Revolutionizing the approach to cardiorespiratory fitness

Presentation on VentriJect and the Seismofit® solution

Distributed by:

FutureMedics

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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 VO_2max
- 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

Individuals who previously had been hospitalized and managed to increase their cardiorespiratory fitness had 20% and 14% lower risk of future cardiovascular and all-cause hospital admission, respectively.

Griffin et al: European Journal of Preventive Cardiology, 2023

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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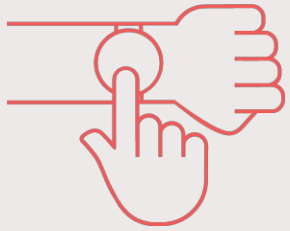
Examples of current approaches for estimating VO_2max

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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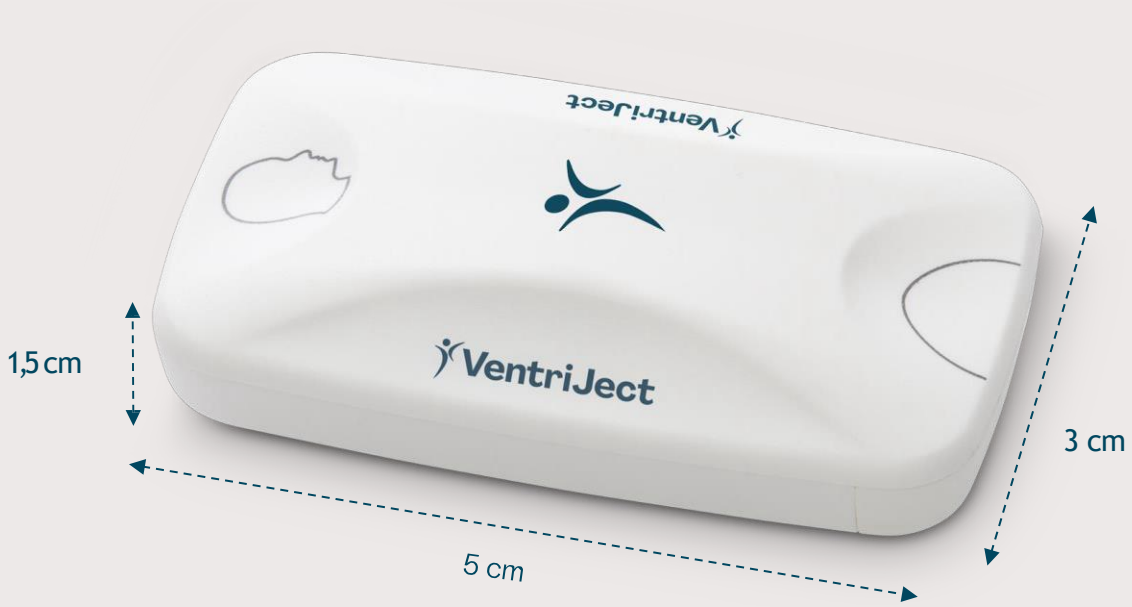

Why Seismofit®?

Patient will be resting during test (no physical exertion)

Seismofit® eliminates the need for physical exertion during VO2max testing, removing a barrier for many, including obese, elderly, and frail patients

Takes less than 3 minutes

Seismofit® sensor measurements take under 3 minutes, a 10x time reduction compared to existing methods that typically require up to 30 minutes, with significantly less complexity.

Precise and reproducible

Seismofit® is precise and reproducible, ensuring reliable and consistent results across multiple tests and users.

Very limited training required

The Seismofit® is user-friendly, often taking less than an hour for anyone, including healthcare professionals like doctors, nurses, and physiotherapists, to learn to operate.

