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Validation of the Korean Munich Chronotype Questionnaire

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Abstract

Purpose The Munich Chronotype Questionnaire (MCTQ) assesses actual sleep-wake timing and has advantages compared to prior chronotype questionnaires in that it differentiates sleep-wake patterns between work days and free days and uses corrected mid-sleep time on free days after correcting for accumulated sleep debt over the week to categorize chronotype. The current study, we validated the Korean version of the MCTQ.

Methods In this study, 310 participants (mean age = 27.09 ± 5.64; 78.1% females) completed the Korean version of the MCTQ.

Results MCTQ parameters were significantly correlated with MEQ (Morningness-Eveningness Questionnaire) scores ($|r| \geq 0.48$), and test-retest reliability was ≥ 0.72. Cutoff scores of 2.5%, which correlated to 2.36 and 8.57 mid-sleep times in our sample, showed the best convergence with MEQ when categorizing chronotype.

Conclusions Our study suggests that the MCTQ is a useful questionnaire in assessing chronotype in young adults.

Keywords Sleep · Chronotype · Munich Chronotype Questionnaire · Mid-sleep time · Validation

Introduction

Morningness-eveningness chronotype is defined as the preferred timing of the sleep-wake cycle [1]. Morning types (M-types) prefer to go to sleep and wake up earlier and perform better in the mornings, whereas individuals who are evening types (E-types) prefer to go to sleep and get up later and performed better in the afternoon [2, 3].

Assessment methods for determining chronotype can generally be divided into physiological methods and self-report questionnaires. While physiological methods such as measuring dim light melatonin onset (DLMO) may be the most accurate method in measuring chronotype, they are limited because of invasive and costly reasons. Thus, the most commonly used method to determine chronotype in clinical settings are self-report questionnaires. The most widely used questionnaire is the Morningness-Eveningness Questionnaire (MEQ), which was developed by Horne and Östberg [4], and asks respondents on preferred timing for various activities, resulting in a total score that categorizes individuals into chronotype. However, the MEQ is aimed to study preferences of circadian rhythm and not real life situations or routine, such as measuring exact sleep times and differences between weekday and weekend sleep times [5].

An alternative measure that addresses these limitations is the Munich Chronotype Questionnaire (MCTQ), developed by Roenneberg et al. [6], which assesses actual sleep-wake timing and differentiates sleep-wake patterns between work days and free days and uses corrected mid-sleep time on free days after correcting for accumulated sleep debt over the week [7]. The MCTQ provides information on sleep timing, including bedtime, sleep latency, sleep onset, offset and time to get up considering work days and free days separately. Chronotype is classified based on mid-sleep time on free days

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[8]. However, most of people tend to accumulate sleep debt on work days and compensate sleep on free days [7]. Therefore, mid-sleep time on free days may over-estimate chronotype [8]. Thus, the MCTQ classifies chronotype based on MSFsc (mid-sleep on free days corrected for sleep debt on work days). Various cutoffs have been used to determine chronotype, with the original study using 2.5% (mid-sleep time of 2.17) to categorize samples into three groups.

The MCTQ is widely used and has been validated in Dutch [9], Japanese [10], and Polish [11]. It also has good correlations with physiological measures, as mid-sleep on free days corrected for sleep debt on work days (MSFsc) have indicated strong correlation with dim light melatonin onset (DLMO) [10] and phase of melatonin secretion [12, 13]. Recently, the Korean version of MCTQ-shift was validated in fast-rotating shift nurses [14]. Therefore, the current study aimed to validate the Korean version of the MCTQ.

Methods

All participants provided informed written consent prior to study participation. This study was approved by the local Institutional Review Board. Participants completed online questionnaires for this study.

Translation of the MCTQ

A bilingual individual with translation experience translated the original English version of the MCTQ. The first Korean version was back-translated into English by an independent translator. Prior to the main study, a pilot study ($n = 249$) was conducted using the back-translated version of the MCTQ. We then reviewed all answers to see if they reflected the intent of the original questions. Thus, we repeated the translation and back-translation process a second time and modified for wording and inconsistencies with the original version, resulting in the final Korean version of the MCTQ.

