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Impact of slouching on heart rate variability and cardiovascular health among medical students

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ABSTRACT

Background: Medical students frequently adopt poor postures such as slouching potentially impacting health. Heart rate variability (HRV) serves as an indicator of autonomic nervous system function, correlated with cardiovascular health. **Aims and Objectives:** The objective of the study was to compare HRV parameters among medical students in three postures: Sitting erect, easy pose (cross-legged), and slouching (stooping head and shoulders). **Materials and Methods:** A comparative cross-sectional study enrolled 26 male medical students. Participants were instructed to maintain each posture for 5 min while HRV was recorded using a Polar V800. Time domain and frequency domain parameters among different postures were analyzed using Friedman's test and *post hoc* tests for pairwise comparisons. P<0.05 was considered significant. Data were expressed as median interquartile range. **Results:** Significant differences were observed in HRV parameters between postures. The easy pose demonstrated a significantly higher median value of root mean square of differences of successive RR intervals (48.28 ms vs. 35.35 ms) and pNN50% (24.40% vs. 13.62%) compared to slouching. Frequency domain analysis revealed a significantly higher median value of high-frequency (HF) power in easy pose (626.56 ms² vs. 378.15 ms²) and HF normalized unit (33.78 vs. 22.55) compared to slouching. A lower low frequency (LF)/HF ratio and (1.96 vs. 3.43) lower LF normalized unit (66.18 vs. 77.30) was also seen in easy pose. Although statistically not significant, the parasympathetic indicators of HRV were higher in erect sitting compared to slouching posture. **Conclusion:** Among medical students, adopting the easy pose (cross-legged sitting) appeared to enhance HRV and thus increase parasympathetic activity, whereas adopting slouching postures decreased it.

Key words: Heart rate; Posture; Medical students; Autonomic nervous system

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INTRODUCTION

Medical students often develop a forward head posture or slouching due to prolonged study hours and frequent use of smartphones. This can lead to neck pain and other musculoskeletal issues.[1,2] Beyond affecting daily functions, posture-related problems may also influence cardiovascular health and heart rate variability (HRV).[3] HRV, a measure of the variation in time intervals between heartbeats, is considered a marker of autonomic nervous system (ANS) activity and cardiovascular health. A higher HRV typically indicates better cardiovascular fitness. Studies have suggested changes in HRV measures with changes in postures.[4,5] Findings from previous studies indicate that correcting posture can positively impact physiological parameters such as blood pressure (BP) and pulse rate.[6]

Studies have investigated the impact of different postures on HRV.[7-9] However, there is a scarcity of research comparing HRV parameters between slouching, sitting upright in a chair, and the easy pose (crossed-legged sitting

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in a wide base chair). Easy pose is also a common sitting posture in Nepal and nearby regions. To date, scientific research has not examined the cardiovascular effect of sitting cross-legged in Nepal. Hence, we aimed to conduct a study to find out the potential cardiovascular benefits and challenges of these various postures among medical students.

Hence, the objective of our study was to assess and compare HRV in medical students in slouching posture, sitting erect, and easy pose posture.

Aims and objectives

The aim of the study was to compare heart rate variability parameters among medical students in three different postures: sitting upright, crossed legged (easy pose) and slouching. The objectives were to measure HRV in each posture, compare time-domain and frequency-domain metrics and to evaluate impact of posture on HRV and autonomic function.

MATERIALS AND METHODS

This comparative cross-sectional study was conducted among 26 apparently healthy young male medical students in the physiology department of Nobel Medical College and Teaching Hospital. The study was conducted from February 2020 to February 2021. Ethical clearance was obtained from the Nobel Medical College and Teaching Hospital. A convenient sampling technique was done. Written informed consent was taken. The test was conducted after a few days of the completion of the semester examination, so that, the effect of exam stress on HRV could be reduced. The tests were conducted in the morning before 12:00 am. Before recording the HRV, participants were instructed to come with a light breakfast 2 h earlier.[4,5]

For sample size calculation, the mean and standard deviation (SD) of heart rate were taken from closely related studies.[8] Mean 1=74.33 and mean 2=79.8, and pooled SD is 7.02. The sample size is calculated using a formula, $n = 2 \times (Z_{\alpha} + Z_{1\text{-}\beta})^2 s^2/d^2$, Where, n=number of samples, d=difference between two means, s=combined population SD of two groups, confidence level 95% corresponding to $Z\alpha \approx 1.96$ and power 80%, corresponding to $Z_{1-\beta} \approx 0.84$, n=25.78≈26.

Students were divided into three groups: Sitting erect (Group 1), easy pose (Group 2), and slouching pose (Group 3). On arrival, they were asked to rest for 15 min after which their BP and anthropometric measurements were taken. HRV was measured with a Polar V800. The strap with the electrodes was moistened with water and placed around the chest. The signals from the electrocardiogram were captured by a Polar watch worn on the wrist of the subject in three postures: Sitting upright, easy pose on a wide-based chair, and slouching. Postures were alternated between subjects to reduce bias. Subjects were instructed differently: The first was asked to sit upright, then crossed-legged, and finally slouched; the second started with crossed legs then slouched, and ended sitting upright; the third began with a slouch then sitting upright and crossed-legged. The rest of 5 min was given to each subject after each posture. Subjects were instructed to report if they were not comfortable in any of the postures. The R-R interval calculated by the polar watch was analyzed by HRV software (Kubios HRV version 3.2 standard).