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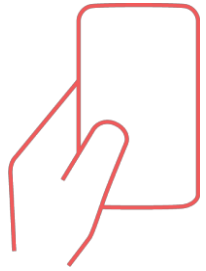
The patient goes to health check

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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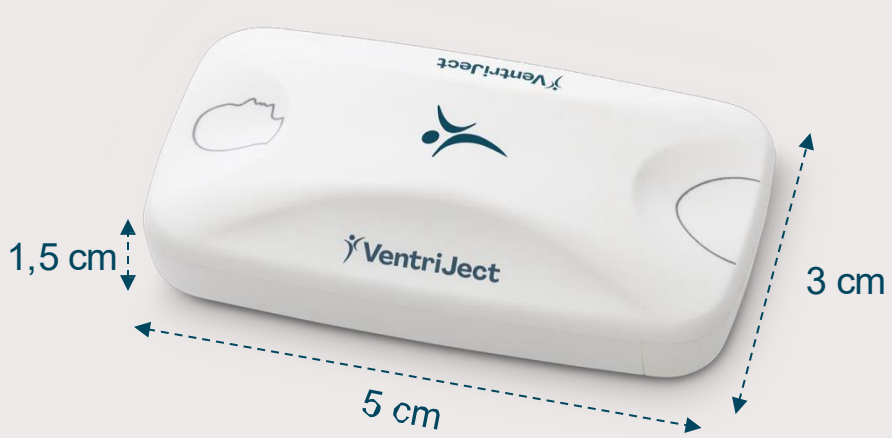

Small, but mighty

CE-marked device
(class 1 medical device)

Patented technology

Clinically validated

Award-winning technology

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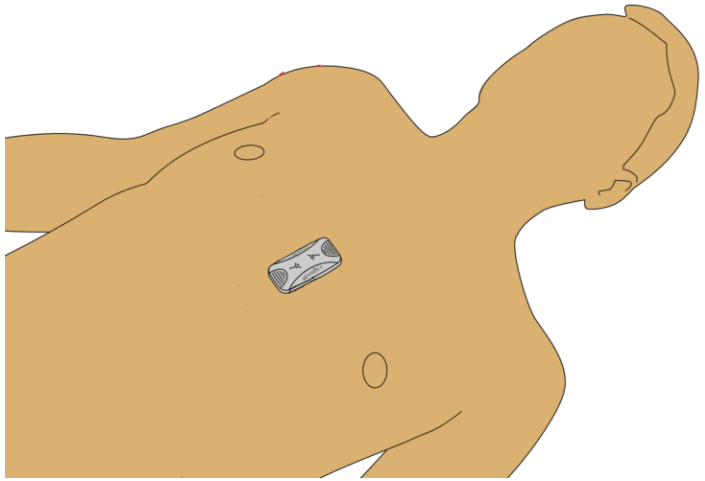
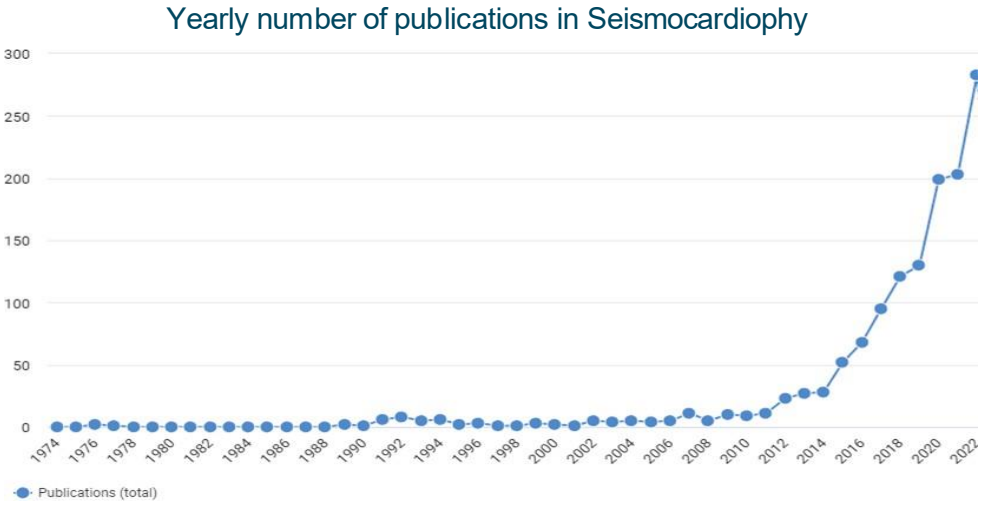
Utilizing SeismoCardioGraphy (SCG)

