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Chronic sleep reduction in adolescents—clinical cut-off scores for the Chronic Sleep Reduction Questionnaire (CSRQ)

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SUMMARY
The Chronic Sleep Reduction Questionnaire is a validated questionnaire that measures symptoms of prolonged insufficient and/or poor sleep and therefore accounts for individuals' sleep need and sleep debt. This study extends its psychometric properties by providing cut-off scores, using a matched sample of 298 healthy adolescents (15.38 ± 1.63 years, 37.9% male, mean Chronic Sleep Reduction Questionnaire score: 32.98 ± 6.51) and 298 adolescents with insomnia/delayed sleep–wake phase disorder (15.48 ± 1.62 years; 37.9% male, mean Chronic Sleep Reduction Questionnaire score: 42.59 ± 7.06). We found an area under the curve of 0.84 (95% confidence interval: 0.81–0.87). Cut-off scores for optimal sensitivity, optimal specificity and based on Youden's criterion are provided. These cut-off scores are highly relevant for use of the Chronic Sleep Reduction Questionnaire in future studies and clinical practice.

INTRODUCTION

Although adolescents often suffer from insufficient and/or poor sleep (Gradisar *et al.*, 2011), sleep variables such as sleep duration do not account for individuals' sleep need and sleep debt. Sleep duration may therefore give an incomplete representation of adolescents' sleep problems and its daytime consequences (e.g. Curcio *et al.*, 2006; Dewald *et al.*, 2010; Gregory and Sadeh, 2012). To overcome this problem, Meijer (2008) developed the Chronic Sleep Reduction Questionnaire (CSRQ), a subjective assessment tool that measures symptoms of chronic sleep reduction, rather than sleep directly. The questionnaire is based on the assumption that prolonged insufficient and/or poor sleep results in chronic sleep reduction, which causes impaired daytime functioning (Dewald-Kaufmann *et al.*, 2013; Meijer, 2008). A high score on the CSRQ therefore indicates that adolescents have developed daytime impairments that are related to chronically reduced sleep. The psychometric properties of a Dutch and an English version of the CSRQ have been evaluated and it was shown to be a reliable and valid measurement (Dewald *et al.*, 2012), making it a promising indicator of chronic sleep reduction (Ji and Liu, 2016). Although a cross-sectional study demonstrated clear differences in daytime functioning between adolescents with low and high chronic sleep reduction (Dewald-Kaufmann *et al.*, 2013), clinical cut-off scores have only been provided for a short version of the questionnaire, showing good discrimination abilities between clinical and healthy adolescents (Van Maanen *et al.*, 2014). A clinical cut-off score of the CSRQ would, however, enhance its usefulness by allowing to screen for adolescents who suffer from clinically relevant reduced sleep, sleep debt and daytime impairments. Cut-off scores are important for the clinical practice (e.g. early detection of sleep problems to prevent the development of more severe sleep disorders and psychiatric diseases such as depression) and future research. The present study aims to calculate cut-off scores, using data from a large sample of adolescents with delayed sleep–wake phase disorder (DSWPD), insomnia and healthy controls. We included patients with insomnia and DSWPD as clinical groups, as they refer to the sleep disorders with high prevalence rates during adolescence (e.g. Johnson *et al.*, 2006; Roberts *et al.*, 2008; Saxvig *et al.*, 2012). Furthermore, both groups are characterized by poor sleep quality and/or later sleep onset times which, in combination with early school start times in the morning, lead to impaired daytime

functioning. These impairments, which are considered to be consequences of chronic sleep reduction (including psychological well-being, sleepiness etc.), are measured by the CSRQ.

SAMPLE

We received ethical approval for the healthy control group (Ethics Commission Faculty of Social and Behavioral Sciences, University of Amsterdam) and the insomnia group (Ethics Commission Academic Medical Center, Amsterdam, the Netherlands). As anonymized data from medical institutions can be used for retrospective health studies unless patients have denied usage of their data, no additional ethical approval was required for the DSWPD group. Sample information is provided in Supporting information, Table S1.

