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Effect of Pranayama and Meditation on Well-being among University Students: A Randomized Controlled Trial

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Abstract: Well-being, reflecting health, happiness and prosperity, is crucial for quality of life. This study aims to assess the effectiveness of *pranayama* and mindfulness (*vipassana*) meditation for improving well-being of university students. In this single-blind randomized control trial, 150 undergraduate students (aged, 18-23 years) were employed. The participants of both genders (male:female = 1:1) were randomly allocated into two groups: yoga (n=75) and control (n=75). The yoga group, engaged in daily 60-min *pranayama* and mindfulness (*vipassana*) meditation sessions over a period of ten-weeks, while the control group maintained their regular routine. The participants were assessed for well-being, body mass index, blood pressure and pulse rate using standard measures. Data were analyzed using SPSS 24.0. Repeated measure analyses of variance (RM-ANOVA) followed by Bonferroni adjusted *post hoc* analyses have shown that there is a significant improvement in overall well-being ($p<0.001$) in the yoga group after ten weeks and at follow-up. Additionally, significant changes were observed in biomarkers (BMI and BP) at different stages of the study ($p<0.05$, in all cases). The findings of this study reveal that the combined practice of *pranayama* and mindfulness (*vipassana*) meditation exhibits potential benefits in improving well-being and biomarker outcomes among university students.

Keywords: pranayama • meditation • well-being • university students • biomarkers

Introduction

In recent years, there has been a growing interest in understanding and enhancing student's well-being, given the pivotal role of this demographic in society (Park et al., 2020). Well-being is often defined as a composite of positive mental states encompassing health, happiness and prosperity (Bipasha & Somnath, 2021). Additionally, the capacity of individuals and societies to contribute meaningfully to the world is integral to well-being. According to the World Health Organization (WHO), "Well-being represents a positive condition observed in individuals and societies. Analogous to health, it functions as a resource in daily life and is determined by social, economic, and environmental factors" (WHO 2021). Global estimates issued by the WHO suggest that 25% of younger people confront mental and behavioral disorders (Sayers, 2001). Previous research studies reveal that higher level of well-being has been essential for improved mental and emotional states (Auerbach et al., 2016; Halsall et al., 2016). Research studies indicate that a considerable proportion of students in higher education experience health and well-being challenges, including heightened levels of anxiety, depression, psycho-emotional distress and many more (Martin & Dahlen, 2005; Yusoff et al., 2021). As undergraduate students face academic challenges, societal expectations and lifestyle adjustments, their well-being becomes a critical concern (Douwes et al., 2023). Considering the pivotal role of students in shaping the future of nation, addressing their well-being is paramount.

In this context, ancient yoga practices offer a holistic approach, that work on physical, mental, social and spiritual aspects of well-

being altogether (Kishan, 2020). Incorporating yoga practices into daily routine can offer substantial benefits to undergraduate students, who often contend with low levels of well-being, high stress and challenging academic schedules (Sunita et al., 2022; Tripathi et al., 2018). Recent findings indicate that engaging in *pranayama*, the discipline of regulating breath, yields favorable outcomes on indicators of clinical stress and anxiety (Novaes et al., 2020). Furthermore, mindfulness meditation exerts positive effects on cerebral functioning and mind-body interactions. A study on *Vipassana* meditation, a subtype of mindfulness meditation, indicates that the participants experienced significant improvements in well-being alongside reductions in ill-being following a 10-day *Vipassana* course (Krygier et al., 2013). Several studies have indicated the effectiveness of various yoga practices in addressing broad spectrum of health issues and promoting overall well-being (Choukse et al., 2018; Hakkim et al., 2021). However, to date, there has been a lack of research on the impact of combined intervention incorporating both *pranayama* and mindfulness (*vipassana*) meditation techniques on well-being. With this background, the present study primarily aims to assess the combined effect of *pranayama* and mindfulness (*vipassana)* meditation in improving well-being of university students. Additionally, the study also examines the effect of intervention on selected biomarkers such as blood pressure (BP), pulse rate (PR) and body mass index (BMI).

