Original article

# Correlation of Body Mass Index with Reaction Time in Unilateral Forced Nostril Breathing: A randomized controlled trial

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**Abstract**

**Background:** Unilateral forced nostril breathing (UFNB) is basically breathing through only one nostril for an extended amount of time. Unilateral nasal and alternate nasal breathing have an effect on cardiopulmonary responses and also on reaction times. Obesity affects various systems, including central nervous system and its effect on reaction time is growing every day. The present study was undertaken to analyze the relationship between body mass index and reaction times in unilateral nasal breathing.

**Methods:** Sixty students were grouped into three groups (20 in each group) by simple random sampling by lot method. Group 1 performed right UFNB, group 2 performed left UFNB and group 3 performed normal breathing. Weight and height of the subjects were recorded and BMI calculated. Auditory reaction time was recorded for auditory beep sound stimulus and visual reaction time for red light stimulus. At first, the auditory and visual reaction times were recorded in a resting state, and later after 5 minutes of unilateral nasal breathing (6 breaths per minute). The reaction times were compared in each of the groups and correlated with body mass indices, statistically by Student's t test and Pearson's correlation.

**Results:** Both visual and auditory reaction times reduced significantly after 5 minutes of UFNB, irrespective of the side, when compared to the resting values. There was also a significant decrease in the visual and auditory reaction times after 5 minutes of both right and left UFNB as compared to the group which performed 5 minutes of normal breathing. Both auditory and visual reaction times were prolonged in the > 23 Kg/m$^2$ BMI group as compared to the ≤23 Kg/m$^2$, both at rest and after 5 minutes of breathing.

**Conclusion:** Auditory and visual reaction times were prolonged with an increase in the BMI; however there was no significant correlation between BMI and visual or auditory reaction time. Hence, UFNB can be used effectively by all subjects irrespective of their BMI.

**Keywords:** body mass index; reaction; nostril breathing

## Introduction

The Anxiety, stress and mental tensions have become almost inevitable companions of human life at all cross sections of populations[1]. Studies have reported higher perceived stress among students in healthcare courses, including dental, medical and nursing courses[2-5], as compared to students from other fields. Yoga and pranayama are ancient sciences which originated in India, which can be practised to combat stress[6]. Yoga has been reported to control stress, to be beneficial in treating stress related disorders, improving autonomic functions, lower blood pressure, increase strength and flexibility of muscles, improve the sense of well being, slow ageing process, control breathing, reduce signs of oxidative stress and improve spiritual growth[7].

Unilateral forced nostril breathing (UFNB) is basically breathing through only one nostril for an extended amount of time[8]. Unilateral forced nostril breathing techniques include specific time-tested variations of selective left or right nostril breathing patterns, or combinations in sequence. Studies have shown that unilateral nasal and alternate nasal breathing have an effect on cardiopulmonary responses- decreases

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blood pressure on left nostril breathing and increases blood pressure on right nostril breathing[9-11]; enhances learning, spatial abilities, memory and problem solving capabilities[9,12,13]; increases metabolism and reduces body weight[14] and also affects autonomic activity[15-18]. A recent study also shows the immediate effects of unilateral nasal breathing on reaction times[10].

Reaction time (RT), a sensitive and simple indicator of central neuronal processing, is the interval between the onset of a signal (stimulus) and the initiation of a movement response and is an indirect index of central neuronal processing as well as a simple means of determining sensory-motor association, performance, and cortical arousal[10].

Body mass index (BMI) is a reliable measure of obesity. The International Association for the Study of Obesity and the International Obesity Task Force proposed the classification of obesity on BMI in Asia in 2000[19], which is much below the cut-off points suggested for Western population. Evidence to suggest that obesity affects various systems[20], including central nervous system and its effect on reaction time[21] is growing every day.

But, there is paucity of literature revealing the relationship between body mass index and reaction time in unilateral nasal breathing, so that we could predict the utility of unilateral nasal breathing on reaction time in obese individuals. Hence, the present study will be undertaken to analyze the relationship between body mass index and reaction times in unilateral nasal breathing.

