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Original Article

Validation of the Epworth Sleepiness Scale for Children and Adolescents using Rasch analysis

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ABSTRACT

Objective: A validated measure of daytime sleepiness for adolescents is needed to better explore emerging relationships between sleepiness and the mental and physical health of adolescents. The Epworth Sleepiness Scale (ESS) is a widely used scale for daytime sleepiness in adults but contains references to alcohol and driving. The Epworth Sleepiness Scale for Children and Adolescents (ESS-CHAD) has been proposed as the official modified version of the ESS for children and adolescents. This study describes the psychometric analysis of the ESS-CHAD as a measure of daytime sleepiness for adolescents.

Methods: The ESS-CHAD was completed by 297 adolescents, 12–18 years old, from two independent schools in Victoria, Australia. Exploratory factor analysis and Rasch analysis was conducted to determine the validity of the scale.

Results: Exploratory factor analysis and Rasch analysis indicated that ESS-CHAD has internal validity and a unidimensional structure with good model fit. Rasch analysis of four subgroups based on gender and year-level were consistent with the overall results. The results were consistent with published ESS results, which strongly indicates that the changes to the scale do not affect the scale's capacity to measure daytime sleepiness.

Conclusions: It is concluded that the ESS-CHAD is a reliable and internally valid measure of daytime sleepiness in adolescents 12–18 years old. Further studies are needed to establish the internal validity of the ESS-CHAD for children under 12 years, and to establish external validity and accurate cut-off points for children and adolescents.

1. Introduction

The Epworth Sleepiness Scale (ESS) was developed in 1990 as a measure of 'daytime sleepiness' for adults [1]. The 'daytime sleepiness' to which it refers is defined as the subject's average sleep propensity in daily life [2], hereinafter referred to as sleepiness. The ESS has become widely used throughout the world for clinical and research purposes [3–6], although there are limitations to its use [7–10]. For example, ESS scores must be recognized as subjective and influenced by bias and inaccuracies. Its validity has been widely researched in nonclinical populations [3,11–13] and clinical populations such as those with narcolepsy [14,15], obstructive sleep apnea [16,17], and Parkinson's disease [18]. The psychometric properties of the ESS in these studies and others have been found to be consistently reliable and valid [19–21].

The ESS is a simple, self-report questionnaire with eight questions and responses on a four-point Likert scale (0–3) [1]. Respondents rate their usual chances of dozing off or falling asleep as they engage in eight different activities. These activities differ in what Johns [22] has called their 'somnificity.' Somnificity is defined as 'the general characteristic of a posture, activity, and environmental situation that reflects its capacity to facilitate sleep onset in a majority of subjects' [22]. For example, 'lying down to rest in the afternoon when circumstances permit' (item 5) is an activity with a high somnificity, whereas 'sitting and talking to someone' (item 6) is an activity with a relatively low somnificity [22]. The ESS score is the sum of the eight item scores ranging from 0 to 24, where a higher score represents greater sleepiness. The mean ESS score

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reported for adults from nonclinical populations has ranged from 4.4 to 7.1 [6,11,23,24]. ESS scores above 10 are thought to represent 'excessive daytime sleepiness' and may indicate the presence of underlying sleep disorders [13].

The need for a consistent measure of sleepiness in adolescents has become evident as sleepiness has been linked to issues around physical and mental health and poor academic performance [25–29]. The ESS provides a consistent measure for adults [30] but is not ideal for adolescents, as it has references to alcohol and driving, with which adolescents may not be able to identify. Despite these references, the ESS in its adult form has been used for studies in adolescents [29,31,32]. Some other studies have simply removed references to alcohol and driving, whereas others have introduced entirely new items [17,33–36], which makes the results of these studies impossible to compare.

The Epworth Sleepiness Scale for Children and Adolescents (ESS-CHAD) has been proposed by Johns, the author of the ESS, as the official modified version of the ESS for children and adolescents [10]. Modifications to the ESS include the removal of the reference to alcohol from item 7 to 'sitting quietly by yourself after lunch', and specifying 'a classroom at school' as a public place in item 3. Item 8 has been replaced by 'sitting and eating a meal' instead of 'in a car, while stopped in traffic for a few minutes in the traffic'. In light of these modifications, the aim of this study was to assess the reliability and internal validity of the ESS-CHAD for adolescents from 12 to 18 years old using exploratory factor analysis and Rasch analysis.

