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The Japanese version of the reduced morningness-eveningness questionnaire

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Circadian typology, or “morningness” and “eveningness,” is generally assessed using the Morningness-Eveningness Questionnaire (MEQ), a 19-item scale that could be burdensome in large-scale surveys. To overcome this, a 5-item version known as the reduced morningness-eveningness questionnaire (rMEQ), which is sensitive to the assessment of circadian typology, was developed; however, a validated Japanese version of the rMEQ is yet to be established. This study aimed to develop and validate the Japanese version of the rMEQ. Five essential items for the rMEQ were selected from existing Japanese MEQ data (N = 2,213), and the rMEQ was compiled. We conducted a confirmatory factor analysis for the psychometric properties of the rMEQ and confirmed its robust one-factor structure for evaluating morningness-eveningness (GFI = 0. 984, AGFI = 0.951, CFI = 0.935, and RMSEA = 0.091). Reliability was evaluated via internal consistency of rMEQ items using Cronbach’s α and McDonald’s ω, and the values were 0.618 and 0.654, respectively. The rMEQ scores strongly correlated with MEQ ($\rho = 0.883$, $p < 0.001$), and classification agreement (Morning, Neither, and Evening types) between rMEQ and MEQ was 77.6% (Cramer's $V = 0.643$, Weighted Cohen's Kappa = 0.72), confirming the validity. The Japanese rMEQ may be a valuable tool for the efficient assessment of circadian typologies.

Keywords: Circadian typology, Morningness, Eveningness, rMEQ, Validation

Introduction

Human rest and activity cycles exhibit high inter-individual variability, a phenomenon known as the circadian typology or morningness-eveningness (Adan et al. 2012; Di Milia et al. 2013). Since approximately 50% of the circadian typology is genetically determined, it is considered a phenotype of an individual's biological clock (Barclay and Gregory 2013). It also correlates with the circadian rhythm period (Duffy et al. 2001; Hasan et al. 2012) and phase (Duffy et al. 1999; Kantermann et al. 2015). Alongside a delay in the circadian phase, individuals exhibiting a strong evening preference show a delay in sleep timing compared with morning and intermediate individuals (Carrier et al. 1997; Taillard et al. 1999; Zou et al. 2022). Owing to social limitations, they tend to accumulate sleep debt from delayed sleep onset times on workdays (Park et al. 1997; Taillard et al. 1999; Roepke and Duffy 2010), which can lead to social jetlag (Wittmann et al. 2006). Several studies have highlighted the circadian typology as a risk factor for cardiovascular (Makarem et al. 2020) and metabolic disorders (Reutrakul et al. 2013), mental health problems (Gaspar-Barba et al. 2009; Kitamura et al. 2010; Coleman and Cain 2019; Wang et al. 2022; Qu et al. 2023), and mortality (Knutson and von Schantz 2018; Hublin and Kaprio 2023). Therefore, the appropriate assessment of circadian typology is of great social and clinical significance, including establishing proper working conditions and sleep hygiene and aiding in the effective prevention and treatment of diseases.

The Morningness-Eveningness Questionnaire (MEQ) is widely used for circadian typology evaluation (Horne and Ostberg 1976), and a Japanese version has been constructed (Ishihara et al. 1984). However, the MEQ has 19 response items, which is a heavy burden on subjects and is difficult to handle in field and large-scale surveys. As a solution, a reduced MEQ (rMEQ) with only five items from the MEQ was proposed (Adan and Almirall 1991). The rMEQ can evaluate circadian typology in one dimension, as it uses a correspondence analysis for the MEQ to extract only questions related to the morningness-eveningness factor. In addition to the English version of the rMEQ, Spanish (Natale et al. 2006), Italian (Natale, Esposito, et al. 2006), German (Randler 2013), French (Caci et al. 2009), Hungarian (Urbán et al. 2011), Polish (Jankowski 2013), Swedish (Danielsson et al. 2019), Hindi (Tonetti and Natale 2019) and Chinese (Carciofo et al. 2012) versions have been established, and their reliability and validity have been confirmed. However, no Japanese version has verified accuracy. The development of a validated Japanese version of the rMEQ would not only make it easier to assess the circadian typology in the Japanese population but also allow comparative studies of circadian typology based on the rMEQ among other language versions. Thus, in this study, we aimed to create a Japanese version of the rMEQ and assess its reliability and validity.

