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Journées de formation **SCS 2018**
2018 CSS Education Meeting

2 & 3 NOV.
2018

Hôtel Le Concorde Québec
Québec, QC, Canada

Wearable Technology and Apps

Alanna Cornish, BSc., RPSGT, RST

- There are many wearable devices and apps available on the market to track sleep duration and quality. With more and more patients accessing this technology how can we utilize this data in the sleep lab. What are some of the drawbacks or areas of concern with regard to this data.



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What is CST?

Consumer sleep technology (CST): Non-prescription devices directly marketed to consumers that may make an assertion to perform sleep monitoring, tracking, or sleep-related interventions.



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Platforms for CST

- Mobile Device
 - Go! To Sleep, Entrain, Sleep Cycle
- Wearable
 - Fitbit, Jawbone UP, Sleep Shepard Hat



Ko PR, Kientz JA, Choe EK, Kay M, Landis CA, Watson NF. Consumer sleep technologies: a review of the landscape. *J Clin Sleep Med*. 2015;11(12):1455–1461.



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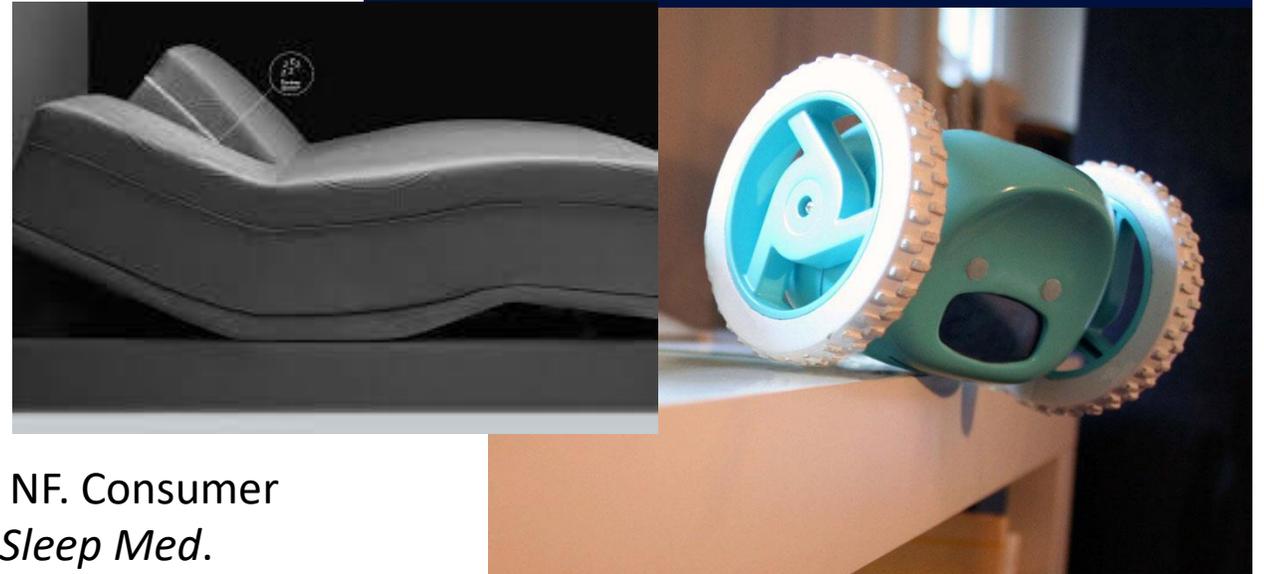
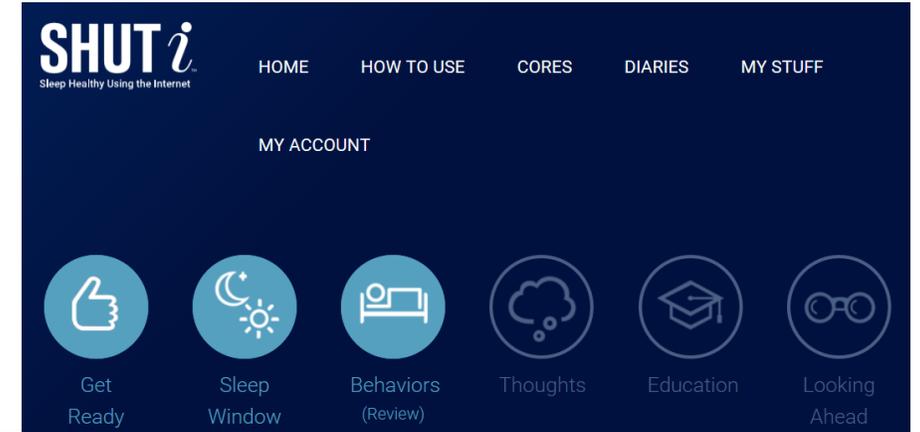