Statistical analysis

Data were analyzed using Microsoft Excel and Statistical Packages for the Social Sciences version 16. Anthropometric and cardiac variables were presented as mean±SD. HRV was expressed as time domain parameters and frequency domain parameters. HRV being non-parametric was expressed as the median interquartile range. Data were analyzed using Friedman's test followed by multiple comparisons between each posture.

Inclusion criteria

Subjects in the study were apparently healthy male students aged 18–26 years with a body mass index (BMI) under 25 kg/m². Inclusion was limited to students who regularly used all three postures and had no difficulty maintaining any of them.

Exclusion criteria

Subjects with any history of cardiovascular diseases, diabetes, and psychiatric illness or currently under medication for any diseases were excluded from the study.

RESULTS

The anthropometric and cardiovascular variables of the subjects are presented in Table 1. Time domain parameter

Table 1: Anthropometric and cardiac variables of the subjects

Variables	Mean±SD
Age (years)	21.46±1.24
Height (cm)	171.73±6.67
Weight (kg)	67.69±9.10
BMI (kg/m²)	22.98±2.1
SBP (mmHg)	120.92±3.71
DBP (mmHg)	79.46±3.22

SD: Standard deviation, BMI: Body mass index, SBP: Systolic blood pressure, DBP: Diastolic blood pressure

Table 2: Comparison of time-domain measures of heart rate variability in male medical students in sitting erect, easy pose, and slouching

Variables	Sitting erect (Group 1) median interquartile range (25-75) %	Sitting easy pose (Group 2) Median interquartile range (25-75) %	Slouching (Group 3) Median interquartile range (25-75) %	P-values		
				P1	P2	P3
BHR (bpm)	86.18 (77.06–92.34)	79.68 (70.72–89.02)	82.22 (78.40–93.19)	<0.001**	<0.001**	1.000
R-R (ms)	696.22 (650.08–778.70)	753.00 (674.23–848.78)	729.75 (643.85–765.71)	<0.001**	<0.001**	1.000
RMSSD (ms)	42.48 (29.37–60.96)	48.28 (28.94–72.11)	35.35 (26.80–40.45)	0.11	0.003*	0.63
NN50	37.50 (15.00–111.00)	82.00 (38.00–122.00)	50.00 (25.75–75.00)	0.05	0.055	1.00
pNN50%	10.35 (6.00–29.73)	24.40 (8.07–34.59)	13.62 (7.14–19.07)	0.017*	0.025*	1.00
SDNN	42.04 (38.04–60.62)	51.77 (31.65–74.22)	42.66 (35.98–49.43)	0.80	0.025*	0.38

SDNN: Standard deviation of RR interval, RMSSD: Root mean square of differences of successive RR intervals, NN50: Number of NN intervals that differ by≥50 milliseconds, pNN50%: Percentage of NN50, $P<0.05$ – significant*, $P<0.01$ – highly significant**, P1 – *P* value comparison between Group 1 versus Group 2, P2 – *P* value comparison between Group 2 versus Group 3, P3 – *P* value comparison between Group 3 versus Group 1

Table 3: Comparison of frequency domain measures of heart rate variability in male medical students in sitting erect, easy pose, and slouching

Variables	Sitting Erect (Group 1) Median interquartile range (25–75) %	Sitting easy pose (Group 2) Median interquartile range (25–75) %	Slouching (Group 3) Median interquartile range (25–75) %	P-values		
				P1	P2	P3
VLF (ms^2)	94.35 (62.99–206.52)	100.12 (48.67–188.95)	87.95 (51.64–204.51)	1.00	1.00	1.00
LF (ms^2)	1093.40 (680.32–1783.83)	1521.75 (525.77–2152.55)	969.22 (727.53–1446.40)	1.00	0.80	0.50
HF ($ms^{2)}$	500.47 (154.71–1040.90)	626.56 (342.48–1696.88)	378.15 (207.91–538.09)	0.21	0.004*	0.49
LF/HF	2.26 (1.44–3.90)	1.96 (1.05–2.98)	3.43 (1.26–4.21)	0.11	<0.001**	0.29
LFnu	69.29 (58.78–79.57)	66.18 (51.08–74.77	77.30 (55.66–80.70)	0.11	<0.001**	0.28
HFnu	30.65 (20.42–41.16)	33.78 (25.06–48.85)	22.55 (19.18–44.25)	0.11	<0.001**	0.28
TP (ms^2)	1663.79 (926.25–3085.69)	2408.46 (863.76–4156.49)	1562.51 (1182.52–2150.79)	1.00	0.49	1.00

