APSS 2011 RECAP

Discussion Group Synopsis

Actigraphy as a Tool for Measuring Sleep: Pros, Cons and Secrets of the Trade

At the 2011 SLEEP meeting, Drs. Buxton & Knutson co-chaired a discussion group on the use of wrist actigraphy. This discussion group was motivated by the fact that despite its use for nearly 30 years, actigraphy in practice can still be more art than science. With the burgeoning use of actigraphy in clinical trials and large epidemiology studies that aim to add an "objective" assessment of sleep duration or fragmentation, an open discussion about the appropriate use of actigraphy was timely. Given the serious lack of critical validations justifying assumptions at every stage of actigraphy use, including the hardware, collection, analysis (software), and interpretation, there is a serious need to clarify the use of actigraphy as a field, with an eye towards empirical and stringent validation of actigraphic assessments of sleep. Furthermore, which actigraphic variables are valid research or clinical measures were discussed.

In addition to the co-chairs, Orfeu M. Buxton, PhD from Harvard Medical School and Kristen L. Knutson, PhD from University of Chicago, there were three discussants: Martica Hall, PhD, University of Pittsburgh; Monique K. LeBourgeois, PhD, University of Colorado at Boulder; Maria Montserrat Sanchez Ortuño, University of Murcia School of Medicine. There were three learning objectives for the discussion group:

1. Participants will be able to understand the assumptions, stated or unstated, in publications describing actigraphy collection analysis and interpretation.
2. Participants will be able to identify the strengths and limitations in the use of actigraphy to assess sleep.
3. Participants will be able to articulate the key research questions surrounding the longitudinal validity of actigraphic assessments of sleep.

We first presented an overview of the strengths and limitations of actigraphy. Wrist actigraphy can be used to obtain rest-activity pattern data from which one may then estimate sleep duration and quality. Strengths of this methodology include that it is relatively unobtrusive and non-invasive and is simple to use by participant/patient. In addition, wrist actigraphy is often cheaper than PSG and can provide data when PSG is impractical. One of the most important strengths is that obtaining measurements over multiple days is much more feasible than PSG. Despite these strengths, actigraphy has many limitations that need to be addressed and discussed, which was the motivation for this discussion group.

Among actigraphy's limitations is the fact that wrist actigraphy data is one-dimensional. These data are based on movements (activity) with the underlying assumption that high levels of activity indicate wake. As such, actigraphy only reports sleep and wake and sleep stages cannot be ascertained. Also since it's based on movement, sedentary behaviors can look like sleep, which can be particularly problematic for estimating sleep in individuals who have low levels of daytime activity (e.g. obese) or who lie quietly awake at night (e.g. insomniacs). Although some devices include light measurements, sleeves and bedcovers may provide estimate light levels that differ from levels experienced by open or closed eyes of the participants. Multi-modal devices including more information about the sleep environment, including light, temperature, sound and/or other data modalities are needed. Another important limitation is that devices can usually be removed by participants, and this removal cannot always be identified by the device. Validation studies are infrequent, often dated, and significant opportunities for improvement remain. Just because "there's an app for that" doesn't necessarily mean the estimates of sleep and wake are valid.

Proposed minimum requirements for actigraphy include, but are not limited to, the need for rigorous validation studies, researcher access to the raw data; user-friendly information for device use, testing, and maintenance; detailed trouble-shooting documentation for device failures from hardware to user to analysis; error support and transparency.

Dr. Buxton discussed the usefulness of actigraphy citing examples from recent findings. In Work, Family, and Health Network studies involving a nursing home worker cohort, his group has shown that managers' behaviors and attitudes in the workplace (openness and flexibility regarding employee work-family issues) are significantly related to employees' measured sleep duration and cardiometabolic risk. Specifically, they observed a significant dose response relationship of that exposure to sleep duration, whereby less creative open and flexible managers have employees who sleep on average 30 minutes less per night than employees supervised by more open, creative and flexible managers, controlling for a host of relevant factors (Berkman et al., 2010). In the same dataset, we observed that black (African/Caribbean migrant) workers slept about an hour less than white (primarily American) workers, a black/white difference that has been observed in other studies. In multivariable regression modeling, nearly 40% of this variance was explained by socioeconomic and occupational factors (especially nightwork shifts). Their results also suggest that working women with a nonstandard work schedule are likely to get an insufficient amount of sleep (Ertel et al., 2011). Such studies highlight the potential usefulness of actigraphy to understand the causes and consequences of sleep deficiency due to work, family, neighborhood or many other levels, and offer the opportunities to explore modifiable health disparities involving sleep.

