Revolutionizing the approach to cardiorespiratory fitness

Presentation on VentriJect and the Seismofit® solution

VentriJect

Cardiorespiratory fitness

- Cardiorespiratory fitness (CRF) represents the body's maximum ability to absorb oxygen and is a measure of one's physical ability and overall health. It is quantified as VO2max.

- CRF is mainly determined by the function and size of the heart.

- The importance of CRF is strongly acknowledged, and several studies are showing a clear link between CRF and excess mortality rates.

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Importance of cardiorespiratory fitness

> Cardiorespiratory fitness (CRF), quantifiable as VO2max, should be regularly examined as a clinical vital sign in general
> clinical practice as probably the **strongest indicator of health.**

American Heart Association (AHA)

> We (again) call on both clinicians and public health professionals to adopt Cardiorespiratory fitness (CRF) as a **key health indicator.**

Editorial comment, Journal of the American College of Cardiology

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Importance of cardiorespiratory fitness

Higher mortality
A registry study of 122.000 patients concluded that the low fitness group had a **5 times higher mortality** versus the high fitness group over 10 years.

Paraphrased from Mandsager, Kyle, et al:
JAMA network open 1.6 (2018): e183605-e183605.

Risk of cancer in men
If you have a high VO2max there is a **significant lower risk of colon and lung cancer** for men, as well as a **lower risk of dying from cancers** in the colon, lung and prostate.

Paraphrased from Ekblom-Bak et al; JAMA Network Open 2023

Relatively small changes have significant impact
A decline in CRF of >2.0 METS was associated with a 74% increase in risk for low-fit individuals with Cardiovascular Diseases (CVD), and 69% increase for those without CVD.

Kokkinos et al.:J Am Coll Cardiol. 2023 Mar, 81 (12) 1137–1147

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The impact of training

Small increases in Cardiorespiratory Fitness (CRF) (eg 3-6 VO2max-units) are associated with **10-30% reduction in adverse cardiovascular events.**

Kodama et al: JAMA. 2009; 301:2024-2035

Exercise performed frequently over weeks or months may **improve CRF with 15-20%** in VO2max in adults.

Skinner et al.:Med Sci Sports Exerc. 2000; 32: 157-161 (HERITAGE)

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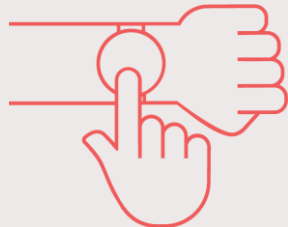Examples of current approaches
for estimating VO$_2$max

CPX / CPET
('the gold standard')

Submaximal
ergometer test

Chester
step test

Sport watches
(Garmin, Polar, etc.)

Current approaches have many flaws

- They all require physical exertion.

- They are all **time-consuming.**

- Most of them are **imprecise.**

- **Regular calibration** will be needed for some of the approaches.

- Some require **large expensive equipment** that is **difficult to transport.**

- **Highly trained staff** is required for some of the approaches.

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The solution: Seismofit®

An easy-to-use, scalable and precise solution to estimate VO$_2$ max

✓	Patient will be resting during test (no physical exertion)
✓	Takes less than 3 minutes
✓	No calibration
✓	Very limited education required

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The patient goes to health check