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Platforms for CST

- Embedded
 - Sleep Number x12, Luna
- Desktop or Website
 - SleepyHead, MedHelp Sleep Tracker, SHUTi
- Accessory Appliance
 - Wake- Up Light, Clocky, emWave



Ko PR, Kientz JA, Choe EK, Kay M, Landis CA, Watson NF. Consumer sleep technologies: a review of the landscape. *J Clin Sleep Med*. 2015;11(12):1455–1461.



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Consumer Sleep Technology: An American Academy of Sleep Medicine Position Statement

“It is the position of the AASM that CST must be FDA cleared and rigorously tested against current gold standards if it is intended to render a diagnosis and/or treatment. Given the unknown potential of CST to measure sleep or assess for sleep disorders, these tools are not substitutes for medical evaluation. However, CSTs may be utilized to enhance the patient-clinician interaction when presented in the context of an appropriate clinical evaluation.”



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Advantages

- Increased patient engagement and awareness
- Provide real time feedback
- Information present in a patient-friendly manner
- Relatively inexpensive and easily accessible
- Potential to reach large portions of the populations



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Patient Engagement

- “We don’t adopt cellphones. We marry them,” B.J. Fogg
 - 9 in 10 patients said they would use an app “prescribed” by a physician
 - 66% would be willing to fill a medicine prescription from their doctor
- Information from CST may encourage patients to seek formal sleep evaluation
- Clinicians should recognize a patient’s use of CST as a commitment to focus on sleep wellness.



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Disadvantages

- Minimal validation of data exists
- Largely raw data and algorithms are unavailable to clinicians
- Potential negative impact on sleep hygiene
- Unnecessary anxiety for some patients
- Underestimation of a sleep problem may cause delayed evaluation and treatment
- Lack of FDA approved devices



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The big question:
Is this information and data validated?



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Mobile devices - Sleep Apps

Review of sleep applications available for mobile devices.

n=76

The primary sleep complaint that apps purported to address included:

- OSA (30.3%)
- Insomnia (11.8%)
- Sleep cycles or circadian rhythms (42.1%)
- General sleep (10.5%)

Lee-Tobin PA, Ogeil RP, Savic M, Lubman DI. Rate my sleep: examining the information, function, and basis in empirical evidence within sleep applications for mobile devices. *J Clin Sleep Med*. 2017;13(11):1349–1354



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Mobile devices - Sleep Apps

Sources of sleep app content

- 32.9% contained empirical evidence supporting their claims
- 15.8% contained clinical input
- 13.2% contained links to sleep literature

App user ratings were not associated with an app drawing on multiple sources of evidence (except for sleep literature only)

Lee-Tobin PA, Ogeil RP, Savic M, Lubman DI. Rate my sleep: examining the information, function, and basis in empirical evidence within sleep applications for mobile devices. *J Clin Sleep Med*. 2017;13(11):1349–1354



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Mobile devices - Sleep Apps

Sleep apps contained information on how sleep is affected by:

- alcohol or drugs (23.7%)
- food (13.2%)
- daily activities (13.2)
- stress (13.2%)

There was a higher average user rating among apps that contained a sleep tip function.

Lee-Tobin PA, Ogeil RP, Savic M, Lubman DI. Rate my sleep: examining the information, function, and basis in empirical evidence within sleep applications for mobile devices. *J Clin Sleep Med*. 2017;13(11):1349–1354



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GO! TO SLEEP®



- Developed by the Cleveland Clinic Sleep Disorders Center
- Assigns a “sleep score” rating the quality of sleep
- Survey questions relate to caffeine, alcohol, exercise and relaxation. Answers are weighted by importance to create an overall score based on lifestyle and morning and nighttime behaviors.
- Includes a timer to keep track sleep and to record interrupted sleep
- Option to upgrade to see past results, chart progress and receive daily sleep tips.



Comparing Wearable CST to PSG

- Devices: Actiwatch, Basis, Fiband, Misfit, Withings
- For all devices they found no difference and strong correlation of total sleep time with PSG
- No devices provided reliable staging data
- Significant data loss for wearable CST devices

Mantua J, Gravel N, Spencer RM. Reliability of Sleep Measures from Four Personal Health Monitoring Devices Compared to Research-Based Actigraphy and Polysomnography. *Sensors (Basel)*. 2016;16(5):646.



