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The Relationship between Body Mass Index and Eustachian Tube Function in Adults

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Abstract

The prevalence of chronic Eustachian tube dysfunction is around 4% of adult's worldwide (Clin Otolaryngol. 1992; 17:317-321). Many studies have linked obesity (defined by WHO as a body mass index of 30 or more) [1] to Eustachian tube dysfunction, as fat deposition around the Eustachian tube can affect its function [2-6]. Other studies have linked acute weight loss to Patulous Eustachian tube, probably because of loss of fat around the Eustachian tube [7-9]. Many tests can be used to diagnose Eustachian tube dysfunction, and tympanometry is one of the most commonly used tests [10]. The aim of this study is to examine the link between different body mass index (BMI) groups and Eustachian tube function using tympanometry. In this study, we have found no statistically significant difference in the Eustachian tube function between different BMI groups except for the underweight group. Further studies with a larger sample size and different tests of Eustachian tube function assessment are required for better understanding of the link between BMI and Eustachian tube function.

Introduction

The prevalence of chronic Eustachian tube dysfunction is around 4% of adults worldwide, however, it can present as an acute problem in a much higher percentage (Clin Otolaryngol. 1992; 17:317-321). World health organization (WHO) classified people based on their body mass index (BMI) into: underweight if their BMI is below 18.5, normal weight if their BMI is 18.5 to 24.9, overweight if their BMI is 25-29.9, and obese if their BMI is 30 or more (3 classes) [1]. Many studies have linked obesity (defined by WHO as a body mass index of 30 or more) to Eustachian tube dysfunction, as fat deposition around the Eustachian tube can affect its function [2]. Furthermore, many studies have suggested a relationship between pediatric obesity and otitis media with effusion because of peri-tubal fat deposition [3-6]. Alternatively, other studies have linked acute weight loss to Patulous Eustachian tube, which is mostly explained by loss of fat around the Eustachian tube [7-9]. Tympanometry is test that is used to diagnose middle ear effusion, tympanic membrane perforation and Eustachian tube pathologies. It measures the compliance and the impedance of the tympanic membrane along with the condition of the ossicles of the middle ear [10]. Valsalva and Toynbee are maneuvers that can change the position tympanic membrane laterally and medially, respectively [11]. Using tympanometry to diagnose Eustachian tube dysfunction is not a new thing. Kumazawa et al. described Eustachian tube function testing using tympanometry measurements and asked their patients to perform Valsalva and Toynbee maneuvers. Based on the results they categorized Eustachian tube function into 3 categories: normal, dysfunctional and Patulous Eustachian tube [12]. Our aim from this study is to use Kumazawa et al's method to study the Eustachian tube, and compare the results between different BMI groups, which has not been done before in our population.

Methodology

Objectives of the study

A. Aim of the study

To study the relationship between obesity and Eustachian tube dysfunction.

B. Secondary objectives

i. To compare tympanometric measurements between different BMI groups.

ii. To compare the effects of Valsalva maneuver on Eustachian tube function between different BMI groups.

iii. To assess the duration of the effects of Valsalva maneuver.

iv. To compare the effects of Toynbee maneuver on Eustachian tube function between different BMI groups.

Materials and Methods

This study is a cross sectional study which was done in a tertiary hospital in Riyadh, Saudi Arabia in the outpatient department of otolaryngology and head & neck surgery, outpatient department. It was done by performing serial tympanograms and comparing the results between obese and non obese patients.

Study subjects

A. Inclusion criteria

i. Every third Saudi adult patient that presented to otorhinolaryngology clinic.

ii. Male and female patients.

iii. Patients that presented to the clinic from first of October 2016 to end of march 2017.

iv. Patients with tympanogram type A and C.

B. Exclusion criteria

i. Pediatric patient younger than 13 years.

ii. Patients with tympanogram type B.

iii. Any patient with craniofacial anomalies.

iv. Symptoms of nasal or nasal pharyngeal obstruction.

Study design

This study is a cross-sectional study.

A. Sample size

The sample size of this study is 82 patients (141 ears) who fulfilled our inclusion and exclusion criteria.

B. Sampling technique

The sampling technique we used is systemic randomization. We included every third Saudi adult patient that presented to the otology clinic.