Healthy controls

Nine hundred and fifty-one (mean age 14.70 ± 1.70 years, 41.3% male) participants were recruited from high schools around Amsterdam. All parents were informed about the study and gave oral informed consent. Participants also gave written informed consent before filling in the online questionnaires, which were administered in 2011 (described in Van Maanen *et al.*, 2014). One hundred and thirty participants were excluded from the group, as they had a clinical score of insomnia (cut-off: 3.61) or Circadian Rhythm Sleep Disorder (CRSD; cut-off: 3.41) (Holland Sleep Disorder Questionnaire; HSDQ; Kerkhof *et al.*, 2013). Of the remaining 821 adolescents, 298 participants were matched for age and gender to the clinical samples.

Delayed sleep–wake phase disorder (DSWPD)

One hundred and eighty-two (mean age: 15.39 ± 1.63 years, 46.2% male) adolescents who were referred to the Centre for Sleep–Wake Disorders and Chronobiology of Hospital Gelderse Vallei in Ede, the Netherlands, were diagnosed with DSWPD according to the International Classification of Sleep Disorders, 3rd edn (AASM, 2014). Diagnoses were based on a clinical interview and late dim light melatonin onset (DLMO; mean DLMO: 22:40 ± 1:35 hr). Oral and written informed consent was obtained by participants and their parents. All adolescents completed the CSRQ before they started melatonin treatment.

Insomnia

One hundred and sixteen (mean age 15.62 ± 1.60 years, 25% male) adolescents who received cognitive behavioural therapy for their sleep onset and maintenance problems (described in De Bruin *et al.*, 2015; registration ISRCTN33922163) completed the CSRQ prior to treatment. Adolescents were included after a diagnostic clinical interview indicating insomnia (sleep onset and/or maintenance

problems). Participants and parents gave written active informed consent.

MEASUREMENTS

Chronic sleep reduction

Chronic sleep reduction was measured using the 20-item CSRQ (Meijer, 2008), consisting of four subscales referring to the previous 2 weeks: 'shortage of sleep' (six items; e.g. 'I am a person who does not get enough sleep'), 'irritation' (five items; e.g. 'others think that I am easily irritated'), 'loss of energy' (five items; e.g. 'I am active during the day') and 'sleepiness' (four items; e.g. 'do you feel sleepy during the day?'). Each question has three ordinal response categories ranging from 1 to 3, with higher scores indicating more chronic sleep reduction. The total CSRQ scale consists of the sum of the four subscales, so the range of possible CSRQ scores varies between 20 and 60 (see Dewald *et al.*, 2012, Appendix 1 for the English version of the questionnaire). Based on the theoretical grounds that individuals with DSWPD have a delayed circadian rhythm, for item 7 ('at noon I feel as energetic as in the morning') a fourth answer category ('at noon I feel more energetic than in the morning') was added for the DSWPD group. To make results between the groups comparable, we dichotomized this item in this group (scoring 'this is true for me' with 1, all other answer categories with 2). With this strategy, participants of the
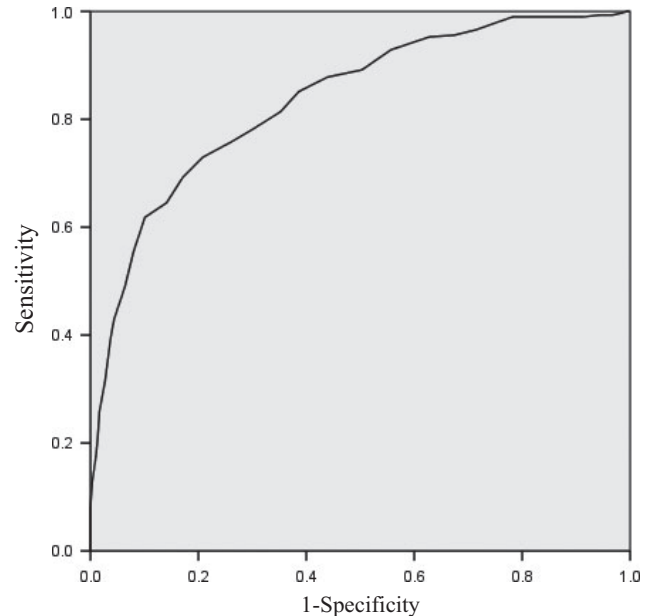
Figure 1. Receiver operating characteristic (ROC) curve for the Chronic Sleep Reduction Questionnaire (CSRQ). *Note:* Area under the curve (AUC) indicates the probability that a person is correctly classified by the questionnaire (i.e. as belonging to the clinical or healthy group). Sensitivity = true positive rate (i.e. the probability of a positive test result if the clinical diagnosis is positive), 1-specificity = false positive rate (i.e. the probability of a positive test result if the clinical diagnosis is negative).

