Fibion Emfit Validity and Reliability


fibion
SLEEP STAGE
REM
HEART RATE
52 BPM
BREATHING RATE
12 BPM
HRV
HEART RATE VARIABILITY
853 ms
SLEEPING POSITION
LEFT SIDE
MOVEMENTS
0.0
fibionsleep

Overview

1. Emfit is a contact-free, under-mattress device that utilizes ballistocardiography (BCG) to monitor sleep, heart rate variability (HRV), breathing, and movements.

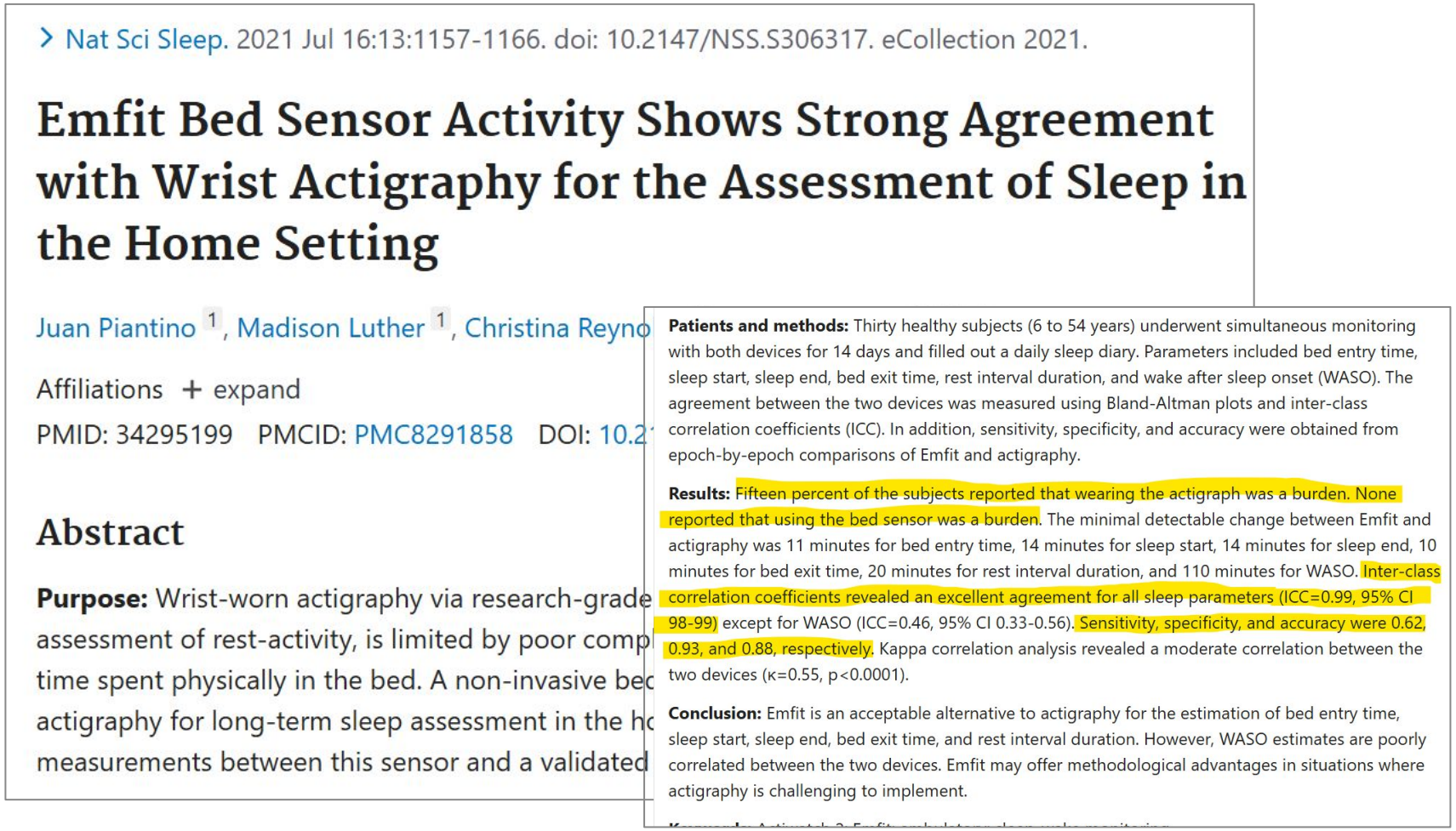
2. Provides non-invasive and unobtrusive long-term monitoring, making it suitable for both research and clinical applications.