The patient lies down with Seismofit® for 40 seconds

Seismofit® data uploads to the cloud
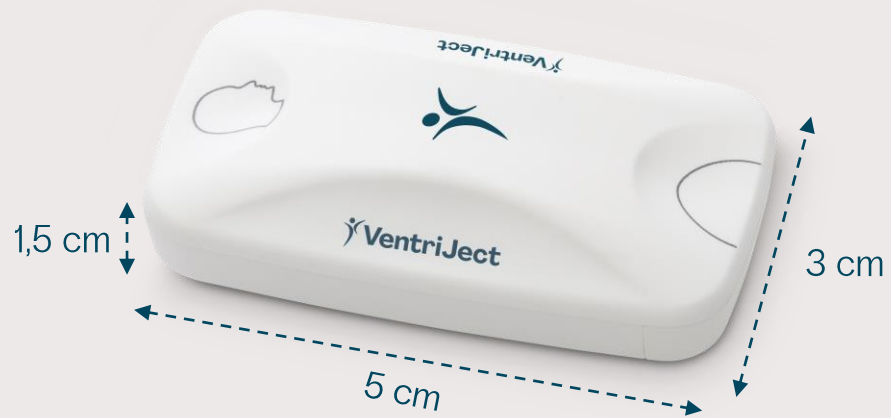
Data gets processed by Seismofit® algorithm

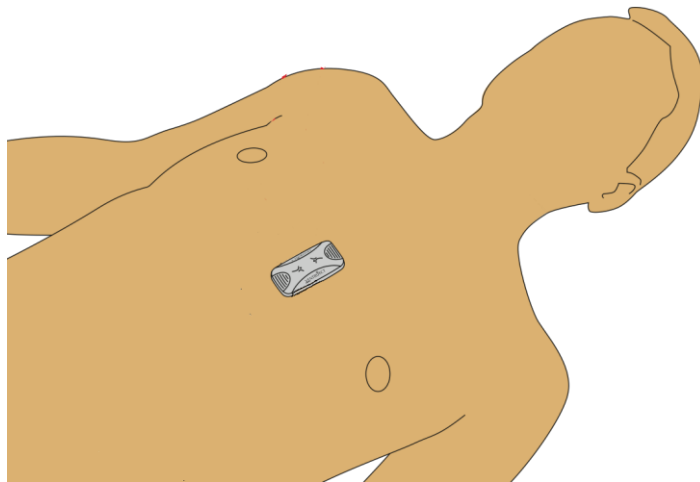Result shows on smartphone

All done in less than 3 minutes

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Small, but mighty

1,5 cm

3 cm

5 cm

CE-marked device
(class 1 medical device)