2. Methods

This study was part of a broader research project that aimed to evaluate the sleepiness of adolescents and their sleep behaviours. With permission of the copyright holder obtained through the Mapi Research Trust (https://eprovide.mapi-trust.org), the ESS-CHAD was included in the second part of an eight-part survey with minor changes; the instruction for the scale was changed from 'Over the last month' to 'Thinking of the last two weeks'. The study was approved by the authors' university human research ethics committee.

Two relatively small independent schools in regional Victoria with similar socio-educational advantage (School 1 ICSEA = 1014, School 2 ICSEA = 1083, retrieved from www.myschool.edu.au) volunteered to participate in this study. Upon receipt of parental and student permission, 297 students (approximately 50% of the secondary students enrolled) voluntarily completed the ESS-CHAD scale in full. Participants completed the surveys online using Qualtrics (n = 184) and on paper (n = 123). Due to differences in the availability of technology, the majority of the participants in the school years 7–9 completed the survey online, whereas the majority of participants in school years 10–12 completed the survey on paper. Participants from School 1 (n = 29) completed the survey twice in week six and week seven during term 1 of the year 2015, for the purposes of a test–retest. Participants from School 2 completed the survey once in the second half of terms one and two of the year 2015, as suited the school. Surveys were completed on different days of the week and at different times of the day during regular class periods. During the time of data collection, the Years 10–12 students in School 1 were preparing for their mid-year examinations to take place in 2–3 weeks.

Descriptive and inferential analyses were completed with the ESS-CHAD item and total scores using SPSS v.22. Initially, the normality of the distribution as well as means, standard deviation, skewness, kurtosis, frequency charts, and group comparisons were ascertained. An independent samples *t* test was used to determine whether there were any significant differences between the two schools. The confidence interval, or absolute error (d), was calculated for the sample size (n = 297) with a 95% confidence level (Z = 1.96) and expected proportion of 50% ($p = 0.5$) using the sample size formula $n = Z^2_{1-\alpha/2}\, p(1-p)/d^2$ [37], which assumes simple random sampling. Calculations were confirmed using a sample size calculator [38]. Test–retest analysis using the intraclass correlation coefficient provided information as to the reliability of the data. Internal validity of the ESS-CHAD was measured using item-total Pearson correlations, and internal reliability was estimated using inter-item correlations and Cronbach's α. Variance of ESS-CHAD scores by year-level and gender was analyzed by two-way analysis of variance. Exploratory factor analysis was performed using principal component analysis (PCA) to extract components with eigenvalues above 1.0, using orthogonal Varimax rotation. These were then compared to eigenvalues generated from random data of the same size (8 variables × 297 respondents) using MonteCarlo PCA for parallel analysis to determine the final factor(s).

In accordance with item response theory, Rasch analysis [39] was used, with Winsteps v.3.92. In Rasch analysis, the parameters of the model represent the position of persons and items on an underlying continuum, which allow a model and associated person and item hierarchies to be determined. Analysis of the model using person and item fit indices (INFIT and OUTFIT) and matching *t* values (ZSTD) allow for evaluation of the model fit where an acceptable model has INFIT and OUTFIT mean square statistics between 0.5 and 1.5, and ZSTD values of 0 ± 2. Person and item reliability offer further evidence of the reliability of the scale whereby a person reliability of >0.5 is acceptable and a low item reliability indicates insufficient sample size. In addition, separation indices indicate how well the scale is able to separate low-performing and high-performing persons and items, where person separation indices >3 indicate an excellent level of separation and item separation values of >2.5 are required for analysis of groups. Rating functioning of the four-point Likert scale was examined using the guidelines suggested by Linacre [40].

3. Results

Preliminary analysis of the ESS-CHAD item and total scores showed that they were normally distributed with minor deviations in skewness and kurtosis (0.53 and −0.26, respectively, for the total scores). An independent-samples *t* test revealed no significant difference in ESS-CHAD scores between School 1 (n = 34, mean = 5.41, standard deviation [SD] = 3.64) and School 2 (n = 263, mean = 5.35, SD = 3.67; $t_{297} = 0.087$, $p = 0.93$), suggesting that data from the two schools could be combined. The sample size of 297 participants provides a confidence interval of 4 with a 95% confidence level for the combined school populations and a confidence interval of 5.7 for a larger population. Demographics of the participants are presented in Table 1.