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 breakthrough is underway



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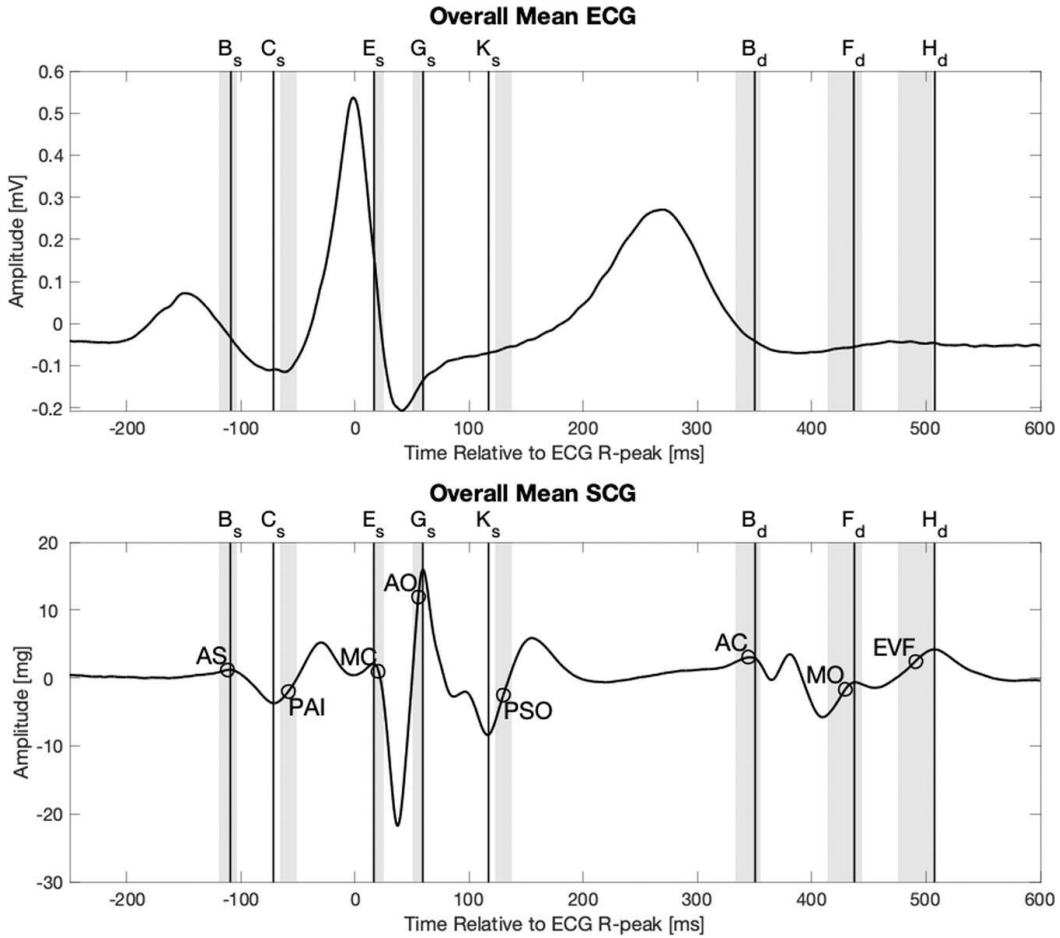

