Obesity and Voice
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Obesity is a worldwide epidemic threat. Its prevalence is rising steadily and currently it affects one-third of the world’s population, spanning several countries across the globe. Based on a report published in the New England Journal of Medicine 2017, close to 2 billion people are either obese or overweight, and the rate of obesity is higher in children than in adults. The economic implications of obesity are devastating. In a study by Finkelstein et al, the annual health cost of obese people in the United States was reported to be 60% higher than that of normal-weight subjects, accounting for a significant proportion of the gross national income. In addition to the increase in health care cost, obesity is associated with a reduction in productivity secondary to absenteeism, which in turn might impair the economic competitiveness. In countries like the United States, China, and Mexico, obesity also is considered a threat to the national security as the compromised physical fitness puts military preparedness in jeopardy. Several strategies have been adopted to motivate obese individuals to lose weight. These include publicizing information on healthy dietary behavior and ehealth communication that constitutes mass customization. The “Let’s Move” campaign that was launched by former First Lady Michelle Obama was another initiative to prevent obesity in children and foster accessibility to healthy food and diet.

Still, the global spread of obesity continues, and the 2 main related concerns are the self-image/esteem and health-related hazards. The association between poor self-esteem and obesity stems from the emphasis on thinness in our contemporary culture and the labeling of overweight and obese individuals. The stigmatization of overweight and obese individuals in society often leads to psychological disturbances that result in suffering of the affected individual. Body image dissatisfaction has become a salient attribute in obese subjects and the negative body image linked to obesity has been associated with appearance anxiety and low self-compassion. The seriousness of this matter has led to the emergence of body image therapy as a psychological approach to alleviate obesity-induced psychological disturbances. In addition, there is a strong association between body image and overall health. The importance of body image in obesity is not confined only to self-esteem and satisfaction. It also can have an impact on physical health-related issues. “Does body satisfaction matter?” is a question that has been addressed by Neumark-Sztainer et al in their investigation on the association between body satisfaction and health behaviors in a sample of 2516 adolescents over the course of 5 years. The results showed that low body satisfaction is associated with unhealthy behaviors such as binge eating, poor weight control, reduced physical activity, and smoking.

Obesity is becoming one the leading causes of disabilities and death. Obese subjects are at a higher risk to develop cardiovascular illnesses, endocrine disorders, and kidney diseases, in addition to psychologi-
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cal disturbances. All systems in the body are affected either directly or indirectly to various degrees. The state of meta-inflammation caused by the excess of adipose tissue, a metabolically active organ, is partially responsible for the impairment in function of these systems. As voice is a reflection of our well-being, phonatory effects of obesity are inevitable. All 3 components of voice production, the respiratory system and abdominal back and thoracic muscles as the power source, the vocal folds as the oscillator, and the vocal tract as the resonator, are targets of anatomic and systemic obesity-induced changes. Hence, weight gain affects voice production.

The purpose of this book is to review the current literature on the impact of obesity on phonation and to highlight the various means by which excessive weight may jeopardize voice quality and endurance. Another impetus for writing this book was the unanswered questions regarding the impact of weight loss and weight fluctuation on voice. “Does weight loss affect my voice?” is a frequent question asked by obese patients, particularly professional voice users who are interested in preserving their individual vocal characteristics. This book discusses weight loss and voice, and it suggests future research trends on the link between weight loss, weight gain, obesity, and phonation.

Chapter 1 reviews the increasing prevalence of obesity and its implications for voice dysfunction. Chapter 2 summarizes current understanding of clinical anatomy and physiology of the voice. Chapters 3 and 4 present state-of-the-art information on medical history and physical examination for patients with voice disorders. In Chapter 5, the authors present core information on obesity, and they review literature correlating body size with voice characteristics. Chapter 6 explains the effects of obesity on sex hormones and the related effects of sex hormone alterations on phonation in obese individuals. Chapter 7 provides insights into basic information about respiration and its importance in phonation. In Chapter 8, the authors explore the relationship between obesity and respiration, explaining the important effects of obesity-related changes in lung function and their consequences for phonation. Chapter 9 includes an exceptionally comprehensive overview of laryngopharyngeal reflux, including more than 600 references. In Chapter 10, the authors highlight what is known about the relationship between reflux and obesity and the effects of obesity-related reflux on the larynx and voice. Chapter 11 is a comprehensive chapter reviewing the most current concepts regarding nutrition and nutrition science, and the relationship between nutrition and voice. In Chapter 12, the authors review the clinically important subject of the effects of weight loss on voice, including “yo-yo” dieting, and bariatric surgery. In the concluding Chapter 13, the authors summarize the information presented in other chapters and highlight the substantial deficits in knowledge about obesity and its impact upon the voice and vocal tract. Clearly, additional research is needed. Considering the epidemic nature of obesity, obesity-related voice research appears to deserve much more attention than it has received, so far.