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Correlations of sleep measures

Table 5. Correlations of measures (r) from each device with PSG. Bold indicates significance ($p < 0.05$) and # indicates marginal significance ($p < 0.1$).

	TST		SE		Light		Deep	
	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.	Unadj.	Adj.
Actiwatch	0.87	0.94	0.30 #	0.35	-	-	-	-
Basis	0.84	0.84	0.26	0.28	0.30 #	0.30 #	0.27	0.28 #
Fitbit	0.97	0.97	0.21	0.21	-	-	-	-
Misfit	0.76	0.87	-0.20	-0.07	0.31 #	0.40	0.20	0.19
Withings	0.84	0.94	0.17	0.21	0.34	0.39	0.36	0.36

Mantua J, Gravel N, Spencer RM. Reliability of Sleep Measures from Four Personal Health Monitoring Devices Compared to Research-Based Actigraphy and Polysomnography. *Sensors (Basel)*. 2016;16(5):646.



Android Health and Fitness App Rankings

	App ⓘ	Publisher ⓘ	Usage Rank ⓘ ▾	Change ⓘ	Store Rank ⓘ
1	 Fitbit	Fitbit, Inc.	1	=	3
2	 Step Tracker - Pedometer, Daily Walking Tracker	Sound Sleep Group	2	=	8
3	 Carrot Rewards	CARROT Insights Inc.	3	=	15
4	 Daily Workout Music-Weight Loss&Health	Health Mate	4	=	16
5	 Sleep Mate - Meditate, Sleep, Relax, White noise	Health Mate	5	=	10
6	 Home Workout - Abs & Butt Fitness	Fitness Tech Team	6	=	-
7	 Relax Music - Meditation& Sleep Music, White Noise	Sound Sleep Group	7	=	1

<https://www.similarweb.com/apps/top/google/store-rank/ca/health-and-fitness/top-free>

Similar Web App rating and usage patterns



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- #1 ranked Android Health and Fitness app by usage in Canada
- Over 75 million units sold and 25 million active users
- 6 billion nights of “sleep stage data”



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Fitbit Sleep Technology



Working to fit a sleep lab in a sensor.

- *Using the power of PurePulse® heart rate, sensitive motion detectors and powerful algorithms, Fitbit's R&D team unlocked the key to understanding your sleep quality: sleep stages.*
- *Now, your Fitbit tracker can record your time spent in light, deep & REM sleep, as well as your time awake, then distills that information in easy-to-reach graphs in the Fitbit app.*

