Effect of BMI on voice quality and different acoustic parameters

Original Article

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ABSTRACT

Introduction: Obesity is a global worldwide health issue that is affecting various aspects of the general wellbeing in Egypt it affects around 40% of its population. It influences voice quality and production and could affect an individual communicative ability by its impact on ones voice and profession.

The aim of this work: Is to compare the voice qualities in terms of perception and various acoustic aspects between obese, over weight and normal patients.

Patients and Methods: 60 patients were divided into three groups according to their Body Mass Index (BMI), were voice recorded and assessed using GRBAS scale of auditory perception analysis and analyzed their acoustic parameters.

Results: Found that a higher BMI affects voice quality in terms of breathiness and alters acoustic parameters in terms of FF, jitter and shimmer.

Conclusion: Obesity can result in poorer voice production and quality.

Key Words: Acoustic parameters, BMI, obesity, voice quality.

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INTRODUCTION

Obesity is a prominent health challenge of the modern day. Egypt is ranked among the highest eighteen countries in obesity according to the world health organization[1]. Its prevalence has increased among Egyptians to reach about 40% according to 100million health survey (2019)[2]. Globally it is estimated to affect more than 2 billion adults (39% of the adult global population[3]. (Obesity is defined as having excessive or abnormal fat accumulation presenting a risk to health. Body mass index above twenty-five is considered overweight while thirty is considered obese[4].

Voice production comes from exhaled air from the lungs, which is then resonated in the vocal folds then further resonation and modifications of this air flow occurs at the pharynx, nasal and oral cavities to final articulation via the palate, tongue and lips. A good quality of voice affects the individuals' communicative abilities on various aspects, it reflects his emotional communicative intent as well as his attitudes and mood[5]. It might affect him professionally as well since voice is an important professional tool where many jobs require specific vocal demand[6].

Obesity has multiple cardiovascular, metabolic, and musculoskeletal implications Excessive accumulation of fat might cause structural changes in vocal tract, upper airways, and abdominal region. Abdominal fat will compromise diaphragmatic and respiratory movements thus reducing maximum phonation effort resulting in voice fatigue and breathiness[7]. Excessive fat around the pharyngeal walls, tongue and oral cavities distorts resonation[8].

The obese voice was described as breathy, hoarse, and unstable. Voice perception by the listener was judged as being of an inadequate quality by using the grade-roughness-breathiness-asthenia-strain scale (GRBAS)[9].

While voice quality and perception are assessed using auditory perceptual tools e.g. GRBAS scale, voice characteristics are measured using specific acoustic variables such as fundamental frequency (FF); the frequency at which the vocal fold vibrates on producing a voiced sound; providing cues to sound pitch[10], jitter; cycle to cycle variations in frequency , shimmer; cyclic variations in amplitude, where high variations in cycles´ frequency and amplitude indicates vocal instability (e.g. Roughness and hoarseness) and noise to harmonics (NHR); the ratio between periodic and aperiodic components of voiced speech. Lower NHR reflects vocal instability, asthenia, and dysphonia. These parameters provide objective and precise values of the voice quality and can be analyzed during the production of sustained steady vowels[11].

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Cycle variations and alterations in jitter and shimmer were reported in morbidly obese patients as well as reduced HNR and increased voice strangulation at the end of emissions[12].

Aim of the study:

The aim was to assess the relation between BMI and voice perception using auditory perception assessment and acoustic features using voice lab samples.

PATIENTS AND METHODS:

This is a case control study. It was conducted on 3 groups with 20 individuals each. They were distributed according to their BMI (above 35), (25-30) and normal BMI (20-25) with matched age, sex, and smoking habits. Individuals were chosen randomly from a private nutrition clinic through six-month time interval.

Inclusion criteria:

1- BMI >30

2- BMI (25-30)

3- BMI (20-25)

Exclusion criteria:

1- All individuals with associated neurological or autoimmune disease

2- Individuals with sophisticated vocal demand or professional voice users as singers or professional religious recitals.

3- Any previous voice problems.

