Sueño – Sleep Habits in HCHS

Overview of Actigraphy Processing

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1. OBJECTIVE

This document is designed to assist users of the Sueño dataset by providing an explanation of the analytic process used to create Sueño actigraphy variables.

This document is organized in the order in which data cleaning and optimization steps were taken and is best understood in conjunction with the Sueño Database Dictionary and Reading Center Manual of Procedures.

2. CONVERTING EPOCH LENGTH

The epoch length (time sampling interval) for data collection was procedurally set to 30-seconds, per study protocol. In cases where the epoch length was accidentally configured to 15-seconds, activity and light data were converted to 30 second epochs. Variable SAWA341 specifies the original epoch length in which data was recorded.

Activity data was converted to 30-second epochs by summing the activity counts in each pair of consecutive 15-second epochs. If data for one 15-second epoch was invalid but the data for the other 15-second epoch in the pair was valid, then the data in the available epoch was multiplied by two.

Light data was converted to 30-second epochs by averaging the light intensity in each pair of consecutive 15-second epochs. If data for one 15-second epoch was invalid but the data for the other 15-second epoch in the pair was valid, then the data in the available epoch was used as the value for the 30-second epoch.

3. DATA OPTIMIZATION

3.1 CALCULATING SLEEP/WAKE STATUS

Each epoch outside of a rest interval is scored as wake, regardless of the activity level. For epochs within a rest interval, Actiware uses a three part process to determine sleep/wake status.

First, Actiware computes a weighted average of the activity count in the epoch of interest, the four previous epochs, and the four subsequent epochs. If this weighted average is less than or equal to the pre-set threshold (40 counts/min for Sueño), the epoch is labeled as a low activity level; if it is greater than this threshold, the epoch is labeled as high activity.

Actiware labels each epoch with a high/low activity status only if a minimum of the five nearest epochs (the epoch of interest, two previous, and two subsequent) have valid counts. Thus, a missing value in one epoch will result in a missing activity level status for a series of 5 consecutive epochs. To minimize the amount of missing data, high/low activity level was recomputed calculating a weighted average based on the subset of nine epochs with non-missing data as long as a minimum of one out of the nine epochs had non-missing data.

Next, Actiware classifies each epoch as mobile or immobile based on the activity count in that epoch. If the count is less than the equivalent of 1 count per 15 seconds, the epoch is classified as immobile and if it is greater than or equal to this threshold, it is classified as mobile. Given the pre-set epoch length of 30 seconds, this translates in Sueño to immobile for an activity count < 2 and mobile for an activity count ≥ 2. Unlike activity level, no imputation was done for missing mobile/immobile scoring.

Finally, Actiware identifies the first low activity level epoch where 9 of the 10 prior epochs are immobile (based on the Sueño pre-set time to sleep onset setting of 5 minutes) as sleep onset. All subsequent epochs labeled as low activity level are then scored as sleep. All subsequent epochs labeled as high activity level as well as all epochs prior to sleep onset are scored as wake.

3.2 SETTING SLEEP OFFSET

The number of immobile minutes for sleep-end was pre-defined for Sueño to be 0. As such, the Actiware software defines sleep offset automatically to the out-of-bed time. For Sueño, sleep offset was redefined as the last epoch in the rest interval scored as sleep. All epochs following this one until the end of the rest interval were defined as snooze time and did not contribute to wake after sleep onset.

3.3 CONVERTING DAYLIGHT SAVINGS TIMES

Attempts were made to avoid data collection overlapping the start and end of daylight savings time (DST) whenever possible due to the abrupt impact of this clock change on sleep patterns. Actiware does not account for daylight savings time as the clock times are fixed at the time the watch is configured by staff. Steps were made to address clock changes resulting from DST. In particular, clock times were adjusted by an hour from those provided by Actiware to account for the actual clock time at the start and end of DST. Adjusted clock times were used to calculate timing variables only. In contrast, duration and sleep quality variables were not adjusted. For example, a participant who went to sleep at 10 PM and awoke at 6 AM on a night where the clock advanced an hour would correctly be noted as having an in-bed time of 10 PM, out-of-bed time of 6 AM, but the sleep duration would be 7 hours. Instances where data collection overlapped with a change in DST are labeled by the variable SAWA340.

