

# Sleep Enhances Motor Skill Learning and Memory Consolidation in Individuals Post-Stroke

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## INTRODUCTION

- Sleep is important for motor learning and memory consolidation in young neurologically intact individuals<sup>1-4</sup> but not for older individuals<sup>5,6</sup>
- Lack of sleep-dependent enhancement on explicit and implicit sequence learning task<sup>5</sup> and declarative word-pair task<sup>6</sup>
- Other learning variables such as type of instruction (i.e. explicit instruction vs. no instruction or implicit learning) may influence sleep-dependent memory consolidation.
- Explicit skill learning is sleep-dependent whereas implicit motor learning is time dependent in young neurologically intact people<sup>7</sup>
- 20-40% of people with stroke have sleep-wake disorders<sup>8</sup>
- 53% of chronic stroke individuals demonstrate abnormal sleep EEG<sup>9</sup>

**Purpose:** To examine the role of sleep and instruction in motor skill learning and memory consolidation in individuals following stroke

## METHODS

### Participants:

- 40 individuals chronic (>6 mo) post-stroke (ST) pseudo-randomized into: 1. sleep/implicit, 2. no-sleep/implicit, 3. sleep/explicit, or 4. no-sleep/explicit groups
- 37 neurologically intact individuals (CT) sex and age-matched (+/- 5 years)

### Task:

- Continuous tracking task practiced in evening (sleep groups) or in morning (no-sleep groups)
- 10 blocks of 10 trials per block; each trial 1 random and 1 repeated segment in counterbalanced order
- Retention test 12 hrs later (+/- 1 hour); 1 block

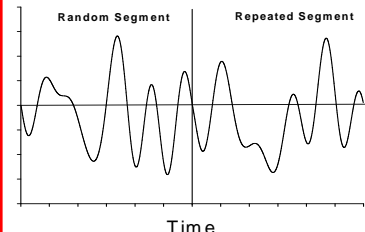


Figure 1. Example of trial. This example shows the random segment followed with repeated segment (12.5s each segment; trial length 25s with 2s baseline trial divider)

**Hand Used:** ST - ipsilesional hand; CT - same as matched ST

## METHODS (cont'd)

**Instruction:** Half in sleep and no-sleep groups implicit condition; other half explicit condition

		Session 1	Session 2
Explicit Condition	Information Provided	1. "There is a repeating pattern" 2. Shown pictorial representation 3. Watch repeated pattern on computer	
	Explicit Knowledge Test	Recognition test prior to practice	Recognition test following retention
Implicit Condition	Information Provided	"This is a tracking task"	
	Explicit Knowledge Test	None	Recognition test following retention

### Other Tests:

- Orpington Prognostic Score & upper extremity motor portion of the Fugl-Meyer (UEFM)
- Mini-mental State Examination (MMSE)
- Stanford Sleepiness Index
- Pittsburgh Sleep Quality Index (PSQI)
- Geriatric Depression Scale (GDS)
- Edinburgh Inventory - all except 2 R hand dominant
- Sleep log for week prior to testing

	Sex	Age	PSQI	GDS	Average sleep
ST Sleep Implicit (n=10)	6 M	62.9	4.89*	5.44*	7.26
	4 F	(10.5)	(2.2)	(3.9)	(1.5)
ST No-Sleep Implicit (n=10)	3 M	65.5	7.4	7.5	7.53
	7 F	(15.4)	(4.3)	(6.7)	(1.1)
ST Sleep Explicit (n=10)	6 M	62.2	5.89	4.44	7.7
	4 F	(10.3)	(2.5)	(4.1)	(1.1)
ST No-Sleep Explicit (n=10)	5 M	59.8	5.2	4.38	7.8
	5 F	(13.7)	(3.9)	(3.9)	(1.5)
CT Sleep Implicit (n=9)	5 M	66.1	5.44	3.33	6.92
	4 F	(7.4)	(3.8)	(2.8)	(0.8)
CT No-Sleep Implicit (n=10)	3 M	64.5	5.2	3.5	7.2
	7 F	(15.5)	(2.7)	(3.0)	(1.3)
CT Sleep Explicit (n=9)	4 M	59.9	6.25	3.14	7.21
	4 F	(10.6)	(2.2)	(2.4)	(0.9)
CT No-Sleep Explicit (n=10)	5 M	59.3	5.6	3.22	7.64
	5 F	(13.0)	(3.5)	(2.2)	(1.4)