4- smokers

The patients were selected from a nutrition clinic, full clinical examination was done by an experienced nutritionist assessing participants BMI and related weight problems. Every patient was subjected to the voice assessment protocol applied at the Phoniatrics Unit-ORL department, Tanta University Hospitals:

I- Elementary Diagnostic Procedures:

A) Patient interview: Personal data: Complete history taking including patient's age, sex, marital status, occupation, and special habits.

B) Auditory perceptual assessment (APA): By careful listening to the patient's voice using modified GRBAS scale (GILBS) scale[13], (G) Overall Grade, (I) Irregular, (L) Leaky, (B) Breathy, and (S) Strained with 4 grades from 0 (normal) to 3 (severe dysphonia) for determining grade and character of dysphonia. The GRBAS rating scales were performed using recorded voice samples and blindly assessed by 3 different voice professionals.

C) Neck examination: For lymph nodes, mass, scars, or any anatomical abnormalities.

D) Vocal tract and cranial nerve examination.

II- Clinical Diagnostic Aids:

A) Documentation of the auditory perceptual assessment: Using audio recording of the patient's voice.

III-Additional Instrumental measures:

A) Acoustic analysis of voice: A voice sample was analyzed using KAY PENTAX Computerized Speech Lab (CSL) model 4500 version corporation Multidimensional Voice Program (MDVP) system; a computer program to obtain parameters including: jitter, shimmer, and noise to harmonic ratio (N/HR) for the vowels /a/, /e/, /o/.

An informed consents were obtained from all participants in this research. All procedures gathered from all individuals volunteering was insuring of the privacy and confidentially of the data.

RESULTS:

The data was wrangled, coded, and analyzed using the SPSS software (Armonk, NY: IBM Corp version 25.0.Quantitative variables were expressed using mean ± SD, median (minimum and maximum). Kruskal Wallis is used to detect any significant differences between the studied groups. Multiple comparisons were done using Bonferroni test. Statistical significance was considered when $p<0.05$.

Sixty subjects were distributed according to their BMI into three groups: normal, overweight, and obese. The mean age ranged between 31.9 in normal and overweight groups to 48.0 in obese group, $p<0.001$, with mean BMI of 22.53 ± 1.75 in normal, 26.9 ± 1.99 in overweight and 38.43 ± 2.86 in obese patients, $p<0.001$. Most of participants were females (90.0%, n= 18, 90.0%, n= 19 and 85.0, n= 17 in normal, overweight, and obese participants, respectively), $p= 0.0891$.

Table 1: Sociodemographic characteristics of the studied groups

	Normal (n= 20)	Overweight (n= 20)	Obese (n= 20)	*p value*
Age (Years):				*<0.001**
Mean ± SD	31.85 ± 8.02$	31.9 ± 12.44+	47.95 ± 14.1$+	
Median (Min – Max)	30.0 (23.0 – 50.0)	28.0 (17.0 – 65.0)	47.0 (24.0 – 68.0)	
BMI (Kg/m^2):				*<0.001**
Mean ± SD	22.53 ± 1.75#$	26.9 ± 1.99#+	38.43 ± 2.86$+	
Median (Min – Max)	22.4 (18.0 – 24.0)	26.9 (23.1 – 29.8)	37.9 (35.0 – 46.0)	
Gender:				*0.891*
Female	18 (90.0)	18 (90)	17 (85.0)	
Male	2 (10.0)	2 (9)	3 (15.0)	

#; Significant between normal and overweight, $; Significant between normal and obese, +; Significant between overweight and obese

