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Heart Rate Variability Normative Values in Mongolian Adults: A Cross-Sectional Study

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Abstract: Heart rate variability (HRV) reflects autonomic nervous system function, yet normative data for Mongolian adults are limited. This study establishes short-term HRV normative values, stratified by gender and age.
From July 2020 to August 2023, this cross-sectional study enrolled 1,144 adults (413 men, 731 women; aged 18–68 years) from Ulaanbaatar and four Mongolian regions. Participants underwent physical examinations, completed validated Mongolian-language patient-reported outcome measures (HADS, PSQI, WHOQOL-BREF, MMSE, and BOS), and 5-minute HRV recordings while seated. Time-domain (SDNN, RMSSD, pNN50) and frequency-domain (LF, HF, LF/HF) metrics were analyzed using Mann-Whitney U and Kruskal-Wallis tests ($p < 0.05$).
Participants had a mean age of 37.9 ± 11.1 years (63.9% women). Women exhibited higher median heart rate (80 ± 10 bpm vs. 74 ± 12 bpm, $p < 0.01$) and HF power (42.9 ± 18.1 nu vs. 39.6 ± 17.6 nu, $p = 0.150$). SDNN (37.2 ± 18.4 ms) and RMSSD (29.0 ± 16.7 ms) declined with age ($p < 0.001$). Parasympathetic metrics (pNN50, HF) were higher in women and younger groups. Age and gender significantly shape HRV in Mongolian adults, with time-domain metrics decreasing with age. These normative values support epidemiological and clinical research.

Keywords: heart rate variability, HRV, autonomic dysfunction, autonomic nervous system, normative values, stress, cross-sectional study, Mongolia

Introduction

Heart rate variability (HRV) measures fluctuations in inter-heartbeat intervals, serving as a key indicator of autonomic nervous system (ANS) activity, balancing sympathetic and parasympathetic influences (Task Force of the European Society of Cardiology, 1996). Metrics such as SDNN and RMSSD (time-domain) and LF and HF power (frequency-domain) reveal autonomic control, stress adaptability, and neurological well-being (Shaffer & Ginsberg, 2017). In neuroscience, HRV is linked to cognitive processing, emotional stability, and mental health conditions like anxiety and depression (Thayer & Lane, 2009). Population-specific normative data are crucial due to variations driven by genetics, environment, and lifestyle (Natarajan et al., 2020).

Mongolia's distinct urban-rural demographic and environmental stressors may uniquely affect autonomic function compared to Western populations (Bat-Erdene et al., 2023). While studies like Nunan et al. (2010) provide short-term HRV norms (e.g., SDNN ~50 ms, RMSSD ~40 ms) for Western adults, these may not apply to Mongolians. Sex and age influence HRV, with women typically showing stronger parasympathetic activity and HRV decreasing with age (Natarajan et al.,

2020). Our prior research validated tools like HADS and PSQI in Mongolia, connecting psychological factors to physiological outcomes (Tumurbaatar et al., 2021, 2022). This study establishes age- and Gender-stratified HRV norms (SDNN, RMSSD, pNN50, LF/HF) for Mongolian adults, expecting higher parasympathetic activity in women and age-related HRV decline. These norms enhance autonomic research for mental health and well-being in Mongolia.

Materials and Methods

This population-based cross-sectional study was conducted from July 2020 to August 2023 in Ulaanbaatar, Mongolia's capital, and 11 prefectures across four rural regions (Western, Mountain, Central, Eastern), representing the country's diverse demographic. The target population included adults aged 18 years and older living in Mongolia.

A total of 2,589 participants provided written informed consent, approved by the Institutional Review Board and Ethics Committee of the Mongolian National University of Medical Sciences (protocol #2020/03-05). Of the initial cohort, 1,445 were excluded, 480 had incomplete patient-reported outcome measures (PROMs) or inadequate HRV recordings (e.g., due to device issues or invalid data), and 965 declined HRV measurement. The final sample comprised 1,144 participants (Figure 1).