fibionemfit

Key Studies Supporting Validity & Reliability (Piantino et al., 2021)

1. This study proved the **validity** of Emfit by showing excellent agreement (ICC = 0.99) with validated actigraphy for key sleep parameters over 14 days.

2. It also demonstrated **reliability**, with consistent results, high accuracy (88%), and better user compliance due to its non-invasive, contact-free design.



Nat Sci Sleep. 2021 Jul 16:13:1157-1166. doi: 10.2147/NSS.S306317. eCollection 2021.

Emfit Bed Sensor Activity Shows Strong Agreement with Wrist Actigraphy for the Assessment of Sleep in the Home Setting

Juan Piantino [1], Madison Luther [1], Christina Reyno

Affiliations + expand

PMID: 34295199 PMCID: PMC8291858 DOI: 10.2

Abstract

Purpose: Wrist-worn actigraphy via research-grade assessment of rest-activity, is limited by poor comp time spent physically in the bed. A non-invasive bed actigraphy for long-term sleep assessment in the ho measurements between this sensor and a validated

Patients and methods: Thirty healthy subjects (6 to 54 years) underwent simultaneous monitoring with both devices for 14 days and filled out a daily sleep diary. Parameters included bed entry time, sleep start, sleep end, bed exit time, rest interval duration, and wake after sleep onset (WASO). The agreement between the two devices was measured using Bland-Altman plots and inter-class correlation coefficients (ICC). In addition, sensitivity, specificity, and accuracy were obtained from epoch-by-epoch comparisons of Emfit and actigraphy.

Results: Fifteen percent of the subjects reported that wearing the actigraph was a burden. None reported that using the bed sensor was a burden. The minimal detectable change between Emfit and actigraphy was 11 minutes for bed entry time, 14 minutes for sleep start, 14 minutes for sleep end, 10 minutes for bed exit time, 20 minutes for rest interval duration, and 110 minutes for WASO. Inter-class correlation coefficients revealed an excellent agreement for all sleep parameters (ICC=0.99, 95% CI 98-99) except for WASO (ICC=0.46, 95% CI 0.33-0.56). Sensitivity, specificity, and accuracy were 0.62, 0.93, and 0.88, respectively. Kappa correlation analysis revealed a moderate correlation between the two devices (κ=0.55, p<0.0001).