Overall mean electrocardiogram and seismocardiogram signal . The circles indicate the mean location of the following physiologic events found in ultrasound images, from left: Atrial systole (AS), peak atrial inflow (PAI), mitral valve closure (MC), aortic valve opening (AO), peak systolic outflow (PSO), 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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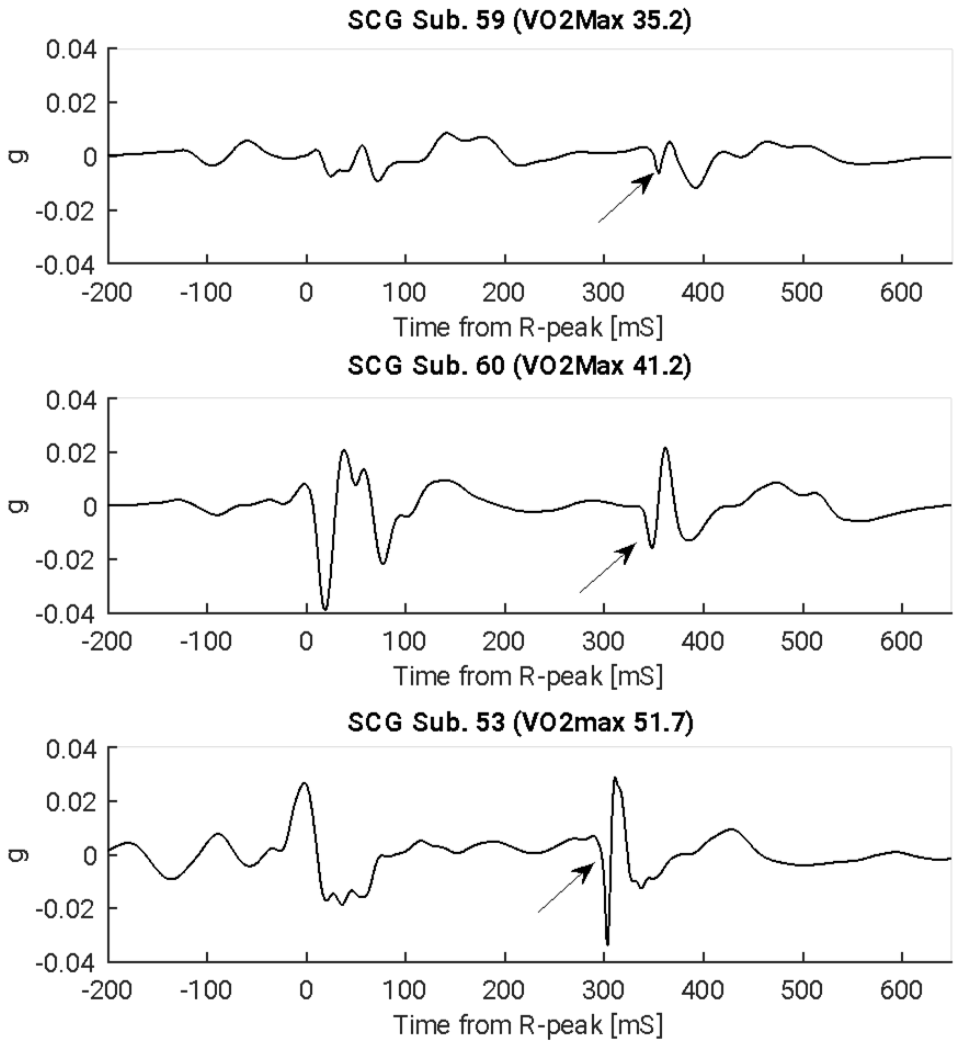

Determining VO_2max

VentriJect uses AI and an advanced algorithm for determining VO_2max

VentriJect's algorithm for prediction of VO_2max is based on:

Basic physical attributes

- Gender
- Height
- Age
- Weight

SCG measurements

- Timings
- Morphology
- Amplitudes
- Variability
- Frequencies

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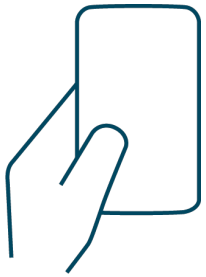
Seismofit® System