Patented technology

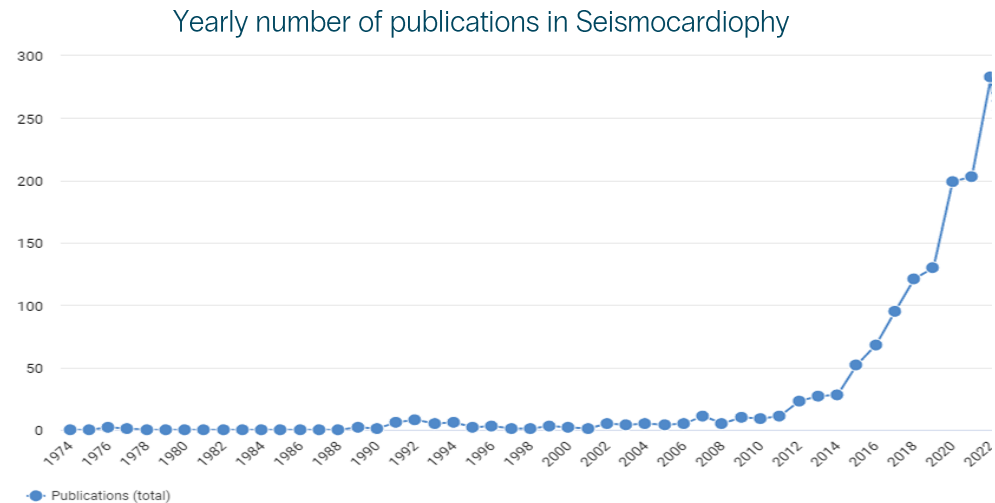Clinical validated

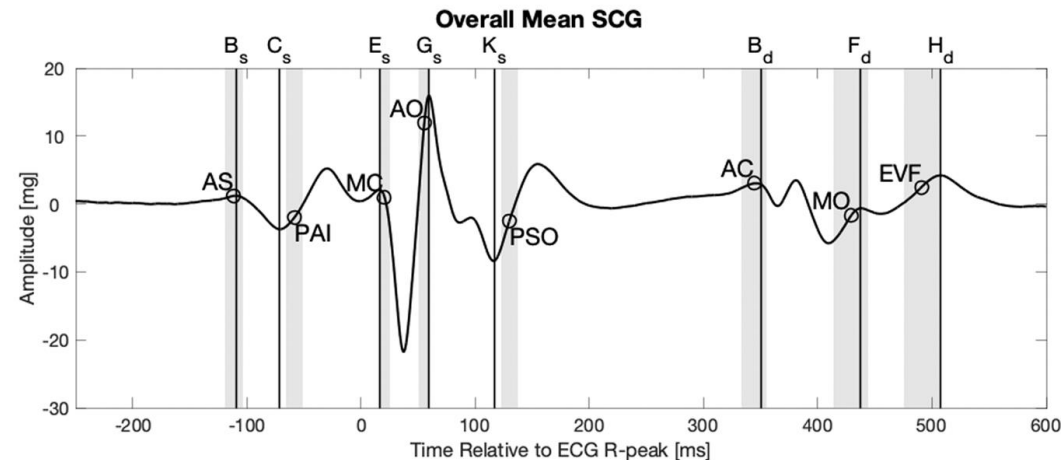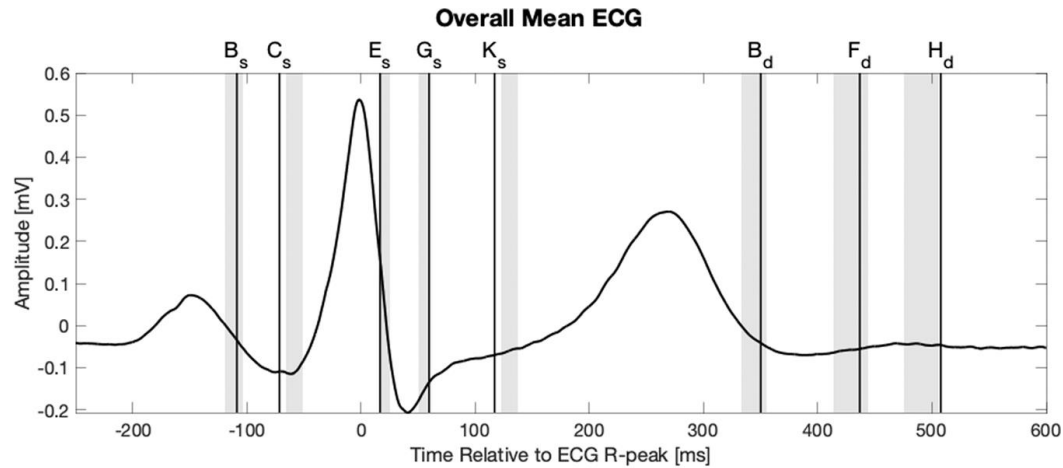VentriJect

Utilizing SeismoCardioGraphy (SCG)

SCG is accelerometer recordings of chest wall vibrations caused by the beating heart.

First demonstrated in 1957.
SCG research has bloomed in recent years due to MEMS accelerometers and clinical break through is underway.

Yearly number of publications in Seismocardiophy

- Publications (total)

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Overall Mean ECG

Overall Mean SCG

Overall mean electrocardiogram and seismocardiogram signal . The circles indicate the mean location of the following physiologic events found in ultrasound images, from left: Atrial systole (AS), peak atrial inflow (PAI), mitral valve closure (MC), aortic valve opening (AO), peak systolic outflow (PSO), aortic valve closing (AC), mitral valve opening (MO), early ventricular filling (EVF). The grey areas indicate the 95% confidence intervals of the means for the physiologic events found in the ultrasound images *.