In the pilot study, only 19.7% responded to all questions correctly. The most common incorrect response was the confusion with the item 2 "Time when you go to sleep" with item 1, "Time when you prepare the bed for sleep", which occurred in 199 participants (79.9%). Confusion between these two items has also occurred with the Japanese validation of this questionnaire [10]. Similar to the Japanese revision, we included the following statements, "Turned off the light and close my eyes" to the original item "Time when you go to sleep." We also added specific examples to this item, and the final version stated "If you go to bed but stay awake for some time doing other activities (i.e., reading in bed or using your cell phone in bed), I turn off the light and close my eyes at _____ (time)" for clarification. The final version was confirmed by Till Roenneberg, who developed the original version of the MCTQ, and was used for the current study.

Participants

For this study, 499 young adults of a wide range of occupations were recruited through brochures, class announcements, and online advertisements in the community. We excluded shift workers from this study, and all employed participants were day workers. Among those recruited, 33 individuals were excluded due to missing MEQ data and 41 individuals were excluded because their responses did not reflect the intent of the questionnaires. For chronotype classification, 106 participants who use an alarm clock on free days were excluded. Thus, 319 participants were used for final analysis in this study. The sample consisted of 70 males (21.9%) and 249 females (78.1%), aged 20–39 years (mean age = 27.09 ± 5.64). A small subset of participants ($n = 78$) were selected to establish test-retest reliability of the MCTQ. This sample consisted of only female, aged 20–27 years (mean age = 21.83 ± 1.67).

Questionnaires

Munich Chronotype Questionnaire [6] The Munich Chronotype Questionnaire (MCTQ) was designed to measure actual sleep times separately for work and free days, and estimate chronotype based on the time-based variable (MSFsc) of the MCTQ. Mid-sleep time on free days corrected for sleep debt on work days (MSFsc) is a useful indicator to estimate chronotype [6]. Before measuring chronotype, responses indicating use of an alarm clock on free days to wake up should be excluded from analyses. If sleep duration on work days were longer than or equal to sleep duration on free days, MSF was used as a marker for chronotype, and if sleep duration on work days were shorter than sleep duration on free days, we used MSFsc to measure chronotype (see equations below).

$$\begin{aligned} \mathrm{MSF} &= \textit{Sleep onset} + \textit{Sleep duration}/2 \textit{MSFsc} \\ &= \mathrm{MSF} - (\textit{Sleep duration} \text{ on } \textit{free days} - \textit{average weekly sleep duration})/2 \end{aligned}$$

As suggested by Kühnle [5], MSFsc or MSF below 2.17 were classified as extreme M-types and MSFsc or MSF above 7.25 were classified as extreme E-types. These criteria were defined 2.5% at each end of the distribution as extreme chronotypes based on the distribution of MSFsc in their sample [5].

Morningness-Eveningness Questionnaire [4, 15] The MEQ is a 19-item self-report questionnaire designed to assess individual's chronotypes classified as M-type, intermediate-type (I-type), or E-type [4, 15]. It consists of mixed-format questions regarding the time in which individuals get up and go to bed, the preferred time to carry out

physical and mental activity, and subjective alertness. The MEQ total score ranges from 16 to 86, with scores above 58 classifying as M-types and scores below 41 as E-types. As suggested by Horne and Östberg [4], scores above 71 were classified as extreme M-types and scores below 31 were classified as extreme E-types. Internal consistency (Cronbach's alpha) was .718 in the current sample.

Insomnia Severity Index [16] The Insomnia Severity Index (ISI) is a 7-item self-report questionnaire that assesses the subjective symptoms and consequences of insomnia [16]. Each item is scored on a 0 to 4 Likert scale, with total scores ranging from 0 to 28. A higher score reflects more severe insomnia. Scores higher than 15 on the ISI indicate clinical insomnia [16]. Internal consistency (Cronbach's alpha) was .769 in the current samples.