<https://www.fitbit.com/en-ca/technology#>



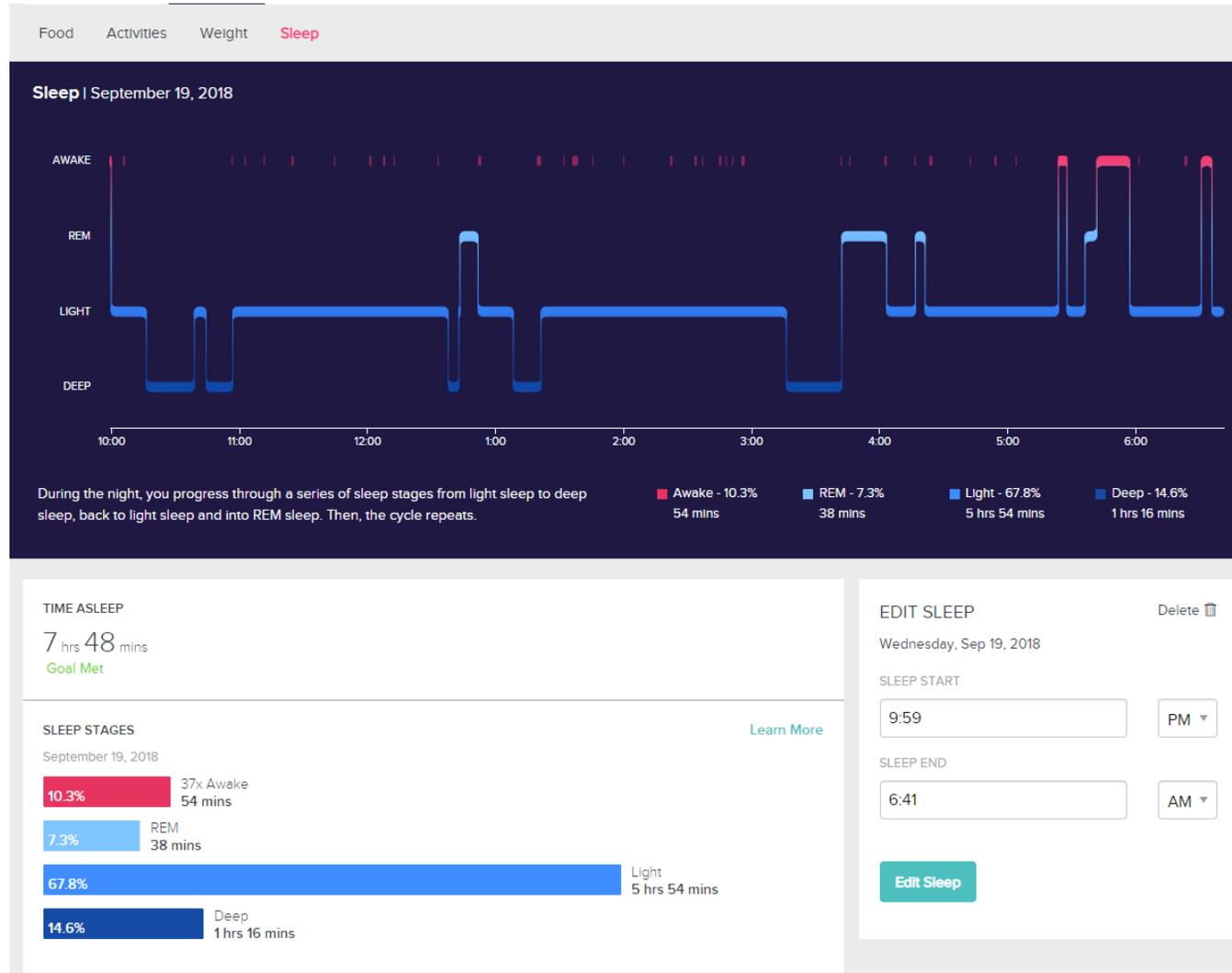
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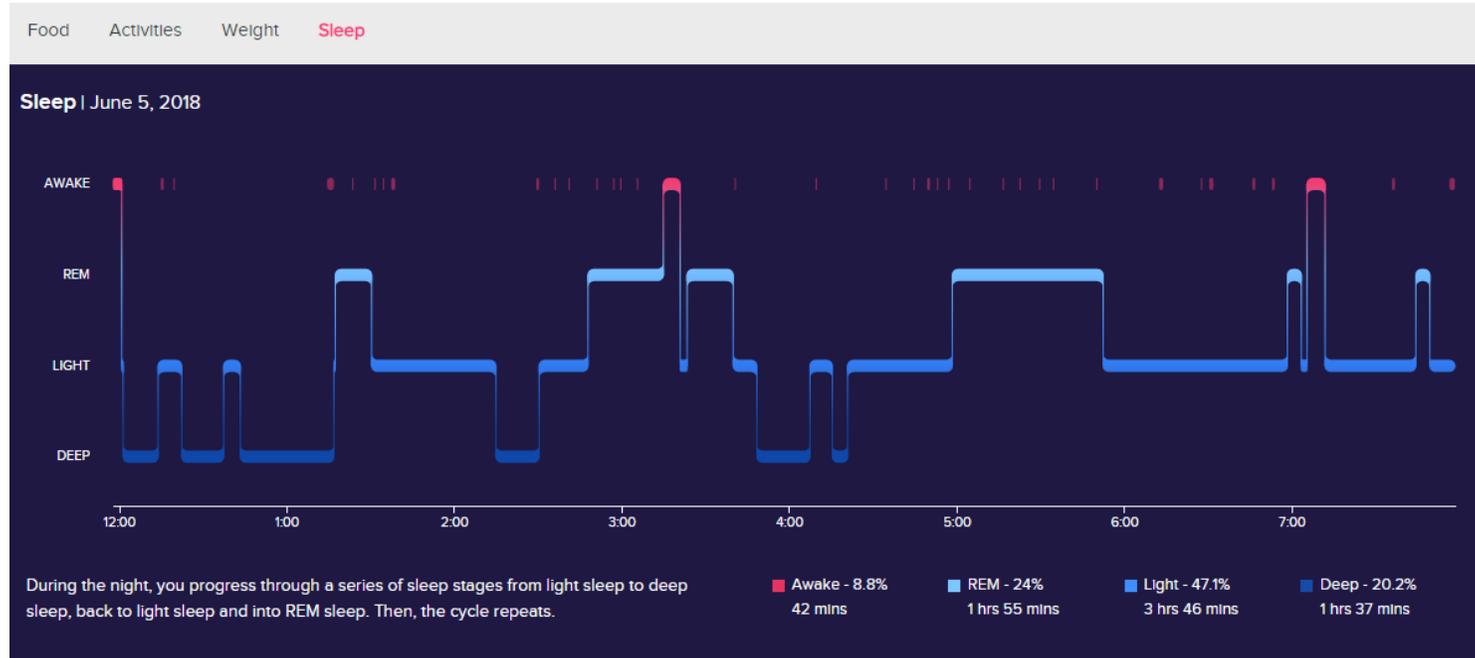
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Sample Data



