SHORT COMMUNICATION

Sleep Science

What wrist should you wear your actigraphy device on? Analysis of dominant vs. non-dominant wrist actigraphy for measuring sleep in healthy adults

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ABSTRACT

Objective: Differences in sleep results due to the placement of actigraphy devices (non-dominant vs. dominant wrist) are yet to be determined. **Methods:** 65 nights of data from 13 adult participants was collected while participants wore two actigraphy devices, one on each wrist. Sleep indices including total sleep time (TST), total time in bed (TTB), sleep efficiency (SE%), sleep latency (SL), wake after sleep onset (WASO), sleep onset time (SOT) and wake time (WT) were assessed between the two devices. **Results:** There were no significant differences between devices for any of the measured sleep variables (p>0.05). SE%, SL and WASO resulted in *high* correlations between devices (0.89, 0.89 and 0.76, respectively), with all other sleep variables resulting in *very high* correlations (>0.90) between devices. **Conclusions:** Based on our results, it does not seem critical which wrist the actigraphy device is worn on for measuring key sleep variables.

Keywords: Polysomnography; Actigraphy; Validity of Tests; Technology.

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INTRODUCTION

The quantification and measurement of sleep amongst various interventional and population research studies and clinical settings is of increasing importance. Sleep monitoring has also become a substantial consumer industry, with a rising rate of commercial companies producing various wearable sleep monitoring devices[1]. Although considered the 'gold standard' method of sleep measurement, polysomnography (PSG) requires a somewhat intrusive and expensive assessment of sleep indices. Wrist actigraphy is a non-intrusive, cost-effective tool used to estimate sleep quantity and quality which has been compared to PSG, showing an accuracy of up to 93% in healthy adults for total sleep time and sleep efficiency[2,3] and as such is widely used in the sleep literature[4].

Actigraphy involves the use of a device housed in a wristwatch that contains a small accelerometer capable of sensing movement along any one of three axes[4]. The accelerometer is sampled multiple times per second and the actigraph is downloaded and either manually or automatically scored for sleep indices. While actigraphy has become commonplace in both the research and consumer setting, the optimal placement of the actigraph itself is relatively unknown.

Traditionally, the majority of research studies recommend that the actigraphy device should be worn on the non-dominant wrist[4], however some studies have suggested that it may be more suitable to wear the actigraph on the dominant wrist[5], and others do not specify what wrist it should be worn on[6]. Furthermore, the new emerging technology over the past decade has seen improved automatic scoring actigraphy devices, reducing the need for sleep technicians.

Given the increasing use of actigraphy for monitoring sleep, the new and emerging technology for automatic scoring of devices and the disparate recommendations in the literature, this is an important area that needs further clarification. Therefore, the aim of the current case study was to determine if differences exist between wearing automatic-scoring actigraphy devices on the non-dominant and dominant wrists in healthy adults.

METHODS

Participants

A total of 13 healthy adults (8 male / 5 female, mean ± SD, age: 26±7) volunteered to take part in the study. All participants were free of any diagnosed sleep disorders. Ethical approval for the study was obtained through the institutions Human Research Ethics Committee.

Study Design

Participants were required to wear a wrist actigraphy device (Readiband, Fatigue Science, Vancouver) on each wrist (dominant and non-dominant) over a period of 5 nights. Participants were instructed to maintain their usual sleep habits and general daily activity patterns during the monitoring period, and were instructed to leave the devices on at all times. The Readiband has been validated against PSG, with accuracy levels of 93% being reported[7] and research from our laboratory has also shown that the Readiband results in acceptable levels of inter-device reliability (ICC = >0.90)[8].

At the conclusion of each recording period, actigraphy data were wirelessly downloaded to a computer using a Nordic 2.4 GHz ANT transceiver, which was then analysed using Fatigue Science software (16Hz sampling rate: ReadibandT, Fatigue Science, Vancouver). The raw activity scores were translated to sleep-wake scores based on computerized scoring algorithms. Sleep indices including total sleep time (TST), sleep efficiency (SE%), total time in bed (TTB), sleep latency (SL), wake after sleep onset (WASO), sleep onset time (SOT) and wake time (WT) were used for comparison between devices.

Statistical Analysis

Simple group statistics are shown as means ± standard deviations unless stated otherwise. An independent-samples T-test was used to compare dominant and non-dominant wrist measures using the Statistical Package for Social Science (V. 22.0, SPSS Inc., Chicago, IL), with statistical significance set at $p<0.05$. Inter-device agreements for dominant and non-dominant wrists were examined using Pearson's correlation coefficients (r) with 95% confidence intervals (95% CI) and interpreted as 0.90-1.00 = *very high* correlation, 0.70-0.89 = *high* correlation, 0.50-0.69 = *moderate* correlation, 0.26-0.49 = *low* correlation and 0.00-0.25 = *little, if any* correlation[9]. Between-device typical error of estimates (TEE) was determined using an excel spreadsheet[10] and are presented as a coefficient of variation percentage (CV%) and as absolute values. Similar to Werner et al.[11], we defined an apriori difference between the 2 devices of = 30 min satisfactory for TST, with a difference < 5% for SE satisfactory.

RESULTS

There were no significant differences between devices for any of the measured sleep variables ($p>0.05$).

Mean differences of 6 mins and 2 min between non-dominant and dominant wrists for TST and TTB were associated with CV% scores of 4.6 and 3.8%, respectively (Table 1).