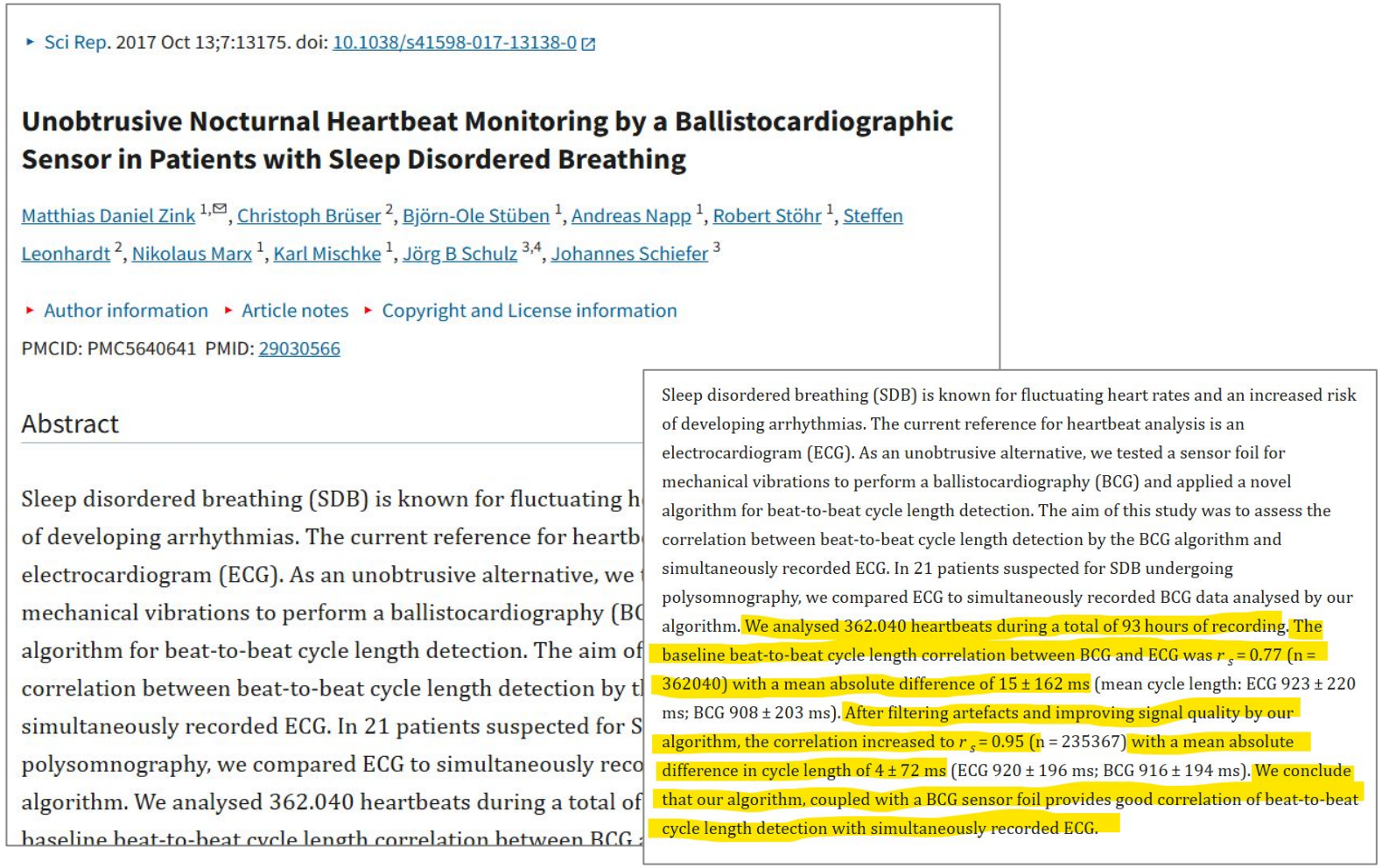
Conclusion: Emfit is an acceptable alternative to actigraphy for the estimation of bed entry time, sleep start, sleep end, bed exit time, and rest interval duration. However, WASO estimates are poorly correlated between the two devices. Emfit may offer methodological advantages in situations where actigraphy is challenging to implement.

Source: https://pubmed.ncbi.nlm.nih.gov/34295199/

Key Studies Supporting Validity & Reliability (Zink et al., 2017)

1. The study demonstrated that Emfit's ballistocardiographic sensor showed a **high correlation (r = 0.95)** with standard ECG for beat-to-beat heart rate detection after artifact filtering.

2. Analysis of over **362,000 heartbeats across 93 hours** confirmed Emfit's validity and reliability for accurate, unobtrusive heart rate monitoring in patients with sleep-disordered breathing.