Table 1
Characteristics of ESS-CHAD study subjects (N = 297).

Characteristic	n	%
Gender		
Female	136	46%
Male	161	54%
Year level (age range, y)		
7 (11–13)	75	25%
8 (13–14)	72	24.5%
9 (14–15)	42	14%
10 (15–16)	54	18%
11 (16–17)	35	12%
12 (17–18)	19	6.5%

Abbreviations: ESS-CHAD, Epworth Sleepiness Scale for Children and Adolescents.

The test–retest data from the subgroup of 29 students provided an intraclass correlation coefficient (two-way mixed, absolute value) of 0.89, indicating a strong test–retest reliability. Item-total Pearson correlations between item score and the total ESS-CHAD scores for all 297 students showed moderate to strong positive correlations (0.39<r>0.73, all $p < 0.001$) for all items. The Cronbach α score was 0.73, which demonstrated a high internal reliability that did not increase when an individual item was deleted. The mean inter-item correlation was 0.27 (range 0.05–0.41), which is acceptable [41].

The mean of ESS-CHAD scores was 5.36 with a standard deviation of 3.66 (Table 2). Two-way analysis of variance of ESS-CHAD scores showed significant main effects for gender ($F_{1,293} = 13.61$, $p < 0.00$) and the two-year-level groups (Years 7–9, Years 10–12) ($F_{1,293} = 14.27$, $p < 0.00$) with a small effect size for both (partial eta squared = 0.044 and 0.046 respectively) (Fig. 1). There was no significant interaction effect between the groups ($F_{1,293} = 3.13$, $p = 0.078$).

An exploratory factor analysis was performed to determine whether the ESS-CHAD loaded on a single factor. It was determined that the sample was suited to exploratory factor analysis, as the correlation matrix from exploratory factor analysis yielded most coefficients of 0.3 or above, the Kaiser-Meyer-Olkin value was 0.79, the Bartlett test of sphericity result was significant ($p < 0.001$) and the communalities range was acceptable (0.43–0.58). PCA extracted two factors with eigenvalues above 1.0 (2.92, 1.2), which explained a total of 51.4% variance (36.4%, 15% respectively). The Varimax rotated solution showed both factors with strong loadings and a strong intercorrelation between the two factors in the component transformation matrix. Parallel analysis for randomly generated data revealed two eigenvalues above 1.0 (1.25 and 1.16), which suggested that only one factor should be retained because the eigenvalue of 1.2 could have arisen by chance. Therefore, PCA was repeated with the analysis forced to one factor that explained 35.9% of the variance with all item loadings above 0.4 (Table 2). This indicated a single factor for the ESS-CHAD item scores.

Table 2
ESS-CHAD mean item scores and item loadings for a one-factor solution using PCA.

	Mean item score (SD)	Item loadings (one-factor solution)
Item 1	0.93 (0.88)	0.63
Item 2	0.86 (0.83)	0.47
Item 3	0.76 (0.90)	0.67
Item 4	0.88 (0.93)	0.73
Item 5	1.39 (1.04)	0.61
Item 6	0.10 (0.33)	0.49
Item 7	0.35 (0.64)	0.68
Item 8	0.08 (0.30)	0.49
Total ESS-CHAD score	5.36 (3.66)	

Abbreviations: ESS-CHAD, Epworth Sleepiness Scale for Children and Adolescents; PCA, principal component analysis; SD, standard deviation.