C. Data collection methods, instruments used, and measurements:

i. Instruments Used:

GSI TympStar Version 1 Middle-Ear Analyzer. It is a computer-based admittance instrument designed to be used in clinical or research settings. The TympStar is based on the sophistication, functionality and flexibility of the GSI 33, offering unparalleled testing capabilities.

ii. In this study

a. Admittance (Y) was measured with a probe tone frequency of 226 Hz in a Screening tympanometry mode (Automatic).

b. P-RANGE daPa: Normal.

c. START daPa: +200.

d. Gradient: Tymp Width daPa.

e. P-RATE daPa/s: 600/200.

iii. Diagnostic Criteria

A. Tympanometry Normative Data

Based on the British Society Of Audiology

i. Tympanic peak pressure and middle ear pressure: Under carefully controlled conditions the 95 % range in normal subjects is –20 to +20 daPa, though pressures from –50 to +50 daPa can be considered normal in adults; pressures down to –100 daPa may be of a little clinical significance in isolation.

ii. Admittance or compliance: Compliance is normally in the range 0.3 to 1.6 cm3 in adults; 0.2 cm3 is acceptable as the lower limit in children aged less than 6 years but over 6 months.

B. Ear-canal volume

Typical values for ear-canal volume (ECV) are between 0.6-1.5cm_3 for adults.

i. Based on studies reviewed in Hunter and Shahnaz (2013).

All Patients underwent 4 tympanograms

a. Tympanogram I: patients underwent a baseline tympanogram.

b. Tympanogram II: patients were asked to perform Valsalva maneuver, then immediately underwent a second tympanogram.

c. Typanogram III: patients were asked to take a 10 minutes break, then underwent a third tympanogram.

d. Tympanogram IV: Patients were asked to perform Toynbee maneuver, then underwent a fourth tympanogram.

Data management and analysis

The data was analyzed using SPSS. Tympanogram variables were analyzed which included external auditory canal volume, pressure, compliance and gradient. The mean, standard deviation, and confidence interval were calculated.

Ethical consideration: Confidentiality was maintained. The research was fully explained to all the participants, and an informed consent was obtained from each participant, patients were told that they were free to withdraw from the research whenever they wished.

Results

After running the data in SPSS, we found that among the 82 patients (93): 56 female patients (64.4%) and 31 male patients

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(35.6%). There was 12 underweight patients a mean age of 15.8 (minimum is 12 and maximum is 36), 22 normal weight patients with mean age of 30.9 (minimum is 12 maximum is 60), 17 overweight patients with a mean age of 39.54 (minimum is 20 maximum is 60) and 36 obese patients with a mean age of 48.12 (minimum is 26 and maximum is 60).

Most variables of tympanometry: type, gradient, compliance and volume didn't show changes in response to Valsalva and Toynbee. However, the only variable of tympanometry that showed changes in response to both maneuvers was (middle ear pressure) for that reason the tympanogram 1, 2, 3, 4 where referred in the (Table 1 & 2) as pressure 1,2,3,4 .

All four BMI groups started with a baseline middle ear pressure (Tymp I) that's within normal limits:

i. Underweight patients: the mean pressure in tymp I was: -70.

ii. Normal weight patients: the mean pressure in tymp I was: -11.

iii. Overweight patients: the mean pressure in tymp I was: -12.

iv. Obese patients: the mean pressure in tymp I was: -19.8.

Table 1: A comparison of the pressure between the different BMI groups.

Comparison	Mean (SD)	P value	Significance
Pressure 1 Normal Underweight	-10.9 (65.7) -69.6 (139.3)	0.098	Not significant
Pressure 2 Normal Underweight	9.6 (67.5) -34.2 (121.5)	0.178	Not significant
Pressure 3 Normal Underweight	-7.4 (63.4) -35.4 (103.1	0.325	Not significant
Pressure 4 Normal Underweight	-30.0 (67.3) -36.3 (93.2)	0.821	Not significant
Underweight Versus Overweight			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 1 Underweight Overweight	-69.6 (139.3) -11.9 (66.9)	0.14	Not significant
Pressure 2 Underweight Overweight	-34.2 (121.5) 0 (69.1)	0.334	Not significant
Pressure 3 Underweight Overweight	-35.4 (103.1) -16.7 (72.4)	0.562	Not significant
Pressure 4 Underweight Overweight	-36.3 (93.2) -31.4 (65.2)	0.867	Not significant
Underweight Versus Obese			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 1 Underweight Obese	-69.6 (139.3) -19.8 (74.5)	0.109	Not significant