## Materials and Methods

This The present study was a randomized controlled trial done on 60 students of MBBS of S. N. Medical College, Bagalkot, Karnataka. Ethical clearance was obtained from Institutional Ethics committee. Informed consent was obtained from the subjects. Sixty students were grouped into three groups (20 in each group) by simple random sampling by lot method. Group 1 performed right UFNB, group 2 performed left UFNB and group 3 performed normal breathing. Weight and height of the subjects were recorded and BMI calculated. Reaction time apparatus connected to audacity software was used to record auditory and visual reaction times. The subjects were made acquainted with the procedure and later three readings were taken and the average calculated. The readings were taken between 10 and 11 am in the morning in a secluded environment in physiology laboratory after 10 minutes of rest. Auditory reaction time was recorded for auditory beep sound stimulus and visual reaction time for red light stimulus. The subjects were instructed to press the response key as soon as they perceived the stimulus. The subjects used their dominant hand while responding to the signal. At first, the auditory and visual reaction times were recorded in a resting state, and later after 5 minutes of unilateral nasal breathing (6 breaths per minute). The results were expressed as mean ± standard deviation. The reaction times were compared in each of the groups and correlated with body mass indices, statistically by Student’s t test and Pearson’s correlation. P value $< 0.05$ was considered statistically significant.

## RESULTS

A There were a total of 60 subjects (30 male and 30 female) in the present study. The mean age (in years) was 19.83 ± 0.71; the mean height (in cm) was 164.98 ± 9.41; the mean weight (in kg) was 58.08 ± 14.46; and the mean BMI (in Kg/m$^2$) was 21.56 ± 4.16. There were 40 subjects in BMI ≤23 Kg/m$^2$ group with mean of 19.22 ± 2.29 and 20 subjects in BMI >23 Kg/m$^2$ group with mean of 26 ± 2.84 (Table 1).

**Table 1.General Characteristics of the subjects**

| | Age (in years) | Height (in cm) | Weight (in Kg) | BMI (in Kg/m$^2$) | | |
|---|---|---|---|---|---|---|
| | | | | Overall (n=60) | ≤23 (n=40) | >23 (n=20) |
| **Mean** | 19.83 | 164.98 | 58.08 | 21.56 | 19.22 | 26 |
| **Std. Deviation** | 0.71 | 9.41 | 14.46 | 4.16 | 2.29 | 2.84 |

### Visual reaction time and unilateral forced nostril breathing (UFNB):

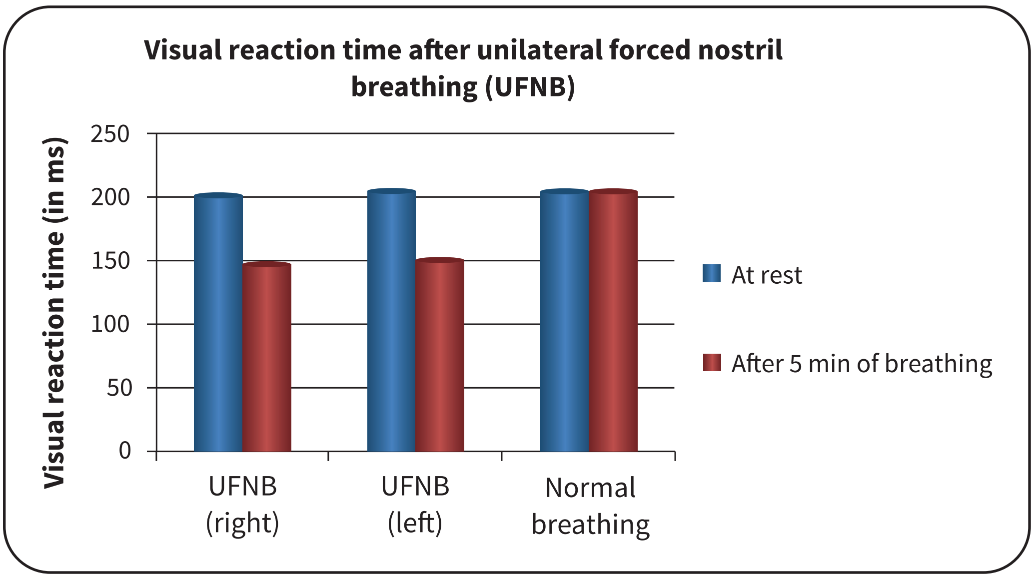
The visual reaction time reduced significantly after 5 minutes of UFNB, irrespective of the side, when compared to the resting values. There was also a significant decrease in the visual reaction time after 5 minutes of both right and left UFNB as compared to the group which performed 5 minutes of normal breathing (Table 2, Figure 1).