3.4 ACTIWARE GENERATED VARIABLES

Variable definitions in the Sueño Database Dictionary containing the following statement indicate variables that were generated by Actiware and were not optimized;

“This variable is similar to SAWAXX; however, SAWAYY is derived from Actiware variable SAWAZZ before data optimization.”

Examples:

SAWA18 (Average Sleep Duration)
This is the average duration of time between sleep onset and sleep offset across all main rest intervals, in minutes. This variable is similar to SAWA152; however, SAWA18 is generated by Actiware software before data optimization.

SAWA45 (Average Sleep Time)
This is the average amount of time spent asleep across all main rest intervals with sleep, in hours. This variable is similar to the Sueño calculated variable SAWA59; however, SAWA46 is calculated based on data generated by Actiware software before data cleaning and imputation.

4. APPROACH TO EPOCHS WITH INVALID DATA

4.1 INVALID ACTIVITY DATA

All mean activity count variables excluded epochs with missing activity data from their calculation. Because days where extended amounts of missing data during a main rest interval were judged invalid and excluded from further analysis, every epoch within a valid main rest intervals has a valid high/low activity level. However, valid days may have included naps with extensive missing activity data and so missing high/low activity level data. These epochs were included in calculating nap durations which were calculated based simply on the time elapsed from the beginning to the end of the interval. However, epochs where activity level status could not be imputed were excluded from calculations of the amount of sleep (or wake) within an interval.

4.2 INVALID LIGHT DATA

Epochs with invalid light data were excluded in calculating any variables involving light exposure.

5. CATEGORIZING MAIN REST INTERVALS

5.1 DURATION

Days with no evidence that the participant had tried to sleep were marked with a 30-second main rest interval. These 30-second main rest intervals were included in the calculation of sleep time (SAWA54, set to 0 minutes), sleep duration (SAWA52, set to 0 minutes) and rest duration (SAWA50, set to 0 minutes) including weekday, weekend, workday, non-workday and reliable days. Main rest intervals of only 30-seconds were excluded in the calculation of all other duration as well as timing and sleep quality variables.

Days on which there was evidence the participant had tried to sleep but had been unsuccessful had a main rest interval marked for the entire period that it appeared they had been trying to sleep. Data from these intervals were included in calculating all main rest interval variables (duration and sleep timing), sleep duration variables (set to 0), sleep bouts (set to 0), sleep efficiency and sleep maintenance efficiency (set to 0) and sleep time (set to 0). Data from intervals with evidence the participant tried unsuccessfully to sleep was excluded in all other duration, sleep quality, and sleep timing variables.

5.2 WEEKDAY/WEEKEND

Main rest intervals were categorized as weekday if the out-of-bed time fell on a Monday-Friday.

Main rest intervals were categorized as weekend if the out-of-bed time fell on a Saturday or Sunday.

5.3 WORK/SCHOOL ATTENDANCE

A main rest interval is categorized as either a workday or a non-workday when the participant self reported in the daily sleep log that they did or did not attend work/school following the end of that main rest interval and before the start of the next main rest interval. Because work/school attendance was determined from the self reported daily sleep log, actigraphy data from a day for which the subsequent

diary entry was missing work/school attendance was excluded in computing workday/non-workday variables.

6. ASSIGNING NAPS TO MAIN REST INTERVALS

6.1 RELIABLE AND OVERALL

Because napping behavior was asked on the daily sleep log for the day prior to each main rest interval, naps were in general assigned to the subsequent main rest interval. Thus, in calculating nap variables “across all days” and “across all reliable days”, naps were assigned to the main rest interval that took place after the nap ended. For example, if the main rest interval that took place after a nap was labeled as ‘reliable’, then all naps preceding that main rest interval until the previous main rest interval would also be labeled as reliable.