Sample Data



TIME ASLEEP

7 hrs 18 mins
Goal Met

Delete

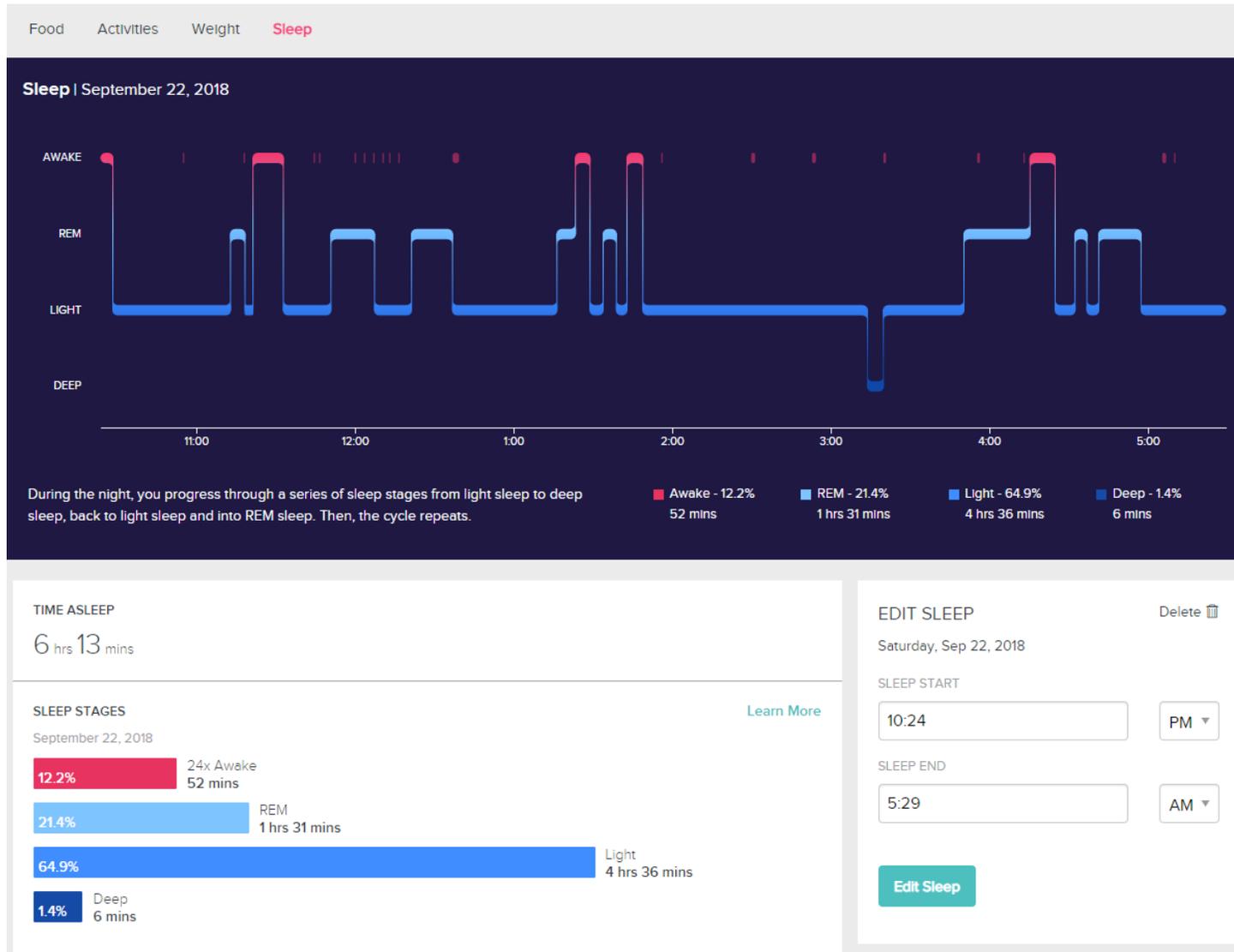
SLEEP STAGES

[Learn More](#)