Epworth Sleepiness Scale [17] The Epworth Sleepiness Scale (ESS) is 8-item self-report questionnaire that measure general level of daytime sleepiness. The ESS consists of eight different situations described chances of dozing off or falling asleep in daily life. Each item is scored on a 0 to 3 Likert scale, with total scores ranging from 0 to 24. Internal consistency (Cronbach's alpha) was .715 in the current samples.

Hospital Anxiety and Depression Scale [18] The Hospital Anxiety and Depression Scale (HADS) is a 14-item self-report questionnaire that assesses state of anxiety and depression [18]. It consists of two subscales, with seven anxiety and seven depression items. Each item is scored on a 0 to 3 Likert scale, with total scores ranging from 0 to 21. A higher score indicates higher levels of anxiety and depression. The HADS demonstrated good internal consistency in the current sample (Cronbach's $\alpha = .858$).

Table 1 Description of the sleep-wake patterns (24-h clock hour)

Variables		Mean	SD
Work days	Bed time	23:53	1:16
	Light off	0:44	1:24
	Sleep onset	0:59	1:30
	Sleep end	7:18	1:29
	Wake time	7:30	1:33
Free days	Bed time	0:38	1:26
	Light off	1:30	1:33
	Sleep onset	1:45	1:40
	Sleep end	9:24	1:49
	Wake time	9:48	1:57

($N = 319$)

Statistical analysis

Characteristics of MCTQ parameters were analyzed using descriptive statistics. Normality of the MCTQ parameter (MSFsc) and MEQ scores was analyzed by the Kolmogorov-Smirnov test. One-way analysis of variance (ANOVA) was used to examine differences in MCTQ parameters between two age groups and also to investigate sex differences. Test-retest reliability of MCTQ was performed by Pearson correlation analysis among MCTQ parameters (MSW, MSF, MSFsc) at baseline and 3-month

