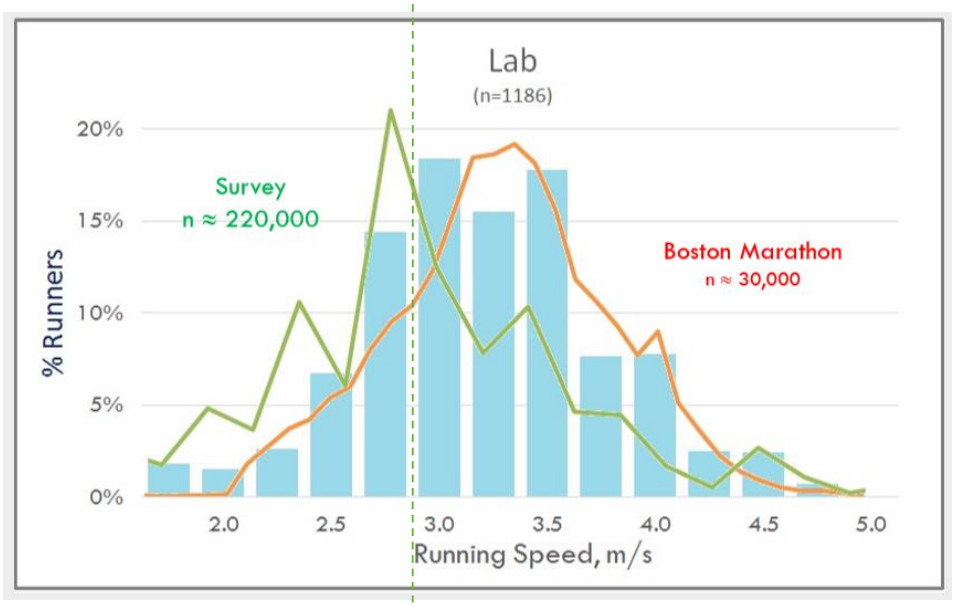
Senne Bonnaerens, Veerle Segers , Dirk De Clercq, FBG, 2019
Young Investigators award



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10 km·h^{-1}

M.Shorten e.a., ISBS 20

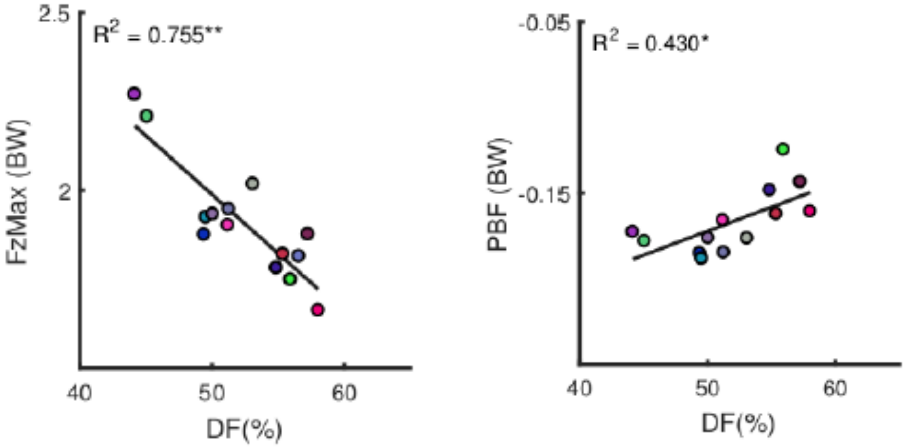
Open access

BMJ Open Sport & Exercise Medicine

2021 Vol 7

Relationship between duty factor and external forces in slow recreational runners

Senne Bonnaerens ,[1] Pieter Fiers,[1] Samuel Galle ,[1] Rud Derie,[1] Peter Aerts,[2] Edward Frederick,[3] Yasunori Kaneko,[4] Wim Derave,[1] Dirk De Clercq,[1] Veerle Segers [1]



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MALISSOUX 2022

CONCLUSION

The present study revealed that lower duty factor (ie, the ratio between contact time and stride time) is an injury risk factor, especially when using softer running shoes. Contrary to widespread belief, vertical impact peak force, loading rates, and step rate were not related to injury risk in recreational runners.