*Sørensen, K., Schmidt, S.E., Jensen, A.S. et al. Definition of Fiducial Points in the Normal Seismocardiogram. Sci Rep **8,** 15455 (2018).
**R. S. Crow et al., "Relationship between seismocardiogram and echocardiogram for events in the cardiac cycle," American Journal of Noninvasive Cardiology, vol. 8, pp. 39–46, Jan. 1994.
***Agam, Ahmad, et al. "Correlation between diastolic seismocardiography variables and echocardiography variables." European Heart Journal-Digital Health 3.3 (2022): 465-472.

SCG is a measure of cardiac function

- Systolic and diastolic events such as heart valve opening and closing are reflected in the SCG signal.

- Correlation between SCG fiducial points and hemodynamic events has been validated using echocardiography.

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SCG Sub. 59 (VO2Max 35.2)

SCG Sub. 60 (VO2Max 41.2)

SCG Sub. 53 (VO2max 51.7)

Determining VO$_2$max

VentriJect uses AI and an advanced algorithm for determining VO$_2$max.

VentriJect's algorithm for prediction of VO$_2$max is based on:

Basic physical attributes
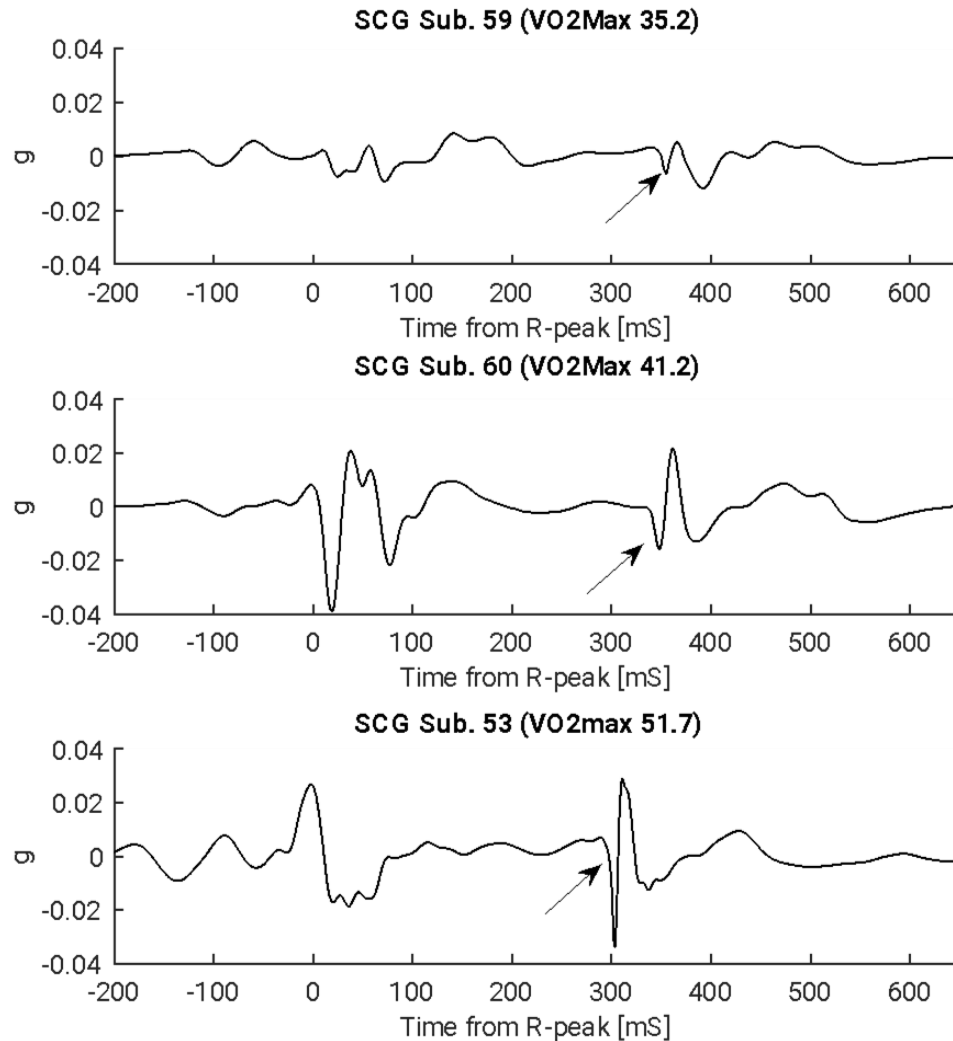
| Gender | Height |
| Age | Weight |