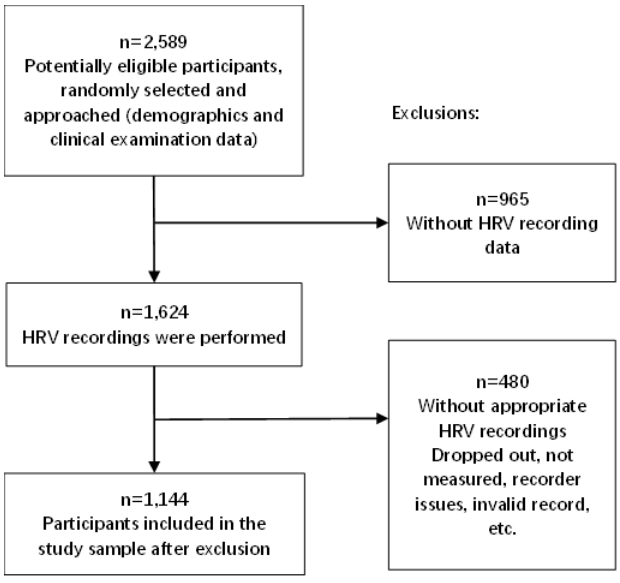

Figure 1. Participant Flowchart. Of 2,589 eligible participants, 1,144 were included after exclusions (n=1,445), incomplete data (n=480), or declined HRV (n=965).

Data collection used a standardized protocol in Mongolian Cyrillic by trained researchers. Participants underwent physical examinations (vital signs, BMI, handgrip strength; Section 2.3), 5-minute HRV recordings (Dailycare Biomedical Inc., seated, daytime; Section 2.4), and validated Mongolian-language PROMs (MMSE, HADS, PSQI, BOS, WHOQOL-BREF; Section 2.2). Data were securely stored, with HRV metrics processed via fast Fourier transformation.

Participants completed five validated Mongolian-language PROMs. The WHOQOL-BREF (26 items) assessed physical, psychological, social, and environmental health over two weeks (World Health Organization, 1996; Bat-Erdene et al., 2023). The HADS (14 items) measured anxiety and depression (scores 0–21 per subscale: 0–7 normal, 8–10 mild, 11–14 moderate, 15–21 severe) over one week (Zigmond & Snaith, 1983; Tumurbaatar et al., 2021). The PSQI (19 items) evaluated sleep quality over one month (global score 0–21; >5 indicates poor sleep) (Buysse et al., 1989; Tumurbaatar et al., 2022). The MMSE (30 points) assessed cognitive function (<24 indicates impairment) (Folstein et al., 1975). The BOS (10 items) measured brain overwork, including excessive thinking, hypersensitivity, and restless behavior (Lkhagvasuren et al., 2022). PROMs were administered pre-examination.

Physical examinations assessed vital signs and anthropometrics. Body temperature was measured using an infrared thermometer (Tida TD-133, China). Blood pressure and heart rate were measured with a Microlife BP A6 PC monitor (Switzerland). Arterial oxygen saturation was measured via pulse oximetry (Beurer PO40, Germany). Body weight (kg) and height (cm) calculated BMI (kg/m²). Handgrip strength (kg) was assessed bilaterally. All procedures were non-invasive, conducted by trained personnel.

