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## Validity of wearable fitness trackers on sleep measure

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### ABSTRACT

Wearable trackers that detect sleep offer users a way to track their sleep quality and patterns without the use of expensive equipment. Few studies have tested the validity of these trackers on sleep measure. **PURPOSE:** To examine the validity of the Actigraph GT9X (AG), SenseWear Mini Armband (SW), Basis Peak (BP), Fitbit Charge HR (FB), Jawbone UP3 (JU), and Garmin Vivosmart (GV) for estimating sleep variables as compared with a sleep diary. **METHODS:** 78 healthy individuals participated in the study. Group 1 (n = 38) and wore the AG, SW, BP, and FB or Group 2 (n = 40) and wore the AG, JU, and GV. Monitors were worn on the non-dominant arm for 3 nights and a sleep log was completed. Sleep variables were total sleep time (TST), time in bed (TIB), sleep efficiency (SE), and wake after sleep onset (WASO). Pearson correlation, mean absolute percentage errors (MAPE), equivalence testing, Bland-Altman plots, and ANOVA were used to assess validity compared with the diary. **RESULTS:** Overall, monitors that showed the greatest correlation with the sleep diary for TST were the JU and FB (effect size= 0.09 and 0.23, respectively). The greatest correlation with the sleep diary for TIB was seen with the SW, GV, and JU (effect size= 0.09, 0.16, and 0.07, respectively). SE and WASO showed very poor correlation with the log. Measures for equivalence testing confirmed the success of the JU, SW, FB, and GV for measuring TIB and TST. **CONCLUSION:** The FB, SW, JU, and GV could be valid measure of TST and TIB. The monitors are not valid regarding wake times during sleep. Further research is needed to validate these monitors with polysomnography.

### INTRODUCTION

- Lack of sleep can lead to serious health concerns, such as poor cognitive function and alertness, increased risk for developing or dying of stroke or cardiovascular events, increased risk of developing Type 2 Diabetes, and increased risk of obesity and weight gain.
- Adequate sleep aids in promoting a healthy immune system, better ability to regulate weight, and better physical and mental performance.
- Sleep behavior can be difficult and costly to assess

### PURPOSE

The purpose of this study was to examine the validity of the Actigraph GT9X, SenseWear Mini Armband, Basis Peak, Fitbit Charge HR, Jawbone UP3, and Garmin Vivosmart for estimating sleep variables as compared with a sleep diary.

### METHODS

Table 1. Demographics of participants

		Group 1		Group 2		TOTAL (n = 78)
		Male (n = 19)	Female (n = 19)	Male (n = 17)	Female (n = 23)	
Age	Mean ± SD	30.1 ± 14.2	27.1 ± 11.3	27.9 ± 7.2	26.3 ± 10.1	27.6 ± 11.0
	Range	19-66	20-65	22-47	19-65	19-66
Height (cm)	Mean ± SD	17.9 ± 6.3	166.2 ± 7.0	179.8 ± 6.8	162.7 ± 6.2	171.3 ± 10.2
	Range	170.2-194.3	154.9-182.9	167.6-195.6	152.5-180.3	152.5-195.6
Weight (kg)	Mean ± SD	87.0 ± 18.9	68.7 ± 12.2	84.4 ± 28.8	71.0 ± 18.1	77.3 ± 21.0
	Range	64.9-129.5	49-92.3	64.9-192.5	51.6-130.0	49-192.5
BMI (kg·m <sup>-2</sup> )	Mean ± SD	26.8 ± 5.5	24.8 ± 4.2	23.4 ± 2.4	25.7 ± 4.8	25.3 ± 4.6
	Range	20.5-39.7	19.4-34.8	20.3-28.2	21.3-38.8	19.4-39.7

### METHODS, cont.

#### Procedures

- Participants signed an IRB approved informed consent
- Participants were instructed on how to wear their respective activity monitors as well as how to fill out the sleep diary
- Participants wore their monitors 24-h a day and kept their sleep diary for 3 nights
- Monitors and diary were returned for data collection