SCG measurements

| Timings | Morphology |
| Amplitudes | Variability |
| Frequencies | |

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Seismofit® System

Seismofit®
Sensor

Seismofit® measures seismocardiography vibrations arising from heartbeats and transmitted to the chest.
Each heart has its own signature relating to the opening and closing of valves and the relaxation and contraction of the heart chambers.

Seismofit®
App
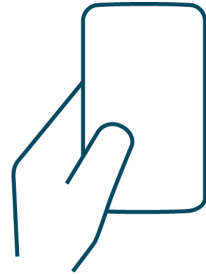
The App for the mobile controls seismocardiography recordings and can be downloaded from App-stores. The App leads the user securely through a recording by instructive screens and images.

Seismofit®
Patch

Patches are for fixation of the sensor to the chest at the distal part of the sternum of the test person. The patch consists of hypoallergenic adhesive to both surfaces covered with release liners.
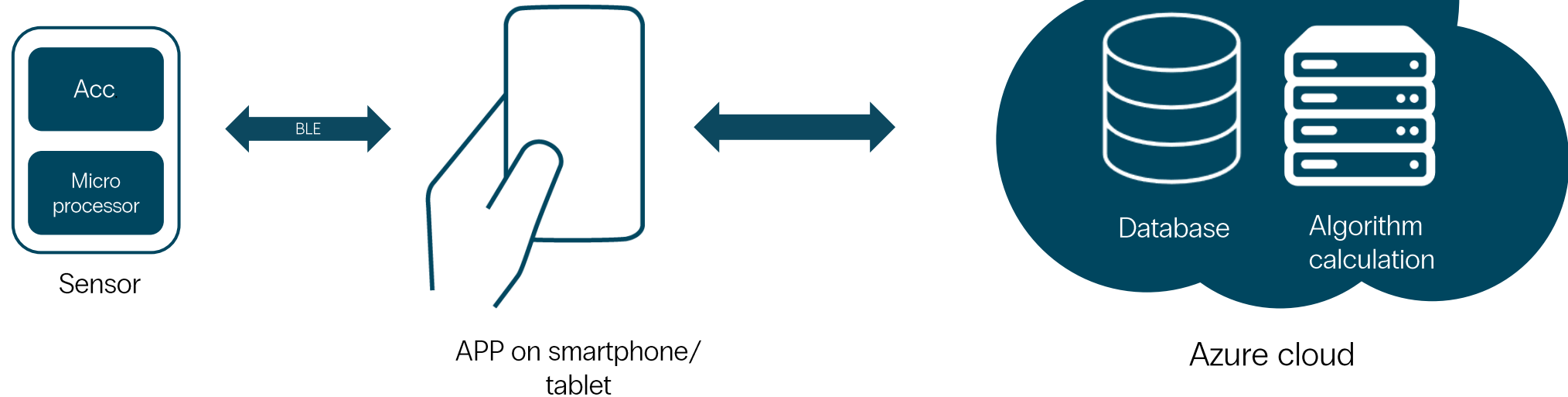
Seismofit®
Algorithm