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Pressure 2 Underweight Obese	-34.2 (121.5) -0.5 (72.3)	0.238	Not significant
Pressure 3 Underweight Obese	-35.4 (103.1) -11.0 (71.3)	0.355	Not significant
Pressure 4 Underweight Obese	-36.3 (93.2) -28.0 (86.1)	0.776	Not significant
Normal Versus Overweight			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 1 Normal Overweight	-10.9 (65.7) -11.9 (66.9)	0.959	Not significant
Pressure 2 Normal Overweight	9.6 (67.5) 0 (69.1)	0.658	Not significant
Pressure 3 Normal Overweight	-7.4 (63.4) -16.7 (72.4)	0.664	Not significant
Pressure 4 Normal Overweight	-30.0 (67.3) -31.4 (65.2)	0.947	Not significant
Normal Versus Obese			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 1 Normal Obese	-10.9 (65.7) -19.8 (74.5)	0.637	Not significant
Pressure 2 Normal Obese	9.6 (67.5) -0.5 (72.3)	0.588	Not significant
Pressure 3 Normal Obese	-7.4 (63.4) -11.0 (71.3)	0.841	Not significant
Pressure 4 Normal Obese	-30.0 (67.3) -28.0 (86.1)	0.924	Not significant
Overweight Versus Obese			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 1 Overweight Obese	-11.9 (66.9) -19.8 (74.5)	0.705	Not significant

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Pressure 2 Overweight Obese	0 (69.1) -0.5 (72.3)	0.98	Not significant
Pressure 3 Overweight Obese	-16.7 (72.4) -11.0 (71.3)	0.781	Not significant
Pressure 4 Overweight Obese	-31.4 (65.2) -28.0 (86.1)	0.882	Not significant

Table 2: Differences in Pressure (Underweight Versus Normal BMI)

Comparison	Mean (SD)	P value	Significance
Pressure 2 - Pressure 1 Normal Underweight	20.4 (43.2) 35.4 (93.2	0.518	Not significant
Pressure 3 - pressure 1 Normal Underweight	3.5 (29.4) 34.2 (83.1)	0.118	Not significant
Pressure 4 - pressure 1 Normal Underweight	-19.1 (34.7) 33.3 (78.1)	0.009	significant
Pressure 3 - pressure 2 Normal Underweight	-8.6 (63.2) -36.4 (102.9)	0.329	Not significant
Pressure 4 - pressure 2 Normal Underweight	-39.6 (55.0) -2.1 (44.2)	0.038	significant
Pressure 4 -pressure 3 Normal Underweight	-22.6 (42.0) -0.8 (23.5)	0.107	Not significant
Differences in the Pressure (Underweight Versus Overweight Bmi)			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 2 - Pressure 1 Underweight Overweight	35.4 (93.2) 11.9 (28.1)	0.321	Not significant
Pressure 3 - pressure 1 Underweight Overweight	34.2 (83.1) -4.7 (23.2)	0.069	Not significant
Pressure 4 - pressure 1 Underweight Overweight	33.3 (78.1) -19.4 (38.2)	0.02	Significant
Pressure 3 - pressure 2 Underweight Overweight	-36.4 (102.9) -17.9 (72.4)	0.568	Not significant