Table 1. Descriptive Information for participants. Data are mean (st dev). M= male; F= female. Average sleep=average amount of sleep week prior to testing determined by sleep log. For those participants who did not keep a sleep log, the PSQI was used to calculate an average sleep score; \*n=9

## METHODS (cont'd)

	Time Post-Stroke (months)	UEFM	Orpington	Side of Lesion
St Sleep Implicit	81.8	41.4	2.48	3 Left;
	(60.9)	(16.0)	(.75)	7 Right
St No-Sleep Implicit	65.0	49.6*	2.62*	3 Left;
	(43.7)	(14.5)	(.85)	7 Right
St Sleep Explicit	63.9	47.3	2.68	4 Left;
	(43.7)	(18.3)	(.76)	6 Right
St No-Sleep Explicit	66.6	47.0	2.27*	7 Left;
	(87.3)	(18.8)	(1.07)	3 Right

Table 2. Descriptive information for stroke participants. Data are mean (st dev); \*n=9

### Data Analysis:

- Root Mean Square Error (RMSE) calculated for repeated segment of each trial
- Median RMSE calculated for each block
- Off-line learning score = retention - last practice block

### Statistical Analysis:

- Parameter estimates determined significant change in performance from last practice block to retention
- One-way ANOVAs determined group differences on descriptive tests.

## RESULTS

**Off-Line Learning:** Both the stroke sleep groups regardless of instruction demonstrated learning at retention

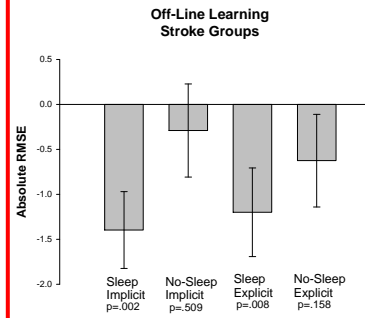


Figure 1. Off-line learning for stroke (ST) groups. A negative score indicates an improvement or less error at retention as compared to the last block of practice. Error bars are SEM.

## RESULTS (cont'd)

**Off-Line Learning:** None of the control groups demonstrated learning at retention

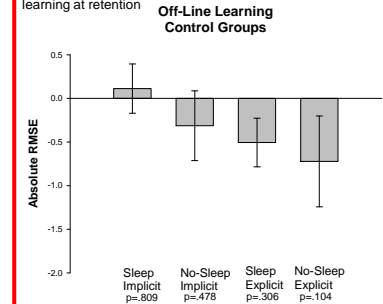


Figure 2. Off-line learning for control (CT) groups. Error bars are SEM.

**Group Descriptives:** No group difference in age (p=.875), Stanford Sleepiness Scale at practice (p=.179) or retention (p=.252), MMSE (p=.131), PSQI (p=.776), GDS (.270), average sleep (p=.458), time-post stroke (p=.911), Orpington (p=.920), or UEFM (p=.630)

## DISCUSSION

- Sleep enhances both explicit and implicit skill learning in post-stroke individuals
- May be due to maintenance of REM sleep and an increase in stage-2 non-REM sleep<sup>9</sup> compared to norms<sup>10</sup>
- Control participants did not benefit from sleep to promote skill learning and memory consolidation
- Provide concurrent evidence that healthy older adults are not reliant on sleep for motor memory consolidation
- Clinical Implications:
  - May lead to an emphasis on the need for sleep between therapy sessions
  - Address underlying sleep disorders

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