The Algorithm on the VJ-server converts the recording into an equivalent to VO$_2$max score by use of features from the heart like timing, morphology, amplitude, peak to peak ratios and HRV in the recorded spectrum of the heartbeats.
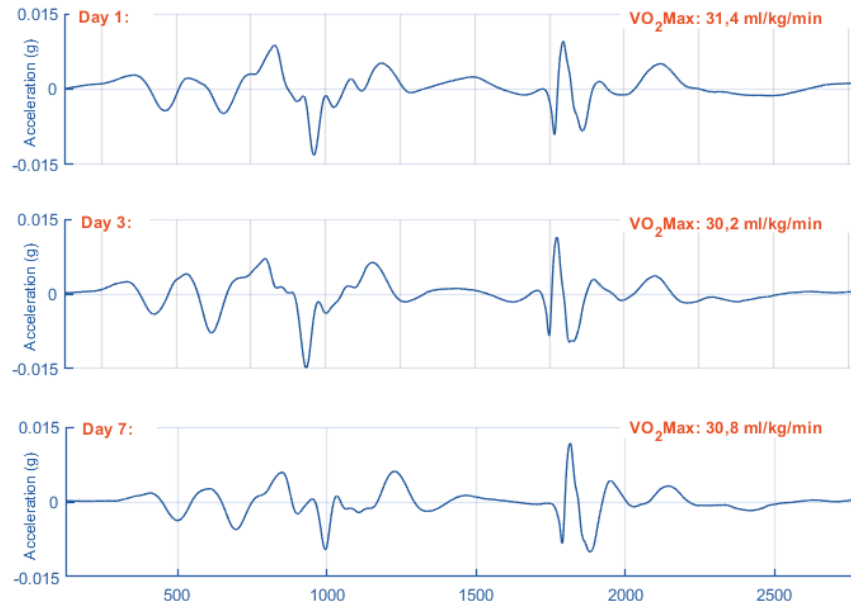
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VentriJect Architecture