**Table 2. Visual reaction time after unilateral forced nostril breathing (UFNB)**

| | UFNB (right)[1] | UFNB (left[2] | Normal breathing[3] | Comparison b/w 1 &3 | Comparison b/w 2 &3 | Comparison b/w 1 &2 |
|---|---|---|---|---|---|---|
| At rest [A] | 200.35±45.13 | 203.75±35.86 | 203.65±48.80 | t=0.22 p=0.82 | t=0.007 p=0.99 | t=0.26 p=0.79 |
| After 5 min of breathing [B] | 146.40±37.54 | 148.15±44.54 | 203.70±48.28 | t=4.19 p=0.0001* | t=3.78 p=0.0005* | t=0.31 p=0.89 |
| Comparison b/w A & B | t=4.11 p=0.0002* | t=4.34 p=0.00009* | t=0.003 p=0.99 | | | |

**Statistically significant*

**Figure 1.Visual reaction time after unilateral forced nostril breathing (UFNB)**




**Auditory reaction time and unilateral forced nostril breathing (UFNB):**

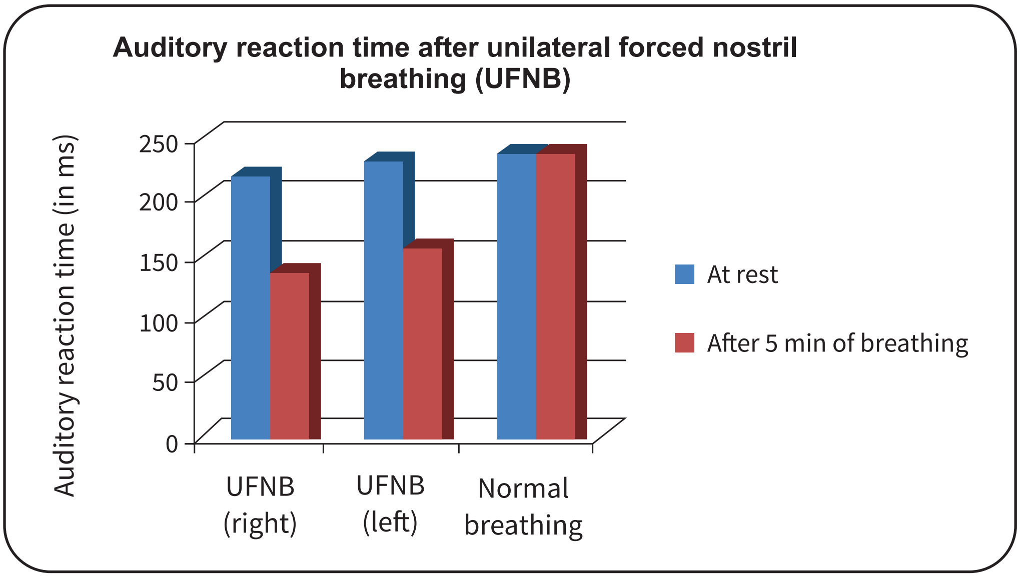
The auditory reaction time reduced significantly after 5 minutes of UFNB, irrespective of the side, when compared to the resting values.There was also a significant decrease in the auditory reaction time after 5 minutes of both right and left UFNB as compared to the group which performed 5 minutes of normal breathing (Table 3, Figure 2).

**Table 3. Auditory reaction time after unilateral forced nostril breathing (UFNB)**

| | UFNB (right)[1] | UFNB (left)[2] | Normal breathing[3] | Comparison b/w 1 &3 | Comparison b/w 2 &3 | Comparison b/w 1 &2 |
|---|---|---|---|---|---|---|
| At rest [A] | 217.75±56.58 | 229.25± 61.35 | 236.05±72.74 | t=0.88 p=0.38 | t=0.31 p=0.75 | t=0.61 p= 0.54 |
| After 5 min of breathing [B] | 137.65±52.54 | 158.05± 45.63 | 235.80±71.86 | t=4.93 p=0.00001* | t=4.08 p=0.0002* | t=1.31 p=0.19 |
| Comparison b/w A & B | t=4.63 p=0.0004* | t=4.16 p=0.0001* | t= 0.01 p=0.99 | | | |

**Statistically significant*

**Figure 2.Auditory reaction time after unilateral forced nostril breathing (UFNB)**




**Body mass index and reaction time:**

Both auditory and visual reaction times were prolonged in the > 23 Kg/m$^2$ BMI group as compared to the ≤23 Kg/m$^2$, both at rest and after 5 minutes of breathing; however these findings were not statistically significant (Table4).