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Pressure 4 - pressure 2 Underweight Overweight	-2.1 (44.2) -31.4 (35.3)	0.054	Not significant
Pressure 4 -pressure 3 Underweight Overweight	-0.8 (23.5) -14.7 (39.1)	0.28	Not significant
Differences in the Pressure (Underweight Versus Obese)			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 2 - Pressure 1 Underweight Obese	35.4 (93.2) 19.3 (40.6)	0.389	Not significant
Pressure 3 - pressure 1 Underweight Obese	34.2 (83.1) 8.8 (32.3)	0.116	Not significant
Pressure 4 - pressure 1 Underweight Obese	33.3 (78.1) -8.3 (68.2)	0.079	Not significant
Pressure 3 - pressure 2 Underweight Obese	-36.4 (102.9) -12.1 (71.2)	0.357	Not significant
Pressure 4 - pressure 2 Underweight Obese	-2.1 (44.2) -27.5 (55.9)	0.156	Not significant
Pressure 4 -pressure 3 Underweight Obese	-0.8 (23.5) -17.0 (56.9)	0.345	Not significant
Differences in the Pressure (Normal Versus Overweight)			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 2 - Pressure 1 Normal Overweight	20.4 (43.2) 11.9 (28.1)	0.474	Not significant
Pressure 3 - pressure 1 Normal Overweight	3.5 (29.4) -4.7 (23.2)	0.338	Not significant
Pressure 4 - pressure 1 Normal Overweight	-19.1 (34.7) -19.4 (38.2)	0.978	Not significant
Pressure 3 - pressure 2 Normal Overweight	-8.6 (63.2) -17.9 (72.4)	0.662)	Not significant
Pressure 4 - pressure 2 Normal Overweight	-39.6 (55.0) -31.4 (35.3)	0.587	Not significant

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Pressure 4 -pressure 3 Normal Overweight	-22.6 (42.0) -14.7 (39.1)	0.542	Not significant
Differences in the Pressure (Normal Versus Obese)			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 2 - Pressure 1 Normal Obese	20.4 (43.2) 19.3 (40.6)	0.914	Not significant
Pressure 3 - pressure 1 Normal Obese	3.5 (29.4) 8.8 (32.3)	0.522	Not significant
Pressure 4 - pressure 1 Normal Obese	-19.1 (34.7) -8.3 (68.2)	0.479	Not significant
Pressure 3 - pressure 2 Normal Obese	-8.6 (63.2) -12.1 (71.2)	0.845	Not significant
Pressure 4 - pressure 2 Normal Obese	-39.6 (55.0) -27.5 (55.9)	0.41	Not significant
Pressure 4 -pressure 3 Normal Obese	-22.6 (42.0) -17.0 (56.9)	0.682	Not significant
Differences in the Pressure (Overweight Versus Obese)			
Comparison	**Mean (SD)**	**P value**	**Significance**
Pressure 2 - Pressure 1 Overweight Obese	11.9 (28.1) 19.3 (40.6)	0.492	Not significant
Pressure 3 - pressure 1 Overweight Obese	-4.7 (23.2) 8.8 (32.3)	0.117	Not significant
Pressure 4 - pressure 1 Overweight Obese	-19.4 (38.2) -8.3 (68.2)	0.519	Not significant
Pressure 3 - pressure 2 Overweight Obese	-17.9 (72.4) -12.1 (71.2)	0.776	Not significant
Pressure 4 - pressure 2 Overweight Obese	-31.4 (35.3) -27.5 (55.9)	0.787	Not significant
Pressure 4 -pressure 3 Overweight Obese	-14.7 (39.1) -17.0 (56.9)	0.878	Not significant

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Discussion

World health organization (WHO) classified people based on their body mass index (BMI) into: underweight if their BMI is below 18.5, normal weight if their BMI is 18.5 to 24.9, over weight if their BMI is 25-29.9, and obese if their BMI is 30 or more (3 classes) [1]. The prevalence of chronic Eustachian tube dysfunction is around 4% of adults worldwide, however, it can present as an acute problem in a higher percentage (Clin Otolaryngol. 1992; 17: 317-321). Many studies have linked obesity (defined by WHO as a body mass index of 30 or more) to Eustachian tube dysfunction, as fat deposition around the Eustachian tube can affect its function [2]. Moreover, other studies have suggested a relationship between pediatric obesity and otitis media with effusion because of peri-tubal fat deposition [3-6]. Alternatively, other studies have linked acute weight loss to Patulous Eustachian tube, probably because of loss of fat around the Eustachian tube [7-9]. Tympanometry is test that is used to diagnose middle ear effusion, tympanic membrane perforation and Eustachian tube pathologies. It measures the compliance and the impedance of the tympanic membrane along with the condition of the ossicles of the middle ear [10]. It is done by applying positive, normal, and negative pressure in the external auditory canal and monitoring the resultant sound energy flow. Valsalva maneuver is a maneuver in which the patient is asked to close the mouth and pinch nostrils and perform an expiratory effort which forces air into the Eustachian tubes, thus increases pressure the middle ear which will push the tympanic membrane laterally [11]. Toynbee maneuver is a maneuver in which the patient will be asked to pinch the nostrils and swallow, thus decreases the middle ear pressure which will move the tympanic membrane medially [11]. Kumazawa took 3 tympanogram measurements for all of his patients: a baseline tympanogram, a second tympanogram after performing Valsalva maneuver, and a third tympanogram after performing Toynbee maneuver. He then categorized the Eustachian tube function into 3 categories: normal if the pressure goes up after Valsalva and goes back to normal after Toynbee, dysfunctional if the pressure goes up after Valsalva and doesn't go back to normal after Toynbee and Patulous if the pressure raises and falls down immediately after performing Valsalva [12]. In this study, we used Kumazawa et al's method to study the Eustachian tube function in Saudi adults, and we compared the results between different BMI groups.