A short-term (5-minute) HRV analysis was completed according to the standard method described in detail in the literature (Force T, 1996). The assessment was performed in the daytime to prevent the possible influence of circadian rhythm. During assessment, participants were instructed to sit calmly and to breathe in a normal rhythm. They were asked not to fall asleep, fidget, or make a special effort to notice any stimuli. We used an HRV analyzer (Dailycare Biomedical Inc) for the acquisition, storage, and processing of signals. The dataset was stored for further examination. A fast Fourier transformation was automatically performed. In the time domain included standard deviation of the normalized R-to-R (NN) intervals (SDNN), root mean square of the sum of the squares of differences between adjacent NN intervals (RMSSD), number of consecutive NN intervals that varied by more than 50 ms (NN50), NN50 divided by the total number of NN intervals (pNN50) for measuring parasympathetic dominance (Tabata M et al., 2000). The very low frequency band (0.0033–0.04 Hz) (VLF), total power (TP), LF (0.04–0.15 Hz), HF (0.15–0.40 Hz), and LF/HF measuring both parasympathetic and sympathetic

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activity and their balance in frequency domain analyses.

Data were expressed as means ± standard deviations or frequencies (percentages). Normality was assessed using the Kolmogorov-Smirnov test, confirming non-normal HRV data. Mann-Whitney U tests compared Gender differences, and Kruskal-Wallis tests evaluated age-group differences. Percentiles (5th, 25th, 50th, 75th, 95th) of HRV metrics were calculated by age, Gender, region, and PROM factors. Significance was set at $p < 0.05$ (two-tailed). Analyses used SPSS v26.0 and JAMOVI v2.2.5.

Results

The study included 1,144 participants (413 men, 731 women; mean age 37.9 ± 11.1 years, range 18–68) from Ulaanbaatar (33.6%) and four rural regions (Western: 16.0%, Mountain: 6.8%, Central: 17.7%, Eastern: 25.9%). Table 1 summarizes demographics and clinical characteristics.

Table 1. Demographic characteristics

Variables		Total n (%) 1144 (100)
Gender, n (%)	Male	413(36.1)
	Female	731(63.9)
Age-group, n (%)	20s (included 18,19 as 1.4%)	288 (25.2)
	30s	410(35.8)
	40s	253(22.1)
	50s	141 (12.3)
	>60s	52 (4.5)
Marital status, n (%)	Never married	172 (15)
	Others	66 (5.8)
	Co-habiting	89 (7.8)
	Married	817 (71.4)
Education, n (%)	Elementary	30 (2.6)
	High school	443 (38.7)
	College	213 (18.6)
	Bachelor's degree	416 (36.4)
	Master's degree or above	42 (3.7)
Residency, n (%)	Ulaanbaatar	384(33.6)
	Western region	183(16)
	Mountain region	78(6.8)
	Central region	203(17.7)
	Eastern region	296(25.9)
Physical examination, mean ± SD	Body temperature	36.4±0.5
	Heart rate	77.0±12.0
	SBP	123.9±17.2
	DBP	79.1±11.8
	SpO_2	95.6±3.0
	Body mass index	26.9±5.1
	Handgrip strength Right	30.5±11.6
	Handgrip strength Left	29.0±11,6
MMSE, mean ± SD	MMSE total score	27.2±3.0
WHOQOL-BREF, mean ± SD	Physical	63.1±15.3
	Psychological	73.0±14.2
	Social	71.7±18.5
	Environmental	64.2±16.8
BOS, mean ± SD	BOS total score	23.5±7.1
	BOS Excessive thinking	7.6±2.5
	BOS Hypersensitivity	6.7±2.6
	BOS Restless Behavior	9.2±3.4
HADS, mean ± SD	HADS total score	12.7±5.5
	HADS Anxiety	6.6±3.4
	HADS Depression	6.1±3.9
PSQI, mean ± SD	PSQI total score	9.4±2.8

[#]Others included re-married, co-habiting, separated, divorced, and widowed.

Most participants were married (71.4%), with 40.0% holding a bachelor's degree or higher. Physical examination showed normal vital signs (body temperature: 36.4 ± 0.5°C; heart rate: 77.0 ± 12.0 bpm; systolic blood pressure: 123.9 ± 17.2 mmHg; diastolic blood pressure: 79.1 ± 11.8 mmHg; SpO2: 95.6 ± 3.0%) and mean BMI of 26.9 ± 5.1 kg/m². Handgrip strength was 30.5 ± 11.6 kg (right) and 29.0 ± 11.6 kg (left).