Duty factor – Loopstijl
= RISICO FACTOR

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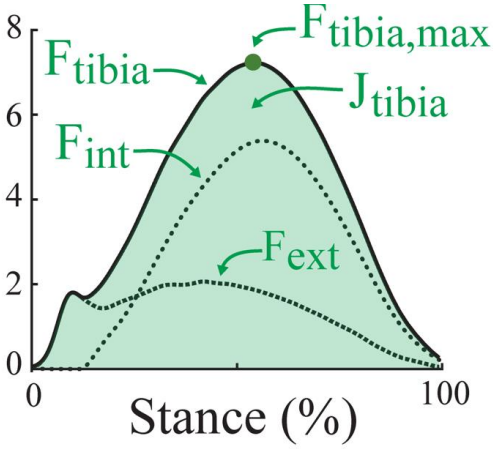
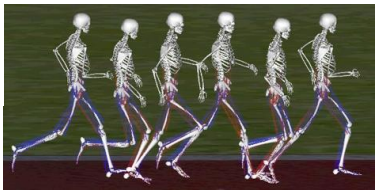
INTERNE BELASTING ↔ EXTERNE KRACHT



Matijevic et al., 2019, PLOS ONE



Medicine & Science IN Sports & Exercise
The Official Journal of the American College of Sports Medicine

2019, Vol 51

Grounded Running Reduces Musculoskeletal Loading

Bonnaerens, Senne[1]; Fiers, Pieter[1]; Galle, Samuel[1]; Aerts, Peter[1,4]; Frederick, Edward C.[2]; Kaneko, Yasunori[3]; Derave, Wim[1]; De Clercq, Dirk[1]

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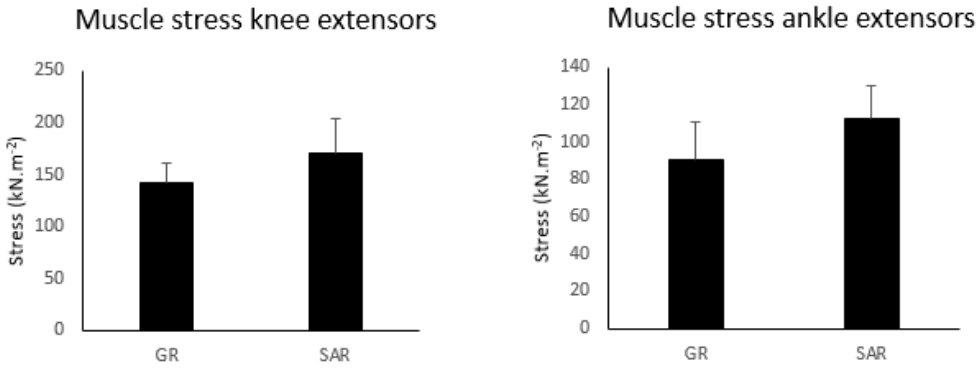
Traag lopen
Met loopstijlaanpassing
Grounded running

7,5 km/u

Traag lopen

GROUNDED RUNNING

- GR = grounded running --- lopen zonder vluchtfase
- SAR = slow aerial running --- lopen met vluchtfase



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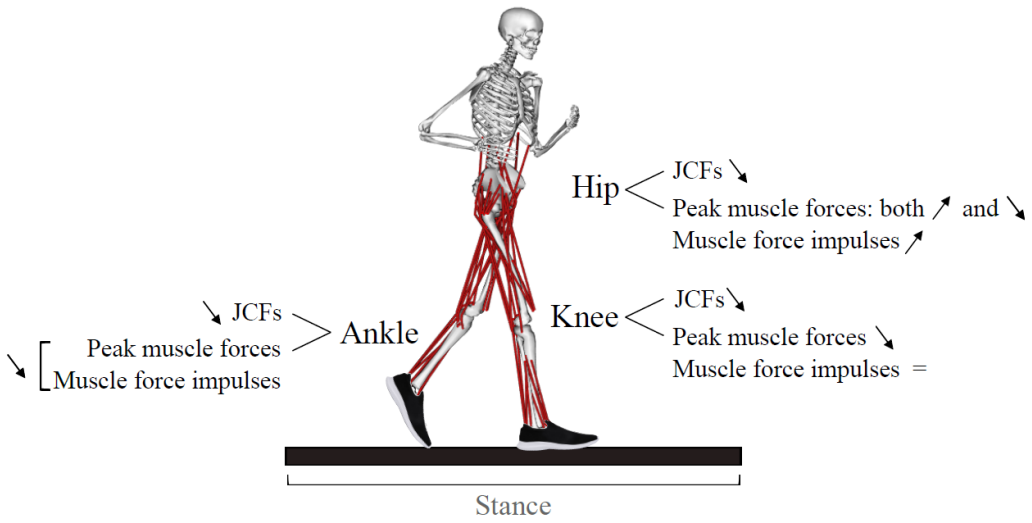
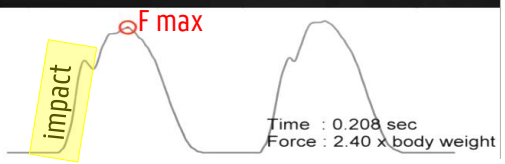
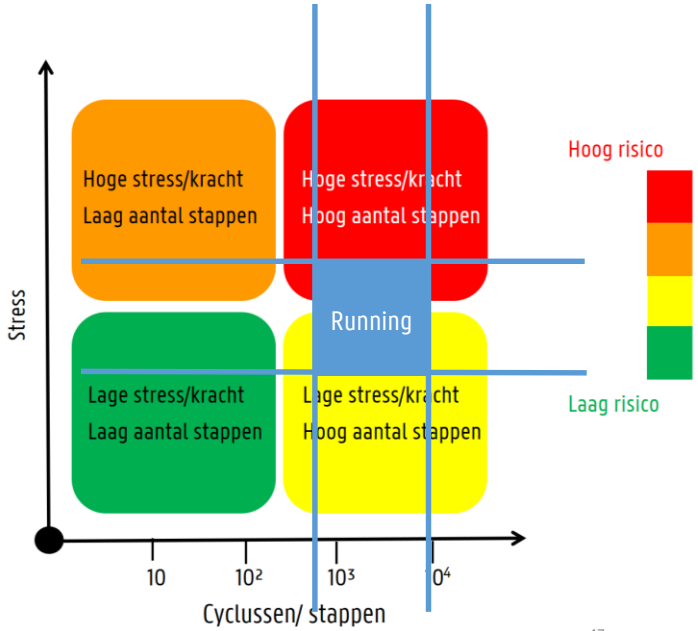
Bonnaerens et al. 2018