Methods

Study population

The target population for this study was respondents to an Internet survey conducted on the Nippon Research Center web panel in 2017. The survey sought to obtain 2,000 responses mirroring the distribution of region, gender, and age, ranging from 20 to 79 years, within the national population of Japan (Ministry of Internal Affairs and Communications 2017).

To exclude respondents who lived day and night in reverse and those who slept for extremely short or long durations, the following exclusion criteria were applied: respondents whose 1) bedtime and sleep onset time were outside the range of 18:00 to 9:00, 2) wake time and rise time were outside the range of 0:00 to 15:00, and 3) sleep duration was not between 4 and 12 hours; and 4) those that were currently engaged in night shift work. In this study, we did not apply the exclusion criteria other than the above sleep schedule-related criteria, such as medication, cigarette habits, or whether they have a sleep disorder, to increase the population generality.

This study was approved by the Ethics Committee of the National Center of Neurology and Psychiatry. A document describing the conduct of the study was provided on the Nippon Research Center's web panel response site. This was a simplified online consent acquisition process, ensuring that all participants were guaranteed the opportunity to decline participation.

Measurements

Participants were asked to respond to a questionnaire that included the Japanese version of the MEQ (Ishihara et al. 1984) and demographic information such as gender, age, and region of residence. The MEQ comprises 19 questions related to circadian typologies, where higher total scores signify morning preference and lower scores indicate evening preference. The total MEQ score ranges 16–86. Data for the rMEQ were generated by extracting five items: questions 1, 7, 10, 18, and 19–from the MEQ (Adan and Almirall 1991). The total rMEQ score ranges 4–25.

Data analysis

MEQ scores were categorized into three types: evening (16–41 points), neither (42–58 points), and morning (59–86 points), following standard criteria (Horne and Ostberg 1976). Similarly, the rMEQ scores were categorized into three types: evening (4–11 points), neither (12–17 points), and morning (18–25 points), in line with the original work (Adan and Almirall 1991). The normality of the rMEQ score was evaluated using the Kolmogorov-Smirnov test. The contribution of all five items to the circadian typology assessment was verified, alongside the original rMEQ, using confirmatory factor analysis. Model fit was evaluated using metrics including the Goodness of Fit Index (GFI), Adjusted GFI (AGFI), Comparative Fit Index (CFI), and Root Mean Square Error of Approximation (RMSEA). Internal consistency of the rMEQ items was evaluated using Cronbach's α (Cronbach 1951) and McDonald's ω (McDonald 1978; McDonald 1999). Correlation between the rMEQ and MEQ scores was evaluated using Spearman's correlation coefficient. Classification agreement for circadian typology (evening, neither, morning type), as categorized by the MEQ and rMEQ, was assessed using Cramer's V and weighted Cohen's kappa. Statistical analyses were performed using R 4.2.2 (R Core Team) and the following R packages: lavaan v. 0.6.15 (Rosseel 2012), psych v. 2.2.5 (Revelle 2022), and rcompanion v. 2.4.18 (Mangiafico 2022). A $p < 0.05$ was considered statistically significant in all analyses.

Results

Responses in the web-based survey were obtained from 2,358 individuals, of whom 2,213 met the inclusion criteria (mean age 50.8 ± 15.4 years, ranging 20–79 years; 51% female), and the remaining were excluded based on the predefined exclusion criteria. Table 1 presents the demographic data of the final samples. The rMEQ score showed a mean ± SD of 16.15 ± 3.98, ranging 4–25. The skewness and kurtosis of the rMEQ score distribution were -0.25 and -0.45, respectively. The Kolmogorov-Smirnov test rejected the normality of the rMEQ score distribution (D = 0.069, $p < 0.001$) (Figure 1). The rMEQ score was significantly associated with age ($r = 0.29$, $p < 0.001$), indicating circadian typology more morningness with aging.