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Chapter 11
The Epidemic of Obesity: 
Incidental Dysphonia

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The Epidemic of Obesity

Several surveys have documented the epidemic nature of obesity as a health crisis worldwide.\textsuperscript{1–9} The increase in its prevalence started in the 1960s with adults being affected more than children and women more than men.\textsuperscript{4} In the United States, the past 3 decades have witnessed a twofold increase in obesity,\textsuperscript{5} with 34.9\% of the adult population reported as being obese.\textsuperscript{3} Using national survey data, Wang et al\textsuperscript{6} projected an increase in the prevalence of overweight or obesity in the United States to 86.3\% of the adult population by year 2030 and to 100\% by year 2048. This epidemic affects all age groups, including children. Based on multiple National Health and Nutrition Examination Surveys, which included 40,780 children and adolescents between the ages of 2 and 19 years, 17\% of the participants were reported to be obese.\textsuperscript{7} There are also ethnic disparities, with Hispanic women and non-Hispanic black people being affected the most.\textsuperscript{3} According to Li et al,\textsuperscript{8} Mexican Americans have the highest mean percent body fat in comparison to non-Hispanic whites. The study was conducted using the National Health and Nutrition Examination Survey, which included 6559 men and 6507 women. The total body fat and fat-free mass were measured using dual-energy x-ray absorptiometry.\textsuperscript{8}

Why the rise in obesity prevalence? The pathogenesis of obesity cannot be attributed to one cause. A holistic approach is needed to determine the many factors contributing to this epidemic entity.\textsuperscript{10} A thorough understanding of obesity requires understanding not only the dietary volitional behavior but also numerous other issues. Looking at the cause is essential in understanding the interplay between obesity and environmental factors. Numerous etiological models have been developed by many authors.\textsuperscript{11–17} Egger and Dixon\textsuperscript{11} described a hierarchy of layers of influence in the etiology of obesity. These were stratified as risk factors/markers, immediate determinants, and/or nonimmediate determinants. The hierarchy included an array of factors partly related to lifestyle and behavior and partly to sociocultural influences, relationships, occupation, and environment.\textsuperscript{11,12} Based on a report by Swinburn et al,\textsuperscript{13} obesogenic environmental factors can be classified as macro and micro factors that include small
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air, soil, and water-polluted particles. These latter have been shown to play a major role in oxidative stress and in disrupting various body systems.14–16 The same authors had also previously described an ecological model consisting of 3 main pillars that maintain the energy balance in a human subject. These include biological influence, behavioral influence, and environmental influence.17 Thus, widespread obesity is the result of many factors that can interact with each other.

But how does it all start? Obesity is the result of a mismatch between the environment we are programed for and the one we live in.11 This mismatch creates stress that is fueled by manmade inducers referred to as anthropogens.18 The interface with or adoption of these anthropogens leads to a state of chronic inflammation that worsens with time.17–20 Several have been identified in the literature, the most important of which are nutrition and inactivity. The intake of processed food, in addition to excessive sugar, has been shown to induce meta-inflammation.19 Similarly, sedentary activity or physical inactivity has been linked to several inflammatory biomarkers, whereas exercise, irrespective of its type and duration, has been shown to be of health benefit.21 Other important anthropogens that were linked to obesity include sleep deprivation, stress, anxiety, and depression.22–24

**Obesity, a Prelude to Systemic Diseases**

The anthropogens that induce obesity incite a metabolic response that becomes systemic over time and leads to low-grade chronic inflammation.11,18,25 When compounded with genetic predisposition, these events predispose to chronic diseases such as cardiac, respiratory, renal, and endocrine disorders.26,27 A large study by Field et al28 investigating the association between overweight and health risks revealed an increase in the incidence of diabetes (DM), hypertension, and heart illnesses with an increase in body weight. The study was conducted on men and women between the ages of 30 and 55 years followed over a period of 10 years.

