Smartphone Applications to Support Sleep Self-Management

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Assessing available technologies in the market for sleep management and its effectivness

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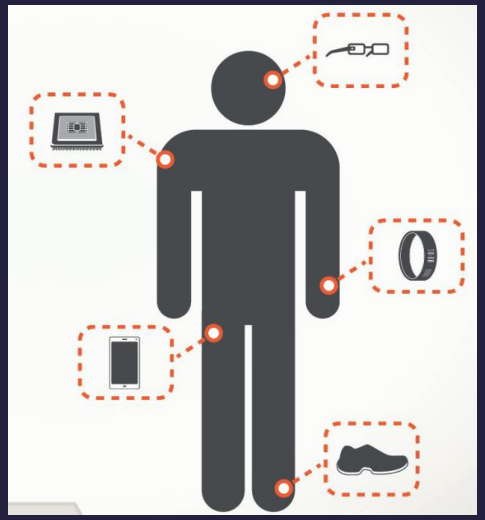
Technologies available for sleep management

- Mobile Electronic Devices
- Wearable Devices (bracelet, pendant, watches)
- Embedded Devices
- Desktop / website
  - Medhelp sleep tracker
  - Sleepyhead or sleepmapper (CPAP…….)

Wearable devices

- Sensor placed directly on the body (bracelet, pendant or attached to or embedded in clothing)
  - Jawbone (rubber)
  - Smartwatches (Fitbit)
  - Mimo baby monitor
- Advantages
  - Increased accuracy
  - Direct contact
- Disadvantages
  - Discomfort,
  - Limited battery life
  - Device misplacement before or during sleep,
  - Sensor damage and inaccuracy from frequent use



Embedded Platforms

- Non-wearable
- Physical devices embedded into the user's native sleep environment.
- Advantages
  - unobtrusiveness
  - increased functionality
- Disavantages
  - Privacy
- Example :
  - Tanita sleep scan
  - Sleep number
  - Luna

Desktop or Website Platforms

- Computer programs
- Websites designed to run on a full desktop
- Operating system : Windows, Mac, Linux, etc.).
  - Advantages
    - Increased host device
    - Processing power
    - Larger data storage
    - Robust visual
    - Improved input/output interfaces providing a richer exchange of information.
  - Disadvantages
    - Include higher cost
    - Decreased portability,
    - large platform

Mobile Device Apps

- The most popular
- Do not require external sensors or other accessories
- Include
  - Sleep tracking
  - Alarm functionality
  - Sleep and dream logging

Advantages

- Easy of use
- Flexibility
- Accessibility

Disadvantages

- Reduced processing
- Power and media input/output capabilities compared to high-end standard
- disruption from noise and light pollution.
- Sensor accuracy may suffer due :
  - individuals on the same sleeping surface,
  - differences in mattress textures and material
  - other sources of artifact

Why Smart App & Sleep ?

- **73%** to **77%** of the population
- Growth of smartphone usage still progressing
- Health-promoting apps has increased exponentially
- Few apps that scored above average in prespecified criteria for quality, content, and functionality for sleep self-management

Downloads markets

EX of 33 apps with download informations

1. 27% (9/33) had fewer than 5,000
2. 27% (9/33) had 5,000 to 50,000,
3. 27% (9/33) had 50,000 to 500,000
4. 18% (6/33) had 500,000 to 500,000,000

Why self management ?

Sleep deficiency is defined as a deficit in the quantity or quality of sleep

- Patient self-management
  - Empower patients health
  - Empower health care outcomes of individuals who have sleep deficiency
  - To improve sleep user generated data

Selection of app ?

- Sleep self-management based
  - Can generated monitoring or tracking data
  - Be used without the assistance of a healthcare provider
  - Be available on the public market
  - Be understood by the user

Functionality ?

- Recording and displaying for self-evaluation
  - Bedtime
  - Wakeup time
  - Average time in bed
  - Amount of time in light
  - Deep sleep
  - Rapid eye movement stage

How to manage in consultation?

Patients who bring questions related to data collected?