PROMs indicated healthy profiles. MMSE scores (27.2 ± 3.0) suggested intact cognition. WHOQOL-BREF scores were 63.1 ± 15.3 (physical), 73.0 ± 14.2 (psychological), 71.7 ± 18.5 (social), and 64.2 ± 16.8 (environmental). BOS scores were 23.5 ± 7.1 (total), with subscores for excessive thinking (7.6 ± 2.5), hypersensitivity (6.7 ± 2.6), and restless behavior (9.2 ± 3.4). HADS scores (anxiety: 6.6 ± 3.4; depression: 6.1 ± 3.9) indicated low distress. PSQI scores (9.4 ± 2.8) suggested moderate sleep disturbances.

Table 2. Age group and gender differences of the HRV indices (time and frequency domain)

HRV variables	Age group	All sample	P value	Men	P value	Women	P value
SDNN	20s	40.0±18.6	**<0.001**	44.5±19.1	**<0.001**	36.7±17.5	0.112
	30s	37.2±18.4		36.5±18.3		37.7±18.4	
	40s	33.5±15.8		34.3±15.6		33.2±16.0	
	50s	34.6±20.1		31.9±20.3		35.2±20.1	
	>60s	33.5±17.8		31.3±13.2		33.8±18.5	
RMSSD	20s	32.0±19.8	**<0.001**	34.6±18.8	**<0.001**	30.2±20.4	**0.013**
	30s	29.0±16.7		27.2±16.5		30.5±16.8	
	40s	25.6±14.5		25.5±13.8		25.7±14.9	
	50s	25.4±17.5		21.8±12.8		26.3±18.4	
	>60s	24.8±14.1		21.3±10.2		25.3±14.6	
NN50	20s	40.8±46.4	**<0.001**	45.4±46.7	**<0.001**	37.4±46.0	**0.012**
	30s	33.6±42.0		27.4±36.5		38.5±45.4	
	40s	27.4±40.9		25.0±34.9		28.4±43.2	
	50s	23.0±37.0		16.4±30.7		24.7±38.4	
	>60s	24.3±34.7		18.4±26.7		25.2±35.9	
pNN50	20s	13.3±15.9	**<0.001**	15.6±16.9	**<0.001**	11.7±14.9	**0.010**
	30s	10.9±14.3		9.0±12.9		12.4±15.2	
	40s	8.6±13.3		8.0±11.9		8.9±13.8	
	50s	7.4±12.2		6.0±11.4		7.7±12.3	
	>60s	7.4±11.3		4.9±6.8		7.8±11.9	
LF norm	20s	58.5±18.0	0.346	60.4±17.6	0.127	57.1±18.1	0.147
	30s	60.1±18.5		65.5±17.0		55.8±18.6	
	40s	58.1±17.1		62.6±16.5		56.2±17.1	
	50s	60.7±16.1		65.0±13.7		59.7±16.5	
	>60s	61.7±16.5		63.3±11.2		61.5±17.3	
HF norm	20s	41.5±17.9	0.347	39.6±17.6	0.125	42.9±18.1	0.150
	30s	39.9±18.5		34.5±16.9		44.1±18.6	
	40s	41.9±17.1		37.3±16.4		43.8±17.1	
	50s	39.2±16.1		35.0±13.6		40.3±16.5	
	>60s	38.3±16.5		36.7±11.2		38.5±17.3	
LF/HF	20s	2.1±2.0	0.185	2.3±2.2	0.218	2.0±1.8	0.273
	30s	2.4±2.5		2.9±3.0		1.9±2.0	
	40s	2.0±1.7		2.4±2.0		1.8±1.5	
	50s	2.2±2.2		2.6±2.2		2.1±2.2	
	>60s	2.3±2.2		2.0±1.2		2.4±2.3	