Methodology

Participants: The present study was conducted at H. N. B. Garhwal University in Uttarakhand, India. To commence the research, an awareness camp was conducted for undergraduate students, focusing on educating them about the potential therapeutic advantages of yoga, particularly emphasizing *pranayama* and mindfulness (*vipassana*) meditation. Additionally, participants were provided with a brief overview of the study, and it was ensured that their involvement was entirely voluntary. The dissemination of information about the camp utilized various channels, including word of mouth, social media and wall posters. A total of two hundred students joined the awareness camp, out of which a total of one hundred fifty eligible participants, comprising both genders (male:female = 1:1), were selected and randomly assigned to yoga group (n=75) and control group (n=75) using computer-generated random numbers. The study did not initially determine the sample size a priori, but *post hoc* power calculation using the 'G' power program was conducted for the study. With a sample size of 75 in the yoga group, a significance level (α) of 0.05, and Cohen's d of 3.37 (derived from overall well-being changes following *pranayama* and mindfulness (*vipassana*) meditation practices), the power of the study is 1.0 (Erdfelder et al., 1996). However, 12 students dropped out for various reasons during the study, resulting in a final analyzed sample of one hundred thirty-eight (Fig. 1). The study was approved by Board of Studies (BoS) Committee, and signed informed consent was obtained from each participant.

Inclusion Criteria

- Students aged between 18 to 23.
- No previous yoga experience.
- Both male and female participants

Exclusion Criteria

- Not willing to participate in the study.
- Having on any kind of medication.
- Major physical or psychological issues.

Design and Procedure: The present study used a randomized controlled trial employing a pre, post and follow-up research design. Participants were randomly distributed either to the yoga group or a control group with an allocation ratio of 1:1. Each participant received a serial number ranging from 1 to 150, regardless of their enrollment order. Subsequently, 150 random numbers were

generated using an online randomizer and assigned to the participants. These random numbers were recorded onto uniform slips of paper and folded identically. One person, uninvolved in the study, placed the slips alternately into two boxes labeled 'YG' and 'CG.' Participants assigned to the 'YG' constituted the yoga group, while those assigned to the 'CG' formed the control group. The yoga group underwent daily 60 minutes sessions of *pranayama* and mindfulness (*vipassana*) meditation over a period of 10-weeks (six days a week). Conversely, the control group maintained their routines activities without any intervention. Data assessments were conducted at three stages: before the intervention at baseline (pre-assessment), immediately after 10-weeks of yoga intervention (post-assessment), and subsequently 2 months after the completion of intervention (follow-up assessment). Both groups continued their academic activities throughout the study period.