#### Instruments



### RESULTS

Table 2. Mean Values for Sleep Variables (Minutes)

	n	TST	TIB	SE (%)	WASO
		Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Diary	195	439.8 ± 94.6	492.4 ± 101.9	88.6 ± 10.8	20.9 ± 33.0
SenseWear Mini	99	403.1 ± 70.6	482.8 ± 87.7	84.1 ± 8.5	79.0 ± 49.3
Fitbit Charge HR	98	417.6 ± 73.1	449.7 ± 77.4	93.3 ± 3.2	31.4 ± 16.8
Basis Peak	93	388.4 ± 116.9	417.2 ± 116.3	92.2 ± 18.8	
Actigraph (Sadeh)	163	325.2 ± 124.0	368.1 ± 140.9	88.3 ± 5.9	42.0 ± 25.8
Actigraph (Cole-Kripke)	183	365.1 ± 122.2	422.1 ± 130.8	87.7 ± 5.8	50.6 ± 27.1
Garmin Vivosmart	96	488.6 ± 102.3	508.2 ± 105.6	96.4 ± 5.6	19.7 ± 32.2
Jawbone UP3	92	448.1 ± 113.1	484.9 ± 125.1	92.5 ± 5.2	36.9 ± 30.9

Table 3. Correlation Matrix and Effect Size: Total Sleep Time

	SenseWear Mini	Fitbit Charge HR	Basis Peak	Actigraph (Sadeh)	Actigraph (Cole-Kripke)	Garmin Vivosmart	Jawbone UP3
Total	0.57**	0.55**	0.28**	0.27**	0.41**	0.52**	0.73**
Effect Size	0.39	0.23	0.54	1.21	0.79	0.52	0.09

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

Table 4. Correlation Matrix and Effect Size: Time in Bed

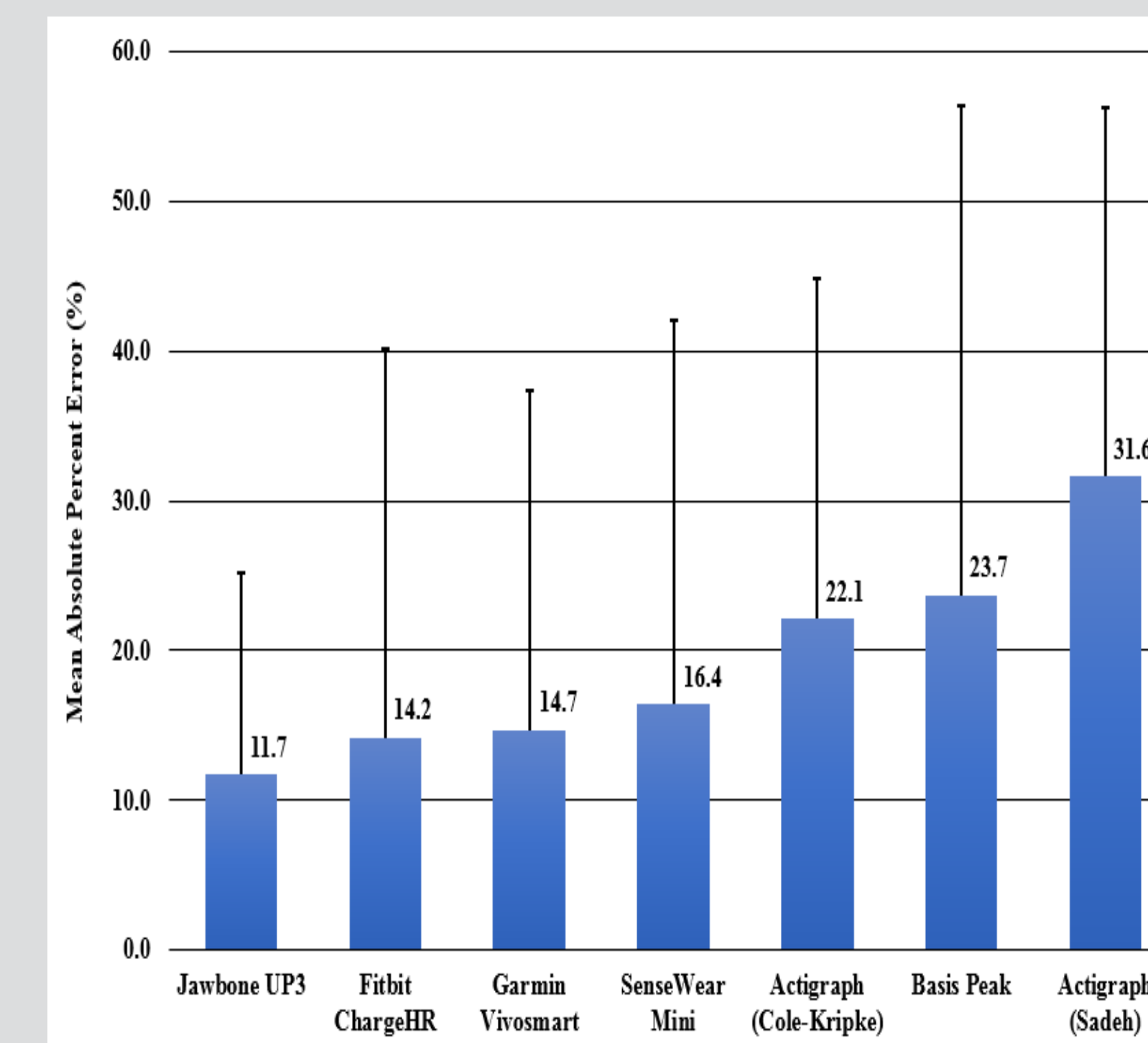
	SenseWear Mini	Fitbit Charge HR	Basis Peak	Actigraph (Sadeh)	Actigraph (Cole-Kripke)	Garmin Vivosmart	Jawbone UP3
Total	0.66**	0.48**	0.36**	0.32**	0.39**	0.49**	0.64**
Effect Size	0.09	0.42	0.74	1.22	0.69	0.16	0.07