Sci Rep. 2017 Oct 13;7:13175. doi: 10.1038/s41598-017-13138-0

Unobtrusive Nocturnal Heartbeat Monitoring by a Ballistocardiographic Sensor in Patients with Sleep Disordered Breathing

Matthias Daniel Zink [1,✉], Christoph Brüser [2], Björn-Ole Stüben [1], Andreas Napp [1], Robert Stöhr [1], Steffen Leonhardt [2], Nikolaus Marx [1], Karl Mischke [1], Jörg B Schulz [3,4], Johannes Schiefer [3]

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PMCID: PMC5640641 PMID: 29030566

Abstract

Sleep disordered breathing (SDB) is known for fluctuating heart rates and an increased risk of developing arrhythmias. The current reference for heartbeat analysis is an electrocardiogram (ECG). As an unobtrusive alternative, we tested a sensor foil for mechanical vibrations to perform a ballistocardiography (BCG) and applied a novel algorithm for beat-to-beat cycle length detection. The aim of this study was to assess the correlation between beat-to-beat cycle length detection by the BCG algorithm and simultaneously recorded ECG. In 21 patients suspected for SDB undergoing polysomnography, we compared ECG to simultaneously recorded BCG data analysed by our algorithm. We analysed 362.040 heartbeats during a total of 93 hours of recording. The baseline beat-to-beat cycle length correlation between BCG and ECG was $r_s = 0.77$ (n = 362040) with a mean absolute difference of 15 ± 162 ms (mean cycle length: ECG 923 ± 220 ms; BCG 908 ± 203 ms). After filtering artefacts and improving signal quality by our algorithm, the correlation increased to $r_s = 0.95$ (n = 235367) with a mean absolute difference in cycle length of 4 ± 72 ms (ECG 920 ± 196 ms; BCG 916 ± 194 ms). We conclude that our algorithm, coupled with a BCG sensor foil provides good correlation of beat-to-beat cycle length detection with simultaneously recorded ECG.

Source: https://pmc.ncbi.nlm.nih.gov/articles/PMC5640641/

Key Studies Supporting Validity & Reliability (Antink et al., 2020)

1. The study demonstrated that Emfit QS bed sensor accurately estimated **beat-to-beat heart rate intervals (BBI)** at night in post-surgical patients, with an **average estimation error of 11.0 ms**, closely matching ECG references.

2. Despite lower temporal coverage in patients, the results confirmed **validity and reliability** of BCG-based monitoring for clinical heart rate assessment.

IEEE J Biomed Health Inform. 2020 Aug;24(8):2230-2237. doi: 10.1109/JBHI.2020.2970298. Epub 2020 Jan 29.

Ballistocardiography Can Estimate Beat-to-Beat Heart Rate Accurately at Night in Patients After Vascular Intervention

Christoph Hoog Antink, Yen Mai, Roosa Aalto, Christoph Bruser, Steffen Leonhardt, Niku Oksala, Antti Vehkaoja

PMID: 32011272 DOI: 10.1109/JBHI.2020.2970298

Abstract

While bed-integrated ballistocardiography (BCG) has potential clinical applications such as unobtrusive monitoring of patients staying in the general hospital ward, it has so far mainly gained interest in the wellness domain. In this article, the potential of BCG to monitor hospitalized patients after surgical intervention was assessed. Long-term BCG recordings (mean duration 17.7 h) of 14 patients were performed with an EMFit QS bed sensor. In addition, ten healthy subjects were recorded during sleep (mean duration 7.8 h). Using an iterative algorithm, beat-to-beat intervals (BBIs) and the ultra-short-term heart-rate-variability (HRV) parameters standard deviation of NN intervals (SDNN) and root mean square of successive differences (RMSSD) were estimated and compared to an ECG reference in terms of average estimation error and temporal coverage. While the absolute BBI estimation error was found to be higher when full-day patient data was used (16.5 ms), no significant difference between healthy subjects (12.7 ms) and patient nighttime data (11.0 ms) was observed. Nevertheless, temporal coverage of BBI estimation was significantly lower in patients (39.3% overall, 51.7% at night) compared to the healthy sleepers (73.2%). This resulted in reduced HRV estimation coverage (9.7% vs. 37.2%) at comparable estimation error levels.