JOINT CONTACT FORCES - JCFs





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J. Biomechanics, 1982, Vol. 15, No. 7, pp. 487–492, 1982.
Printed in Great Britain

0021–9290/82/070487–06 $3.00/0
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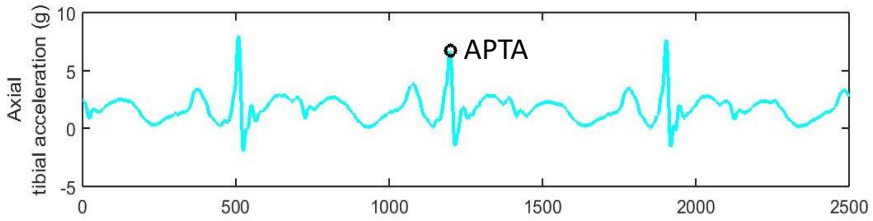
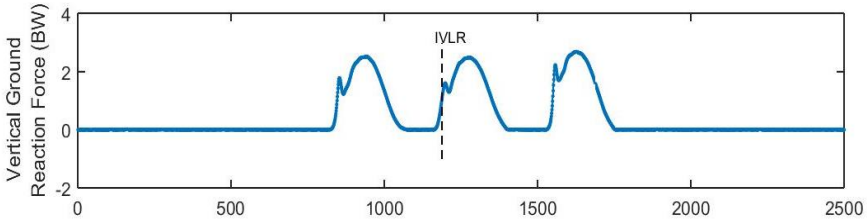
EFFECT OF PROLONGED WALKING ON CONCRETE ON THE KNEES OF SHEEP*

ERIC L. RADIN

Radin et al, 1982

Axial Peak Tibial Acceleration (APTA)