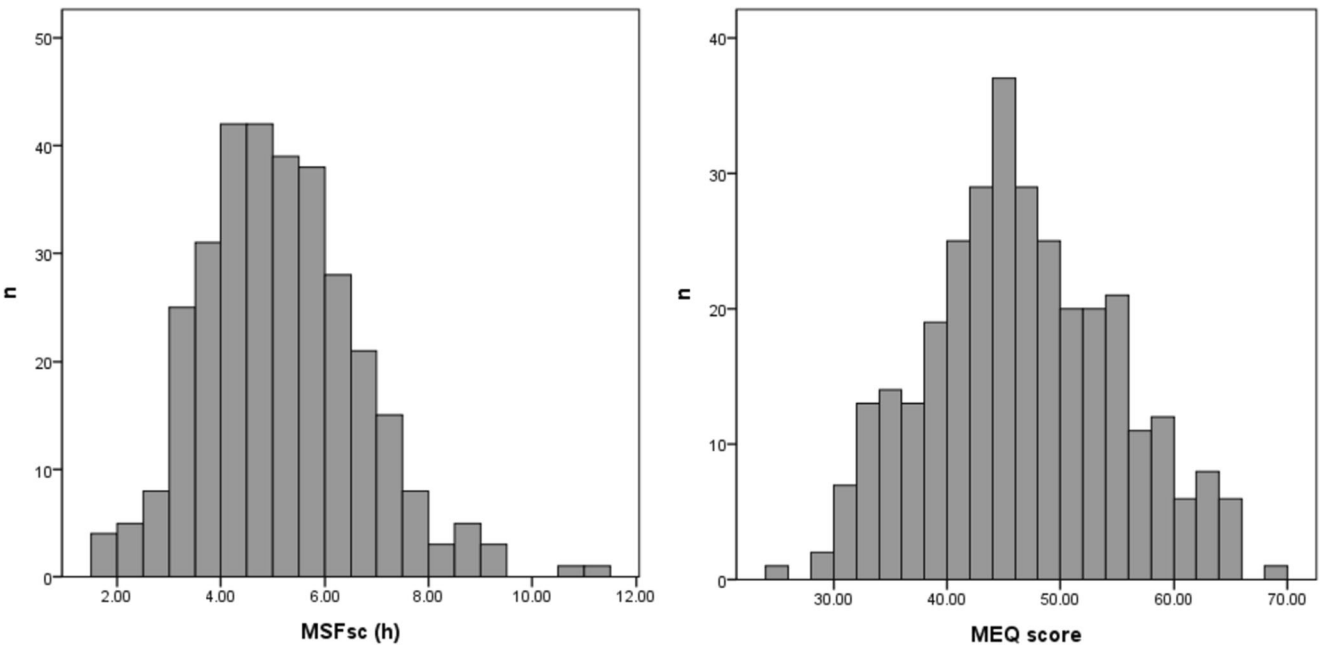

Fig. 1 Distribution of MCTQ parameters (mid-sleep on free days corrected for sleep debt on work days; MSFsc) and MEQ score

Table 2 Average values of the MCTQ parameters per age and gender group (characteristics of MCTQ parameters)

Variable names		*n*	MSW		MSF		MSFsc	
			M (SD)	*F*	M (SD)	*F*	M (SD)	*F*
Total		319	4.15 (1.34)		5.58 (1.58)		5.13 (1.54)	
Age	20s	213	4.52 (1.34)	74.05***	6.09 (1.50)	99.72***	5.60 (1.47)	85.32***
	30s	106	3.39 (.97)		4.54 (1.19)		4.18 (1.19)	
Gender	Male	70	3.90 (1.14)	3.03	5.45 (1.50)	.59	4.96 (1.46)	1.01
	Female	249	4.21 (1.38)		5.61 (1.60)		5.17 (1.56)	

Abbreviations: *MSW* mid-sleep on work days, *MSF* mid-sleep on free days, *MSFsc* mid-sleep on free days corrected for sleep debt on work days

($N = 319$)

***$p < .001$

follow-up. To evaluate the validity of the MCTQ, correlation analyses were conducted looking at the association between MCTQ parameters with MEQ and clinical variables. Additionally, chronotype classified by MEQ and MCTQ were presented using frequency analysis. SPSS software version 21.0 (SPSS Inc., Chicago, IL, USA) was used for data analyses.

Results

Validation of the MCTQ

After modifications were made from the pilot study to the original translation, 92.91% participants ($n = 433$) responded to the questions correctly in the current study. The sleep-wake pattern on workdays and free days documented by MCTQ are presented in Table 1. Free days showed delayed sleep-wake patterns including bed time, light off, sleep onset, sleep end, and wake time. Mean values for the MCTQ parameter MSFsc was 5.13 ± 1.54 with a normal distribution (D (319) = .04, p = .200) (Fig. 1, left). In our sample, 2.5% cutoffs were 2.36 and 8.57, which were slightly higher compared to the original 2.17 reported by Kühnle [5].

We divided the sample into two age groups (20s and 30s) and gender for comparison. Average values of the MCTQ parameters for two different age groups and gender are shown in Table 2 including MSW, MSF, and MSFsc. The mid-sleep time on work days and free days were significantly later for young adults in their 20's compared to those in their 30's (all $ps < .001$). Mid-sleep time on free days corrected for sleep debt on work days (MSFsc) was also later for young adults in their 20s compared to those in their 30s (MSFsc 5.60 ± 1.47 vs. 4.18 ± 1.19), with younger age being more strongly associated with eveningness tendencies (F (1, 252.52) = 85.32, $p < .001$). There was no significant gender difference for all MCTQ parameters.