Source: https://pubmed.ncbi.nlm.nih.gov/32011272/

Key Studies Supporting Validity & Reliability (Kortelainen et al., 2010)

1. The study validated Emfit's ability to classify sleep stages by comparing it to polysomnography, achieving **79% accuracy** and a **kappa index up to 0.44**.

2. Results confirm Emfit's **validity and reliability** as a low-cost, consistent method for sleep staging based on heart-beat intervals and movement detection.

Journals & Magazines > IEEE Transactions on Informat... > Volume: 14 Issue: 3

Sleep Staging Based on Signals Acquired Through Bed Sensor

Publisher: IEEE | Cite This | PDF

f Electrical and Electronics Engineers

Juha M. Kortelainen ; Martin O. Mendez ; Anna Maria Bianchi ; Matteo Matteucci ; Sergio Cerutti All Authors

165 Cites in Papers | 12 Cites in Patents | 2690 Full Text Views

Abstract

Document Sections

I. Introduction

II. Material and Methods

III. Results

IV. Discussion

V. Conclusion

Authors

Figures

Abstract:
We describe a system for the evaluation of the sleep macrostructure on the basis of Emfit sensor foils placed into bed mattress and of advanced signal processing. The signals on which the analysis is based are heart-beat interval (HBI) and movement activity obtained from the bed sensor, the relevant features and parameters obtained through a time-variant autoregressive model (TVAM) used as feature extractor, and the classification obtained through a hidden Markov model (HMM). Parameters coming from the joint probability of the HBI features were used as input to a HMM, while movement features are used for wake period detection. A total of 18 recordings from healthy subjects, including also reference polysomnography, were used for the validation of the system. When compared to wake-nonrapid-eye-movement (NREM)-REM classification provided by experts, the described system achieved a total accuracy of 79±9% and a kappa index of 0.43±0.17 with only two HBI features and one movement parameter, and a total accuracy of 79±10% and a kappa index of 0.44±0.19 with three HBI features and one movement parameter. These results suggest that the combination of HBI and movement features could be a suitable alternative for sleep staging with the advantage of low cost and simplicity.