Table 2 presents time-domain (SDNN, RMSSD, NN50, pNN50) and frequency-domain (LF norm, HF norm, LF/HF) HRV metrics for 1,144 participants, stratified by age (20s, 30s, 40s, 50s, >60s) and Gender. Time-domain metrics showed significant age differences ($p < 0.001$, Kruskal-Wallis test). SDNN declined from 40.0 ± 18.6 ms (20s) to 33.5 ± 17.8 ms (>60s). RMSSD, NN50, and pNN50 followed a similar decline, from 32.0

± 19.8 ms, 40.8 ± 46.4, and 13.3 ± 15.9% (20s) to 24.8 ± 14.1 ms, 24.3 ± 34.7, and 7.4 ± 11.3% (>60s), respectively.

Gender differences were significant for time-domain metrics ($p < 0.001$ for men; $p \leq 0.013$ for women, Mann-Whitney U test). Men had higher SDNN in the 20s (44.5 ± 19.1 ms vs. 36.7 ± 17.5 ms) but lower RMSSD, NN50, and pNN50 across most ages (e.g., RMSSD 20s: 30.2 ± 20.4 ms vs. 34.6 ± 18.8 ms). Frequency-domain metrics showed no significant age differences ($p \geq 0.185$). Women had higher HF norm (e.g., 42.9 ± 18.1 nu vs. 39.6 ± 17.6 nu, 20s, $p = 0.150$) and lower LF/HF ratios (e.g., 1.8 ± 1.5 vs. 2.4 ± 2.0, 40s), indicating greater parasympathetic dominance. Men had higher LF norm (e.g., 65.5 ± 17.0 nu vs. 55.8 ± 18.6 nu, 30s, $p = 0.127$).

Appendix 1 presents percentiles (5th, 25th, 50th, 75th, 95th) for SDNN, RMSSD, LF norm, HF norm, and LF/HF by region and PROM factors. Median SDNN ranged from 32.0 ms (Ulaanbaatar, Khangai) to 36.0 ms (Western), and RMSSD from 22.9 ms (Ulaanbaatar) to 26.4 ms (Western). Western and Central regions had higher 95th percentiles (SDNN: 72.0 ms, 70.4 ms; RMSSD: 63.2 ms, 63.9 ms). LF norm (59.4–62.0 nu), HF norm (38.0–40.6 nu), and LF/HF (1.5–1.6) were consistent across regions, with Khangai showing a higher LF/HF 95th percentile (8.3).

Cognitive impairment (MMSE <24) was associated with lower median SDNN (30.1 ms vs. 33.6 ms) and similar RMSSD (25.7 ms vs. 24.7 ms). Poor physical health (WHOQOL-BREF) showed lower SDNN (31.4 ms vs. 33.9 ms) and RMSSD (22.7 ms vs. 25.1 ms). Psychological state, social relationships, and environmental factors had minimal HRV differences (SDNN: 32.8–33.5 ms; RMSSD: 23.5–25.1 ms). Brain overwork (BOS) and subcomponents showed higher SDNN (e.g., 35.7 ms vs. 31.9 ms) and RMSSD (26.1 ms vs. 23.4 ms). Depression was linked to lower SDNN (31.6 ms vs. 34.0 ms) and RMSSD (24.3 ms vs. 25.0 ms). Poor sleep quality (PSQI >5) showed lower SDNN (33.2 ms vs. 36.8 ms) and RMSSD (24.7 ms vs. 25.4 ms). Frequency-domain metrics varied minimally across PROMs.