DSWPD group could not score higher than 2 on this item, and it can therefore be seen as a conservative approach as it ensures that discriminating effects between the clinical and the healthy group are not overestimated. For the total CSRQ Cronbach's alpha was 0.85 in the clinical group and 0.87 in the control group after groups were matched for age and gender.

Analyses

The two clinical groups did not differ on their total CSRQ score ($t_{(294)} = -0.60$; $P = 0.55$) and were therefore treated as one clinical group. Participants from the healthy sample were matched to the clinical samples based on age and gender, resulting in a group of 298 clinical participants (mean age: 15.48 ± 1.62 years; 37.9% male, mean CSRQ score: 42.59 ± 7.06) and 298 healthy controls (mean age: 15.38 ± 1.63 years, 37.9% male, mean CSRQ score: 32.98 ± 6.51). To determine cut-off scores, receiver operating characteristic (ROC) curves were used. ROC curves graphically depict the proportions of true positives ('sensitivity'; i.e. the probability of a positive test result if the clinical diagnosis is positive), against the proportions of false positives ('1, specificity'; i.e. the probability of a positive test result if the clinical diagnosis is negative). The area under the curve (AUC) indicates the probability that a person is correctly classified by the questionnaire (i.e. as belonging to the clinical or healthy group). Depending on the purpose of the cut-off score, one may be interested in a cut-off score with optimal sensitivity, optimal specificity or one that maximizes the sum of sensitivity and specificity (Youden's criterion; Youden, 1950).

RESULTS

We found a ROC curve with an AUC of 0.84 (95% confidence interval: 0.81–0.87) (see Fig. 1). The optimal cut-off according to Youden's criterion, giving equal weight to sensitivity and specificity, was 39.5. With this cut-off, 69% of the clinical cases and 83% of the healthy sample were correctly identified. For optimal sensitivity, a cut-off of 27.5 was found (correctly identifying 99% of the clinical cases but only 22% of the healthy sample), and for optimal specificity a cut-off of 50.5 was found (correctly identifying only 1.3% of the clinical cases but 99% of the healthy sample). As the CSRQ only includes whole numbers, we suggest using 28, 40 and 51 as cut-off scores.

DISCUSSION

The present study extends previous research on the CSRQ by providing cut-off scores of the complete questionnaire with a high sensitivity and specificity as well as a combined cut-off score, which enables correct identification of 69% of the clinical cases and 83% of the healthy sample. Although the CSRQ aims to measure symptoms of insufficient and/or

poor sleep rather than sleep disorders, the results indicate the CSRQ to be a suitable tool for a first clinical screening. Based on our results, cut-off scores can be chosen depending on the setting (e.g. it is recommended to use a high sensitivity cut-off score for the identification of all possible individuals with chronic sleep reduction). Similarly, based on one's clinical and/or research aims, it is now possible to choose between usage of the complete questionnaire or its adapted short version (Van Maanen *et al.*, 2014). Some limitations should be mentioned: (1) the healthy sample was selected from the general population; however, we did not control for other sleep disorders (e.g. sleep apnea) than insomnia and CRSD; (2) although the sample size was large, it does not allow calculation of norm scores for different age groups separately; and (3) the optimal cut-off according to Youden's criterion yielded moderate sensitivity and specificity, which could be due to differential relations between subscales of the CSRQ and different causes of insufficient/poor sleep.

AUTHOR CONTRIBUTIONS

JFD-K contributed to the study design, data collection, paper conceptualization, analyses and manuscript preparation. EJDeB and MS contributed to the data collection and manuscript preparation. BJHZ contributed to the statistics and manuscript preparation FJO contributed to the study design, paper conceptualization, statistics and manuscript preparation. AMM contributed to the study design, paper conceptualization and manuscript preparation.

CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the supporting information tab for this article:

Table S1. Descriptive statistics and sleep variables