A small group from the original sample ($n = 78$) was selected for 3-month follow-up to determine test-retest reliability of MCTQ. The result of correlation the parameters between baseline and follow-up was significantly positive (MSW $r = .73$, $p < .001$; MSF $r = .72$, $p < .001$; MSFsc $r = .72$, $p < .001$). Results are summarized in Tables 3 and 4. We also examined how consistent chronotype classification would be at 3-month follow-up in this sample. The rate of consistency of chronotype

Table 3 Test-retest reliability of MCTQ

		MSW	MSF	MSFsc	MSW_f	MSF_f	MSFsc_f
Baseline ($n = 319$)	MSW	1					
	MSF	.736***	1				
	MSFsc	.769***	.956***	1			
3-month follow-up ($n = 78$)	MSW_f	.737***	.628***	.678***	1		
	MSF_f	.569***	.721***	.719***	.733***	1	
	MSFsc_f	.615***	.685***	.723***	.817***	.951***	1
	Mean	4.15	5.58	5.13	5.48	6.82	6.39
	SD	1.34	1.58	1.54	1.44	1.78	1.62

Abbreviations: MSW = mid-sleep on work days, *MSF* = mid-sleep on free days, *MSFsc* = mid-sleep on free days corrected for sleep debt on work days

($n = 78$)

***$p < .001$

Table 4 Rate of consistency using different cutoffs in classifying chronotypes

	Cutoffs			
Rate of consistency	2.17		2.5%	
	Extreme morning 0% Intermediate 87.3%	89%	Extreme morning 0% Intermediate 87.9%	93.3%
	Extreme evening 100%		Extreme evening 100%	

($n = 78$)

was 89% when using mid-sleep time of 2.17, and was higher at 93.3% when using the 2.5% criterion. When using 2.17 as the cut-off for classifying chronotype, consistency was highest in classifying extreme E-types after 3 months (100%, $n = 10$), followed by I-types (87.3%, $n = 55$) and 0% for extreme M-types. When using 2.5% criterion from our sample, consistency was still highest for extreme E-types (100%, $n = 7$), followed by I-types (87.9%, $n = 58$), and extreme M-types (0%).

MSW, MSF, and MSFsc were not significantly correlated with insomnia, daytime sleepiness, depression, and anxiety at baseline (Table 5).

Comparison with MEQ

Mean MEQ scores for all participants was 46.09 ± 8.38. Distribution was not normal for MEQ scores ($D(319) = .06$, $p = .002$), and skewness and kurtosis were slightly differ from the normal distribution (skewness = .16, kurtosis = − .40) (Fig. 1, right).

There was a significantly negative relationship between MEQ scores and all MCTQ parameters, including MSW, MSF and MSFsc (all $ps < .01$). Results are summarized in Table 5. In addition, we compared classification of chronotype based on MEQ and MCTQ. The concordance rate of MEQ and MCTQ using mid-sleep time cutoff 2.17 was 88.4%, which was lower than 94% when using 2.5% of extreme scores of the sample (Table 6).

Discussion

The current study aimed to validate the Korean version of the MCTQ. We validated the MCTQ in a Korean sample of young adults, and compare MCTQ parameters with other chronotype measures (MEQ). In the validation process, a pilot study revealed similar confusion of bedtime and lights out as the Japanese version [10]. Similar modifications were also made to the Korean version as well as the Japanese version that were approved by the original developer of the MCTQ (T.R.), with 92.91% of respondents answering correctly to the final modified version. The MCTQ also yielded adequate convergent validity, with mid-sleep time parameters (MSW, MSF, and MSFsc) being significantly correlated with MEQ scores ($|r| \geq 0.48$). While the correlations are slightly lower than what is found in the Japanese, Dutch, and Polish version of the MCTQ [9–11], they were significant and within adequate range. The MCTQ parameter that showed the strongest correlation with MEQ was MSF ($r = -.517$) which was consistent with the original version and also with the Japanese version [10].