Cloud based infrastructure

- Ensures a constant data flow

- Rapid updates to software and algorithms

- Pay per service
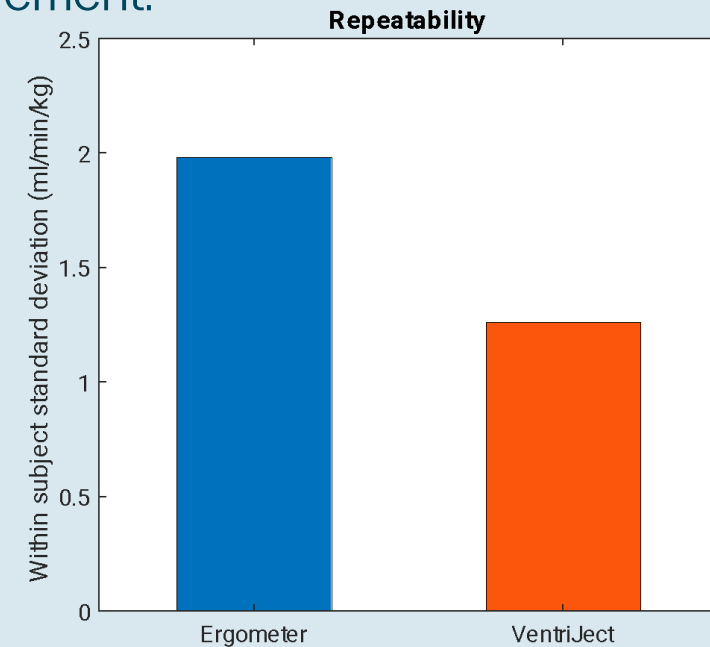
Acc

Micro processor

Sensor

BLE

APP on smartphone/ tablet

Database   Algorithm calculation

Azure cloud

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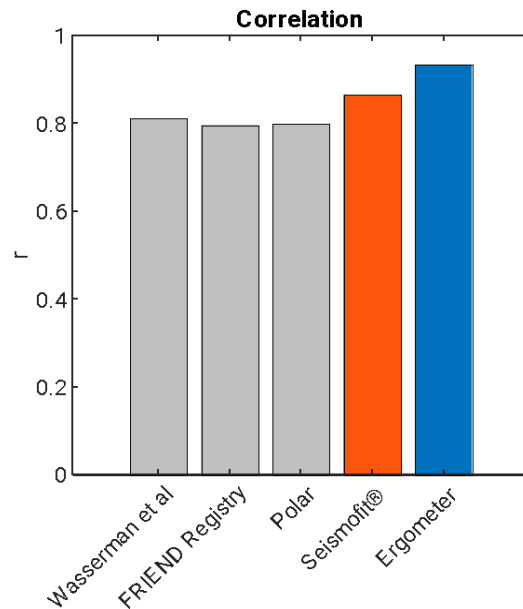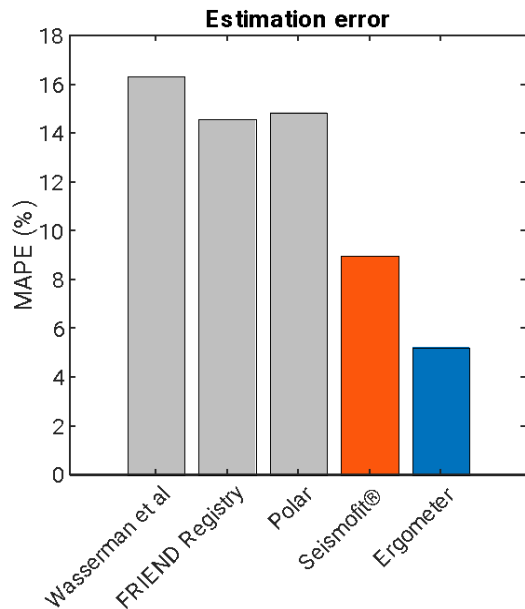
Seismofit® has high reproducibility

Example of the same patient measured on 3 different days

Seismofit® is at least as reproducible as today's gold standard of VO_2max measurement.

Overall better performance in test-set
(n=98)

MAPE (Mean absolute percentage error) compared to other tests

Seismofit ® performance from Schmidt, S. E., Hansen, M. T., Sørensen, K., Rømer, T., Gliemann, L., Karbing, D. S., Poulsen, M. K., Helge, J. W., & Søgaard, P. (2022). A Chest-Mounted Accelerometer for Estimation of Cardiorespiratory Fitness. Cardiovascular Digital Health Journal, 3(4

Comparison to other test methods

- Seismofit® comes close to the Gold Standard (CPX/CPET – in this graph labeled as Ergometer).

- Seismofit® significantly overperforms vs. the substandard test methods.

An experienced management team

Chief Executive Officer (CEO)
Mikkel Kristiansen
M.Sc. Investment/finance
- 10+ years experience from the MedTech industry, in various international leadership roles, focusing on commercialization and strategy

Chief Technology Officer (CTO), and co-founder
Kasper Sørensen
M.Sc. and PhD in Health Science and Technology
Experience:
- Research Assistent, AaU
- REDCap supporter at AaU

Chief Operations Officer (COO), and co-founder
Peter Samuelsen,
M.Sc. Chem. Eng
Experience:
- 30+ years experience from the MedTech industry, including Coloplast as VP Corporate R&D and VP Corporate Venture
- Co-founder/ CEO/ Chair in Acarix A/S

Chief Medical Officer (CMO), and co-founder
Peter Søgaard
MD, Professor Cardiology
Experience:
- Associate Professor, Aalborg Uni. ,
- Co-inventor of multiple patents
- Co-inventor of SCG-fitness application

Chief Scientific Officer (CSO), and co-founder
Samuel Schmidt
PhD, Biomedical engineering
Experience:
- Associate professor, Aalborg Uni., and PhD supervisor
- Co-inventor of multiple patents
- Co-inventor of SCG-fitness application

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Some of our valued customers