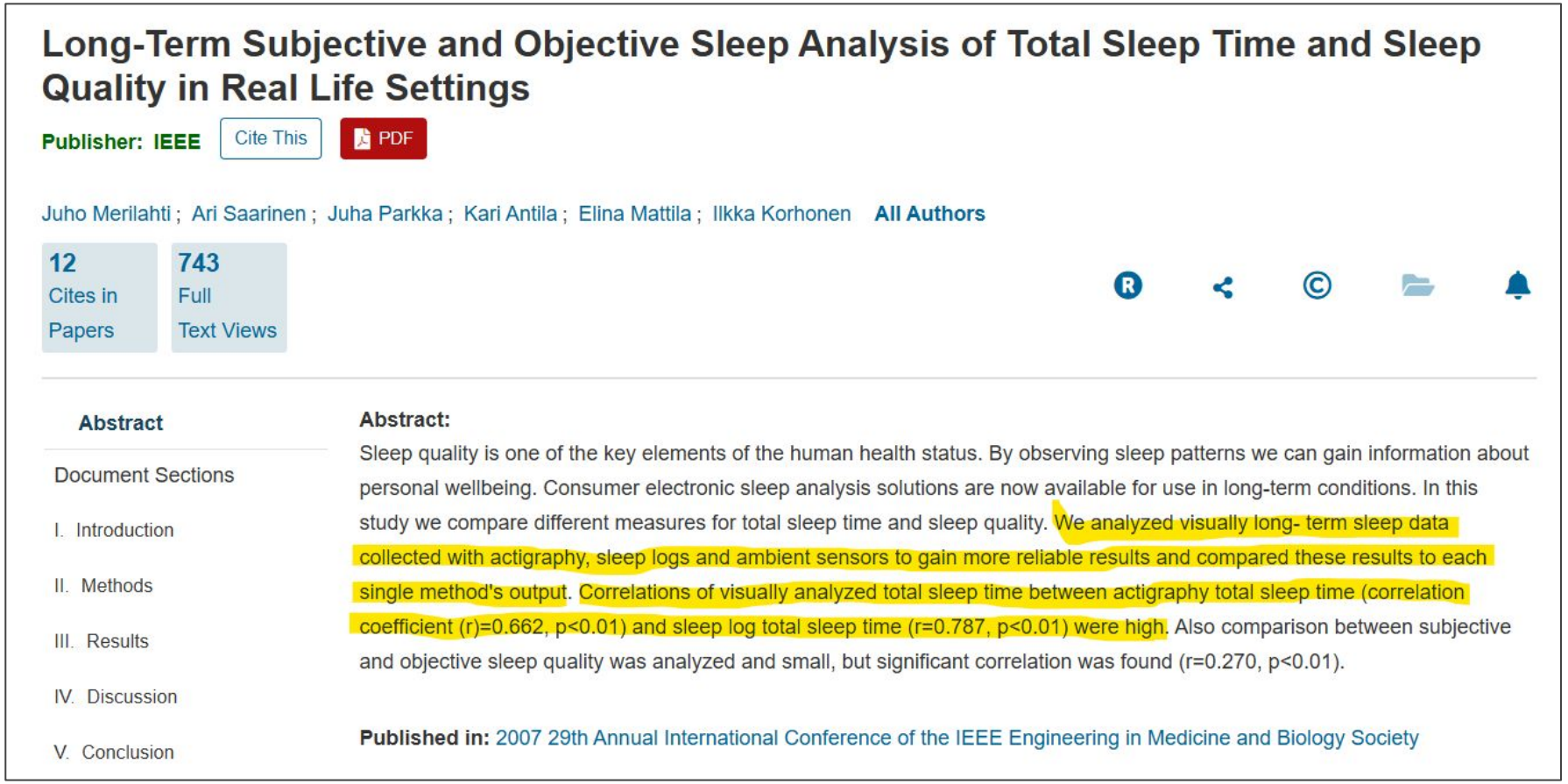
Published in: IEEE Transactions on Information Technology in Biomedicine (Volume: 14 , Issue: 3, May 2010)

Source: https://ieeexplore.ieee.org/document/5447696

Key Studies Supporting Validity & Reliability (Merilahti et al., 2007)

1. This study showed that Emfit's total sleep time measurements correlated strongly with actigraphy (r = 0.662) and sleep logs (r = 0.787), confirming its **validity** in long-term real-world monitoring.

2. Consistent long-term data collection highlighted the **reliability** of Emfit for sleep quality and duration assessment.



Long-Term Subjective and Objective Sleep Analysis of Total Sleep Time and Sleep Quality in Real Life Settings

Publisher: IEEE | Cite This | PDF

Juho Merilahti ; Ari Saarinen ; Juha Parkka ; Kari Antila ; Elina Mattila ; Ilkka Korhonen **All Authors**

12 Cites in Papers

743 Full Text Views

Abstract

Document Sections

I. Introduction

II. Methods

III. Results

IV. Discussion

V. Conclusion

Abstract:

Sleep quality is one of the key elements of the human health status. By observing sleep patterns we can gain information about personal wellbeing. Consumer electronic sleep analysis solutions are now available for use in long-term conditions. In this study we compare different measures for total sleep time and sleep quality. We analyzed visually long- term sleep data collected with actigraphy, sleep logs and ambient sensors to gain more reliable results and compared these results to each single method's output. Correlations of visually analyzed total sleep time between actigraphy total sleep time (correlation coefficient (r)=0.662, p<0.01) and sleep log total sleep time (r=0.787, p<0.01) were high. Also comparison between subjective and objective sleep quality was analyzed and small, but significant correlation was found (r=0.270, p<0.01).