**Table 4. Comparison of reaction times with body mass index**

| BMI (in Kg/m2) | Visual reaction time | | Auditory reaction time | |
|---|---|---|---|---|
| | At rest | After 5 min of breathing | At rest | After 5 min of breathing |
| **≤23** (n=40, mean 19.22 ± 2.29) | 196.12 ± 40.08 | 158.75 ± 46.10 | 222 ± 63.36 | 171.72 ± 70.48 |
| **>23** (n=20, mean 26 ± 2.84) | 217 ± 44.23 | 180.42 ± 56.30 | 242 ± 62.11 | 188.15 ± 73.34 |
| | p=0.07 | p=0.12 | p=0.25 | p=0.41 |

There was no significant correlation between BMI and visual or auditory reaction time in any of the groups, namely UFNB (right), UFNB (left) and normal breathing (Table 5, Table 6).

**Table 5. Correlation between BMI and visual reaction time**

| | UFNB (right)[1] | | | UFNB (left)[2] | | | Normal breathing[3] | | |
|---|---|---|---|---|---|---|---|---|---|
| | BMI | Reaction time | Pearson's Correlation | BMI | Reaction time | Pearson's Correlation | BMI | Reaction time | Pearson's Correlation |
| At rest [A] | 22.78 ± 4.19 | 200.35 ± 45.13 | r=0.210 | 21.30 ± 3.63 | 103.75 ± 35.86 | r=0.138 | 20.61 ± 4.53 | 203.65 ± 48.80 | r=0.407 |
| After 5 min of breathing [B] | 22.78 ± 4.19 | 146.40 ± 37.54 | r=0.163 | 21.30 ± 3.63 | 148.15 ± 44.54 | r=0.142 | 20.61 ± 4.53 | 203.70 ± 48.28 | r=0.412 |

**Table 6. Correlation between BMI and auditory reaction time**

| | UFNB (right)[1] | | | UFNB (left)[2] | | | Normal breathing[3] | | |
|---|---|---|---|---|---|---|---|---|---|
| | BMI | Reaction time | Pearson's Correlation | BMI | Reaction time | Pearson's Correlation | BMI | Reaction time | Pearson's Correlation |
| At rest [A] | 22.78 ± 4.19 | 217.75 ± 56.58 | r=0.234 | 21.30 ± 3.63 | 229.25 ± 61.35 | r=0.435 | 20.61 ± 4.53 | 236.05 ± 72.74 | r=0.141 |
| After 5 min of breathing [B] | 22.78 ± 4.19 | 137.65 ± 52.54 | r=0.438 | 21.30 ± 3.63 | 158.05 ± 45.63 | r=0.173 | 20.61 ± 4.53 | 235.80 ± 71.86 | r=0.145 |

## Discussion

Unilateral forced nostril breathing (UFNB) is basically breathing through only one nostril for an extended amount of time[8].

Forced breathing is to breathe deeply and slowly for certain duration of time voluntarily, overcoming the autonomic or involuntary breathing drive. 'Pranayam' is a kind of voluntary regulated forced breathing characterized by timed breath holding (Kumbhak) either at the end of inspiratory phase or at the end of expiratory phase[22].

Bhavanani et al conducted a study on differential effects of uninostril breathing (UNB) and alternate nostril breathing (ANB) on cardiovascular parameters and reaction time. Twenty yoga-trained subjects came to the laboratory on six different days, and reaction time, heart rate and blood pressure were recorded randomly before and after nine rounds of right UNB (suryanadi [SN]), left UNB (chandranadi [CN]), right initiated ANB (suryabhedana [SB]), left initiated ANB (chandrabhedana [CB]), nadishuddhi (NS), and normal breathing (NB).The overall comparison of Δ % changes for reaction time showed statistically significant differences between groups that were significantly lowered following both SB and SN[10].

Another study conducted by Marshall et al[12] explored the benefits of unilateral nostril breathing practice post-stroke with respect to attention, language, spatial abilities, depression, and anxiety. Eleven post-stroke individuals participated in a 10-week UNB program. Five individuals had stroke-induced left hemisphere damage with no diagnosis of aphasia (left hemisphere damage control group; LHD), and six individuals experienced left hemisphere damage with a diagnosis of aphasia (individuals with aphasia group; IWA). Individuals were assessed on measures of attention, language, spatial abilities, depression, and anxiety before, during, and after UNB treatment. UNB significantly decreased levels of anxiety for individuals in both groups. Performance on language measures increased for the individuals with aphasia. Significant findings for language and affect measures indicate that further investigation regarding duration of UNB treatment and use of UNB treatment alongside traditional speech-language therapy in post-stroke individuals is warranted.