In underweight patients, tympanogram I mean pressure was a little bit in the negative side: -70 (normal is from -50 to +50, although readings down to -100 can be of little significance in isolation). After performing tympanogram II, the mean pressure went up to -34.2. Following tympanogram III, the mean pressure decreased was -35.4. Following tympanogram IV, the mean pressure was -36.3. From the above readings we can conclude that underweight patients have an element of Eustachian tube dysfunction as Valsalva increased the middle ear pressure but Toynbee failed to return the pressure to the baseline, which can also be seen in (Table 2) in the significant difference in pressure between pressure 4 - 1 and pressure 4-2 (which represents the effect of Toynbee from baseline or after Valsalva maneuver respectively) between normal weight and underweight group and between pressure 4-1 between overweight and underweight. However, it should be taking in consideration that mean age of this BMI group is 15.8 which is younger than the other three BMI groups. In the 3 other BMI groups, patients had a baseline mean pressure which was within normal. In tympanogram II, after performing Valsalva, all 3 groups' mean pressures increased significantly and proportionally and the new readings were still within the normal limits. This inclination in pressure suggests that Valsalva maneuver is effective in raising middle ear pressure in all groups in a similar way. In tympanogram III, all 3 groups' mean pressure decreased proportionally near the baseline, this declination implies that the effect of Valsalva doesn't last for 10 minutes. In tympanogram IV, after performing Toynbee, all 3 groups' mean pressures decreased significantly and proportionally and the new readings were still within the normal limits. This declination proves that Toynbee maneuver is effective in decreasing middle ear pressure in both groups in a similar way.

From the above, we can conclude that, using our method, underweight patients had a baseline mean pressure that was in the negative side and that surprisingly they had an element of Eustachian tube dysfunction, which contradicts other papers that suggested that these obese patients are at more risk of Eustachian tube dysfunction because of increased peri-tubal fat. However, it should be taking in consideration that mean age of this BMI group is 15.8 which is younger and closer to pediatric age group than the other three BMI groups and it is known that pediatric age group has higher incidence of Eustachian tube dysfunction. There was no significant difference in the effects of Valsalva and Toynbee or the duration of the effect of Valsava between the other 3 BMI groups (Table 2).

These results are in a way similar to the results of a previous study that was conducted by the authors, in which a comparison was made between obese and non-obese patients, and it was concluded that there was no significant difference in the effects of Valsalva and Toynbee in the middle ear pressure between the 2 groups [13].

Conclusion

In summary, using our method, we found that underweight patients have an element of Eustachian tube dysfunction. And that in the other 3 BMI groups, Valalva and Toynbee maneuvers have significant effects on in the middle ear pressure. Valsava maneuver increases the middle ear pressure significantly but temporarily with an effect that lasts less than 10 minutes in the 3 BMI groups. There was no difference in the Eustachian tube function between the other 3 BMI groups. There was no significant difference between these 3 BMI groups in baseline pressure, effects of Valsalva and Toynbee, or the duration of

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the effects of Valsalva. Other studies with different methods of Eustachian tube function assessment and larger sample sizes are needed for better understanding of the relationship between the body mass index and the Eustachian tube function.

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