The psychometric properties of the rMEQ were verified using confirmatory factor analysis with a one-factor model. The results showed that the rMEQ assessed a one-factor structure corresponding to circadian typology with a high model fit (GFI = 0.984, AGFI = 0.951, CFI = 0.935, and RMSEA = 0.091). The factor loading of question items 1 to 5 of rMEQ corresponding to 1, 7, 10, 18 and 19 of MEQ was 0.533, 0.384, 0.472, 0.431 and 0.782, respectively. The Cronbach's α and McDonald's ω, indicating the internal consistency of the rMEQ items, were 0.618 and 0.654, respectively. Excluding any of the question items didn't improve the value of the Cronbach's α (excluded items Q1: 0.529, Q2: 0.599, Q3: 0.565, Q4: 0.587 and Q5: 0.499) and McDonald's ω (excluded items Q1: 0.606, Q2: 0.650, Q3: 0.626, Q4: 0.630 and Q5: 0.515).

Further, the rMEQ score was significantly correlated with the MEQ score ($\rho = 0.882$, $p < 0.001$; Figure 2). In terms of classification agreement, 77.6 % (1717 responses) of the 2213 responses were classified using the same circadian typology, with Cramer's V = 0.643 and weighted Cohen's kappa = 0.72 (Table 2). Of the respondents classified as E, N, or M-type on the MEQ, 87.4, 70.9 and 87.0% were classified as the same circadian typology on the rMEQ, respectively. The N-type had the lowest classification agreement, with 12.0% of respondents classified as N-type on the MEQ being classified as E-type and 17.1 % as M-type on the rMEQ. Respondents who were E-type on the MEQ were not classified as M-type on the rMEQ, nor were M-type on the MEQ classified as E-type on the rMEQ.

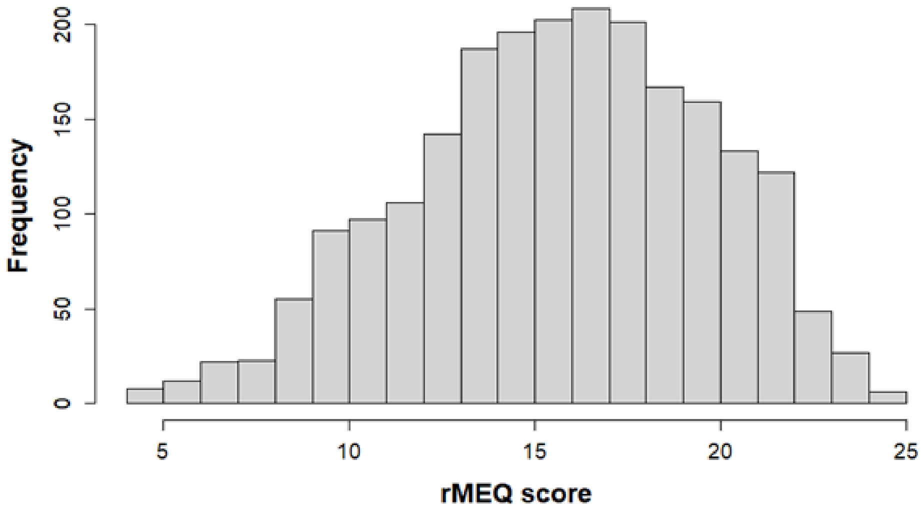

Figure 1. Histogram of the distribution of participants in the Japanese version of the rMEQ score.