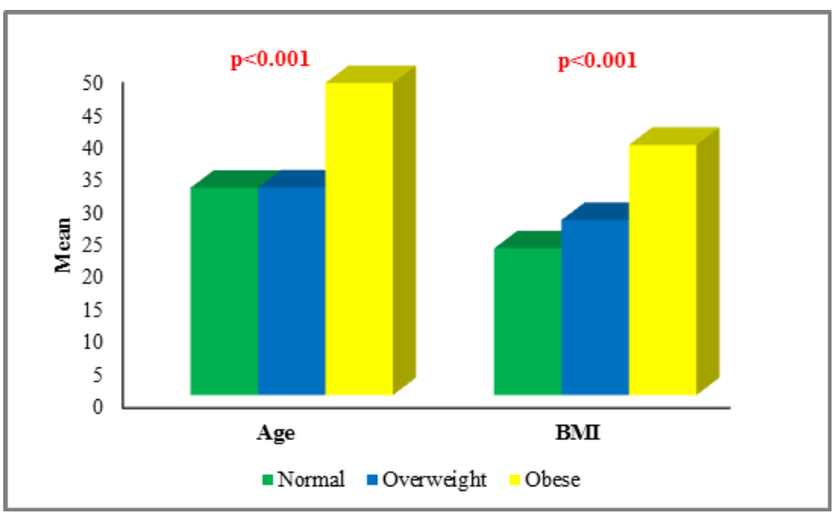

Fig. 1: Sociodemographic characteristics of the studied groups

The vowel /a/ comparison between the three studied groups showed a significant difference in average FF as the median was higher among normal weight participants (215.94 ± 41.27), than obese (201.59 ± 45.32) and overweight participants (188.68 ± 37.65), *p= 0.019*. Jita, Jitt, Shdb, Shim and NHR parameters showed no statistically significant differences between the studied groups, (Table 2).

Table 2: Comparison of vowel /a/ between the studied groups

	Normal (n= 20)	Overweight (n= 20)	Obese (n= 20)	*p value*
Average FF:				*0.019**
Mean ± SD	215.94 ± 41.27#	188.68 ± 37.65#	201.59 ± 45.32	
Median (Min – Max)	232.4 (110.39 – 258.34)	198.34 (96.85 – 259.54)	209.33 (114.91 – 273.99)	
Jita:				*0.435*
Mean ± SD	60.62 ± 41.17	70.81 ± 33.85	64.69 ± 32.24	
Median (Min – Max)	53.34 (14.54 – 151.18)	65.67 (31.51 – 150.7)	52.56 (32.3 – 143.94)	
Jitt:				*0.88*
Mean ± SD	1.19 ± 0.64	1.23 ± 0.64	1.25 ± 0.62	
Median (Min – Max)	1.15 (0.36 – 2.39)	1.15 (0.603 – 2.41)	1.04 (0.56 – 3.31)	
Shdb:				*0.474*
Mean ± SD	0.31 ± 0.17	0.31 ± 0.11	0.35 ± 0.16	
Median (Min – Max)	0.24 (0.15 – 0.74)	0.27 (0.19 – 0.51)	0.3 (0.18 – 0.79)	

Shim:				*0.823*
Mean ± SD	3.45 ± 2.04	2.97 ± 0.96	3.34 ± 1.43	
Median (Min – Max)	2.65 (1.6 – 8.6)	2.99 (1.92 – 5.702)	2.8 (1.95 – 6.82)	
NHR:				*0.432*
Mean ± SD	0.12 ± 0.02	0.12 ± 0.02	0.13 ± 0.02	
Median (Min – Max)	0.122 (0.076 – 0.152)	0.119 (0.079 – 0.158)	0.132 (0.089 – 0.163)	

#; Significant between normal and overweight, +; Significant between overweight and obese groups

