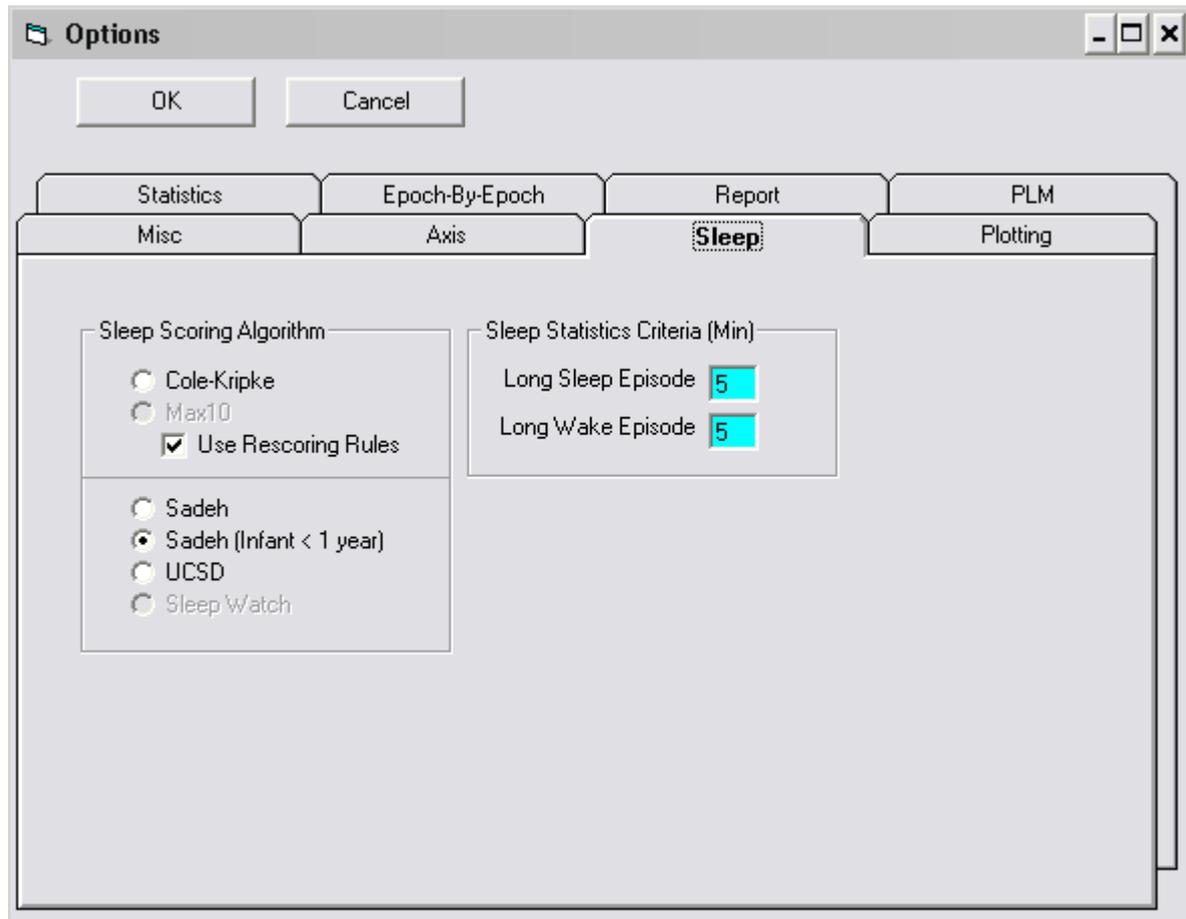


## Sleep Options

When a DAT file is opened, each **epoch** is scored as sleep or wake using one of three methods: **Cole-Kripke, Sadeh, or Sadeh (infant)**. If the data were collected with a Sleep Watch, which scores sleep on the wrist using the Cole-Kripe algorithm (without rescoreing), the on-wrist scores can be restored by selecting "Sleep Watch".

**Note:** when a new sleep scoring algorithm is selected, it will not take effect until a new DAT file is read in, or **Analyze: Score Sleep** is chosen from the main menu.



The "SleepStatistics Criteria" panel allows the user to set criteria for what will be considered a "Long Wake Episode" and a "Long Sleep Episode" (see [Statistics](#)). These statistics are included to roughly estimate "awakenings" and "naps".

### Cole-Kripke Sleep Estimation

The method described by Cole & Kripke (1988), and Cole, *et al.* (1992) computes a weighted sum of the activity in the current minute, the preceding 4 minutes and the following two minutes as follows:

$$S = 0.0033 * (1.06 * a_n4 + .54 * a_n3 + .58 * a_n2 + .76 * a_n1 + 2.3 * a_0 + .74 * a_1 + .67 * a_2)$$

where  $a_n4$ - $a_n1$  are activity counts from the prior 4 minutes,  $a_0$  is the current minute and  $a_1$  and  $a_2$  are the following 2 minutes.

The current minute is scored as sleep if  $S < 1$ .