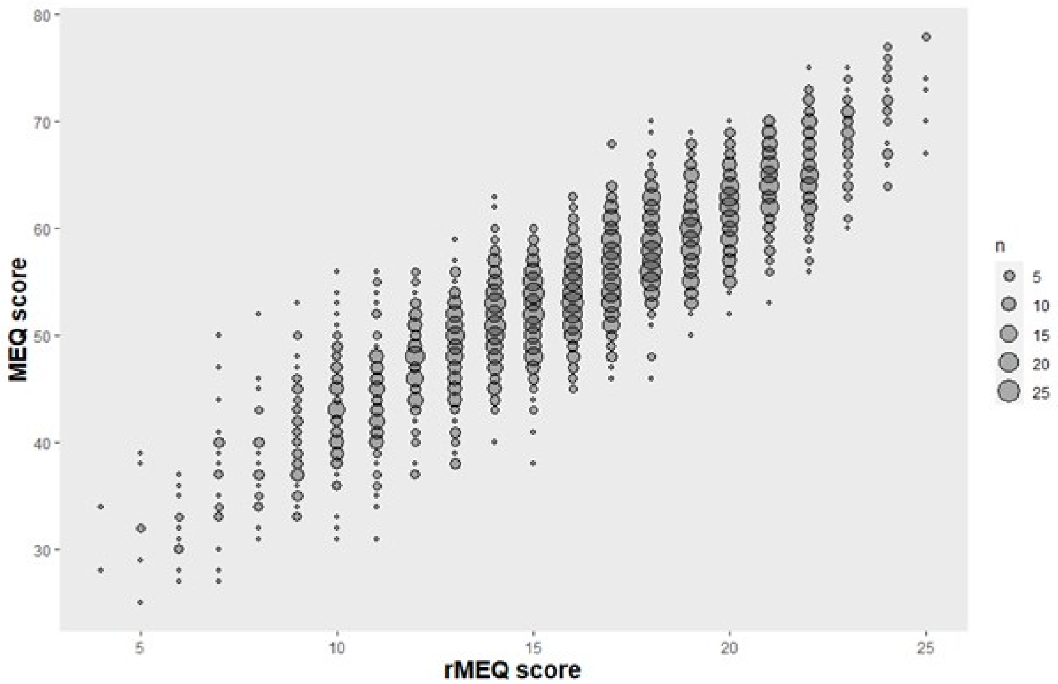

Figure 2. Correlation relationship between rMEQ and MEQ total scores.

Discussion

In this study, we reconstructed the Japanese version of the rMEQ from the 19-item version of the MEQ, following the original study (Adan and Almirall 1991), and the reliability and validity of rMEQ were evaluated. The distribution of the rMEQ scores diverged from normality, consistent with the English (Adan and Almirall 1991), Polish (Jankowski 2013), and German (Randler 2013) versions, thereby corroborating the results across different language versions.

The results of the confirmatory factor analysis indicated that the five items of the Japanese version of the rMEQ had a one-factor structure, reflecting only questions related to circadian typology assessment. This finding aligns with that of the original study, indicating a one-factor structure in the rMEQ (Adan and Almirall 1991). The Cronbach's α and Mcdonald's ω results showed that the internal consistency of the Japanese version of the rMEQ items is acceptable (van Griethuijsen et al. 2015; Taber 2018), and that the value of Cronbach's α was same as in the other language versions (Caci et al. 2009; Urbán et al. 2011; Carciofo et al. 2012; Danielsson et al. 2019), confirming the reliability of the Japanese rMEQ. Although the Cronbach's α value of the Japanese version of rMEQ didn't satisfy 0.7, considered an acceptable value (Tavakol and Dennick 2011) as same as some other language versions of rMEQ (Caci et al. 2009; Urbán et al. 2011; Carciofo et al. 2012; Danielsson et al. 2019), the values of correlation coefficients between rMEQ and MEQ score, and that of classification agreement of the circadian typologies were comparable to other language versions of rMEQ. Therefore, we believe that the Japanese version of rMEQ could be useful for international comparisons of the circadian typology using various language versions of rMEQ.