FALCK

WellB

HEALTH GROUP

GB
GESUNDHEIT IN BEWEGUNG

Aleris

iPN®

AG Sundhedsfremme®

motio
Arbeit einfach besser machen

COPENHAGEN MEDICAL

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Some of our close partners

Published clinical studies

Validity and reliability of seismocardiography for the estimation of cardiorespiratory fitness

Mikkel T. Hansen, Tue Rømer, Amalie Højgaard, Karina Husted, Kasper Sørensen, Samuel E. Schmidt, Flemming Dela, Jørn W. Helge

Cardiovascular Digital Health Journal, 2023

DOI: https://doi.org/10.1016/j.cvdhj.2023.08.020

Estimation of Cardiorespiratory fitness using a using a chest mounted accelerometer

Samuel Emil Schmidt, Mikkel Thunestvedt Hansen, Tue Rømer, Peter Søgaard, Jørn W. Helge

2022 ESC congress – Barcelona

DOI: https://doi.org/10.1093/eurheartj/ehac544.2769

A Clinical Method for Estimation of VO2max Using Seismocardiography

Kasper Sørensen, Mathias Krogh Poulsen, Dan Stieper Karbing, Peter Søgaard, Johannes Jan Struijk, Samuel Emil Schmidt

International Journal of Sports Medicine, 2020 sep.;41(10):661-668

DOI: https://doi.org/10.1055/a-1144-3369

Accuracy of a Clinical Applicable Method for Prediction of VO2max Using Seismocardiography

Mikkel Thunestvedt Hansen, Karina Louise Skov Husted, Mathilde Fogelstrom, Tue Romer, Samuel Emil Schmidt, Kasper Sørensen, Jorn Helge

International Journal of Sports Medicine. 2022

DOI: https://doi.org/10.1055/a-2004-4669

Determination of Maximal Oxygen Uptake Using Seismocardiography at Rest

Mikkel Hansen, Birk Mygind, Tue Rømer, Kasper Sørensen, Samuel Emil Schmidt, Jørn W. Helge, Mathilde Fogelstrøm

2021 Computing in Cardiology (CinC)

DOI: https://doi.org/10.23919/CinC53138.2021.9662756

A Chest-Mounted Accelerometer for Estimation of Cardiorespiratory Fitness

Samuel Emil Schmidt, Mikkel Thunestvedt Hansen, Kasper Sørensen, Tue Rømer, Lasse Gliemann, Dan Stieper Karbing, Mathias Krogh Poulsen, Jørn W. Helge, Peter Søgaard

2022 Cardiovascular Digital Health Journal – HRX San Diego

DOI: https://doi.org/10.1016/j.cvdhj.2022.07.050

Validity and reliability of a clinical non-exercise method for assessment of cardiorespiratory fitness using seismocardiography

M Thunestvedt Hansen, T Roemer, A Hoejgaard, K Husted, K Sørensen, S Schmidt, F Dela, J Wulff Helge

European Heart Journal, Volume 42, Issue Supplement_1, October 2021, ehab724.3172

DOI: https://doi.org/10.1093/eurheartj/ehab724.3172

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Further clinical studies on-going

- Royal Marsden Hospital (UK)

- Imperial College London (UK)

- Sheffield Hallam University (UK)

- St James's University Hospital, Leeds (UK)

- James Cook University Hospital, Middlesbrough (UK)

- York and Scarborough Teaching Hospitals (UK)

- Sheffield Teaching Hospitals (UK)

- Universität Hamburg (DE)

- German Sport University Cologne/Deutsche Sporthochschule Köln (DE)

- Southern Cross University (AU)

- Rigshospitalet (DK)

- Herlev Hospital (DK)

- Copenhagen University (DK)

- Aalborg University (DK)

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Seismofit®
by VentriJect

simple
fast
reliable

estimation of VO$_2$max
in less than 3 minutes

"....probably the strongest indicator of health..."

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