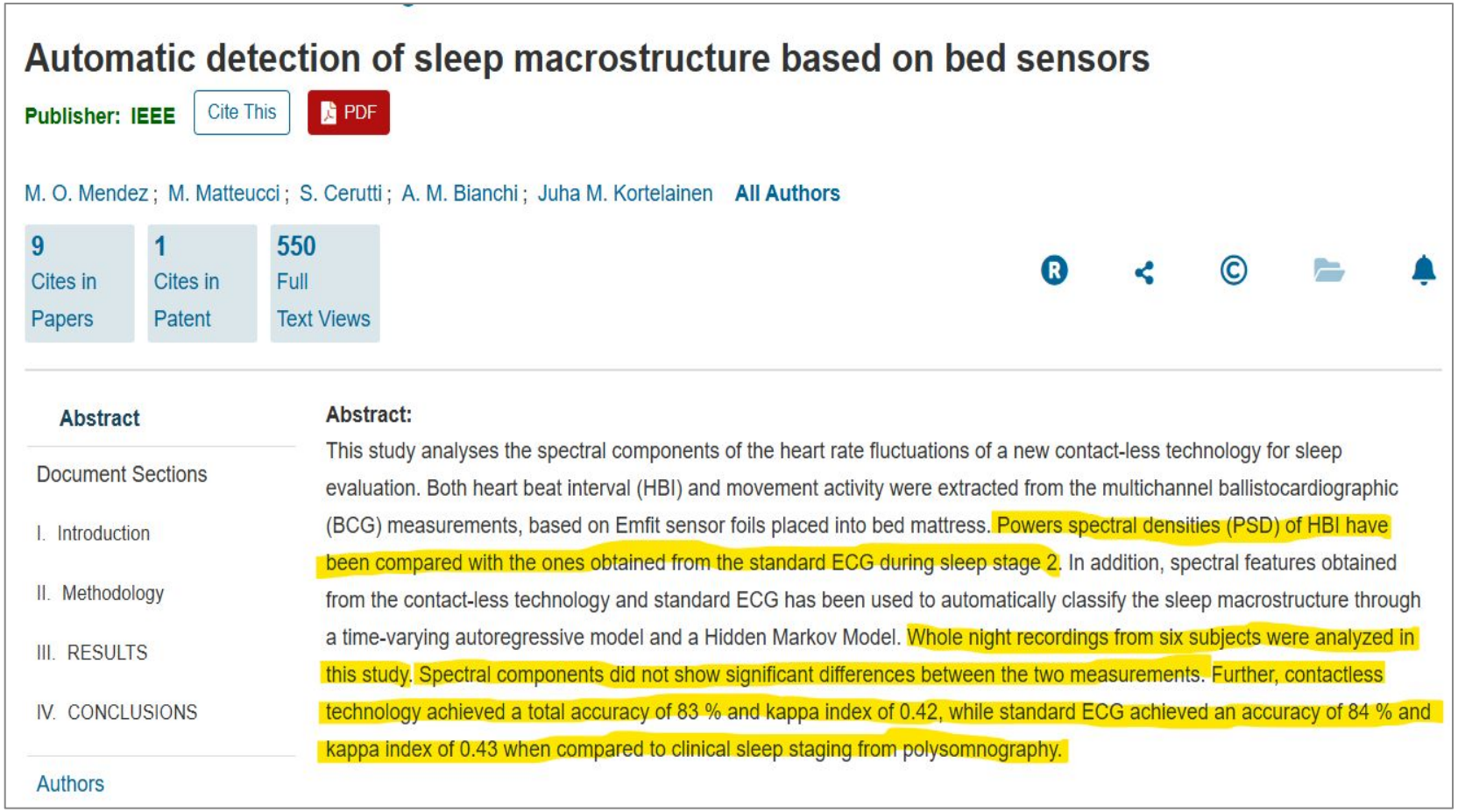
Published in: 2007 29th Annual International Conference of the IEEE Engineering in Medicine and Biology Society

Source: https://ieeexplore.ieee.org/document/4353514

Key Studies Supporting Validity & Reliability (Mendez et al., 2009)

1. The study showed that Emfit's heart rate spectral components closely matched ECG results, with no significant differences, achieving **83% accuracy** and a **kappa index of 0.42** for sleep staging.