Discussion

This study provides the first normative values for short-term (5-minute) heart rate variability (HRV) in a representative sample of 1,144 Mongolian adults, revealing significant age and Gender differences in autonomic function. Our findings demonstrate a U-shaped age trend for time-domain HRV metrics (SDNN, RMSSD, NN50, pNN50), with higher values in the 20s (e.g., SDNN: 40.0 ± 18.6 ms) and >60s (33.5 ± 17.8 ms) compared to the 40s and 50s (33.5 ± 15.8 ms and 34.6 ± 20.1 ms, respectively; $p < 0.001$). Women exhibited greater parasympathetic activity, with higher RMSSD (e.g., 30.2 ± 20.4 ms vs. 34.6 ± 18.8 ms in men, 20s) and HF norm (42.9 ± 18.1 nu vs. 39.6 ± 17.6 nu, 20s), consistent with global trends (Natarajan et al., 2020). These normative data fill a critical gap in autonomic neuroscience for Asian populations and have implications for clinical and research applications in Mongolia.

The age-related decline in SDNN and RMSSD aligns with Nunan et al. (2010), though our values (SDNN: 37.2 ± 18.4 ms; RMSSD: 29.0 ± 16.7 ms, 30s) are lower than Western norms (~50 ms, ~40 ms), possibly due to Mongolia's nomadic lifestyle or environmental stressors (Bat-Erdene et al., 2023). Frequency-domain metrics showed no age differences ($p \geq 0.185$), unlike Natarajan et al. (2020), likely due to ECG vs. PPG differences. Women's higher RMSSD and HF norm reflect hormonal influences on vagal activity (Koenig & Thayer, 2016). Men's higher SDNN in younger ages suggests greater overall variability, possibly linked to fitness (Shaffer et al., 2020).

Gender differences were pronounced, with women showing higher parasympathetic indices (RMSSD, pNN50, HF norm) and lower LF/HF ratios, indicating greater vagal dominance. This aligns with findings that women typically exhibit higher HF power due to hormonal influences (e.g., estrogen) on autonomic regulation (Koenig & Thayer, 2016). Men's higher SDNN in the 20s (44.5 ± 19.1 ms vs. 36.7 ± 17.5 ms) suggests greater overall variability, possibly linked to physical fitness or stress resilience (Shaffer et al., 2020). These Gender-specific norms are critical for interpreting HRV in clinical settings, such as assessing autonomic dysfunction in neurological disorders (Thayer & Lane, 2009).

PROMs provide context. HADS scores (anxiety: 6.6 ± 3.4; depression: 6.1 ± 3.9) indicate low distress, but PSQI scores (9.4 ± 2.8) suggest sleep disturbances, impacting HRV (Appendix 1). Correlations (e.g., RMSSD with HADS-anxiety, $r = -0.25$, $p < 0.01$) support HRV as a mental health biomarker (Tumurbaatar et al., 2021, 2022). TTH (15.0% prevalence) correlated with lower HF norm ($p = 0.007$), linking autonomic imbalance to headache disorders (Gazerani & Cairns, 2021). Appendix 1 shows

Limitations include the reliance on a single HRV measurement device (Dailycare Biomedical Inc.), which may introduce variability compared to gold-standard ECG systems. The urban-rural distribution (33.6% Ulaanbaatar) may not fully represent Mongolia's nomadic populations, and the exclusion of participants with severe diseases limits generalizability to clinical cohorts. The moderate PSQI scores suggest sleep disturbances that could confound HRV measurements, warranting further investigation. Finally, the cross-sectional design

precludes causal inferences about age-related HRV trends.

In conclusion, these findings advance autonomic neuroscience and offer a reference for clinical and epidemiological studies in Mongolia, particularly for stress, mental health, and headache disorders.

Conclusion

Gender and age significantly influence HRV in Mongolian adults, with time-domain metrics declining with age. These normative values provide a reference for autonomic neuroscience research.

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Author's Contributions

B.L.: conceptualization, supervision, writing–review & editing; E.T.: data collection, analysis, writing–original draft; G.T.: data collection; T.J.: resources. All authors interpreted the data, approved the final version of the manuscript, and agree to be accountable for all aspects of the work.

Conflict of Interest Statement

The authors declare that they have no conflicts of interest to disclose.