June 5, 2018

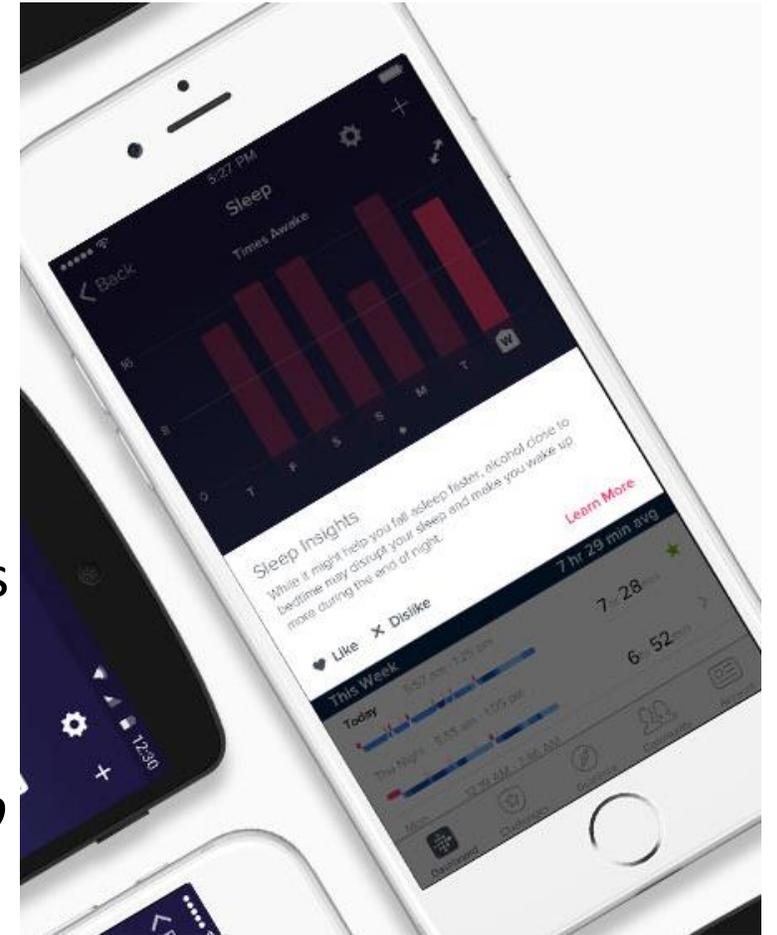


Sample Data



Sleeping better with Fitbit

- Auto Sleep tracking and sleep stages
- Sleep Schedule
 - Set sleep goals and target wake up times
 - Friendly bedtime reminders
- Sleep Insights
 - Personalized information about sleep stats and trends
 - Tips for improving sleep quality and nightly routines
 - *“Starting your day at a regular time helps lock in a stable circadian rhythm. This week you did a great job by having a consistent wake-up time!”*



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Accuracy of Fitbit Devices

- Overestimate of total sleep time
- Overestimate of sleep efficiency
- Underestimate sleep disruption
- Poor specificity in detecting wake
- Underestimate of wake after sleep onset

Feehan LM, Geldman J, Sayre EC, et al. Accuracy of Fitbit Devices: Systematic Review and Narrative Syntheses of Quantitative Data. *JMIR Mhealth Uhealth*. 2018;6(8):e10527.



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FitbitChargeHR™

- High overall accuracy (91%) and high sensitivity (97%) in detecting sleep
- Poor specificity (42%) in detecting wake on a min-to-min basis
- On average significantly but negligibly overestimated total sleep time by 8min and sleep efficiency by 1.8%
- Underestimated wake after sleep onset by 5.6min ($p < 0.05$)

de Zambotti M., Baker F.C., Willoughby A.R., Godino J.G., Wing D., Patrick K., Colrain I.M. Measures of sleep and cardiac functioning during sleep using a multi-sensory commercially-available wristband in adolescents. *Physiol. Behav.* 2016;158:143–149



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Sleep outcomes from one overnight recording in 30 healthy adolescents