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_2max 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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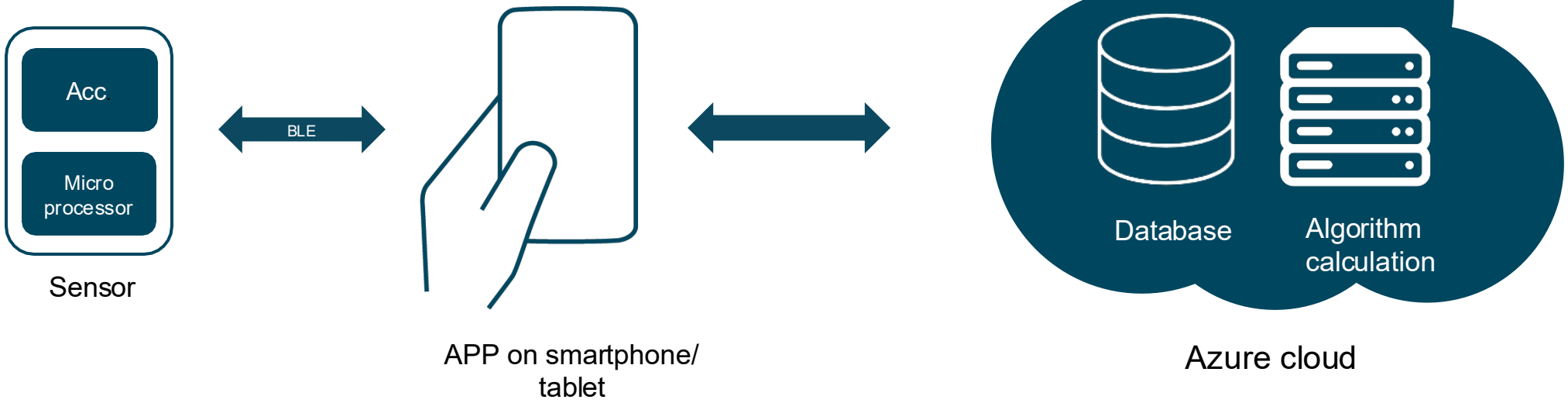
VentriJect Architecture

Cloud based infrastructure

- Ensures a constant data flow
- Rapid updates to software and algorithms
- Pay per service



Sensor

APP on smartphone/ tablet

Azure cloud

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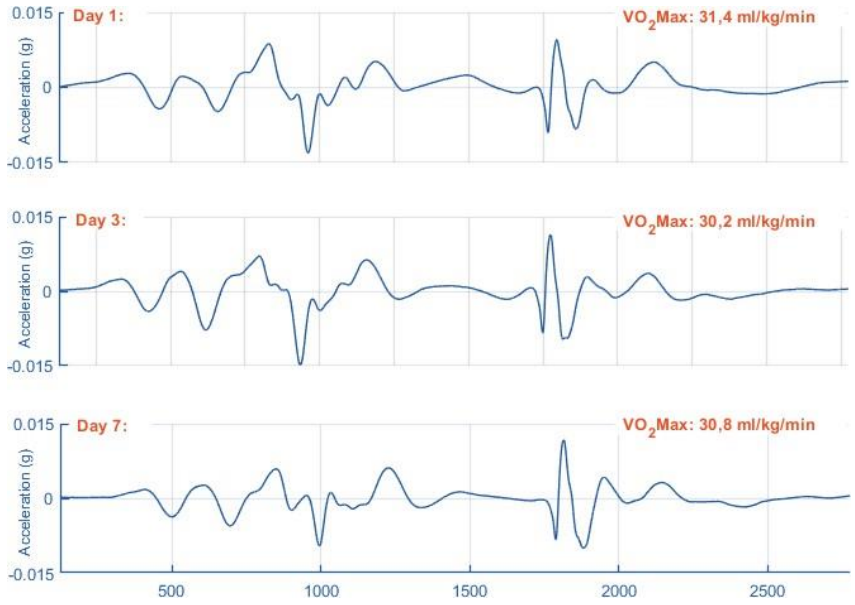
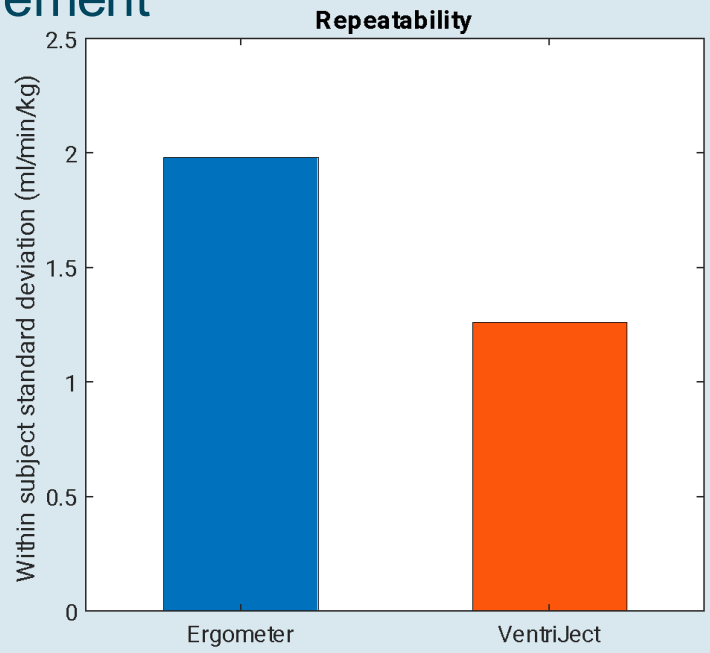
Seismofit® has high reproducibility