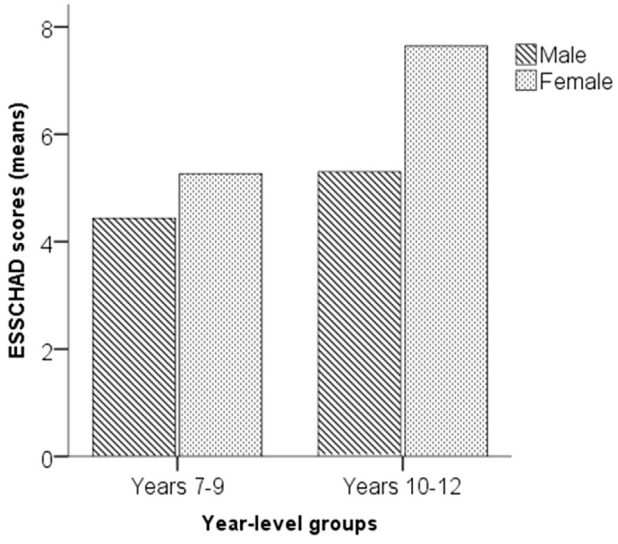

Fig. 1. Mean Epworth Sleepiness Scale for Children and Adolescents (ESS-CHAD) score by year-level group and gender.

Rasch analysis of ESS-CHAD item scores was conducted to further investigate the hierarchy of the items, model fit, and unidimensionality of the construct. The Wrightmap (Fig. 2) indicated the hierarchy of the items, with respondents most likely to doze off when lying down for a rest or nap (item 5). They were least likely to doze off when sitting and eating a meal (item 8) and when sitting and talking to someone (item 6). The fit analysis (Table 3) showed a good model fit as a unidimensional construct. The OUTFIT and INFIT mean square values were close to one (perfect fit) with no items or persons with scores over two [39]. Person separation and reliability figures indicated that the scale was able to discriminate between one or two levels of respondents [39] and item separation (>3) and reliability figures (~1) further verified the item hierarchy [39]. Scale functioning analysis using the Linacre guidelines [40] (Table 4) confirmed the full use of the scale by respondents with only one small violation for the C→M of category 3 (14%) and justified the Likert four-item response options for ESS-CHAD for the total scores (Fig. 3), as well as for each item. Separate Rasch analyses of the four subgroups (male and female, Years 7–9 and Years 10–12) were very similar.

4. Discussion

The results of our analyses of ESS-CHAD data are very similar to those reported for the ESS. The ESS-CHAD distribution, mean, and standard deviation scores were consistent with those previously reported for adolescents using the adult ESS [29,31,34,36] and nonclinical adult samples [6,11,13,22,23,42]. The test–retest data reported an intraclass correlation coefficient of 0.89, indicating a strong correlation between the two samples that was within the range reported for the ESS [6,15,31,42]. Internal reliability as indicated by intercorrelation and Cronbach's α were very similar to those found for the ESS in university students [11] and other nonclinical groups [3,12] as well as those reported for ESS in studies with children and adolescents [34,36]. The data indicated a small, yet significant difference between boys and girls, with greater sleepiness in girls. Previous studies on the influence of gender on ESS scores have differed in their conclusions, with some studies having found significant differences [43–45], whereas others have not [12,29,31,46]. The small yet significant difference in year-level groups was as expected, with the increase in sleepiness in older year levels consistent with adolescent maturational trends brought on by changes in environmental, social, and biological developments [35,47,48].

The exploratory factor analysis of ESS-CHAD was similar to that found by others who have analyzed ESS item scores among adults. For example, Sargento et al. [3] found a strong interrelation between their two factors and forced a one-factor solution. Their single factor model explained 39.92% of variance, which is comparable to our finding of 35.9%. A single factor construct is also consistent with other studies of the ESS in adults [11,18,49], although some studies have maintained two factors [3,12,19,50]. However, the conclusions of the latter studies may be misleading,