2. Whole-night recordings confirmed the **validity and reliability** of Emfit as a contactless tool for sleep evaluation.



Automatic detection of sleep macrostructure based on bed sensors

Publisher: IEEE | Cite This | PDF

M. O. Mendez ; M. Matteucci ; S. Cerutti ; A. M. Bianchi ; Juha M. Kortelainen **All Authors**

9 Cites in Papers | 1 Cites in Patent | 550 Full Text Views

Abstract

Document Sections

I. Introduction

II. Methodology

III. RESULTS

IV. CONCLUSIONS

Authors

Abstract:
This study analyses the spectral components of the heart rate fluctuations of a new contact-less technology for sleep evaluation. Both heart beat interval (HBI) and movement activity were extracted from the multichannel ballistocardiographic (BCG) measurements, based on Emfit sensor foils placed into bed mattress. Powers spectral densities (PSD) of HBI have been compared with the ones obtained from the standard ECG during sleep stage 2. In addition, spectral features obtained from the contact-less technology and standard ECG has been used to automatically classify the sleep macrostructure through a time-varying autoregressive model and a Hidden Markov Model. Whole night recordings from six subjects were analyzed in this study. Spectral components did not show significant differences between the two measurements. Further, contactless technology achieved a total accuracy of 83 % and kappa index of 0.42, while standard ECG achieved an accuracy of 84 % and kappa index of 0.43 when compared to clinical sleep staging from polysomnography.

Source: https://ieeexplore.ieee.org/document/5333734

Key Highlights

1. High Agreement with Gold Standards

Studies show Emfit matches closely with validated tools. For example, Piantino et al. (2021) reported an inter-class correlation coefficient (ICC) of **0.99** for key sleep parameters when compared to actigraphy, and Zink et al. (2017) found a strong correlation of **r = 0.95** between Emfit and ECG for heart rate monitoring.

2. Robust Accuracy Across Studies

Emfit has demonstrated **up to 83% accuracy** in sleep staging (Mendez et al., 2009; Kortelainen et al., 2010) and precise beat-to-beat heart rate estimation with an error margin as low as **11 ms** (Antink et al., 2020), confirming the device's validity in both healthy individuals and patient populations.

3. Reliable in Real-World & Clinical Settings

Merilahti et al. (2007) showed strong correlations between Emfit's long-term sleep data and actigraphy/sleep logs (**r = 0.662** and **r = 0.787**), supporting its reliability. Consistent performance across diverse environments and long recording durations underlines Emfit's capability for **continuous, unobtrusive monitoring**.

fibionemfit

Fibion Krono - New Product

Actigraphy with Advanced Light and Temperature Tracking

Circadian Rhythm & Sleep Research

Several key characteristics of the device:

1. 20 days of measurement on a single charge
2. Event marking button
3. Double light sensor: visible light and filtered blue light
4. Temperature sensor
5. Watertight magnetic Micro-USB charging
6. Accelerometer

A couple of research articles:

1. Arguelles-Prieto, R. et al. (2019) 'Determining light intensity, timing and type of visible and circadian light from an ambulatory circadian monitoring device', Frontiers in Physiology, 10. doi:10.3389/fphys.2019.00822.
2. Madrid-Navarro, C.J. et al. (2019) 'Validation of a device for the ambulatory monitoring of sleep patterns: A pilot study on Parkinson's disease', Frontiers in Neurology, 10. doi:10.3389/fneur.2019.00356.

https://web.fibion.com/krono/

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