Data Availability Statement

HRV data are available upon request to corresponding author.

Ethics

This study was conducted in accordance with the principles of the Declaration of Helsinki. The Mongolian National University of Medical Sciences IRB approved the study (protocol #2020/03-05). Written informed consent was obtained from all participants.

References

Bat-Erdene E, et al. Quality of life in the general population of Mongolia: Normative data on WHOQOL-BREF. PLOS One. 2023; 18(9). https://doi.org/10.1371/journal.pone.0291427

Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. Psychiatry Res. 1989;28(2):193–213. https://doi.org/10.1016/0165-1781(89)90047-4

Folstein MF, Folstein SE, McHugh PR. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12(3):189–98. https://doi.org/10.1016/0022-3956(75)90026-6

Koenig J, Thayer JF. Gender differences in healthy human heart rate variability: a meta-analysis. Neurosci Biobehav Rev. 2016;64:288–310. https://doi.org/10.1016/j.neubiorev.2016.03.007

Lkhagvasuren B, et al. The Brain Overwork Scale: a population-based cross-sectional study on the psychometric properties of a new 10-item scale to assess mental distress in Mongolia. Healthcare. 2023;11:1003. https://doi.org/10.3390/healthcare11071003

Natarajan A, Pantelopoulos A, Emir-Farinas H, Natarajan P. Heart rate variability with photoplethysmography in 8 million individuals: a cross-sectional study. Lancet Digit Health. 2020;2(12):e650–7. https://doi.org/10.1016/s2589-7500(20)30246-6

Nunan D, Sandercock GR, Brodie DA. A quantitative systematic review of normal values for short-term heart rate variability in healthy adults. Pacing Clin Electrophysiol. 2010;33(11):1407–17. https://doi.org/10.1111/j.1540-8159.2010.02841.x

Shaffer F, Ginsberg JP. An overview of heart rate variability metrics and norms. Front Public Health. 2017;5:258. https://doi.org/10.3389/fpubh.2017.00258

Shaffer, F., Meehan, Z. M., & Zerr, C. L. (2020). A critical review of ultra-short-term heart rate variability norms research. *Frontiers in Neuroscience, 14*, 594880. https://doi.org/10.3389/fnins.2020.594880

Tabata M, et al. Cosinor analysis of heart rate variability in ambulatory migraineurs. Headache. 2000;40(6):457-463. https://doi:10.1046/j.1526-4610.2000.00068.x

Task Force of the European Society of Cardiology. Heart rate variability: standards of measurement, physiological interpretation, and clinical use. Circulation. 1996;93(5):1043–65. https://doi.org/10.1161/01.CIR.93.5.1043

Thayer JF, Lane RD. Claude Bernard and the heart–brain connection: further elaboration of a model of neurovisceral integration. Neurosci Biobehav Rev. 2009;33(2):81–8. https://doi.org/10.1016/j.neubiorev.2008.08.004

Tumurbaatar E, et al. Translation, reliability, and structural validity of the Hospital Anxiety and Depression Scale (HADS) in the general population of Mongolia. Neuroscience Research Notes. 2021;4(3):30–39. https://doi.org/10.31117/neuroscirn.v4i3Suppl.101

Tumurbaatar E, et al. Psychometric properties of the Mongolian version of the Pittsburgh Sleep Quality Index. Neurosci Res Notes. 2023;6(3): 190.1–190.8,. https://doi.org/10.31117/neuroscirn.v6i3.190

World Health Organization. WHOQOL-BREF: introduction, administration, scoring and generic version of the assessment. Geneva: WHO; 1996. https://www.who.int/publications/i/item/WHOQOL-BREF

Zigmond AS, Snaith RP. The Hospital Anxiety and Depression Scale. Acta Psychiatr Scand. 1983;67(6):361–70. https://doi.org/10.1111/j.1600-0447.1983.tb09716.x