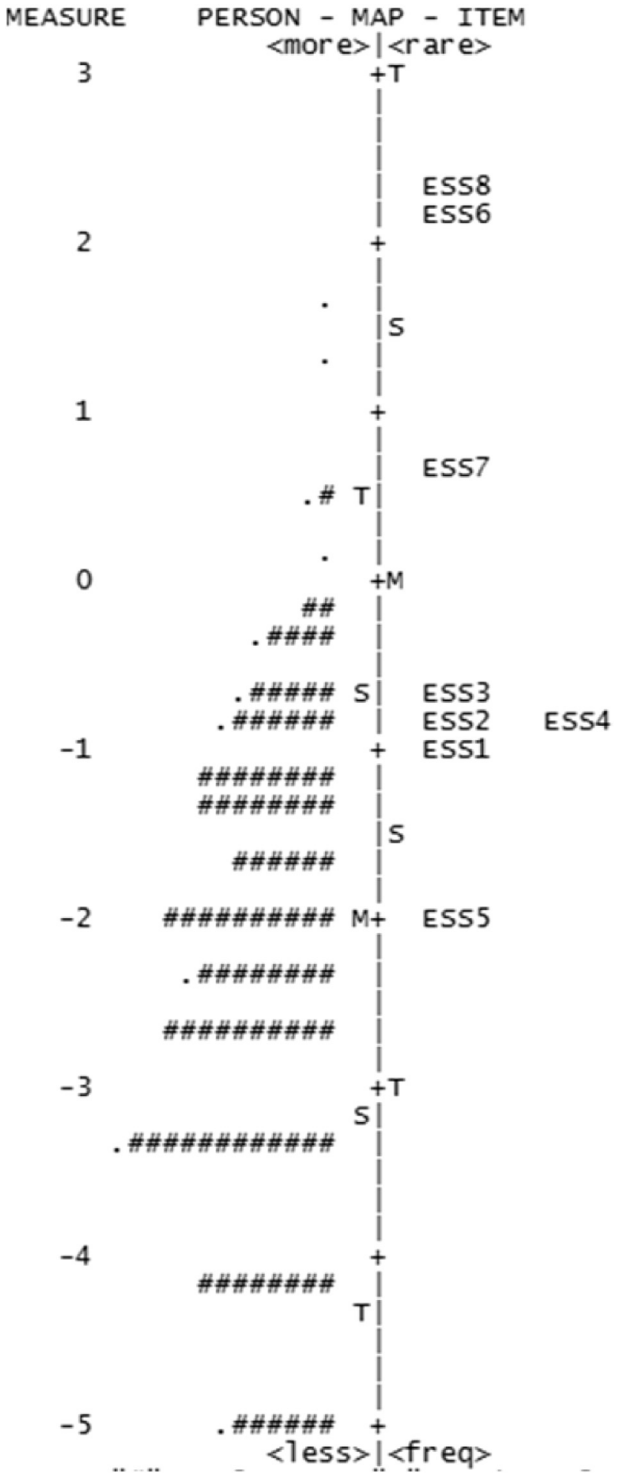

Fig. 2. Rasch Wrightmap of Epworth Sleepiness Scale for Children and Adolescents (ESS-CHAD) (N = 297).

as they did not report conducting parallel analysis to remove chance results.

Rasch analysis of the ESS-CHAD data confirmed a unidimensional construct that is reliable and valid, and consistent with results for the adult ESS [3,18,51]. The hierarchy of items and person, model fit, and scale functioning results for the total sample as well as the four subgroups (male and female, Years 7–9 and Years 10–12) indicated that all groups were able to answer questions

Table 3
Summary of Rasch item and person estimates for ESS CHAD (N = 297).

Measure summary	Item	Person
Mean (SD adjusted)	0.00 (1.48)	−2.17 (1.44)
Reliability of estimate	0.99	0.66
Separation	11.23	1.39
Fit statistics		
Infit mean square		
Mean (SD)	1.02 (0.08)	1.00 (0.66)
Infit *t* (SD)	0.3 (1.00)	0.00 (1.1)
Outfit mean square		
Mean (SD)	0.90 (0.19)	0.90 (0.76)
Outfit *t* (SD)	−0.3 (1.30)	0.10 (0.90)

Abbreviations: ESS-CHAD, Epworth Sleepiness Scale for Children and Adolescents; SD, standard deviation.

reliably using all four Likert scale options. This suggests that the changes to the items to accommodate younger individuals have not had a significant impact on the scale's capacity to measure daytime sleepiness, and supports the conclusion that the ESS-CHAD scale is valid and reliable for use with male and female adolescents 12–18 years old.

As with other studies, these results need to be considered in light of this study's limitations. This study was conducted with a sample of 297 students from similar backgrounds in only two schools, with the majority of the participants from only one school. The survey was not administered on the same day of the week or at the same time of day for different classes, which may have affected students' responses. Other factors such as the upcoming examinations for the older year levels and the use of different data collection techniques for the Years 7–9 and Years 10–12 groups (online vs paper, respectively) may have also had an impact on the results. More broadly, this study did not externally validate the ESS-CHAD against more objective measures such as actigraphy. Use of the ESS-CHAD for clinical and research purposes will need to be

Table 4
Rasch scale category effectiveness for four-point response category in the ESS-CHAD using guidelines set out by Linacre [40].