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



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High level of accuracy

Several clinical studies have been conducted on the accuracy of the Seismofit®.

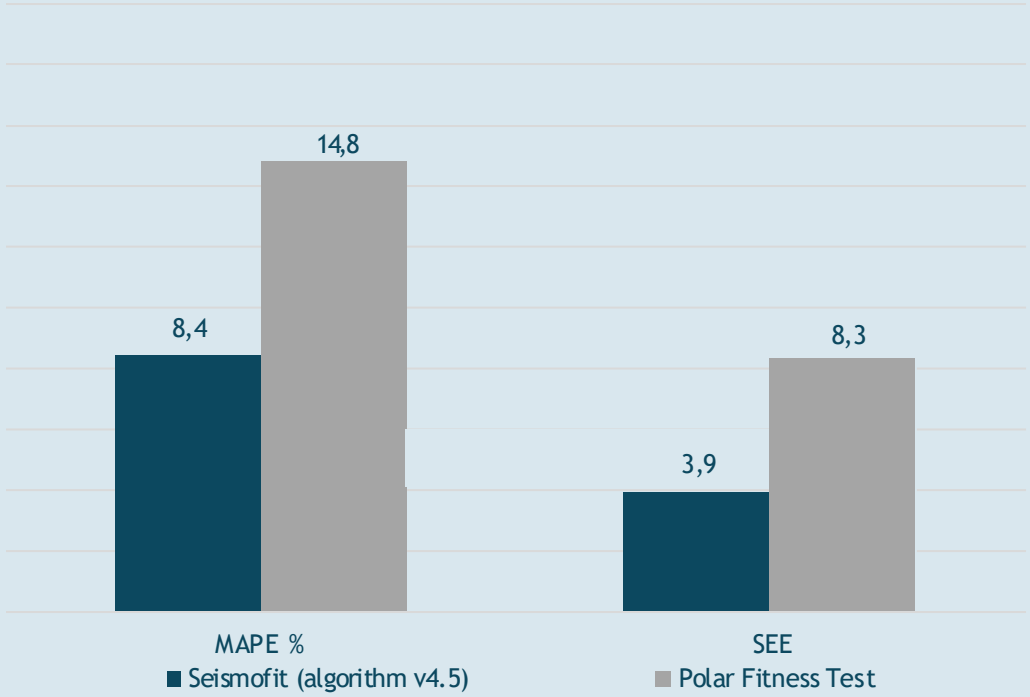
The studies show that Seismofit® significantly overperforms vs. the substandard test methods and come very close to the accuracy of the Cardiopulmonary exercise test (CPET), which is seen as the gold standard within VO_2max testing.