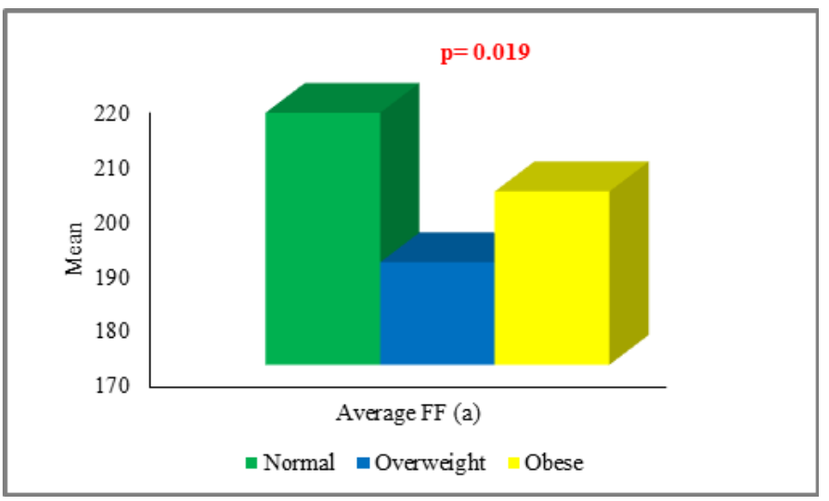

Fig. 2: Average FF (a) of the studied groups

Vowel /e/ comparison between the studied groups were shown in table 3. Jita was significantly higher among obese participants (87.84 ± 35.79) versus overweight (68.73 ± 45.51) and normal weight participants (61.6 ± 38.28), *p= 0.029*. Jitter was also significantly higher among obese (1.84 ± 0.88) versus overweight (1.28 ± 0.68) and normal weight participants (1.26 ± 0.65), *p= 0.028*. Average FF, Shdb, Shimmer and NHR were not statistically differ between the studied groups.

Table 3: Comparison of vowel (e) between the studied groups

	Normal (n= 20)	Overweight (n= 20)	Obese (n= 20)	*p value*
Average FF:				*0.066*
Mean ± SD	222.02 ± 40.21	199.23 ± 39.98	212.16 ± 39.0	
Median (Min – Max)	226.15 (121.77 – 264.58)	181.04 (99.63 – 267.49)	222.27 (116.43 – 255.61)	
Jita:				*0.029**
Mean ± SD	61.6 ± 38.35$	68.73 ± 45.51+	87.84 ± 35.79$+	
Median (Min – Max)	53.19 (15.93 – 136.74)	61.99 (20.06 – 213.94)	76.12 (48.35 – 200.06)	
Jitt:				*0.028**
Mean ± SD	1.26 ± 0.65$	1.28 ± 0.68+	1.84 ± 0.88$+	
Median (Min – Max)	1.2 (0.39 – 2.58)	0.94 (0.4 – 2.6)	1.59 (0.97 – 4.75)	
Shdb:				*0.557*
Mean ± SD	0.42 ± 0.51	0.26 ± 0.08	0.31 ± 0.18	
Median (Min – Max)	0.24 (0.13 – 1.88)	0.25 (0.15 – 0.47)	0.28 (0.11 – 0.97)	
Shim:				*0.469*
Mean ± SD	4.21 ± 5.31	2.42 ± 0.71	2.79 ± 1.26	
Median (Min – Max)	2.66 (1.34 – 19.57)	2.3 (1.53 – 4.68)	2.67 (1.14 – 6.88)	

NHR:				*0.964*
Mean ± SD	0.12 ± 0.03	0.11 ± 0.02	0.12 ± 0.047	
Median (Min – Max)	0.12 (0.073 – 0.16)	0.11 (0.065 – 0.153)	0.12 (0.054 – 0.29)	

#; Significant between normal and overweight, $; Significant between normal and obese, +; Significant between overweight and obese.

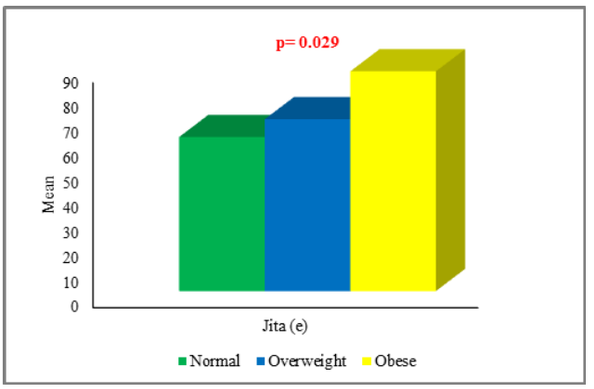

Fig. 3: Jita (e) of the studied groups

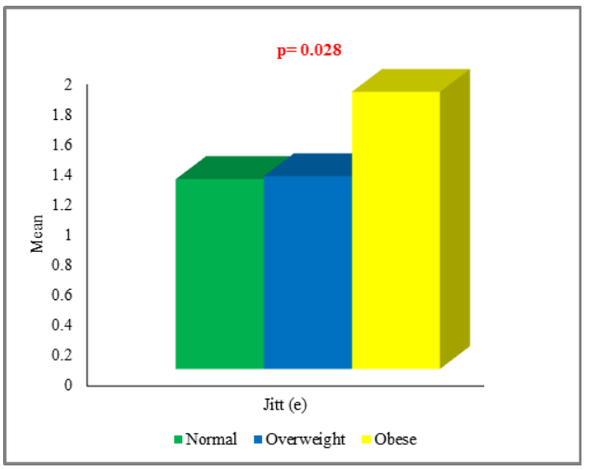

Fig. 4: Jitt (e) of the studied groups

Average FF, Jita, Jitter, Shdb, Shimmer and NHR of vowel /o/ were not statistically differ between the studied groups as illustrated in (Table 4).