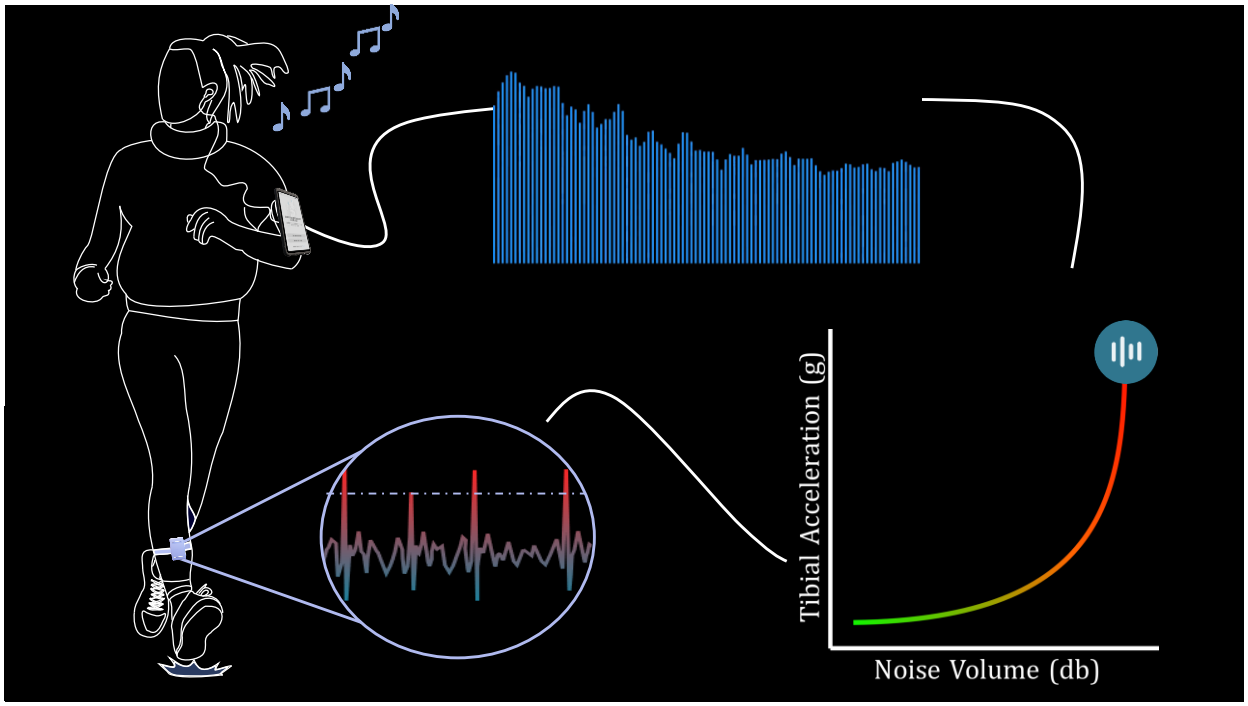


Van den Berghe et al., 2019
Derie et al., 2020

GHENT UNIVERSITY

SPORT SCIENCE LABORATORY
Jacques Rogge

LOWER IMPACT RUNNER


Tibial Acceleration (g)
Noise Volume (db)


Product
Lower your running impact step by step
Follow the rhythm of the music and keep going as never before
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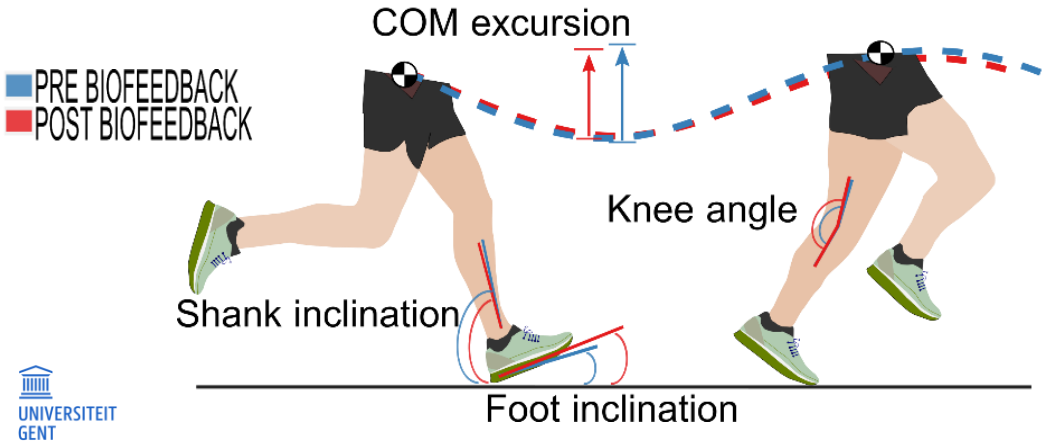
OPEN

Music-based biofeedback to reduce tibial shock in over-ground running: a proof-of-concept study

Pieter Van den Berghe[1✉], Valerio Lorenzoni[2], Rud Derie[1], Joren Six[2], Joeri Gerlo[1], Marc Leman[2] & Dirk De Clercq[1]

Scientific Reports | (2021) 11:4091 | https://doi.org/10.1038/s41598-021-83538-w nature portfolio

LOOPSTIJLAANPASSING NA LOOPHERSCHOLING MET LIR



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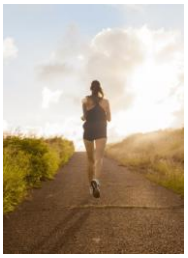
Gebaseerd op onderzoek



Belastingverlagende aanpak

- Daling Fz max
- Gebruik LIR

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In combinatie met opbouwen belastbaarheid

‘let’s connect’

Veerle Segers
Professor Biomechanics

Dirk De Clercq
Emeritus Professor Biomechanics

Rud Derie
PhD Biomechanics
Biomechanics of distance running

Senne Bonnaerens
PhD Biomechanics
Biomechanics of distance running

Kristof De Mey
PhD Physiotherapy &
Sports business developer

Pieter Van den Berghe
PhD Biomechanics

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WITH a special thank you to em. Prof Dirk De Clercq

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