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Beyond mean values: Quantifying intraindividual variability in pre-sleep arousal and sleep in younger and older community-dwelling adults

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ABSTRACT

Intraindividual variability is an often understudied aspect of health outcomes research that may provide additional, complementary information to average values. The current paper aims to further our understanding of intraindividual variability in health research by presenting the results of a daily diary study of sleep and pre-sleep arousal. Pre-sleep arousal is often implicated in poor sleep outcomes, although the arousal–sleep association is not uniform across age groups. The examination of intraindividual variability in different age groups may provide a more complete understanding of these constructs, which, in turn, can inform future research. The overall objectives of the current study are to quantify the amount of intraindividual variability in pre-sleep arousal and sleep and to examine age differences in this variability. A sample of older ($n=50$) and younger ($n=50$) adults recruited from North Central Florida and online completed 14-consecutive-day diaries assessing pre-sleep arousal and sleep outcomes. Significant age differences were found for sleep and pre-sleep arousal; older adults displayed poorer, more variable sleep for the majority of sleep outcomes, and higher levels of pre-sleep arousal than younger adults. The high amount of intraindividual variability has implications for the assessment of pre-sleep arousal and sleep across age groups.

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1. Introduction

Pre-sleep arousal, both cognitive and somatic, has been implicated in poor sleep outcomes [10,17,19,30]. However, the pre-sleep arousal/sleep association is not uniform across

age groups, with cognitive and somatic pre-sleep arousal showing differing associations with sleep in younger and older adults [23]. The examination of intraindividual variability (IIV), an often understudied factor in health outcomes research, may provide a more complete understanding of

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these constructs to inform future research. It is well known that sleep is a variable process, but the literature is unclear regarding age differences in IIV in sleep. Mezick et al. [15] and Van Hilten [28] reported no age differences in IIV in sleep. Yet, Dillon and colleagues [8] identified that IIV in sleep was actually lower at older ages. Furthermore, compared with the literature support for IIV in sleep [13,18,28], less is known about IIV of pre-sleep arousal, and how pre-sleep arousal IIV may vary across ages. If pre-sleep arousal and sleep show considerable IIV, the traditional analytic approach of relying on the examination of mean values, or single measurements, may not be the most appropriate level of measurement for these variables [10]. As variability in a behavior increases, mean values become less accurate, suggesting that for highly variable processes, the use of IIV values may add complementary information to the mean values [7,27].

Of the few studies that have examined daily values, there are none, to our knowledge, that examined IIV in pre-sleep arousal and sleep on a daily basis in both younger and older adults. Notably, the study by Shoji et al. [23] examined age differences in the arousal-sleep relationship by investigating whether mean or daily pre-sleep arousal better predicted sleep outcomes, but did not specifically examine or quantify IIV in these constructs. The current study extends these findings by explicitly quantifying IIV (and age differences in this variability) in pre-sleep arousal and sleep outcomes across 14 days, in both younger and older adults.

Prior research suggests that good sleepers are often younger [16] and older adults experience more sleep problems, such as taking longer to fall asleep, more awakenings, less total sleep time, and spending more time in light sleep [18]. Importantly, however, the majority of changes in sleep occur before the age of 60 [18]. Other factors besides age, but often associated with aging, may contribute to sleep disturbances (e.g., co-occurring physical or mental health conditions [2]). In other words, it may not be age specifically that is associated with poorer sleep, but changes associated with aging that result in poorer sleep in older adults [29].

Whereas traditional analyses have relied on mean values to represent a construct, there may be a significant amount of additional information gleaned from examining IIV. In a study of older adults with and without insomnia, Buysse et al. [4] found little correlation between sleep variables from night-to-night. Furthermore, compared to good sleepers, older adults with insomnia showed greater IIV on sleep measures including sleep onset latency, wake after sleep onset, and total sleep time, suggesting an association between greater IIV and poorer sleep overall [4].

Examination of intraindividual fluctuations in nightly pre-sleep arousal is an understudied area that may inform future research on disordered or disrupted sleep. Sánchez-Ortuño et al. [22] examined IIV of sleep variables and pre-sleep arousal in adults (mean age=47.1 years) classified as having either primary insomnia (PI) or insomnia related to a mental disorder (IMD). The authors found that participants with IMD displayed more IIV in total sleep time and emotional arousal than the PI group, and exhibited higher levels of mean levels of emotional arousal. Additionally, the association between arousal and sleep was stronger in the PI group, who displayed more stability in their arousal and sleep outcome ratings

from one night to the next [22], suggesting the predictive utility of pre-sleep arousal may depend on the IIV fluctuations in arousal and sleep outcomes. Although the above-mentioned research assessed IIV in sleep and emotional arousal, the sample was comprised only of individuals with insomnia and, further, did not include older adults. Therefore, there is a need for research examining age-related differences in IIV in pre-sleep arousal and sleep.

1.1. Aims and hypotheses of the present study

The overall objective of the present study is to quantify the extent of IIV in pre-sleep arousal and sleep, and to examine age differences in this variability. Quantification of IIV is a foundational step for research examining behaviors that potentially fluctuate on a daily basis [21]. The findings could have clinical implications for the assessment of arousal and sleep in younger and older adults. Furthermore, quantification of IIV could prove useful for the development of treatment targets such as the reduction of IIV in arousal or sleep.

The first specific aim of the present study was to examine age differences in mean levels of pre-sleep arousal and sleep outcomes. Mean values were obtained to present the traditional descriptive metric (means) as a point of comparison for the subsequent analyses. Given previous research indicating poorer sleep outcomes for older adults, we hypothesize that older adults will report worse mean sleep outcomes. Since previous findings are unclear regarding age differences in arousal, the first aim is exploratory for the arousal variables. In addition, because findings for cognitive arousal have differed from those for somatic arousal, these two types of pre-sleep arousal will be investigated separately in analyses.

The second aim of this study was to determine the extent of IIV in pre-sleep arousal and sleep outcomes. This aim contrasted the amount of variance in these variables that can be attributed to IIV versus between-person differences. Since sleep is highly variable, we hypothesize that there will be a substantial amount of IIV in sleep (e.g., greater than five percent [11]). The literature on variability in arousal is limited, making this part of the second aim of the study exploratory in nature.

The third aim of this study was to examine age differences in IIV in pre-sleep arousal and sleep outcomes. There has been limited research investigating age differences in IIV in sleep and arousal outcomes. Although existing research on age differences in IIV in sleep lacks consensus, greater IIV in sleep outcomes is observed in poor sleepers, suggesting that older adults, who are expected to display poorer sleep than younger adults, may also display greater IIV in sleep outcomes. Therefore, we hypothesize that older adults will display more IIV in sleep outcomes than younger adults. Given the scarcity of literature examining pre-sleep arousal across age groups, the comparison of IIV in arousal across age groups is exploratory.

2. Method

2.1. Participants

Participants were community-dwelling individuals recruited from North Central Florida and online. Recruitment materials

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