TST, TTB, SOT and WT all resulted in *very high* correlations (>0.90), with SE%, SL and WASO resulting in *high* correlations between devices (0.89, 0.89 and 0.76, respectively).

DISCUSSION

The main finding in the current study was that there were no significant differences between non-dominant and dominant wrist actigraphy for monitoring sleep in healthy adults. The non-significant differences between devices were associated with *high* to *very high* correlations for all sleep measures and relatively low (~5%) CV's for the key sleep variables of total sleep time, total time in bed and sleep efficiency. The typical error of estimate for total sleep time and total time in bed was ~20 minutes and the mean bias was ~5 minutes, suggesting that there is little difference in what wrist the actigraph is worn on.

Table 1. Mean ± SD values for the measured sleep variables between non-dominant and dominant wrist-actigraphy devices. Comparison between devices are reported using mean bias, Pearson correlations (r), typical error of estimates (TEE) and coefficient of variation % with 95% confidence intervals.

	Non-Dominant	Dominant	Mean bias	Pearson's r	TEE	CV%
Total Sleep Time (mins)	436±72	442±80	6±19	0.97 (0.95 - 0.98)	18 (15 -22)	4.6 (3.8 - 4.7)
Total Time in Bed (mins)	552±85	554±83	2±20	0.97 (0.95 - 0.98)	20 (17 - 25)	3.8 (3.1 - 4.7)
Sleep Efficiency (%)	81±9	82±6	1±4	0.89 (0.81 - 0.94)	4 (3 - 5)	5.3 (4.4 - 6.6)
Sleep Latency (mins)	29±34	28±31	-1±15	0.89 (0.82 - 0.94)	15 (13 - 19)	102.4 (80.2 - 140.7)
Wake After Sleep Onset (mins)	53±38	52±43	-1±28	0.76 (0.61 - 0.86)	25 (21 - 32)	60.5 (47.7 - 82.5)
Sleep Onset Time (time of day)	23:25±1:32	23:24±1:33	-1±11	0.99 (0.99 - 0.99)	12 (11 - 15)	0.8 (0.7 - 1.0)
Wake Time (time of day)	7:30±1:21	7:31±1:21	1±11	1.00 (1.00 - 1.00)	11 (9 - 14)	2.5 (2.1 - 3.1)

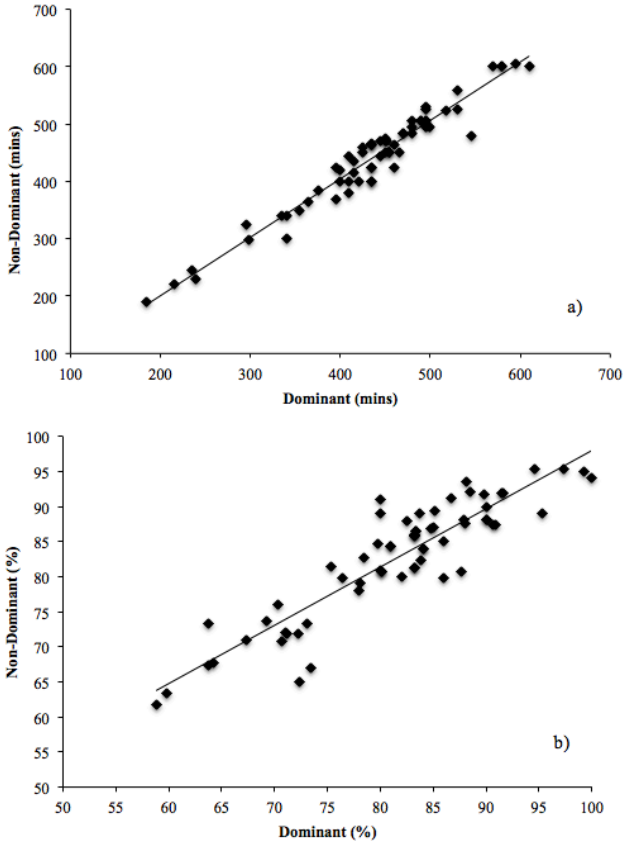

Figure 1. Correlation plots between non-dominant and dominant wrist actigraphy data for: a) total sleep time (mins), and b) sleep efficiency (%).

The use of wrist-actigraphy for monitoring sleep is becoming increasingly popular in numerous research fields, including athletic[12], clinical[13], adolescent[14] and pediatric[15] populations. However, while traditionally it was suggested that actigraphy devices should be worn on the dominant wrist of participants[16], there is a lack of evidence to show whether or not any differences actually exist. Furthermore, the ever-evolving technology of sleep monitoring via actigraphy has introduced automatic-scoring devices[8], further identifying the need to investigate differences in the placement of devices.

As previously suggested[6,17], care should be taken when interpreting results for WASO and SL when measured via wrist actigraphy, as the accuracy of these measures when compared to PSG is questionable. The current study would support this, as these were the most variable sleep indices between the two devices, with typical error of estimates and CV% of ~25 minutes and ~60% for WASO and ~15 minutes and ~100% for SL, respectively.

Results from the current study would suggest that the placement of the actigraphy device (dominant vs. non-dominant wrist) is not critical for accurate sleep measurement of key sleep measures including total sleep time, total time in bed, sleep onset and wake time. Given this, the authors would recommend that individuals wearing actigraphy devices, either as general consumers or research participants, should opt to wear their actigraphy device on whatever wrist feels the most comfortable. Indeed, if the device feels uncomfortable, it is more likely to influence adherence to wearing the monitor and overall sleep results.

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