Dr. Knutson raised the issue that we need a good estimate of bed time ("lights off") and wake time ("lights on") in order to conduct the analysis. There are a few sources from which to obtain these estimates. Many people ask participants to complete a sleep log/diary in conjunction with wearing the actigraphy monitor. This can provide reasonable estimates in compliant, diligent subjects/patients. However, there are many instances where the times in the diary do not correspond well to the actigraphy data. An additional means to determine bed time and wake time is to use the device's "event marker", a button the wearer can press to mark the data. Discussion indicated highly variable success with using this button,

which may vary by subject population. Furthermore, a subject can forget to push the button, in which case alternative methods are required. The third method is to simply use the data itself to select a bed time and wake time that encompasses all of the apparent nocturnal inactivity (i.e. "sleep"). This method has its limitations as well, particularly if the wearer participates in sedentary activities prior to their actual bedtime (e.g. watching television or reading). Some devices include a measure of light and it was suggested that the light data be used to identify "lights off" and "lights on", which would be reasonable for subjects/patients who have dark curtains and don't share a bedroom with someone else who could turn on the light. It was suggested that at least two people review problematic actigraphy records to come to consensus on bed times and wake times. Many audience members expressed similar difficulties with identifying bed times and wake times. What was the final solution to this problem? It remains to be determined.

Dr. Hall presented data concerning how many days of recording are enough to estimate the various sleep characteristics calculated from wrist actigraphy. She analyzed actigraphy data collected in adult men and women who had at least 14 days of recordings available. She then estimated the number of days necessary to provide a stable estimate of sleep duration, sleep latency, wake after sleep onset, sleep efficiency and sleep fragmentation. Results indicated that, not surprisingly, more than one day is required, but with the exception of sleep latency, 7 days of recording could suffice.

Dr. Montserrat Sanchez Ortuño discussed the use of actigraphy in insomnia. Historically, when using actigraphy in insomnia treatment studies, the trend is to use mean values of sleep quantity measures, such as SOL, WASO, TST and SE. Typically these actigraphy-derived measures show fewer effects than diary-derived measures. This is one of the chronic frustrations in insomnia treatment studies: that actigraphy-derived measures cannot detect treatment benefits shown by sleep diaries, and even PSG. She suggested an alternate approach for using actigraphy in insomnia research, one that exploits its main strength: the fact that it can be used for multiple nights. Rather than using mean values, it may be more useful to take advantage of the multiple nights of recording and documenting night-to-night sleep changes. Dr. Sánchez Ortuño proposed the use of an index of variability called the mean square successive differences (MSSD) (Von Neumann et al., 1941, Sanchez-Ortuno et al., 2011). As its name implies, this index takes into account changes from one night to the next. She presented preliminary data suggesting that the amplitude of night-to-night changes of actigraphy-derived sleep measures, as measured by the MSSD, was significantly related to perceived sleep quality in chronic insomnia sufferers. That is, greater sleep instability was related to poorer sleep quality

Dr. LeBourgeois discussed methods to enhance compliance in children. Researchers and clinicians working with children have the additional challenge of working with younger, perhaps less compliant subjects/patients. Dr. LeBourgeois has had a lot of experience working with children and shared what she has learned from this experience. If you give a parent and child an actigraphy monitor with minimal explanation and instruction, compliance will be low. However, she suggested that a combination of detailed training on the use of the device, follow-up with telephone calls and emails to the parents, frequent visits and questions of the parents can greatly enhance compliance and subsequently the quality of the data collected. This is valuable advice for those who wish to collect good quality actigraphy data in young children, but is also applicable to studies of all age groups.

In summary, many researchers and clinicians are using or interested in using wrist actigraphy to estimate sleep, both in clinical practice and in research. It was suggested that a consensus report be developed to address these issues and limitations in order to try to unify methodologies and minimum reporting standards. We believe a related effort is ongoing in the American Academy of Sleep Medicine. In addition, more detail in the "methods" section of articles describing how these issues were addressed could be included, but some were concerned about being the first person to be peer-reviewed with these details included! Unfortunately, it is precisely this lack of transparency and unified methodology that led to the need for this Discussion Group. It is important to recognize both the strengths and the limitations of wrist actigraphy, as with any method or device. The field would benefit from increased methodological and technical transparency, coupled with further validation studies addressing all assumptions, stated or unstated, about the use of actigraphy.

References

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