The latest published study (shown on the right) shows that Seismofit® has a Median Average Percentage Error (MAPE) of 8,4% against the CPET. In the same study, the Polar Fitness Test, showed a MPE of 14,8%.

Seismofit® algorithm continuously to improve with the increased use of it. Currently the algorithm is running on version 4.7.2, and have already shown great improvement since previous versions

Find all the published studies on Seismofit® on our website: LINK

Accuracy between non-exercise VO2 peak estimations and a gold standard cardiopulmonary exercise test (CPET)



Mikkel T. Hansen, et al. "Validity and reliability of seismocardiography for the estimation of cardiorespiratory fitness", Cardiovascular Digital Health, September 2023

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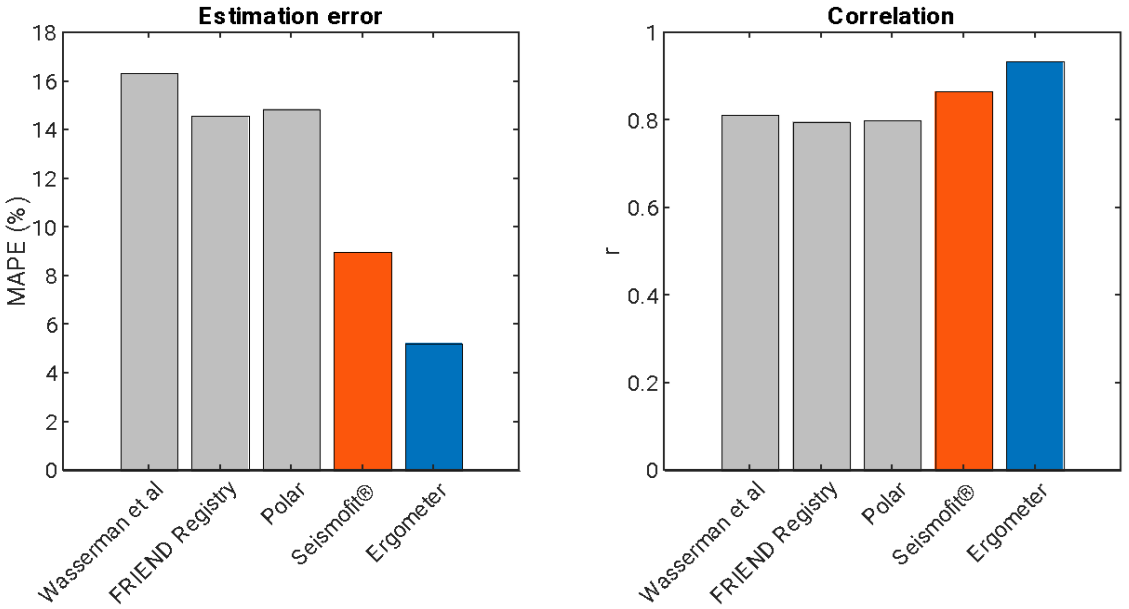
Overall better performance in test-set
(n=98)

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

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Examples of use cases with Seismofit®

Health assessment

Seismofit® is being used at several providers of health assessments.

The Seismofit® adds an easy measurement of an important health indicator, often together with other measurements.

In the past, VO2max assessment was only provided in executive health assessments, but with Seismofit®, the assessment becomes available for a broader audience

Professional sport

Seismofit® is being used at professional sport clubs (football, basketball, handball, etc.).

With the Seismofit®, the clubs are able to continuously track the fitness and health of their players.

Current methods are used limited in professional sport clubs, as they are costly, time-consuming and impacting the players' training regime, due to the need of exercise while testing.

Training

Seismofit® is being used at personal trainers, fitness coaches and fitness centers to provide added value to their clients.

With the Seismofit®, they can enhance and monitor their clients' workout routines. It provides the opportunity to motivate the clients with tangible results that are unbiased.

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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

VentriJect

Seismofit®
by VentriJect

simple
fast
reliable

estimation of VO_2max
in less than 3 minutes

“….probably the strongest indicator of health…”

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