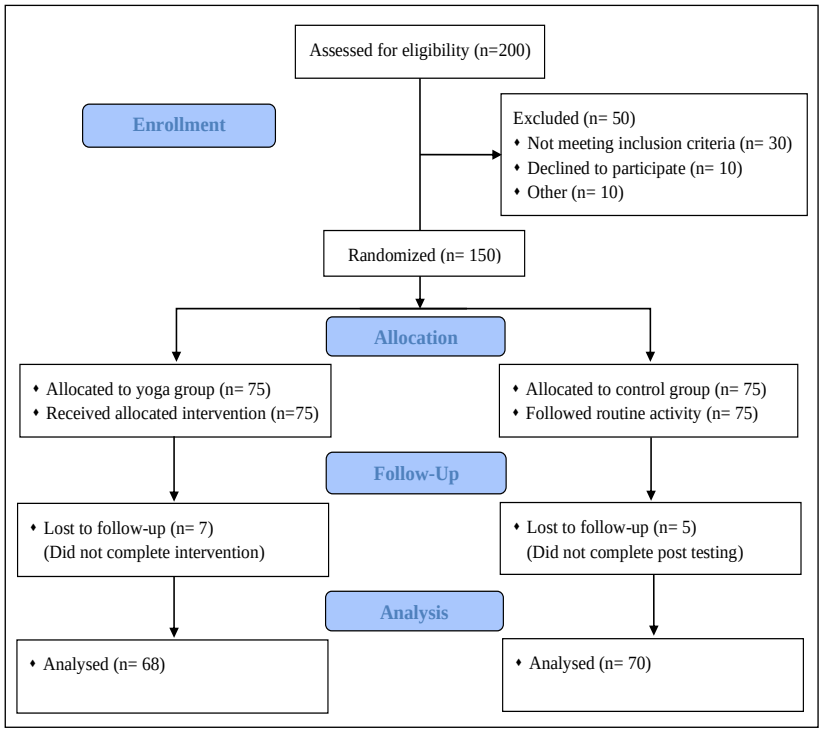

Fig. 1. Flow chart of study enrollment

Measurement Tools: Well-being Index (WBI) was used to assess the well-being of the participants as a primary outcome measure. WBI is a self-reported, standardized psychometric tool, comprising of 50 items rated on a 5-point likert scale. It evaluates overall well-being (OWB) across six dimensions: emotional well-being (EmW), psychological well-being (PsW), social well-being (SoW), spiritual well-being (SpW), self-awareness (SA) and physical well-being (PhW). Scoring involves assigning values from 5 (always) to 1 (never) for positive items, whereas from 1 (always) to 5 (never) for negative items. The total score ranges from 50 to 250, with a higher score indicating improved level of well-being (Vijayalaxmi & Varsha, 2016).

Standard measuring tape, weighing machine and digital blood pressure monitor were used to assess height, weight, blood pressure and pulse rate respectively. Body mass index was calculated using the formula weight/height^2 (Kg/m^2).

Yogic Intervention: In the present study, the yoga group received an intervention involving

pranayama and mindfulness (*vipassana*) meditation, while the control group was instructed to follow their routine activities during this period. The intervention sessions were administered under the supervision of an experienced yoga instructor for the duration of 60 minutes each, at a frequency of six days a week, for 10 weeks (total 60 sessions). Of these, all participants attended a minimum of 50 sessions. The intervention commenced with a 2-minute prayer, followed by the practice of *Nadishodhan*, *Bhastrika*, and *Bhramari pranayama* for 8 minutes each, with a 2-minute rest after each *pranayama*. Subsequently, a 25-minute mindfulness (*vipassana*) meditation session was conducted. Finally, the intervention ended with a closing prayer (3-minute). The techniques used are as follows:

(i) *Nadishodhan Pranayama* (Alternate nostril breathing)**:** The participants were instructed to sit in any comfortable meditative posture and to make *Nasikagra Mudra* with the right hand and *Chin/Gyan Mudra* with the left hand. They were instructed to breathe in and out slowly and deeply through both nostrils initially. Following this, they were guided to inhale slowly through the left nostril while closing the right nostril. After completing the inhalation participants were asked to retain their breath (*kumbhaka*) with the chin lock (*Jalandhara bandha)* for a proportionate time and slowly exhale through the right nostril at the end of the breath-holding. They were then told to inhale through the same nostril and to continue in same manner (Saraswati, 2008).

(ii) *Bhastrika Pranayama* (Bellows breathing): The participants were instructed to maintain a seated meditative posture with closed eyes and a straight spine. They were then instructed to engage in *Bhastrika pranayama* by rapid inhale-exhale through both nostrils, focusing on thoracic (chest) breathing. After 20 strokes of rapid inhale-exhale, participants were directed to inhale through the right nostril, retain the breath (*kumbhaka*) and then exhale through the left nostril (Swatmarama, 2017).

(iii) *Bhramari Pranayama* (humming bee breath)**:** The participants were asked to sit in a comfortable position with eyes closed and a straight spine. They were then instructed to close their ears with both thumbs and to gently place all fingers on the eyes. Next, they were guided to inhale slowly and exhale while producing a humming bee sound, by maintaining a ratio of 1:2 for inhalation to exhalation. They were instructed to continue this practice in the same manner (Swatmarama, 2017).