- Quality and the functionalities of the apps
  - MARS rating scale
  - IMS functionality score
- Medical devices
- Sleep self-management app /category of “lower risk” products
  - Lifestyle apps
  - Entertainment apps

Rating Tool MARS

App Quality Scoring Criteria	Subscales
1. Engagement	1.1 Entertainment 1.2 Interest 1.3 Customization 1.4 Interactivity 1.5 Target group
2. Functionality	2.1 Performance 2.2 Ease of use 2.3 Navigation 2.4 Gestural design
3. Aesthetics	3.1 Layout 3.2 Graphics 3.3 Visual appeal: how good does the app look?
4. Information	4.1 Accuracy of app description 4.2 Goals 4.3 Quality of information 4.4 Quantity of information 4.5 Visual information 4.6 Credibility 4.7 Evidence base
5. Subjective quality	5.1 Would you recommend this app? 5.2 How many times do you think you would use this app? 5.3 Would you pay for this app? 5.4 What is your overall star rating of the app?

MARS = Mobile Application Rating Scale.

IMS Institute for Healthcare Informatics functionality scoring criteria

Functionality Scoring Criteria	Description
1. Inform	Provides information in a variety of formats (text, photo, video)
2. Instruct	Provides instructions to the user (eg, app user guides, instructions to interpret sleep charts)
3. Record	Capture user-entered data (eg, manual sleep log, sensor-based automatic sleep log)
3.1 Collect data	Able to enter and store health data on individual phone
3.2 Share data	Able to transmit health data (eg, export, upload, email sleep data)
3.3 Evaluate data	Able to evaluate the entered health data by patient and provider, provider and administrator, or patient and caregiver
3.4 Intervene	Able to send alerts based on the data collected or propose behavioral intervention or changes (eg, smart wakeup alarm based on user sleep data, anti-snoring alerts when snoring is detected)
4. Display	Graphically display user-entered data/output user-entered data (eg, sleep trends chart)
5. Guide	Provide guidance based on user-entered information, and may further offer a diagnosis, or recommend a consultation with a physician/a course of treatment (eg, recommendations for improving sleep based on user sleep data)
6. Remind or alert	Provide reminders to the user (eg, bedtime notification)
7. Communicate	Provide communication between health care providers, patients, consumers, caregivers and/or provide links to social networks (eg, email or upload sleep data to Facebook)

Total score (0 to 11): one point is assigned to each functionality that is present.

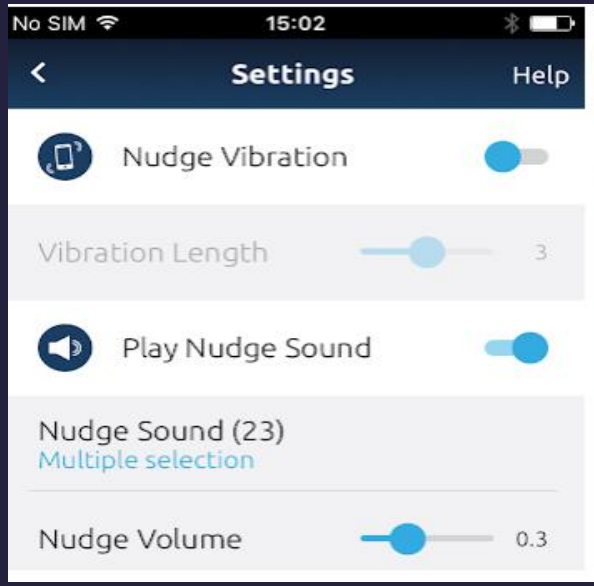
Snoring Applications

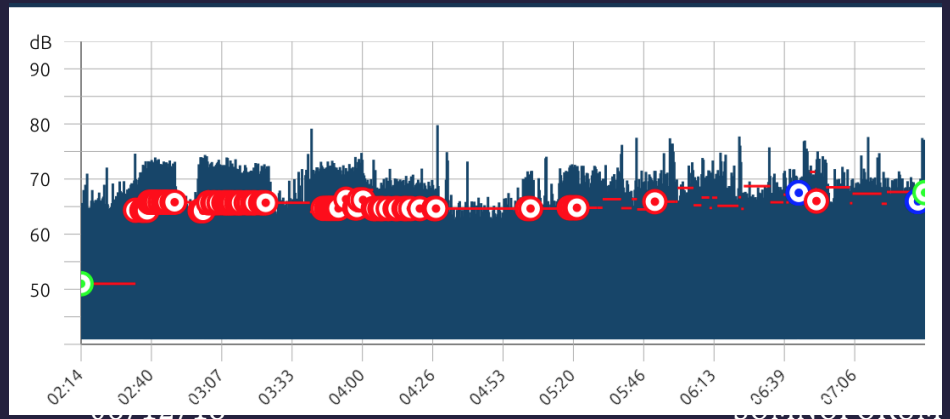
- 126 snoring apps / 13 can be used
  - EX : Quit Snoring
- App snoring sensitivities ranged 64% to 96%
- Positive predictive values ranged 93 %to 96%