VLF: Very low frequency, LF: Low frequency, HF: High frequency, power expressed in ms^2 (millisecond), nu: Normalized units, TP: Total power. $P<0.05$ – significant*, $P<0.01$ – highly significant**, P1 – *P* value comparison between Group 1 and Group 2, P2 – *P* value comparison between Group 2 and Group 3, P3 – *P* value comparison between Group 3 and Group 1

analysis and frequency domain parameter analysis of HRV variables among three groups (Group 1 – sitting erect, Group 2 – easy pose, and Group 3 – slouching) are presented in Tables 2 and 3, respectively. In time domain analysis (Table 2), the basal heart rate was highest and the RR interval was shortest in Group 1, followed by Group 3 and Group 2. Significant differences in basal heart rate were only seen between Group 1 and Group 2 as well as Group 2 and Group 3. The root mean square of differences of successive RR intervals (RMSSD), pNN50%, and standard deviation of RR interval (SDNN) were also highest in Group 2. A significant difference was seen only between Group 2 and Group 3. No significant differences were seen in Group 1 and Group 2 and Group 1 and Group 3. In frequency domain analysis, LH/HF, and HF normalized unit (HFnu) were highest in easy posture (Group 2). While LF normalized unit (LFnu) is lowest in the same posture. No change in LF was observed.

DISCUSSION

This comparative cross-sectional study was conducted among 26 healthy male medical students. We selected students of the same age range and BMI as these are seen to affect HRV.[4,5] Although many studies have been done on other postures such as squatting, sitting, and exercise,[9,10] few studies have been done on the different sitting postures adopted by students. Hence, in our study, we explored the influence of different sitting postures on HRV, a widely used indicator of ANS function and cardiovascular health. Specifically, we focused on time domain and frequency domain analyses to understand how posture affects these physiological parameters.

Time domain analysis (Table 2) provides insights into the variability of heartbeats over successive intervals. Group 1, sitting erect, exhibited the shortest RR intervals. RMSSD values were highest in Group 2, in a crossed-legged pose (easy pose), suggesting stronger parasympathetic influence. This finding is further supported by higher pNN50% values in Group 2, indicating enhanced short-term HRV and better parasympathetic activity. SDNN values, reflecting overall HRV across all frequency ranges, were also notably higher in Group 2, suggesting optimal ANS function and cardiovascular health.[4,5]

Moving to frequency domain analysis (Table 3), we examined HF power, which represents the high-frequency component of HRV primarily driven by parasympathetic activity.[4,5] Group 2 demonstrated significantly higher HF power compared to other groups, indicating greater parasympathetic modulation and respiratory sinus arrhythmia. This finding aligns with higher HFnu and lower LF/HF ratios observed in Group 2, suggesting a shift toward parasympathetic dominance and enhanced relaxation in the easy sitting posture. Conversely, LFnu was decreased and LF power did not vary significantly across different postures, indicating consistent sympathovagal balance irrespective of sitting position.[3] Although statistical significance was only seen between crossed-legged posture and slouching, trends in our data consistently showed that crossed-legged posture had the highest values across these frequency domain measures representing more parasympathetic activity, followed by sitting erect and slouching.

Our results are consistent with prior studies by Govindan et al., which found posture to significantly influence HRV parameters during mental workload conditions.[3] However, our study focused on baseline HRV differences in static postures rather than during cognitive tasks. In addition, studies by Budgell and Polus[11] and Hagins et al.,[12] have highlighted how dynamic interventions such as yoga and physical activity can improve HRV, likely through their effects on posture and ANS regulation. While our study did not investigate dynamic interventions, it suggests that simply altering sitting posture could potentially enhance HRV measures and promote cardiovascular health.

Interestingly, Wang et al. also observed changes in HRV between different postures, including neutral and forward flexion positions.[8] While our study did not find significant differences between erect and slouching postures in HRV parameters, there was a consistent trend toward increased HRV measures in sitting erect compared to slouching. This trend supports the notion that even subtle changes in posture can influence ANS regulation and cardiovascular outcomes. However, our study showed a significant difference and HRV parameters between crossed-legged and slouching. Hence overall our study suggested the highest parasympathetic activity in crossed-legged posture and the least in slouching posture.

Limitations of the study

We were unable to evaluate the impact of varying degrees of slouching. Additionally, the study did not include long-term assessment of posture which could have offered the deep understanding of its effect over time.

CONCLUSION

Our study indicates that the easy sitting pose promotes the highest levels of parasympathetic activity among the postures examined, whereas, slouching had the lowest parasympathetic modulation. These findings suggest that adopting a specific sitting posture could potentially enhance HRV and contribute to better ANS regulation and cardiovascular health. However, further research is warranted to validate these findings and explore the long-term effects of posture interventions on physiological outcomes. Understanding the relationship between posture and HRV not only contributes to our knowledge of ANS function but also suggests practical interventions for improving overall cardiovascular well-being.

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NG- Designing the study, reviewing literature, drafting, and refining the manuscript, implementing the protocol, collecting, and analyzing data, and managing the submission; **SM-** Study's concept, design, clinical protocol, manuscript preparation, and revision.

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