Reaction time (RT), a sensitive and simple indicator of central neuronal processing, is the interval between the onset of a signal (stimulus) and the initiation of a movement response and is an indirect index of central neuronal processing as well as a simple means of determining sensory-motor association, performance, and cortical arousal[10]. A recent study also shows the immediate effects of unilateral nasal breathing on reaction times[10].

Obesity, defined by accumulation of excess adipose tissue, has become a worldwide epidemic with dramatic consequences for health because of its association with increased heart disease, hypertension, diabetes, stroke and cancer[23,24]. While some of these medical co-morbidities are themselves associated with adverse cognitive effects[25-28], recent research suggests that adiposity has a specific association with cognitive function. Obese rats have been shown to perform worse on learning and memory tasks compared with rats of normal weight[29, 30].

Rush E et al conducted a study on body size, body composition, and fat distribution: a comparison of young New Zealand men of European, Pacific Island, and Asian Indian ethnicities. Their aims where to investigate body size and body fat relationships and fat distribution in young healthy men drawn from New Zealand European, Pacific Island, and Asian Indian populations. A total of 114 healthy men (64 European, 31 Pacific Island, 19 Asian Indian) aged 17-30 years underwent measurements of height, weight, and body composition by total body dual-energy X-ray absorptiometry (DXA). Body mass index (BMI) was then calculated. Percent body fat (%BF), fat-free mass, bone mineral content, bone mineral density, abdominal fat, thigh fat, and appendicular skeletal muscle mass (ASMM) were obtained from the DXA scans. From the results, it was obtained that for the same BMI, %BF for Pacific Island men was 4% points lower and for Asian Indian men was 7-8% points higher compared to Europeans. Compared to European men for the same %BF, BMI was 2-3 units higher for Pacific Island and 3-6 units lower for Asian Indian. The ratio of abdominal fat to thigh fat, adjusted for height, weight, and %BF, was significantly higher for Asian Indian men than European (p=0.022) and Pacific Island (p=0.002) men. ASMM, adjusted for height and weight, was highest in Pacific Island and lowest in Asian Indian men. Hence the study concluded that the relationship between %BF and BMI is different for European, Pacific Island, and Asian Indian men which may, at least in part, be due to differences in muscularity. Asian Indians have more abdominal fat deposition than their European and Pacific Island counterparts. Use of universal BMI cut-off points are not appropriate for comparison of obesity prevalence between these ethnic groups[31].

Savita Singh et al conducted a research on influence of pranayamas and yoga-asanas on serum insulin, blood glucose and lipid profile in type 2 diabetes. In this study, the aim was to see if yoga-asanas and pranayamas have any influence in modifying certain biochemical parameters. Sixty patients of uncomplicated type 2 diabetes were divided into two groups: Group 1 performed yoga along with the conventional hypoglycemic medicines and group 2 patients only received conventional medicines. Basal recordings of blood glucose (fasting and post-prandial), lipid profile and serum insulin were taken at the time of recruitment and the second reading after forty five days. Results showed a significant improvement in all the biochemical parameters in group 1 while group 2 showed significant improvement in only few parameters, thus suggesting a beneficial effect of yoga regimen on these parameters in diabetic patients[32].

Jeong et al investigated associations between obesity and poor cognitive performance using data from a community study of 467 individuals aged ≧65 years in South Korea. Cognitive function was ascertained using the Korean Mini-Mental State Examination (K-MMSE), and obesity using anthropometric measures including waist circumference and body mass index (BMI). Poor cognitive performance was present in 37% of the sample. General obesity (BMI ≧25) and poor cognition were strongly associated in the presence of abdominal obesity. Poor cognition was negatively associated with overweight (BMI 23–25) with normal waist circumference33.

In humans, recent investigations across the lifespan have examined whether obese individuals have cognitive deficits compared with their normal-weight counterparts. Childhood and adult obesity is increasing dramatically and if obese individuals show early impairment of cognitive performance - this could lead to a larger and even more devastating epidemic: that of earlier onset dementia. Midlife obesity is already a risk factor for dementia in the elderly[34-38].