Table 4: Comparison of vowel /o/ between the studied groups

	Normal (n= 20)	Overweight (n= 20)	Obese (n= 20)	*p value*
Average FF:				*0.157*
Mean ± SD	221.63 ± 40.14	202.95 ± 43.12	211.08 ± 37.1	
Median (Min – Max)	227.92 (121.77 – 266.46)	206.84 (102.99 – 272.51)	220.02 (107.33 – 260.05)	
Jita:				*0.428*
Mean ± SD	68.38 ± 41.73	70.4 ± 36.24	102.39 ± 104.98	
Median (Min – Max)	59.64 (18.11 – 152.63)	59.14 (32.65 – 166.53)	78.47 (25.74 – 494.14)	
Jitt:				*0.281*
Mean ± SD	1.41 ± 0.75	1.27 ± 0.55	1.99 ± 1.74	
Median (Min – Max)	1.31 (0.468 – 3.286)	1.11 (0.655 – 2.828)	1.62 (0.63 – 7.93)	
Shdb:				*0.442*
Mean ± SD	0.448 ± 0.52	0.302 ± 0.12	0.398 ± 0.23	
Median (Min – Max)	0.24 (0.096 – 1.882)	0.261 (0.154 – 0.534)	0.336 (0.147 – 0.971)	
Shim:				*0.525*
Mean ± SD	4.65 ± 5.48	2.69 ± 0.97	3.85 ± 2.44	
Median (Min – Max)	2.53 (1.129 – 19.569)	2.201 (1.508 – 4.783)	3.37 (1.332 – 10.821)	
NHR:				*0.065*
Mean ± SD	0.11 ± 0.03	0.12 ± 0.03	0.15 ± 0.072	
Median (Min – Max)	0.114 (0.073 – 0149)	0.123 (0.069 – 0.167)	0.138 (0.079 – 0.424)	

GRBAS scale assessment between the three studied groups is shown in table 5. Asthenia mean was significantly higher among obese participants (0.35 ± 0.49) versus overweight (0.05 ± 0.22) and normal weight participants (0.3 ± 0.47), *p= 0.049*. The mean of strain was significantly higher among {normal participants and obese participants} compared to overweight {(0.3 ± 0.47 & 0.35 ± 0.49) vs 0.05 ± 0.22 respectively}, *p= 0.041*. Also, the overall grade was significantly lower among normal weight participants (0.5 ± 0.69) versus overweight (0.095 ± 0.3) and obese participants (0.4 ± 0.5), *p= 0.045*. While roughness and breathiness were not statistically differed between the studied groups.

Table 5: GRBAS scale for the three studied groups

	Normal (n= 20)	Overweight (n= 20)	Obese (n= 20)	*p value*
Roughness:				*0.483*
Mean ± SD	0.3 ± 0.66	0.095 ± 0.3	0.1 ± 0.31	
Median (Min – Max)	0.0 (0.0 – 2.0)	0.0 (0.0 – 1.0)	0.0 (0.0 – 1.0)	
Breathiness:				*1.0*
Mean ± SD	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	
Median (Min – Max)	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	0.0 (0.0 – 0.0)	
Asthenia:				*0.049**
Mean ± SD	0.3 ± 0.47	0.05 ± 0.22+	0.35 ± 0.49+	
Median (Min – Max)	0.0 (0.0 – 1.0)	0.0 (0.0 – 1.0)	0.0 (0.0 – 1.0)	
Strain:				*0.041**
Mean ± SD	0.45 ± 0.69	0.095 ± 0.3+	0.45 ± 0.51+	
Median (Min – Max)	0.0 (0.0 – 2.0)	0.0 (0.0 – 1.0)	0.0 (0.0 – 1.0)	
Overall grade:				*0.019**
Mean ± SD	0.1 ± 0.31#$	0.55 ± 0.66#	0.8 ± 0.95$	
Median (Min – Max)	0.0 (0.0 – 1.0)	0.0 (0.0 – 2.0)	0.0 (0.0 – 2.0)	