(iv) Mindfulness (*Vipassana*) Meditation: Originated from Buddhist *Theravada* tradition, *Vipassana* is a widely known form of mindfulness meditation that involves breath focusing and mindful observation of physical sensations within the body (Zeng et al., 2015). Participants were instructed to follow specific steps during the initial stages of meditation: (i) participants were prompted to assume a comfortable meditative posture with closed eyes, (ii) they were encouraged to bring awareness to their natural breathing pattern (*Anapana sati*), (iii) attention was directed to move systematically from head to feet and back, observing sensations in each body part, (iv) participants were guided to observe various sensations such as heat, coolness, pain, itching, touch, and vibrations throughout the body, (v) participants were instructed to observe the transient nature of thoughts and emotions, recognizing their ever-changing nature (Sayadaw, 1978).

Statistical Analyses: Repeated measures analyses of variance (RM-ANOVA) were performed for each variable and all data were analyzed using SPSS Version 24.0. Each ANOVA had one between-subject factor with two levels: yoga & control groups, and one within-subject factor with three states (pre, post and follow-up). An interaction effect of groups×states was determined for each

variable. The interaction effects between groups and states suggested the interdependence of the two. The level of significance was taken at 0.05. The Bonferroni adjusted *post hoc* analyses were carried out for the variables that showed a significant main effect on groups, states, or interaction of groups and states.

Table 1. Demographic characteristics

Variables	Yoga Group (n=75)	Control Group (n=75)
Age (year) Mean, SD	19.51 ± 1.19	19.82 ± 1.36
Male, n (%)	33 (44)	42 (56)
Female, n (%)	42 (56)	33 (44)
Rural area, n (%)	38 (50.6)	41 (54.6)
Urban area, n (%)	37 (49.3)	34 (45.3)
Joint family, n (%)	29 (38.6)	32 (42.6)
Single family, n (%)	46 (61.3)	43 (57.3)
Note: Standard Deviation (SD), number (n) and percentage (%).		

Repeated Measures Analysis of Variance (RM-ANOVA): The F-values, df, Huynh–Feldt epsilon and p-values for groups, states and groups×states for different variables are provided in Table 2. A significant interaction between the group and states indicates the interdependence of the two.

There was a significant main effect of groups for (i) SBP ($p = 0.01$), (ii) EmW ($p<0.001$), (iii) PsW ($p<0.001$), (iv) SoW ($p<0.001$), (v) SpW ($p<0.001$), (vi) SA ($p<0.001$), (vii) PhW ($p<0.001$) and (viii) OWB ($p<0.001$) Scores.

There was a significant main effect of states for (i) BMI ($p<0.001$), (ii) SBP ($p = 0.002$), (iii) DBP ($p = 0.031$), (iv) EmW ($p<0.001$), (v) PsW ($p<0.001$), (vi) SoW ($p<0.001$), (vii) SpW ($p<0.001$), (viii) SA ($p<0.001$), (ix) PhW ($p<0.001$) and (x) OWB ($p<0.001$) Scores.

There was a significant main effect of groups × states for (i) SBP ($p<0.001$), (ii) DBP ($p<0.001$), (iii) EmW ($p<0.001$), (vi) PsW ($p<0.001$), (v) SoW ($p<0.001$), (vi) SpW ($p<0.001$), (vii) SA ($p<0.001$), (viii) PhW ($p<0.001$) and (ix) OWB ($p<0.001$) Scores.

Post hoc analysis: Group mean ± SD, *post hoc* finding and confidence interval of the variables assessed at baseline, post-intervention and after two months of follow-up are shown in Table 3.

Results

The demographic and baseline characteristics of age, gender (male/female), area (rural/urban) and type of family (joint/single) of the variables (Table 1).