By default, after initial scoring with this algorithm, several "rescoring rules" are applied to correct some of the more obvious difficulties with the weighted average method. These rules are:

- rule 1: rescore one minute of sleep as wake if the preceding 4 minutes were wake
- rule 2: rescore three minutes of sleep as wake if the preceding 10 minutes were wake
- rule 3: rescore four minutes of sleep as wake if the preceding 15 minutes were wake
- rule 4: if 6 min or less scored as sleep surrounded by at least 15 min before AND after scored as wake, then rescore as wake
- rule 5: if 10 min or less scored as sleep surrounded by at least 20 min before AND after scored as wake, then rescore as wake

The rescoring feature can be disabled with the **Use Rescoring Rules** option.

The Cole-Kripke sleep-scoring algorithm used by Action-W is identical to that used by the Action-W Version 1 program. For normal subjects, the correlation between sleep scores produced by this algorithm and sleep/wake scores from concurrent polysomnography is generally around 0.9. when subjects are in bed trying to sleep.

### Max10 scoring

Similar to the Cole-Kripke scoring method except that epochs of 1, 2, 5, or 10 seconds are assembled into a series of continuous 10 second bins inside of a minute of activity (e.g. 1 second epochs = 51 bins, 2 second epochs = 26 bins, 5 second epochs = 11 bins, 10 second epochs = 6 bins). Those continuous bins are scanned for the highest activity count. That count is then used for that particular minute's sleep scoring.

#### Limitations on automatic sleep scoring:

1. Automatic scoring will be performed only if the epoch duration is either 60 seconds or is evenly divisible into 60 seconds. Thus, epochs of 1, 2, 3, 4, 5, 6, 10, 12, 15, 20, 30, and 60 seconds are legal. Sleep scoring will not be performed for any other epoch durations. If the epoch is less than 60 seconds, epochs are pooled to make 60-second epochs for purposes of sleep scoring unless the **Max10** option is selected.
2. Some (not all) Mini-Motionlogger actigraphs have user-selectable sensitivity and bandpass amplifier settings. **The sleep scoring algorithm is validated only for setting 18** (Basic actigraphs may show a setting of 0 which is equivalent to 18). If any other setting is used, Action-W will not score sleep.
3. Cole-Kripke and Sadeh sleep scoring will be performed only if the data were collected in Zero-Crossing Mode. That is, Time Above Threshold or Proportional Instrument Mode data will not be scored. The UCSD Algorithm will handle either Zero-crossing or PIM data.
4. The sleep estimations performed by Action-W are valid only for wrist-worn actigraphs. That is, if the actigraph is worn on the waist or ankle, the sleep estimations are not valid.

#### References:

- Cole RJ and Kripke DF (1988). Progress in automatic sleep/wake scoring by wrist actigraph. *Sleep Research*, **17**, 331.
- Cole RJ, Kripke, DF Gruen W, Mullaney DJ, and Gillin JC (1992). Automatic sleep/wake identification from wrist activity, *Sleep*, **15**, 461-469.
- Jean-Louis, G, Kripke, DF, Mason, WJ, Elliot, JA, and Youngstedt, SD (2001) Sleep estimation from wrist movement quantified by different actigraphic modalities. *Journal of Neuroscience Methods*; **105**, 185-191.
- Webster JB, Kripke DF, Messin M, Mullaney DJ, Wyborney, G ( 1982). An activity-based sleep monitor system for ambulatory use. *Sleep*, **5**: 389-399.

### Sadeh (adult) Sleep estimation

This algorithm estimates sleep according to the method described by Sadeh, Sharkey, and Carskadon (1994). The formula used is:

$$PS = 7.601 - 0.065 * MW5 - 1.08 * NAT - 0.056 * SD6 - 0.073 * \ln(ACT)$$

where:

**MW5** = average activity counts during the scored minute, the 5 preceding minutes, and the 5 following minutes

**NAT =** number of epochs with activity level  $\geq 50$  and  $< 100$  in the same 11-min window described for MW5

**SD6 =** standard deviation of the scored minute and the 5 minutes preceding it

**ln(ACT) =** natural logarithm of the activity counts for the scored epoch + 1

If PS is zero or greater, then the epoch is scored as sleep, otherwise the epoch is scored as wake.

#### **Sadeh (infant) Sleep estimation**

This algorithm was designed for use with infants  $< 1$  year of age. It estimates both normal sleep and "light sleep".

#### *References:*

Sadeh, A., Alster, J., Urbach, D., and Lavie, P. (1989). Actigraphically based automatic bedtime sleep-wake scoring: Validity and clinical applications. *J. Ambulatory Monitoring*, **2**, 209-216.

Sadeh, A., Sharkey, K. M., and Carskadon, M. (1994). Activity-based sleep-wake identification: an empirical test of methodological issues. *Sleep*, **17**, 201-207.

#### **Sleep Latency**

Option to select latency as minutes to start of 1st continuous block of at least:  
20 minutes of sleep (default) or 10 minutes.