EVALUATIONS OF EFFECTS OF HIGH REBOUND AND LOW REBOUND MATTRESS PADS ON SLEEP AND ASSOCIATED PHYSIOLOGY

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Introduction

Although increasing the sleep quality by choosing the optimal sleep environment important, little scientific evaluation has been made for the effect of bedding on sleep and its associated phenomena. Recently, several new materials for mattresses have been introduced. Although some of these, such as low rebound (or pressure-absorbing) and high rebound mattresses have fairly different characteristics, effects of these mattresses on sleep have never been evaluated scientifically.

In the current study, we have evaluated effects of airweave™ (a high rebound [HR] mattress pad sold in Japan) on sleep and its associated physiology and the effects were compared to those of a low rebound mattress pad (LR) with a design similar to the HR mattress.

Materials & Methods

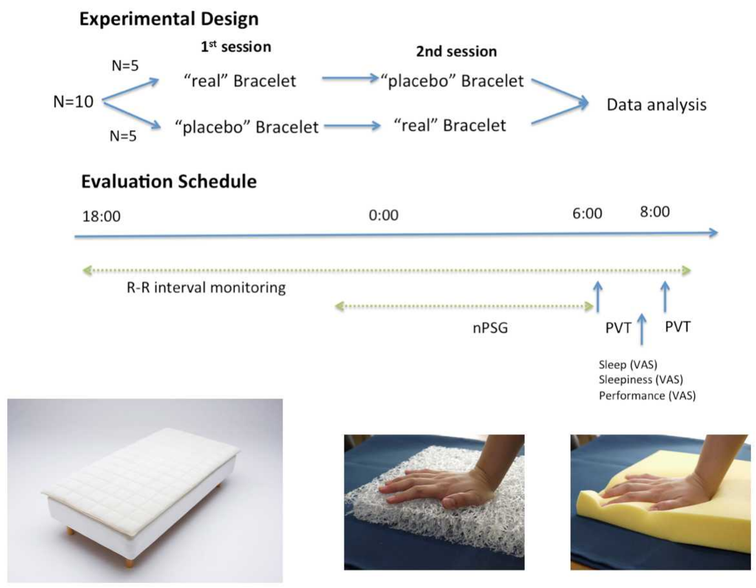
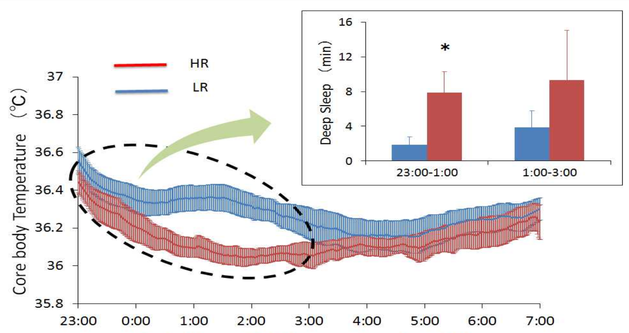


Fig.1. Experimental design and schedule.
Bottom figures: airweave mattress pad (left) used in the study. HR (airweave, center) and LB (right) materials.