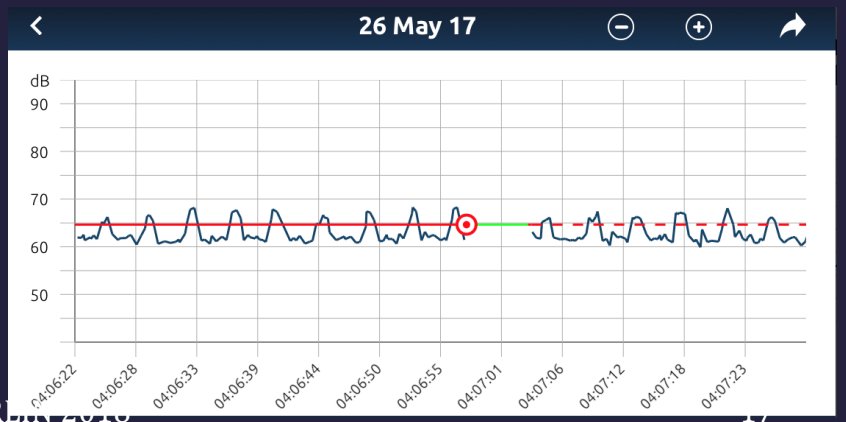
Snores demonstrates the potential clinical utility of such apps

J Clin Sleep Med. 2014 Jan 15;10(1):73-8. doi: 10.5664/jcsm.3364.
Monitoring sound to quantify snoring and sleep apnea severity using a smartphone: proof of concept.
Nakano H1, Hirayama K1, Sadamitsu Y1, Toshimitsu A1, Fujita H1, Shin S1, Tanigawa T2.

Ex : Quit Snoring







Snoring Apps what the value?

- Can be used for monitoring snoring and OSA
- Not as a substitute for the type 4 OSA monitor

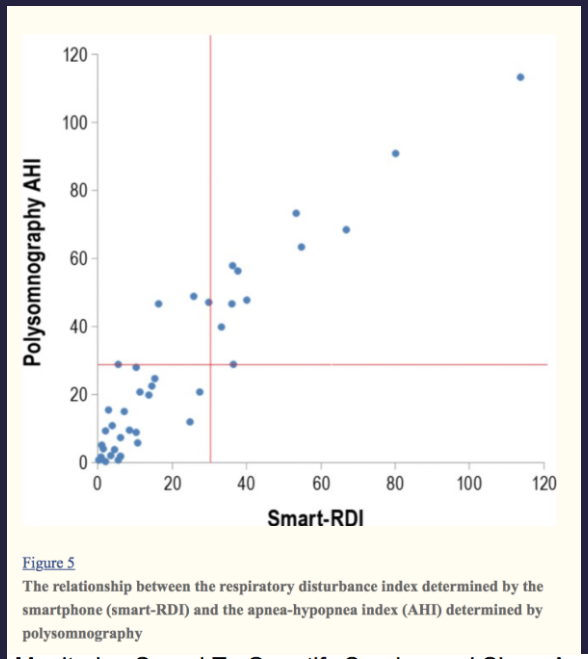
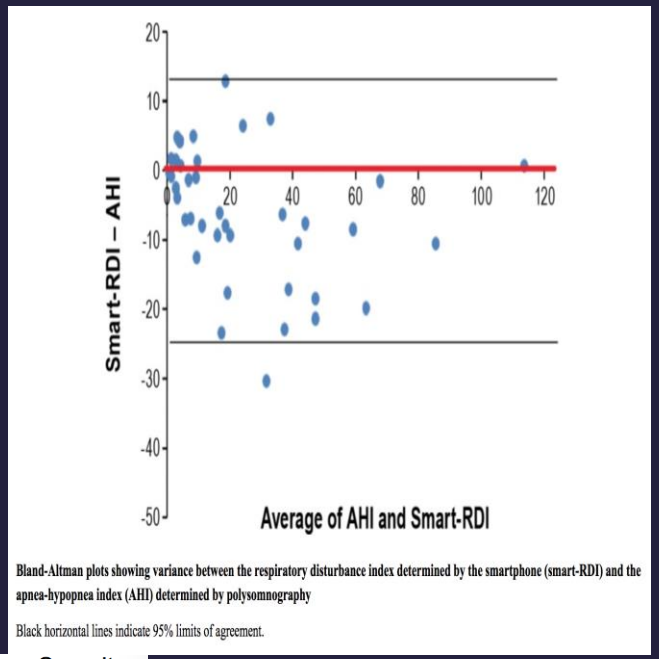
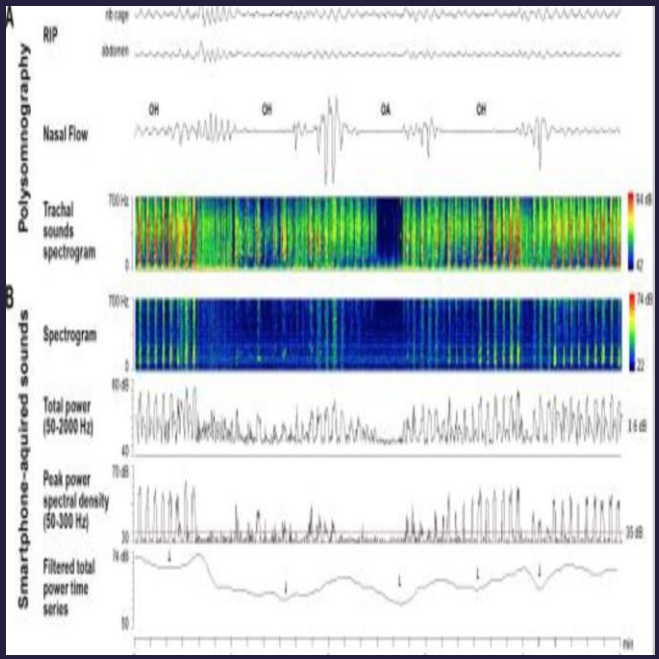