No.	Guideline	ESS-CHAD[a]		
1	At least 10 observation of each category	Category 0 = 1330 (56%) Category 1 = 619 (26%) Category 2 = 308 (13%) Category 3 = 119 (5%)		
2	Regular observation distribution	Observation distribution triangular peaked at category 0		
3	Average measures advance monotonically with category	Category 0 = −3.12 Category 1 = −1.11 Category 2 = −0.09 Category 3 = 0.69		
4	OUTFIT mean square <2.0	Category 0 = 1.06 Category 1 = 0.74 Category 2 = 0.89 Category 3 = 1.15		
5	Step calibrations advance	Category 0 = none Category 1 = −1.41 Category 2 = 0.12 Category 3 = 1.29		
6	Ratings imply measures, and measures imply ratings	Coherence[b] Category 0 Category 1 Category 2 Category 3	M→C 84% 46% 41% 77%	C→M 79% 58% 41% 14%
7 and 8	Step difficulties advance by at ≥1.4 logits and by < 5.0 logits	Category 0 = −2.65 Category 1 = −0.76 Category 2 = 0.80 Category 3 = 2.57		

Abbreviations: ESS-CHAD, Epworth Sleepiness Scale for Children and Adolescents.
[a] Categories: 0 = never doze; 1 = slight chance of dozing off; 2 = moderate chance of dozing off; 3 = high chance of dozing off.
[b] M→C Does measure imply category? C→M Does category imply measure?

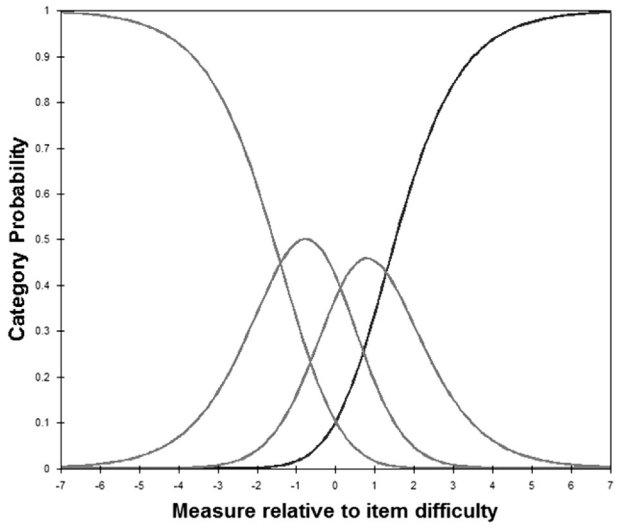

Fig. 3. Rasch category probability curve for Epworth Sleepiness Scale for Children and Adolescents (ESS-CHAD).

considered with limitations similar to those for the ESS [7–10]. For example, it will need to be recognized that ESS-CHAD scores are subjective reports and therefore may be influenced by bias and inaccuracies. As with the ESS, the ESS-CHAD is not designed to be a diagnostic tool on its own, and cannot distinguish between sleep disorders or other causes of daytime sleepiness [7–10].

5. Conclusion

This study supports the conclusion that the ESS-CHAD is a unidimensional scale that is reliable and internally valid for measuring daytime sleepiness among adolescents 12–18 old. Exploratory factor analysis using PCA confirmed a one-factor structure that explained 35.9% of variance. Rasch analysis provided a hierarchy of all eight items with good fit indices, reliability, and separation figures. Scale functioning rankings confirmed full use of the four-point Likert scale by adolescents. This study's findings are consistent with published ESS findings suggesting that the changes to the items to accommodate younger individuals in the ESS-CHAD have little impact on the scale's capacity to measure daytime sleepiness as defined for the ESS. It is therefore concluded that the ESS-CHAD may be used in ways similar to those of the ESS, with similar limitations [7–10]. Further investigations are needed to validate the ESS-CHAD for children under 12 years, especially for those who require parental assistance. Future studies should also investigate the external validity of this scale, and should aim to determine whether the cut-off points for children and adolescents are comparable to those for adults.

Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2017.01.014.

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