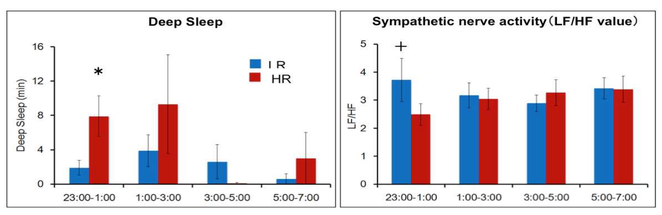
The study was conducted in 10 healthy males, with a randomized cross over single-blind design of one night PSG at the sleep laboratory (i.e., Ota Memorial Sleep Center) with 1-2 day intervals (Fig. 1). The mattress pads were placed on regular beds equipped in the laboratory (Fig.1, insert). Thirty subjects without any sleep disorders, circadian rhythm disorders, or allergic rhinitis were initially selected. Acclimation PSG night was performed in subjects with low Pittsburg Sleep Quality Index Score (PSQID), and 10 subjects with 3% Oxygen Desaturation Index (ODI) of <5 and respiratory disturbance index (RDI) of < 5 were finally selected. The mean age of the 10 subjects was 26.7±7.7(SD) yrs, height, 169.6±6.3m, weight, 61.9±5.2kg, BMI, 21.2±1.7, PSQID, 3.0±0.7, 3% ODI, 2.3±1.1, RDI, 1.8±1.2. In addition to the PSG (23:00 to 7:00), number of roll-over during sleep, autonomic nerve activity (by monitoring EKG heart rate variability), core rectal temperature monitoring, urinary growth hormone (GH) levels were assessed. Subjective sleep evaluations were done on the following morning, using visual analogue scales (good sleep/feel fine [VAS-S] and performance [VAS-P]) and the Stanford sleepiness scale (SSS). Performance was also evaluated with psychomotor vigilance test (PVT). All subjects were blind to the information of the mattress used, and the significances of the effects (between HR and LR) were evaluated with the paired-t test, except effects of rectal temperature monitoring for which a repeated measures ANOVA with a grouping factor (mattress types) was applied. The study was approved by the IRB of Ota Sleep Disorders Center, and all subjects provided informed consent.

Results



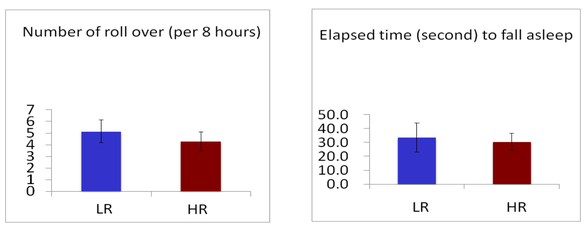
Changes in core body temperature during sleep

Fig. 2. Changes in core body temperature during sleep with HR and LR. Larger and longer lasting decrease in core body temperature was seen in the initial half of the sleep period with HR. During this period, large amounts of deep sleep (stage 4) were seen with HR (right/top insert).



＊P<0.05, ＋P<0.1

Fig. 3. Amounts of deep sleep and sympathetic nerve activity (LF/HF values) during each 2 hour period with HR and LR. Predominance of parasympathetic nerve activity (as well as increase in deep sleep) was seen during the initial phase of sleep with HR.



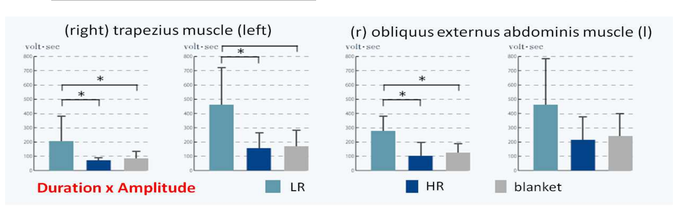


Fig. 4. Top: **Number of roll overs per night and the mean elapsed time (seconds) to fall in sleep after the roll over during sleep with HR and LR .**
Bottom: **Muscle activities needed for having rollover with HR and LR mattress** (Data from Dr. Uchida, Waseda University).

- Subjects fell asleep rapidly with both HR (7.1±2.1 min) and LR (9.1±2.6 min). Interestingly, the core body temperature rapidly and continuously decreased with HR and reached the nadir (36.0 ºC) at 2:00-3:00, while decline of the temperature with LR was modest and remained 0.4 ºC higher than that with HR between 1:00 to 2:00 (p=0.002) (Fig. 2). In overall 8 hours sleep evaluations by PSG, there were little differences between HR and LR. REM latency was shortened marginally with HR (Table 1). Since significant difference in core temperature was observed the initial phase of the sleep, PSG data was also analyzed for each 2 hour time bin, 23:00 to 1:00, 1:00 to 3:00, 3:00 to 5:00, and 5:00 to 7:00.
- A significant increase in Stage 4 sleep was found with HR between 23:00 to 1:00 (Fig.1, insert and Fig. 2, left). In addition, decrease in sympathetic nerve activity (low frequency/high frequency ratio of heart rate intervals) was prominent with HR between 23:00 to 1:00 (Fig. 2 right). Numbers of rollover and elapsed time to fall in sleep after the rollover with HR (Fig. 4, top) had a non-significant tendency be lower than with LR. A separate study conducted in Waseda University (Dr. Sunao Uchida) also reported that much smaller efforts are needed for rolling over with HR than with LR mattress (Fig. 4, bottom); the result may partially be reflected in the results of the sleep study. Subjective wakefulness and performance of the next morning with HR was improved marginally significantly (Fig. 5).