(i) Between Group Comparison

Following ten-weeks of *pranayama* and mindfulness (*vipassana*) meditation practice, the SBP was significantly differing in the yoga group at post state ($p<0.05$), and follow-up state ($p<0.001$) compared to the respective state of the control group. We also found the DBP significantly differed in the yoga group at follow-up ($p<0.001$) compared to the respective state of the control group.

Following ten-weeks *pranayama* and mindfulness (*vipassana*) meditation practices, EmW, PsW, SoW, SpW, SA, PhW and OWB scores were significantly higher in the yoga group at all post states ($p<0.001$), and follow-up states ($p<0.001$) as compared to the respective all states of the control group.

(ii) Within-Group Comparison

After ten-weeks *pranayama* and mindfulness (*vipassana*) meditation practices, the yoga group showed a significant decrease in BMI at post state ($p<0.01$) and follow-up state ($p<0.01$), SBP at follow-up state ($p<0.001$) and DBP at follow-up state ($p<0.001$) as compared to its all pre states. After ten-weeks *pranayama* and mindfulness (*vipassana*) meditation practices, the yoga group showed a significant increase in EmW, PsW, SoW, SpW, SA, PhW and OWB at all post states

($p<0.001$), and follow-up states ($p<0.001$) as compared to its all pre states.

Table 2. Repeated Measure Analysis of Variance (RM-ANOVA) results for all variables

Variables	Factors	F-value	Degree of freedom (df)	Huynh-Feldt ε	p-value
BMI (Kg/m^2)	group	1.164	1,136	1.000	0.283
	states	9.06	2.000,272.000	1.000	<0.001
	group×states	1.84	1,136×2.000,272.000	1.000	0.161
SBP (mmHg)	group	6.773	1,133	0.925	0.01
	states	6.521	1.851,246.146	0.925	0.002
	group×states	10.877	1,133×1.851,246.146	0.925	<0.001
DBP (mmHg)	group	0.871	1,136	0.883	0.352
	states	3.714	1.766,240.136	0.883	0.031
	group×states	24.657	1,136×1.766,240.136	0.883	<0.001
PR (BPM)	group	0.341	1,136	0.934	0.56
	states	1.126	1.868,254.071	0.934	0.323
	group×states	2.693	1,136×1.868,254.071	0.934	0.073
EmW	group	61.07	1,136	0.93	<0.001
	states	37.552	1.859,252.879	0.93	<0.001
	group×states	33.399	1,136×1.859,252.879	0.93	<0.001
PsW	group	85.448	1,136	0.859	<0.001
	states	186.047	1.718,233.685	0.859	<0.001
	group×states	199.582	1,136×1.718,233.685	0.859	<0.001
SoW	group	201.231	1,136	0.958	<0.001
	states	130.761	1.917,260.678	0.958	<0.001
	group×states	114.775	1,136×1.917,260.678	0.958	<0.001
SpW	group	126.223	1,136	0.885	<0.001
	states	84.654	1.770,240.674	0.885	<0.001
	group×states	88.548	1,136×1.770,240.674	0.885	<0.001
SA	group	104.313	1,136	0.772	<0.001
	states	68.563	1.543,209.908	0.772	<0.001
	group×states	92.963	1,136×1.543,209.908	0.772	<0.001
PhW	group	115.008	1,136	0.963	<0.001
	states	133.07	1.926,261.963	0.963	<0.001
	group×states	134.577	1,136×1.926,261.963	0.963	<0.001
OWB	group	251.451	1,136	0.806	<0.001
	states	371.03	1.612,219.211	0.806	<0.001
	group×states	380.913	1,136×1.612,219.211	0.806	<0.001

Table 3. The Mean ± Standard deviation (SD), *post hoc* findings and confidence interval of the variables assessed at pre, post and follow-up states.