Figure 5
The relationship between the respiratory disturbance index determined by the smartphone (smart-RDI) and the apnea-hypopnea index (AHI) determined by polysomnography



Bland-Altman plots showing variance between the respiratory disturbance index determined by the smartphone (smart-RDI) and the apnea-hypopnea index (AHI) determined by polysomnography

Black horizontal lines indicate 95% limits of agreement.



Monitoring Sound To Quantify Snoring and Sleep Apnea Severity Using a Smartphone: Proof of Concept

Hiroshi Nakano, Ph.D.,[1] Kenji Hirayama, Ph.D.,[1] Yumiko Sadamitsu, R.N.,[1] Ayaka Toshimitsu, M.T.,[1] Hisayuki Fujita, M.T.,[1] Shizue Shin, M.T.,[1] and Takeshi Tanigawa, Ph.D.[2]

Sleep applications

- 2,431 apps in 2018
  - Unrelated to sleep content (n = 437),
  - Playing environmental or relaxation sounds (n = 642)
  - Alarm service (n = 305)
  - Required other external devices to operate (n = 238).
- Only 73 functional for sleep self-management
- MARS score was 3.1 out of 5
  - Half of apps (42/73, 58%) had a minimum acceptability score of 3.0
- IMS functionality of 7 (range 2 to 11)
- 66% app not updated