#; Significant between normal and overweight, $; Significant between normal and obese, +; Significant between

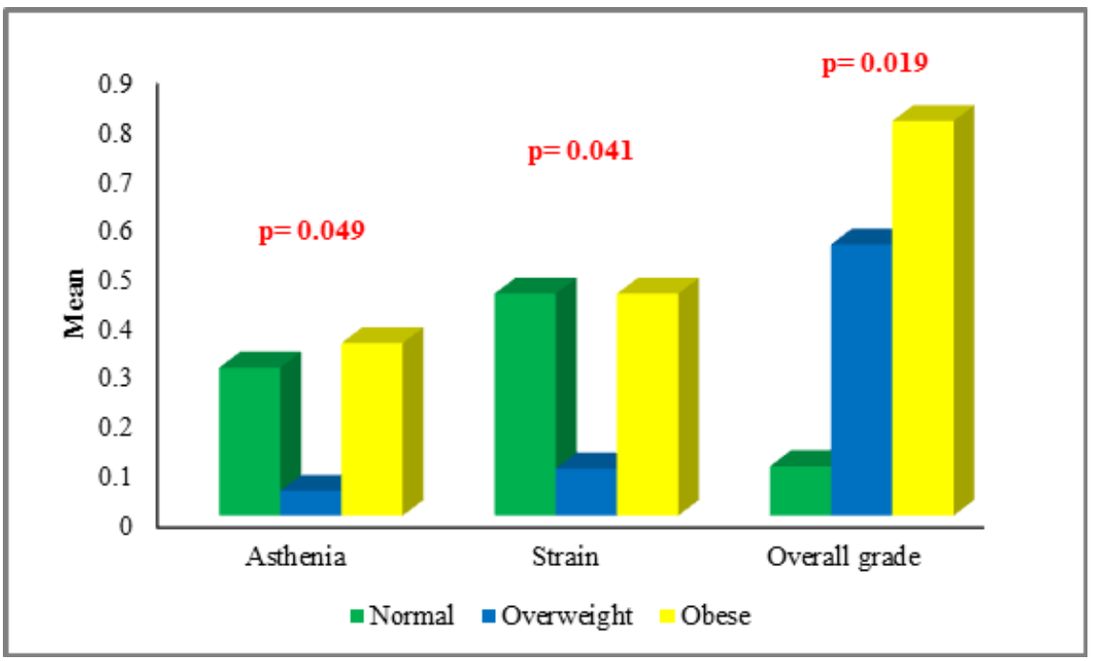

Fig. 5: GRBASI score of the studied groups

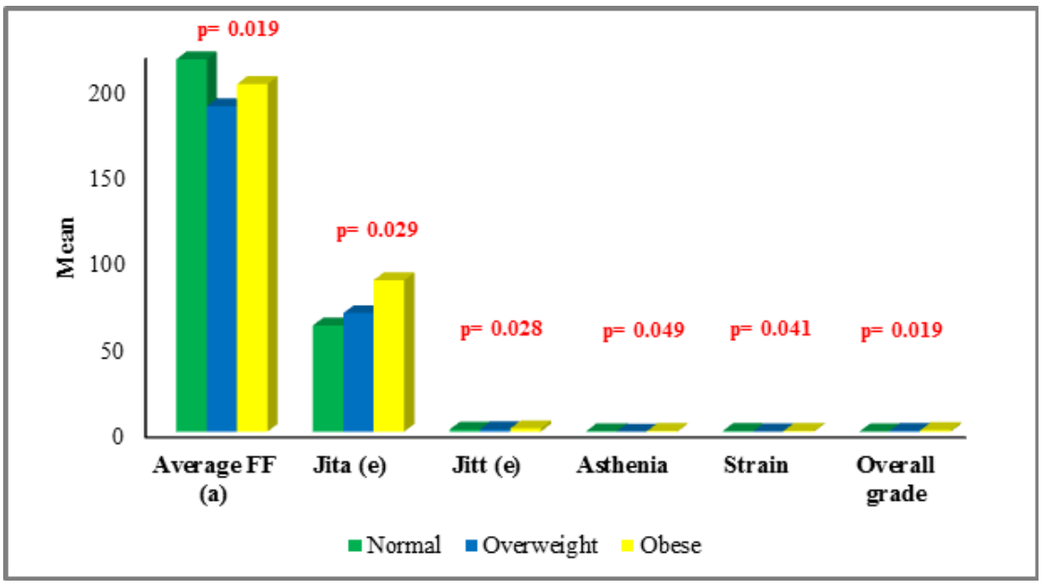

Fig. 6: significant findings among the studied groups

DISCUSSION

Obesity has been proven to affect its patient's quality of life in various aspects. It has an impact an individual`s voice production, quality, and strength. In Egypt obesity prevails in around 49.7 million of its adult population and assessing this factor among others should be considered in providing voice care management. It is important to understand how BMI affects vocal characteristics using perceptual methods and acoustically using analytical methods.

Voice recordings of three groups; divided by their BMI, were collected analyzed using GRBAS scale. The recordings were sent to three different clinicians blindly assessing the patients and controls voices and the average was taken from the three. The acoustic characteristics were compared using computerized speech lab during sustained vowel production /a/, /e/ and /o/, to avoid overlapping with other factors that affects voice quality, smokers, patients with any chronic or autoimmune diseases were excluded.

The fundamental frequency among the obese groups was found lower compared to the non-obese ones in this study. Fundamental frequency (FF) is the frequency of vocal fold vibrations in connected speech and is preserved as pitch[14]. It serves in identifying the speaker`s age, gender, emotional state, it serves in communication as it varies with stress pattern and tone according to sentence meaning and type. FF has become a standard objective method in assessing voice quality and its baseline before any intervention. Fundamental frequency that is too high or too low indicates a voice malfunction or dysphonia[15]. In the study done by Souze and Santos the same finding where obese population had lower FF than controls was found[16]. A possible explanation is how adipose tissue distribution interferes with breath support, as maximum phonation time was also lower among the obese patients. Some studies have suggested increase in the vocal fry and strangulation among obese patients as cause of change in pitch[12].