	Polysomnography			FitbitChargeHR™		
	Mean ± SD	-95%CI	+95%CI	Mean ± SD	-95%CI	+95%CI
Lights-off (hh:mm)	23:13 ± 1:03	22:50	23:37			
Lights-on (hh:mm)	07:04 ± 00:45	06:47	07:21			
TIB (min)*	471.3 ± 55.9	450.4	492.2			
TST (min)	427.9 ± 56.8	406.7	449.1	435.9 ± 51.1	416.8	455.0
SOL (min)	16.2 ± 11.7	11.8	20.5	13.6 ± 9.4	10.1	17.1
WASO (min)	27.2 ± 20.4	19.6	34.9	21.7 ± 19.3	14.5	28.9
SE (%)	90.8 ± 5.6	88.7	92.9	92.3 ± 4.2	91.0	94.2

de Zambotti M., Baker F.C., Willoughby A.R., Godino J.G., Wing D., Patrick K., Colrain I.M. Measures of sleep and cardiac functioning during sleep using a multi-sensory commercially-available wristband in adolescents. *Physiol. Behav.* 2016;158:143–149



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Validation study of Fitbit Charge 2™

- In-lab PSG and Fitbit Charge 2™ data were obtained from a single overnight recording in 44 adults (19-61 years; 26 women; 25 Caucasian).
- Shows promise in detecting sleep-wake states and sleep stage composition relative to gold standard PSG



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Validation study of Fitbit Charge 2™

- 0.96 sensitivity (accuracy to detect sleep)
- 0.61 specificity (accuracy to detect wake)
- 0.81 accuracy in detecting N1+N2 sleep ("light sleep")
- 0.49 accuracy in detecting N3 sleep ("deep sleep")
- 0.74 accuracy in detecting rapid-eye-movement (REM) sleep

Massimiliano de Zambotti, Aimee Goldstone, Stephanie Claudatos, Ian M. Colrain & Fiona C. Baker (2017): A validation study of Fitbit Charge 2™ compared with polysomnography in adults, *Chronobiology International*, DOI: 10.1080/07420528.2017.1413578



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Validation study of Fitbit Charge 2™

- Overestimated PSG TST by 9 min
- Overestimated N1+N2 sleep by 34 min
- Underestimated PSG SOL by 4 min
- Underestimated N3 sleep by 24 min
- Outcomes did not differ for WASO and time spent in REM sleep.

Massimiliano de Zambotti, Aimee Goldstone, Stephanie Claudatos, Ian M. Colrain & Fiona C. Baker (2017): A validation study of Fitbit Charge 2™ compared with polysomnography in adults, *Chronobiology International*, DOI: 10.1080/07420528.2017.1413578



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Conclusions

- Keep in mind the trends seen in research
 - High sensitivity for sleep, lower specificity in detecting wake and deep sleep
 - Overestimation of total sleep time
- Accuracy and reliability need to be further investigated in different settings and in different populations in which sleep composition is known to vary



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CST and PAP Therapy



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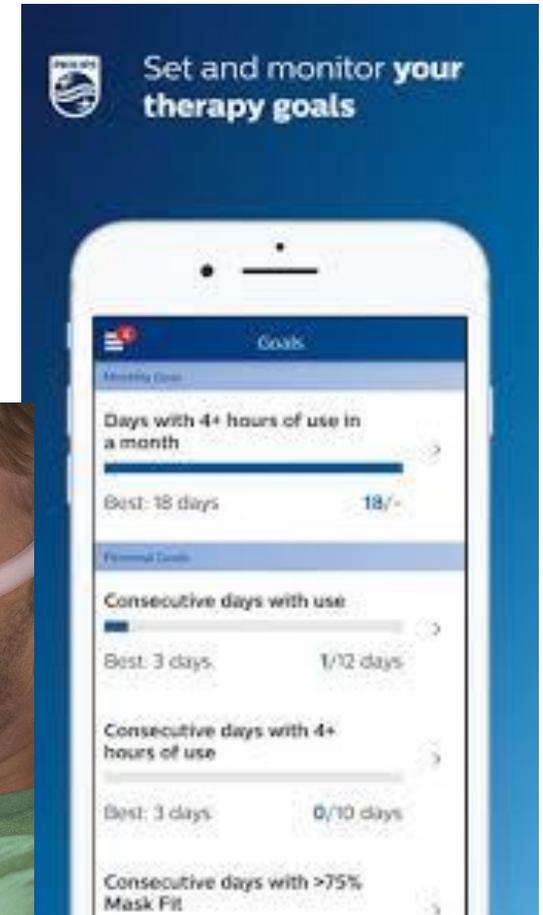