Variables	Yoga Group (n=68)			Control Group (n=70)			95% CI [Upper limit, lower limit] $
	Pre	Post	Follow-up	Pre	Post	Follow-up	
BMI (Kg/m^2)	21.26 ± 3.77	21 ± 3.62**	21.03 ± 3.54**	20.57 ± 3.08	20.5 ± 2.81	20.39 ± 3.05	[1.590, -0.590]
SBP (mmHg)	121.4 ± 10.8	119.07 ± 7.35	115.55 ± 8.61***	122.24 ± 12.1	122.27 ± 8.74#	122.99 ± 9.02###	[-0.211, -5.747]
DBP (mmHg)	74.87 ± 10.35	73.4 ± 7.64	65.96 ± 16.21***	70.41 ± 7.71##	72.41 ± 7.28	74.93 ± 8.06###*	[3.494, -1.529]
PR (BPM)	81.69 ±	80.31 ±	79.82 ±	79.19 ±	78.27 ±	81.2 ± 7.17	[5.696, -1.622]

	14.36	13.72	17.28	10.93	7.06		
EmW	19.63 ± 2.84	23.63 ± 3.94***	22.78 ± 3.74***	18.41 ± 2.84#	18.51 ± 2.59###	18.54 ± 2.69###	[6.238, 3.999]
PsW	26.34 ± 3.08	37.72 ± 4.41***	36.87 ± 4.28***	28.84 ± 3.74###	28.43 ± 3.57###	28.93 ± 3.65###	[10.641, 7.943]
SoW	49.04 ± 4.07	62.28 ± 7.4***	59.93 ± 6.97***	46.26 ± 4.28###	46.67 ± 4.05###	46.64 ± 4.14###	[17.609, 13.607]
SpW	16.94 ± 2.02	22.51 ± 2.66***	22.25 ± 2.9***	16.3 ± 2.94	16.19 ± 2.84###	16.3 ± 3.13###	[7.255, 5.403]
SA	29.46 ± 2.68	36.74 ± 4.26***	35.84 ± 4.21***	29.2 ± 3.51	28.71 ± 3.51###	28.61 ± 3.54###	[9.332, 6.710]
PhW	17.68 ± 2.31	26.03 ± 2.77***	25.12 ± 2.84***	19.14 ± 2.87##	19.29 ± 3.03###	18.89 ± 3.09###	[7.723, 5.764]
OWB	159.09 ± 8.73	208.91 ± 20.84***	202.78 ± 19.81***	158.16 ± 9.33	157.8 ± 7.72###	157.91 ± 9.48###	[56.374, 45.849]

- (***p<0.001, **p<0.01, *p<0.05) Based on Bonferroni adjusted *post hoc* analysis when post and follow-up states were compared with respective Pre-value.
- (###p<0.001, ##p<0.01, #p<0.05) Based on Bonferroni adjusted *post hoc* analysis when pre, post and fellow-up states of the yoga group were compared with the respective states of the control group.
- $95% confidence interval for between group comparison (yoga group post vs. control group post differences)

Discussion

The outcomes of this study revealed notable changes in various psychological and biomarker parameters among participants engaged in *pranayama* and mindfulness (*vipassana*) meditation sessions over ten weeks. Specifically, significant improvements were found for all the domains of well-being: EmW, PsW, SoW, SpW, SA, PhW and OWB scores in between and within group analyses (Fig. 2 and Fig. 3), underscoring the potential of *pranayama* and mindfulness (*vipassana*) meditation practices to positively influence holistic well-being among undergraduate students. Additionally, significant changes in BMI were observed within the yoga group, indicating the potential benefits of these practices for weight management. After regular practice of *pranayama* and mindfulness (*vipassana*) meditation for ten weeks, the yoga group demonstrated a significant reduction in BP level at the follow-up state. Furthermore, the participants in the yoga group showed a significant change in BP levels at various stages as compared to the control group as shown in Table 3, suggesting a nuanced impact of the intervention on cardiovascular health. In this study, no statistically significant changes were found in PR, representing a balanced respiration. These findings collectively support the efficacy of contemplative practices in fostering physiological and psychological improvements, emphasizing their relevance in promoting well-being in university students.