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

### RESULTS (Cont.)

Figure 1. MAPE for Total Sleep Time



\*MAPE: Mean Absolute Percentage Error

Figure 2. MAPE for Time in Bed

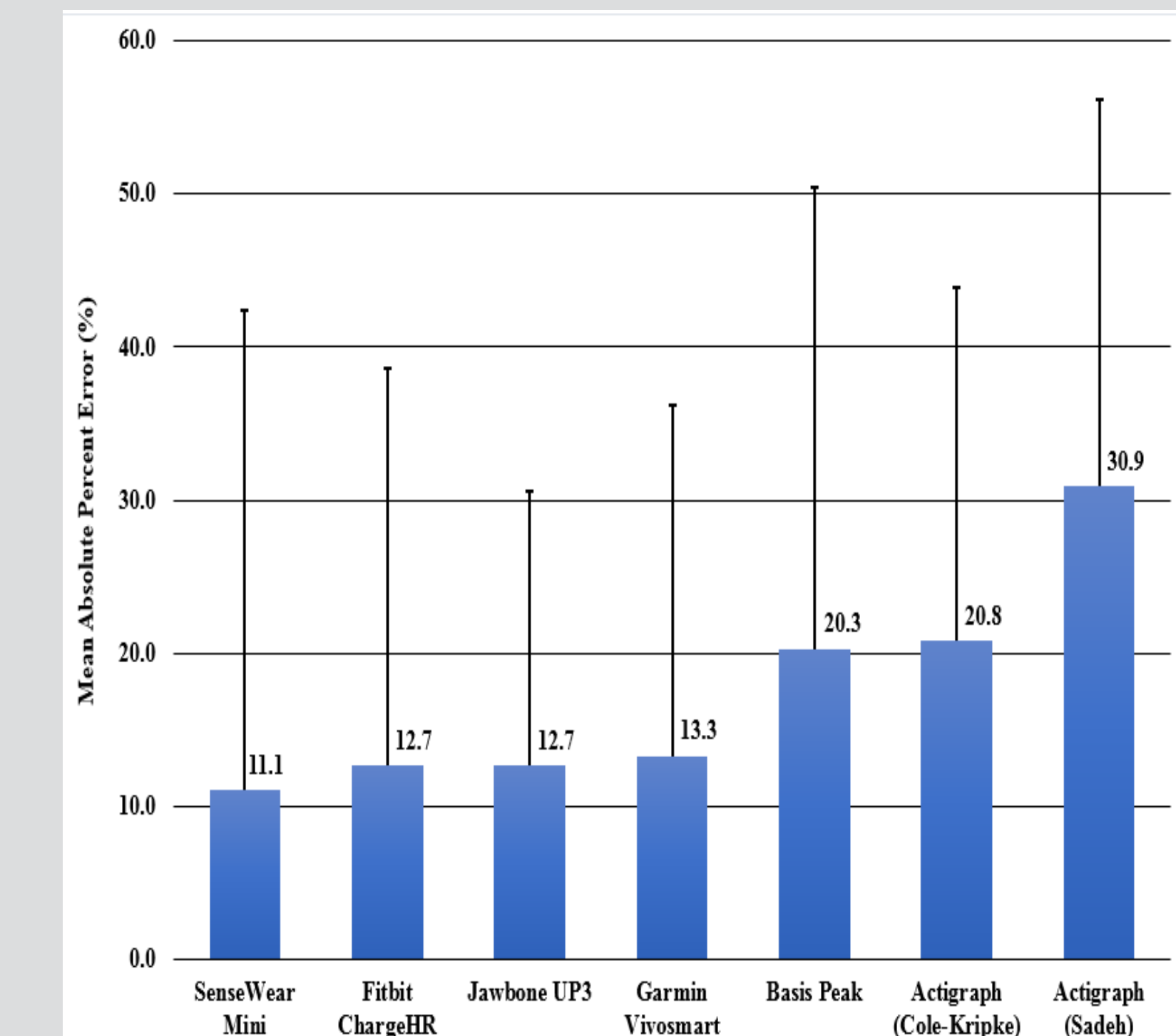
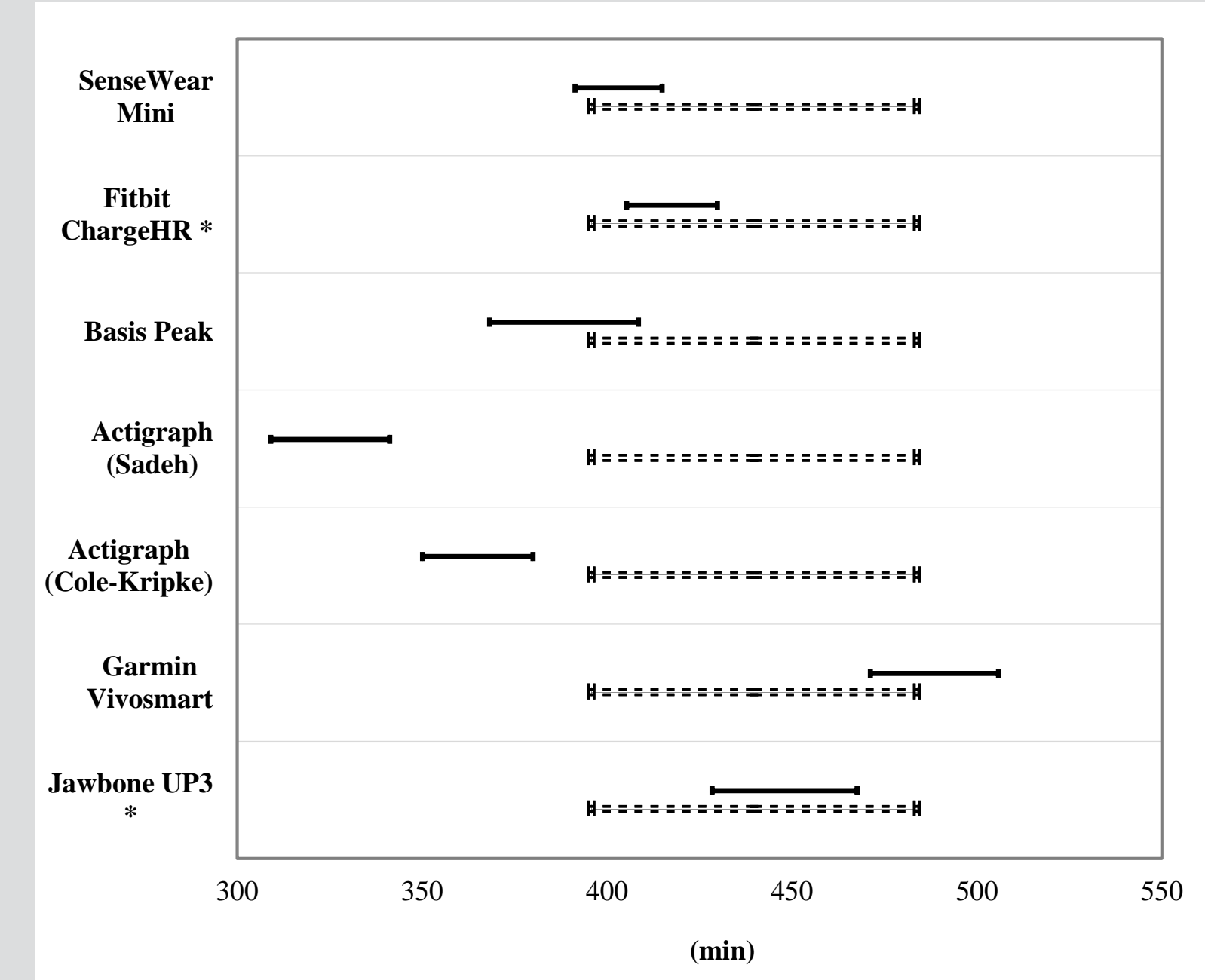
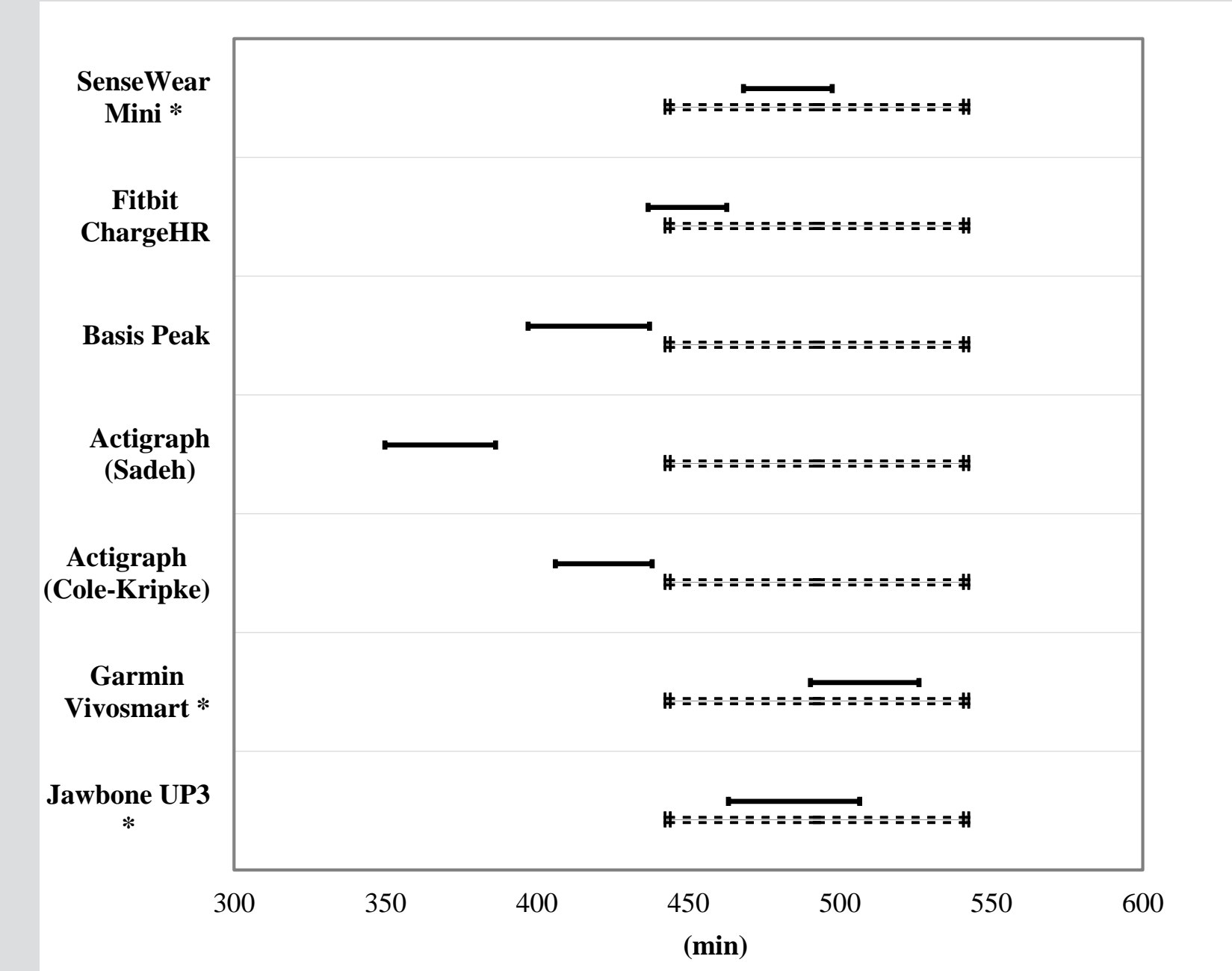


Figure 3. Equivalence Testing for Total Sleep Time



\* Within the 10% equivalence zone.

Figure 4. Equivalence Testing for Time in Bed



- Sleep Efficiency: Low to no correlation with diary
- Wake After Sleep Onset: Large variation in reporting; no correlation with diary
- ANOVA post-hoc (Tukey HSD) revealed no significant difference for TST between the sleep diary and the SenseWear, Fitbit, Garmin, and Jawbone.
- ANOVA post-hoc (Tukey HSD) revealed no significant difference for TIB between the sleep diary and the SenseWear, Garmin, and Jawbone.

### CONCLUSION

- As compared with a sleep diary, consumer monitors (and the SenseWear Armband) performed better than the Actigraph.
- The Fitbit Charge HR, Jawbone UP3, and Garmin Vivosmart can be valid measures of total sleep time
- These monitors are not valid regarding wake times during a night of sleep.
- More research is needed to validate these monitors with polysomnography, as well as explore the differences between the way each monitor tracks sleep variables