A significant difference in jitter measurements was found between the three groups, where the obese individuals with the highest BMI had the highest jitter both in its absolute and average measurements. Jitter reflects perturbations in cycle frequency and is due to lack of control on vocal fold vibrations it`s perceived as irregularity, roughness, or hoarseness of voice. Jitter measurements include absolute jitter (Jita) which is cycle to cycle variation of fundamental frequency and relative jitter (jitt) which reflects the average of these differences between the cycles divided by average period it's expressed as percentage[17]. In a study done by Cunha *et al*., it was reported that higher jitter values in obese individuals[12]. It was explained by the decreased phonatory effort and decreased subglottic pressure, which resulted in irregular vibrations of the vocal folds. Excessive abdominal fat might hinder the respiratory effort affecting glottal efficiency. The voice could be further altered at the resonating area as result of excessive neck fat accumulation affecting the pharyngeal resonator properties. This finding also corroborates with the study by Abdel-Hamid *et al*. conducted on a sample of thirty obese children, jitter was found altered among the obese group compared to controls[18].

Auditory perception analysis using GRBAS scale found that asthenia was significantly higher among the obese group. Cunha *et al*.,[12] found altered voice quality in roughness and breathiness. Irregularity and breathiness were also found significant among obese patients[19] Celebi *et al*.,[9] also reported a poorer voice quality in the obese group compared to controls by assessing asthenia and strain scale, which was explained by having a reduced maximum phonation time as result of altered air flow from the abdominal and thoracic areas.

CONCLUSION

BMI affects voice quality in terms of perception and its acoustic properties of FF, jitter and shimmer.

CONFLICT OF INTEREST

There are no conflicts of interest.

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