Several studies concur that obesity and overweight are among the most important risk factors associated with the development of DM and its complications.29–31 Guh et al29 reported that obese men and women have 7- and 12-fold increased risk for DM type 2, respectively. A systemic review on the prevalence of obesity and DM by Colosia et al30 showed that 30% to 50% of patients with DM are obese. Weight loss following bariatric surgery has been shown to reverse DM type 2 and is considered a management strategy preferable to medical therapy.31 Similar to the association between obesity and DM, obesity is associated also with higher risk of cardiovascular diseases.32–40 A body mass index (BMI) of less than 25 kg/m² is considered ideal for cardiovascular health,41 whereas excessive weight is an independent risk factor that increases the odds for coronary artery diseases (1.46 for men and 1.64 for women).34 The effect is mediated through several mechanisms: (1) obesity-induced structural changes, where the increase in weight leads to an increase in peripheral resistance, which in turn leads to hypertrophy of cardiac muscles and worsening of their function; (2) the effect of obesity on systemic diseases such as hypertension, diabetes, and dyslipidemia, which impact cardiac function adversely and are considered as cardiac risk factors; and (3) adipose tissue-induced inflammatory response and its known systemic impact.42 Numerous studies also have documented that obesity is associated with abnormal kidney function and high prevalence of kidney diseases.43–53 The effect of obesity
The impact of obesity on voice has scarcely been discussed in the literature. There are studies on the phonatory characteristics of obese patients in comparison to normal-weight subjects, and on vocal parameters' predictive value of body size and contour, with only a few studies on the impact of weight loss on voice. The impact of weight gain on voice has not been investigated thoroughly. This scarcity of reports is surprising given that voice is a reflection of our well-being. The complexity of voice production and the multiplicity of factors that contribute to phonation are indisputable. In addition to our genetic background and phonatory habits, body traits and health are important influences on acoustic cues that determine one's vocal identity. Numerous reviews highlight the vulnerability of voice vis-à-vis systemic diseases and the importance of adipose tissue as an endocrine organ. Review of 3 facets of the interplay between obesity and voice helps clarify clinical issues, as summarized in the next section.
that predisposes to numerous diseases.\textsuperscript{90} In addition to playing a major role in energy homeostasis and its metabolic effect, obesity impacts systems in the body that are integral to voice production. Excessive weight can adversely affect breathing by mechanical impairment, reduction in chest compliance, and alteration in lung perfusion.\textsuperscript{91–96} Obesity also can alter the sex hormone environment in both men and women.\textsuperscript{97–103} There is reduction in total and free testosterone levels in men and peripheral conversion of androgen to estrogen via several enzymes.\textsuperscript{99,100} In menopausal women, the excess fat can act as a reservoir for estrogen replenishment to mitigate the postmenopausal androgenic state.\textsuperscript{102,104,105} Obesity also can affect the gastrointestinal system. It has been proven to exacerbate the symptoms and signs of reflux disease by delaying gastric emptying time, altering the function of the lower esophageal sphincter, displacing the gastroesophageal junction zone, and increasing the risk of hiatal hernia.\textsuperscript{106–113}

As phonation is a complex process intimately linked to these systems, it is reasonable to infer that obesity-induced alterations in the function of these systems may jeopardize phonation and lead to voice disorders. Further discussion on this topic is presented in Chapters 5, 6, 7, and 8 of this book.

The Positive Energy Imbalance

As previously mentioned in this chapter, obesity is the result of excessive energy intake and/or decrease in energy use (activity level). Both factors are linked to voice production. Diet and voice are discussed in Chapter 58, “Nutrition and the Professional Voice,” of the fourth edition of Professional Voice,\textsuperscript{114} republished for the readers’ convenience as Chapter 11 of this book. In summary, dietary behavior in terms of amount and type of nutrients as well as fluid intake is important for vocal performance. A nutrition strategy based on a balanced diet is often needed in order to meet the dietary requirements of professional voice users just as it is to meet the requirements of other professional athletes. For instance, a meal rich in carbohydrate and low in fat often is recommended a few hours prior to a long performance. Similarly, consumption of fruits and vegetables with lean proteins is always advised.\textsuperscript{115} The eating pattern and dietary behavior of obese subjects may have an adverse effect on their vocal performance.\textsuperscript{116,117} The imbalance in energy intake and energy expenditure in obese subjects may put the singer at risk of vocal fatigue, hunger, or gastrointestinal discomfort. By the same reasoning, the sedentary activity experienced by obese patients may also affect vocal performance adversely. Jarosz et al\textsuperscript{118} examined the correlation between BMI, physical inactivity, and fatigue in 69 African American women (BMI greater than 30 kg/m\textsuperscript{2}). The results indicated a significant correlation between obesity and body fatigue, which substantiates the deterrent effect of obesity on body activity and lifestyle. Vgontzas et al\textsuperscript{119} correlated the excessive daytime sleepiness and fatigue in obese subjects with metabolic disorders even in the absence of obstructive sleep apnea. Given that professional voice users are vocal athletes,\textsuperscript{120} body fatigue associated with obesity may have a detrimental effect on voice performance and lead to vocal disorders.\textsuperscript{118–120} Further research on this topic is needed to elucidate the relationship between obesity, body fatigue, and voice.

The Vocal Tract and the Bottleneck

Although the vocal signal is energized by breathing and is emitted at the level of the vocal folds, what shapes our vocal iden-
tity is the morphology and contour of the supraglottic vocal tract, the bottleneck for sound production. With obesity, there is alteration in the shape and cross-sectional area of the pharyngeal lumen, as well as the configuration of other regions of the vocal tract, which may affect voice quality.121–124 The upper airway is a target for morphologic changes in obese subjects. Weight-induced fat deposition at various sites of the vocal tract has been described by numerous authors. For example, a study by Busetto et al125 conducted on female obese subjects showed a strong correlation between weight, fat distribution, and size of the upper airway. Accumulation of fat was noted at the base of tongue, lateral pharyngeal walls, and at the palatopharyngeal folds. Several other studies also have documented an association between obesity and upper airway fat distribution.125,126 Similarly, Pahkala et al127 reported hypertrophy of the pharyngeal fat pad in obese subjects scheduled for bariatric surgery. This alteration in the size and configuration of the vocal tract in relation to BMI certainly carries acoustic implications given that formants’ dispersion and position depend heavily on the shape of the vocal tract.128–132 A more thorough discussion on the correlation between vocal tract morphology in obese subjects and phonatory output is reviewed in Chapter 5 of this book, namely, on obesity, body size, and vocal tract.

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