6.2 WEEKDAY/WEEKEND

Because napping behavior on a Friday was felt to better reflect weekday behaviors and those on a Sunday to reflect weekend behaviors, nap assignments were reversed in calculating weekday/weekend variables. That is to say, in calculating nap variables “across all weekdays” and “across all weekends”, naps were assigned to the previous main rest interval. Therefore, naps were assigned to the main rest interval that took place before the nap started. For example, if the main rest interval that took place before a nap was initiated was labeled as a ‘weekday’, then all naps following that main rest interval, and before the next main rest interval, were categorized as ‘weekday naps’.

6.3 WORKDAY/NON-WORKDAY

Similarly, in calculating nap variables “across all workdays” and “across all non-workdays”, naps were assigned to the previous main rest interval. Therefore, naps were assigned to the main rest interval that took place before the nap started. For example, if the main rest interval that took place before a nap was initiated was labeled as a ‘workday’, then all naps following that main rest interval, and before the next main rest interval, were categorized as ‘workday naps’.

7. CALCULATING STATISTICS FOR CLOCK TIMES

7.1 GENERAL PROCEDURES

For the purpose of calculating means of clock times, times were first expressed in date-time format. Dates were then replaced with each day’s ordinal number, corresponding to its entry order in the QS database (see Reading Center MOP, section E). Clock times were expressed as the number of minutes away from midnight of the corresponding day. For example, an in bed time of 11:30 PM, is expressed as -30. If the next in bed time takes place at 10:00 AM on that same day, it is expressed as -840 (distance from the next midnight) and not as 600 (distance from closest midnight). Once all individual times have been converted, the mean is calculated and the time is then converted back to clock time by referencing to midnight. Standard deviations of clock times were similarly calculated.

8. PROCEDURES FOR DETERMINING SAWA338 AND SAWA339

8.1 DEFINING DAYS

In calculating variables SAWA338 (inter-day stability) and SAWA339 (intra-day variability), the goal was to identify a period of 7 consecutive days with minimal missing sleep/wake status data in which to perform the computations.

Days were defined as 24-hour periods of time starting at the pre-set start hour in Actiware. In most cases, this was set to noon with the exception of a few participants with highly unusual sleep patterns (see Reading Center MOP Section B).

8.2 IMPUTATION

Sleep/wake data was then further imputed beyond that described in Section 3.1 above for any missing patches lasting 1 hour or less by making the sleep/wake status of the entire missing patch equivalent to the status of the 15 minutes preceding the bout and 15 minutes following the bout assuming all 60 epochs were uniform in sleep/wake status (all sleep or all wake). No imputation was done if either 15-minute frame was not completely uniform (all wake or all sleep), if the preceding and subsequent 15 minute frames did not match, or if a single epoch in either frame had a missing sleep/wake status. In addition, no imputation was performed on missing patches of greater than 1 hour in duration.

8.3 OPTIMIZATION

Any day with more than 4 hours of missing data after imputation was excluded. In addition, days noted to have data failure due by the scorer due to a malfunctioning device were excluded.

Records with fewer than 7 consecutive days available for analysis were assigned a missing value for both SAWA 338 and SAWA 339. In addition, all 7 consecutive days were required to be before or after a DST change. For each record, with more than 7 consecutive days and no DST overlap meeting minimal criteria for data completeness, the 7-day interval with the least amount of missing data was selected for computation of SAWA338 and SAWA339.

8.4 IS AND IV CALCULATION

The inter-day stability (SAWA338) was calculated as the ratio between the variance of the average 24-hour sleep/wake pattern and the overall variance in sleep/wake status. This calculation uses 1-hour bins to compare wake/sleep ratios across all 24-hour days in the 7-day frame. This variable ranges from 0 to 1 with values closest to 1 indicating a stable sleep pattern over 24-hour days.

The intra-day variability (SAWA339) was calculated as the ratio of the mean squares of the difference between the proportion of sleep in all successive 1-hour bins and the overall variance across all epochs in the 7-day frame. This variable ranges from 0 to 1 with values closest to 1 indicating a more fragmented pattern within each day.