The rise in overweight and obesity in all societies is prompting intense research into the causes and effects of the condition. Obesity disrupts many body systems including glucose and lipid metabolism, circadian rhythms and liver function. It also causes or increases inflammation and oxidative stress. Within cells, the endoplasmic reticulum (ER) appears to be particularly susceptible to such metabolic disruption[34]. The morbidity from obesity-associated disorders increases with higher body mass index and begins within the normal weight range. The costs (direct and indirect) associated with treating obesity and its comorbid conditions are notable and increasing. Obesity rates in patients with schizophrenia are at least as high, if not higher, than in the general population[23].

Arunachalam R conducted a study to know the effectiveness of yoga versus aerobic exercises in controlling obesity in young adults. Male subjects aged between 15 and 25 years with BMI more than 26 participated in this clinical trial. Subjects were randomly assigned to two groups namely group A and B. Group A subjects received a set of aerobic exercises that included elliptical exercises, tread mill walking, cycling in magnetic stationary cycling, floor exercises like squats, jumps and lunges. Group B subjects received a set of kriya, asana, pranayama, mudras and bandha. Results of this study concluded that both yogic practice and aerobic training are effective in reducing the lipid profile abnormalities. Though there is no significant difference between the two groups at the end of the 6th week, the results suggest that yoga practice results in a constant and steady correction of lipid profile in obese young adults. Hence, this study concludes that yoga is an effective way of normalizing the lipid profile values in obese young adults[39].

Reaction time is an indirect index of central neuronal processing as well as a simple means of determining sensory-motor association, performance, and cortical arousal[10]. The results of the present study show that both visual and auditory reaction times were reduced on UFNB as compared to their resting values, and also when compared with the normal breathing group. These findings are similar to the results obtained by Bhavanani et al[10]. Decrease in reaction time (RT) signifies an improvement in central neuronal processing ability of the special children. This may be due to[1] greater arousal and faster rate of information processing;[2] improved concentration; and/or[3] ability to ignore or inhibit extraneous stimuli. RT tends to improve as arousal increased and it has been reported that RT is fastest with an intermediate level of arousal and deteriorates when the subject is either too relaxed or too tensed[10].

Auditory reaction times were more prolonged than visual reaction times in the present study. These findings were similar to the results got by Shenvi et al[40] and in contrast to the findings obtained by Bhavanani et al[10]. Prolonged auditory reaction times can be explained in view of polysynaptic auditory pathway as compared to visual pathway[40].

General obesity (BMI ≧25) and poor cognition were strongly associated in the presence of abdominal obesity. Poor cognition was negatively associated with overweight (BMI 23–25) with normal waist circumference33. In humans, recent investigations across the lifespan have examined whether obese individuals have cognitive deficits compared with their normal-weight counterparts. Midlife obesity is already a risk factor for dementia in the elderly34-38. Moreover, obesity rates in patients with schizophrenia are at least as high, if not higher, than in the general population23.

In the present study, both auditory and visual reaction times were prolonged in the > 23 Kg/m$^2$ BMI group as compared to the ≤23 Kg/m$^2$, both at rest and after 5 minutes of breathing; however these findings were not statistically significant, may be due to the small sample size. The findings of the present study are similar to the results obtained by Deore et al[41,42].

Obesity disrupts many body systems including glucose and lipid metabolism, circadian rhythms and liver function. It also causes or increases inflammation and oxidative stress. Within cells, the endoplasmic reticulum (ER) appears to be particularly susceptible to such metabolic disruption[34]. Obesity induces vascular disease. Also, secretions of adipose tissue like hormones, cytokines, growth factors affect brain health[43]. This may explain the prolongation of reaction times in overweight subjects.

A study by Nikam et al[44] has shown correlation between BMI and reaction time, in contrast to the present study, which did not reveal any significant correlation in any of the groups. The reason for this could be the small sample size in each of the groups.

The limitations of the present study were the small sample size in each group and also each group could have been subdivided into equal number of subjects with normal and abnormal BMI.

***Conclusion:*** From the present study, it can be concluded that both visual and auditory reaction times reduced significantly after 5 minutes of UFNB, irrespective of the side, when compared to the resting values. There was also a significant decrease in the visual and auditory reaction times after 5 minutes of both right and left UFNB as compared to the group which performed 5 minutes of normal breathing. Both auditory and visual reaction times were prolonged in the > 23 Kg/m$^2$ BMI group as compared to the ≤23 Kg/m$^2$, both at rest and after 5 minutes of breathing; however there was no significant correlation between BMI and visual or auditory reaction time in any of the groups, namely UFNB (right), UFNB (left) and normal breathing. Hence, UFNB can be used by all subjects irrespective of their BMI, but a larger sample size is needed to reiterate this.

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