Table 1. Comparisons of sleep and sleep-related parameters between HR and LR

	SPT	TST	SL	REM latency	SE (TST/SPT)	%stage1 (/TST)	%stage2 (/TST)	%stage34 (/TST)	%stageREM (/TST)	SE (TST/TIB)
HR	470.85±2.50	428.60±17.27	7.05±2.12	75.80±14.43	91.01±3.61	8.29±0.50	56.63±1.81	11.32±1.15	23.81±2.08	89.29±3.60
LR	470.90±2.61	443.00±7.74	9.10±2.61	93.65±17.73	94.11±1.79	8.83±0.76	52.84±2.41	12.65±1.23	25.68±2.60	92.28±1.62
p-value	0.84	0.64	0.46	0.07	0.81	0.64	0.16	0.18	0.40	0.60

	%stageWAKE (/SPT)	%stage1 (/SPT)	%stage2 (/SPT)	%stage34 (/SPT)	%stageREM (/SPT)	arousal index	Roll over total	Roll over during sleep	wake (sec) afther roll over
HR	9.45±3.70	7.53±0.54	51.06±1.43	10.24±1.07	22.23±2.39	4.65±0.64	7.11±3.29	4.29±0.81	30.50±6.12
LR	5.88±1.79	8.24±0.63	49.70±2.28	11.81±1.03	24.38±2.57	4.33±0.38	4.44±1.29	5.14±0.97	33.51±10.51
p-value	0.14	0.31	0.94	0.12	0.43	0.70	0.50	0.26	0.77

	VASS	SSS	VASP	SSS2	VASP2	GH	LF/HF
HR	7.27±0.60	2.60±0.22	7.59±0.42	1.20±0.13	8.97±0.35	7.73±1.19	3.05±0.42
LR	5.93±0.75	2.60±0.16	6.51±0.66	1.30±0.15	8.35±0.63	7.25±1.03	3.30±0.47
p-value	0.07	0.93	0.05	0.34	0.11	0.58	0.46

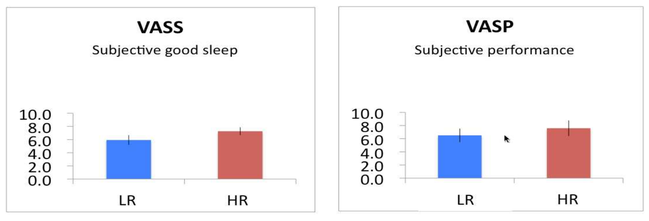


Fig. 5. Subjective visual analogue scale (VAS) having good sleep and performance after sleep with HR and LR.

Total Sleep Period (sleep period time)
Total Sleep Time (TST)
SL (sleep latency)
SE (sleep efficacy)
VASS (visual analogue scale good sleep)
VASP (visual analogue scale performance)
SSS (Stanford Sleepiness Scale)
GH (growth hormone)
LF/HF (low frequency/high frequency hear rate variability)

Conclusions

- We found that two types of mattresses, namely high rebound and low rebound mattresses had significantly different effects on sleep and sleep related physiological parameter. The HR mattress we used induced rapid and continuous decline in core body temperature. The increased amount of deep sleep and the predominance of parasympathetic nerve activity occurred in association with changes in the core temperature observed.
- Our results suggest that effective heat loss while in bed occurred with HR, and this may facilitate restorative sleep. Our results also confirm that the selection of the bedding is one of the important factors to improve sleep and its associated phenomena.