Table 5 Clinical correlates of variables at baseline

	MSW	MSF	MSFsc	MEQ	ISI	ESS	ANX	DEP
MSW	1							
MSF	.736**	1						
MSFsc	.769**	.956**	1					
MEQ	−.488**	−.571**	−.546**	1				
ISI	.058	.024	.018	− .046	1			
ESS	.055	.106	.092	− .112*	− .071	1		
ANX	.110	.078	.090	− .152**	.024	.178**	1	
DEP	.014	− .037	− .041	− .098	.059	.184**	.550**	1
Mean	4.15	5.58	5.13	46.09	11.01	7.75	6.41	6.58
SD	1.34	1.58	1.54	8.38	20.06	3.60	3.90	3.33

Abbreviations: *MSW* = mid-sleep on work days, *MSF* = mid-sleep on free days, *MSFsc* = mid-sleep on free days corrected for sleep debt on work days; *MEQ* = Morningness-Eveningness Questionnaire, *ISI* = Insomnia Severity Index; ESS = Epworth Sleepiness Scale, *ANX* = anxiety, *DEP* = depression

($N = 319$)

*$p < .05$, **$p < .01$

Table 6 Comparison with MCTQ and MEQ

	MEQ	MCTQ with cutoff of 2.17 mid-sleep time			MCTQ with cutoff of 2.5% of sample		
	n	%	*n*	%	Concordance rate	*n*	%	Concordance rate
Extreme late	6	1.9	27	8.5	88.40%	8	2.5	94%
Late	88	27.6	286	89.7		304	95.3	
Normal	200	62.7						
Early	25	7.8						
Extreme early	0	0	6	1.9		7	2.2	

Abbreviations: *MCTQ* = Munich Chronotype Questionnaire, *MEQ* = Morningness-Eveningness Questionnaire (*N* = 319)

A slightly lower correlation with MEQ compared to different countries may have been due to several reasons. The age range from our sample may have been smaller compared to the Japanese (age range 20–81), Dutch (age range 17–78), and Polish (age range 13–46) versions. Another explanation could be that the sleep duration in the Korean sample was 6.7 h, which was significantly shorter than the Dutch (7.74 h) or German and Swiss (7.74 h) samples (the TST for the Japanese sample was not reported). The short total sleep time found in our study was also consistent with other studies using Korean samples, with all studies reporting less than 7 h [14, 19, 20]. Finally, another explanation can be found in bigger discrepancy between weekday and weekend total sleep times. In our study, the difference between weekday and weekend TST was 1.31–1.56 h, while it was 1.02 h in the Japanese sample and 1.1 h in the Dutch sample. This was consistent with another study investigating sleep behavior in a Korean sample, reporting 1.52 h of discrepancy between weekdays and weekend TST [19].

In regard to selecting a cutoff for classifying chronotype, 2.5% (corresponding to 2.36 and 8.57 in our sample) proved to be the most accurate when compared to classification in the MEQ. Test-retest reliability at 3 months in a subsample of individuals also showed that correlation after time with original baseline scores remained high (correlation range 0.56–0.73). Using the 2.5% cutoff yielded the best test-retest reliability of 93.3%, with highest consistency extreme E-types (100%), followed by I-types (87.9%). This is not surprising considering our sample consisted of young adults, who tend to show overall stronger eveningness tendencies [21].

Despite our findings, this study had limitations. This study was conducted on a relatively narrow age range of participants, with young adults in their 20s and 30s, and thus generalizability to other age ranges are limited. This resulted in a low frequency of M-types in our sample. However, despite our narrow age range, the phase of mid-sleep on work days, free days, and mid-sleep on free days corrected for sleep debt were significantly later for young adults in their 20s compared to those in their 30s, with younger age being more strongly associated with having more eveningness tendencies. Additionally, test-retest reliability was only measured in females for study 1, and not in males, and thus future studies may be needed to generalize across gender in addition to other age groups.

Conclusion

The current study examined the validity of the Munich Chronotype Questionnaire (MCTQ) in a Korean sample. The MCTQ demonstrated adequate validity in the Korean sample compared to the MEQ, and cutoff scores of 2.5% showed the best convergence with the MEQ.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Informed consent Informed consent was obtained from all individual participants included in the study.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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