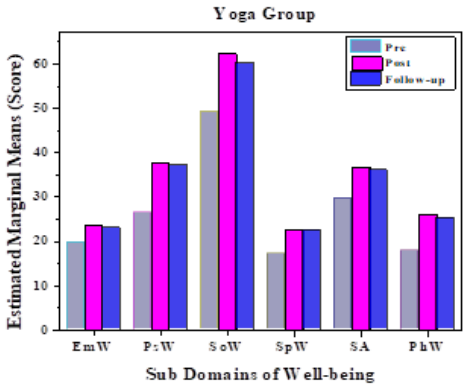

Fig. 2 Graphical representation of sub-domains scores of well-being for yoga group.

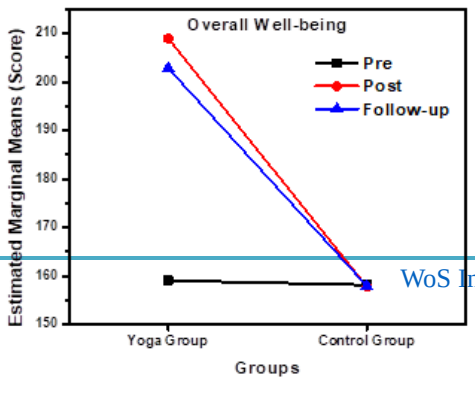

Fig. 3 Graphical representation of overall well-being scores for yoga and control group.

Previous studies suggest that after yoga practices, physiological mechanisms underlying well-being involve intricate relations between various mind-body systems (Kjellgren et al., 2007). At the neurological level, well-being is associated with the activation of regions within the brain associated with positive emotions, such as the prefrontal cortex and limbic system (Gothe et al., 2019). Neurotransmitters like serotonin, dopamine, and endorphins play crucial roles in regulating mood and emotional states, with higher levels correlating with greater feelings of well-being among meditators (Kasala et al., 2014). Furthermore, the endocrine system, through hormones such as cortisol and oxytocin, regulates stress responses and social bonding, contributing to overall well-being (Brown & Gerbarg, 2005). Prior research supported *pranayama's* effects on the autonomic nervous system, particularly the parasympathetic branch, which influences well-being by promoting relaxation responses and reducing stress hormone production, thereby modulating physiological functions such as pulse rate, blood pressure, and respiratory rate (Akhtar et al., 2013; Jayawardena et al., 2020). In summary, the physiological mechanisms of well-being involve complex interplays between neural signaling, hormonal regulation, and autonomic nervous system activity, all of which collectively influence an individual's physical and mental well-being (Bowles et al., 2022). Similar trends in BMI and BP were also seen in previous studies after the yoga, *pranayama* and meditation practices (Harinath et al., 2004; Nivethitha et al., 2017; Ray et al., 2001). Our study is the first study to evaluate the biomarkers (BMI, BP, and PR) with well-being after the ten-week *pranayama* and mindfulness (*vipassana*) meditation practices of university undergraduate students.

The present study has certain limitations. It restricted its scope to undergraduate students within the university, and the sample selection process did not involve survey-based methodologies but rather relied on university enrollment criteria. Despite these limitations, the study has proven successful in making a significant contribution to addressing the issues faced by students at the university. Future study is essential to explore the strength and direction of relationships between well-being and indicators of health status among undergraduate university students. However, the potential for further investigation using better parameters on a broader spectrum of individuals remains promising. Conducting this research study with additional variables and a more diverse sample population could potentially yield comparable or enhanced outcomes.

Conclusion

The findings of this study reveal that the combined practice of *pranayama* and mindfulness (*vipassana*) meditation exhibits potential benefits in improving well-being and biomarker outcomes among university students. These practices demonstrate favorable outcomes in promoting measures such as biomarkers (BMI and BP), alongside various dimensions of overall well-being. The implications of these findings emphasize the importance of designing tailored programs for university students, facilitated by stakeholders, to address both physical and mental health needs within the academic environment.

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