The rMEQ score demonstrated a strong correlation with the MEQ score, aligned closely with other language versions such as English (Adan and Almirall 1991) and Chinese versions (Carciofo et al. 2012), and confirmed its validity. In the terms of classification agreement of the circadian typologies, 77.6% of the 2,213 responses were consistent between rMEQ and MEQ. This agreement rate, along with the Cramer's V and weighted Cohen's kappa values (0.643 and 0.72, respectively) is comparable to those of the other language versions of the rMEQ (e.g., 78 % in English (Adan and Almirall 1991), 80 % and Cramer's V = 0.66 in English (Chelminski et al. 2000)). Further, the weighted Cohen's kappa fell within the range considered “substantive agreement” (Landis and Koch 1977). Examination of the agreement rates for each of the three circadian typologies revealed high agreement rates for all classifications. Therefore, the Japanese version of the rMEQ is considered valid and allows comparative studies of circadian typology based on the rMEQ among other language versions. On the other hand, there may be situations that need a relative classification of circadian typology (Roenneberg 2015) because the circadian typology depends on various factors, including age as shown in the results for the correlation between rMEQ and age.

Although this study established the reliability and validity of the Japanese version of the rMEQ, it had several limitations. First, the rMEQ in this study was reconstructed by extracting the MEQ data, and the rMEQ and MEQ were not evaluated independently. The possibility that independent implementation of the Japanese version of the rMEQ may lower circadian typology classification agreement needs to be verified in future studies. Next, the MEQs was also used as an external reference for validating the rMEQ. In the Italian version, sleep habits and acrophases of activity measured by actigraphy were used as external references to validate the rMEQ (Natale, Grandi, et al. 2006; Natale, Esposito, et al. 2006). Validation studies using actigraphy and/or dim light melatonin onset (DLMO), a standard marker of the circadian rhythm phase (Benloucif et al. 2008), as external references are needed for the Japanese version of the rMEQ.

In summary, we successfully developed a Japanese version of the rMEQ, a five-item circadian typology assessment questionnaire, and evaluated its reliability and validity. The rMEQ is a one-factor structure that assesses circadian typology, which involves phase differences in circadian rhythmicity and entrainment with an environmental light-dark rhythm. In the future, this version of rMEQ could be anticipated to serve as a valuable tool for efficiently evaluating circadian typologies in Japan.

Acknowledgments

Not applicable.

Declaration of Interest statement

The authors declare that they have no competing interests.

Availability of data and materials

The datasets analyzed in this study are not publicly available because of the privacy policy but are available from the corresponding author upon reasonable request.

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Tables

Table 1. Respondent demographic data.

Characteristic	Frequency (%)
Gender	
Male	1085 (49.0)
Female	1128 (51.0)
Age (years old)	
20–29	261 (11.8)
30–39	349 (15.8)
40–49	439 (19.8)
50–59	390 (17.6)
60–69	447 (20.2)
70–79	327 (14.8)
Region of residence	
Hokkaido/Tohoku	278 (12.6)
Tokai/Koshinetsu/Hokuriku	424 (19.2)
Kanto	711 (32.1)
Kansai	370 (16.7)
Chugoku/Shikoku/Kyushu	430 (19.4)

Table 2. Classification agreement of circadian typologies (Evening: E-type, Neither: N-type, Morning: M-type) between rMEQ and MEQ in the Japanese version.

		rMEQ			
		E-type	N-type	M-type	Total
MEQ	E-type	152 (87.4%)*	22 (12.6%)	0 (0.0%)	174 (100%)
	N-type	156 (12.0%)	923 (70.9%)	222 (17.1%)	1301 (100%)
	M-type	0 (0.0%)	96 (13.0%)	642 (87.0%)	738 (100%)
	Total	308 (13.9)	1041 (47.0)	864 (39.1)	2213 (100%)

*Percentages of each circadian typology in MEQ

Figure legends

Figure 1. Histogram of the distribution of participants in the Japanese version of the rMEQ score.

Figure 2. Correlation relationship between rMEQ and MEQ total scores.