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Respironics Dreammapper

- At 90 days
 - 78% of patients using the app had met CMS adherence criteria
 - 63% of patients with standard care had met CMS adherence criteria



Respironics Dreammapper

- On average used therapy 1.1 hours longer each night
- “Struggling patients”
 - With Dreammapper 46% went on to achieve adherence
 - With Standard care 12% went on to achieve adherence



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ResMed myAir™

- Brand new CPAP users
 - 75.4% met Medicare adherence in 30 days
 - 83.9% met Medicare adherence in 90 days
 - median time to achieve Medicare adherence was 23 days



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Case Study

- 60 year old male
- Moderate OSA, ESS 6, reports he has good daytime energy
- Hx: no comorbidities, snoring and witnessed apneas
- Goal for therapy: eliminate snoring and apneas
- Started a trial of APAP therapy
 - Struggled with compliance
 - Issues with mask fit



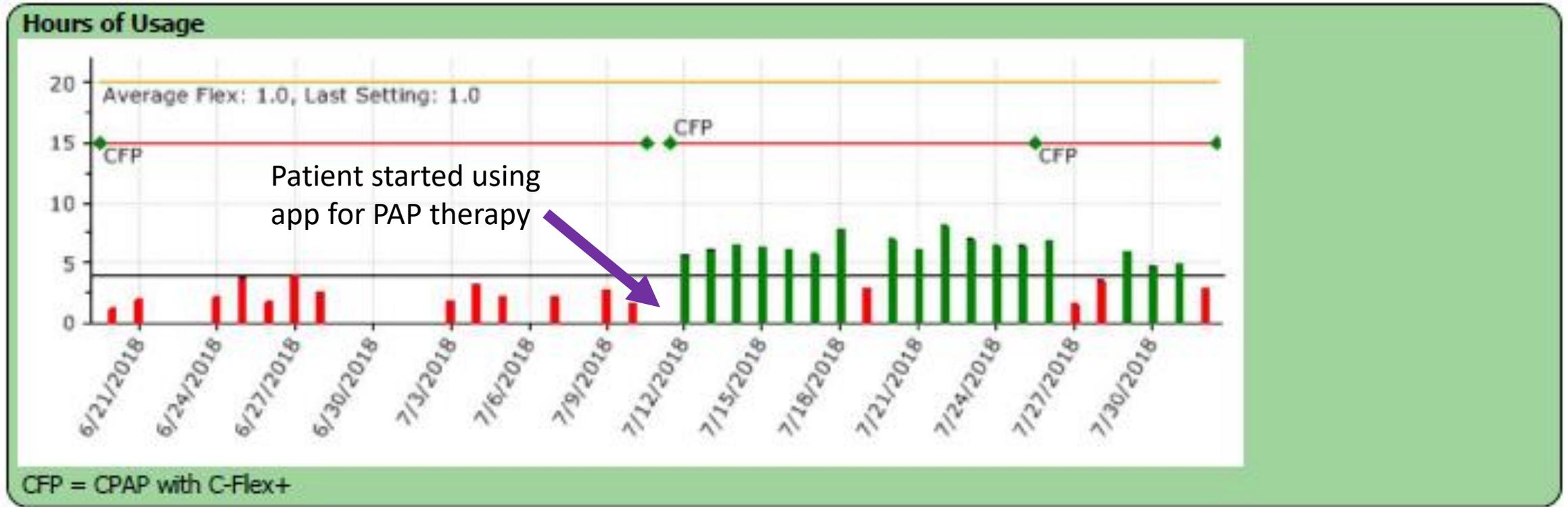
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Case Study:



Discussing CST with patients

- Clinicians should have a general awareness of CST and an openness to discuss CST with patients
 - Data can be utilized as a tool for opening discussions with patients
 - Discuss difference between CST and gold-standard sleep measurements
 - Connect patient's symptoms with the data presented by the CST
 - Present options for ongoing use of the CST (eg, to set personal goals, assess change over time)
 - If the patient has developed anxiety, unreasonable expectations, or inadequate sleep hygiene related to the use of the CST encouraging the patient to discontinue use



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Opportunities for CST

- Patients utilizing CST may favor engaging with validated online therapies such as CBT-I
- Patients starting PAP therapy may benefit from the use of a therapy application to reach and maintain adherence
- As technology advances and may undergo validation CST may have a greater role in clinical care and scientific research



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Thank you!



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