Smartphone Applications to Support Sleep Self-Management: Review and Evaluation
Yong K. Choi, MPH,1 George Demiris, PhD,2 Shih-Yin Lin, PhD, MPH, MM,1 Sarah J. Iribarren, PhD, RN,1 Carol A. Landis, PhD, RN,1 Hilaire J. Thompson, PhD, RN, ARNP, CNRN, AGACNP-BC,1 Susan M. McCurry, PhD,1 Margaret M. Heitkemper, PhD, RN,1 and Teresa M. Ward, PhD, RN1
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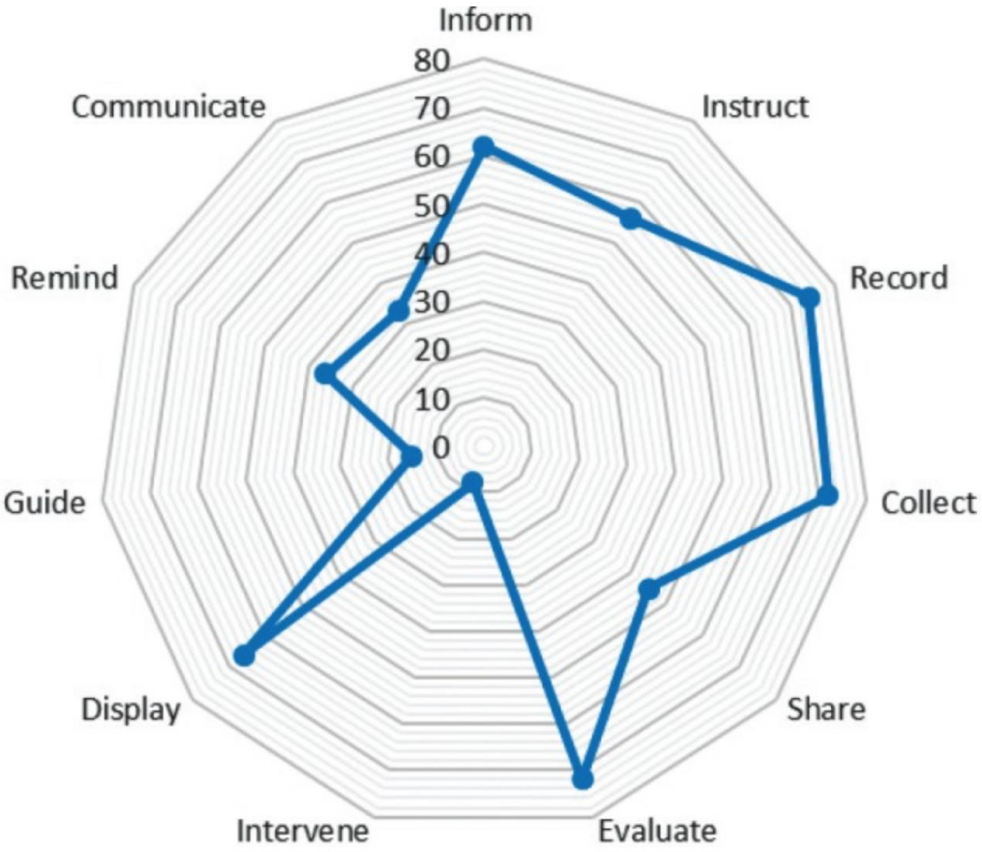
What functionalities ?



Functionality of included apps based on IMS Institute for Healthcare Informatics functionality scores.

What the value ?

1. Sleep Cycle
2. MotionX
3. Sleep Time

1. Sleep Cycle [iOS, Android]

3. Sleep Time [iOS]

5. MotionX-24/7 [iOS]

Bhat S, Ferraris A, Gupta D, et al. Is there a clinical role for smartphone sleep apps? Comparison of sleep cycle detection by a smartphone application to polysomnography. J Clin Sleep Med. 2015;15;11(7):709–715. [PMC free article]

.Toon E, Davey MJ, Hollis SL, Nixon GM, Horne RSC, Biggs SN. Comparison of commercial wrist-based and smartphone accelerometers, actigraphy, and PSG in a clinical cohort of children and adolescents. J Clin Sleep Med. 2016;12(3):343–350. [PMC free article]

Patel P, Kim JY, Brooks LJ. Accuracy of a smartphone application in estimating sleep in children. Sleep Breath. 2017;21(2):505–511.

What the value ?

- Formally evaluated for clinical validity.
- The apps poorly correlated with PSG
  - Failed to accurately reflect the sleep stages
  - Not useful as a clinical tool.

What the governmental regulation says?

- Medical devices !!
- Sleep self-management app /category of "lower risk" products
  - Lifestyle apps
  - Entertainment apps

What the sleep association says ?

- AASM /sleep technology intended for a diagnosis and/or treatment of sleep disorders must be
  - Cleared by the FDA
  - Undergo rigorous testing
- Lack of validation
  - limits ability for any recommandation
- Technology tools cannot replace a clinical evaluation and validated diagnostic instruments

Conclusion

- Self-management
  - Help raise awareness
  - Promote healthy sleep habits
- Used with caution
- Needs regulation safe usage of consumer
- Future research should focus
  - Testing the efficacy
  - Demonstrating the magnitude of behavior sleep health change outcomes.
- Workshop for sleep app in future