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Obesity and sexually selected anorexia nervosa

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Summary Anorexia nervosa is diagnosed by drastic weight loss, a fear of gaining weight, a distorted body image, and, in women, three consecutive episodes of amenorrhea. It is often associated with a compulsive need for exercise, a bright outlook on life, and a high level of competitiveness. It afflicts primarily young women in higher socioeconomic strata who are highly competitive and otherwise overachievers. There are three adaptive explanations for anorexia nervosa: the reproductive suppression, the fleeing famine and the pseudo-female hypotheses. Here I present a novel hypothesis, the age-related obesity hypothesis. It posits that the otherwise normal tendency by women to seek a youthful appearance can become maladaptive and lead to anorexia nervosa in environments in which thinness becomes the primary indicator of youth, such as in modern industrialized societies. This hypothesis explains the aforementioned associated features of anorexia nervosa, and its increasing prevalence in western societies. The hypothesis generates several testable predictions: (1) Prevalence of anorexia nervosa across societies should be related to the degree to which thinness is an indicator of youth in a population. (2) Conversely, perceptions of the weight-age relationship should differ among populations depending on the prevalence of anorexia nervosa. (3) Anorectic individuals, or those with the propensity to develop the disease, should have a biased perception of the weight-age relationship. (4) Experimental manipulation of individuals' perception of the weight-age relationship should affect weight concerns, particularly among anorectic or at-risk individuals. Should the hypothesis be supported it might be used to screen at-risk individuals. Furthermore, it would call for more integrative public health programs that take a comprehensive approach encompassing both obesity and anorexia.

Anorexia nervosa is a disease diagnosed by weight loss of more than 15% of normal or expected body weight, an intense fear of gaining weight or becoming fat, a distorted body image whereby the extreme weight loss is not acknowledged, and, in women, three consecutive episodes of amenorrhea [1,2]. In addition to these four diagnostic features, which are thought by some to be too restrictive [e.g., 3], the disease is often associated with compulsive exercise, a bright outlook on life, and a high level of competitiveness. The disease afflicts up to 1% of women, at a rate about 10 times that of men. It is most prevalent among women in their mid-teenage years, and it wanes thereafter. Typically in industrialized societies, individuals afflicted were from high socioeconomic strata, but as the rates of anorexia nervosa increased over the past 20 years, it began to spread across cultural and

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socioeconomic groups. Few effective treatments exist; the disease can become chronic, and the mortality rate is the highest of all psychiatric illness [4—11]. As it would be expected for such a multifaceted medical condition, anorexia nervosa has been studied from many perspectives: biomedical, psychological, physiological, genetic, sociological, and nutritional. Although evolutionary explanations have been proposed, none of them has been thoroughly tested, nor, more importantly, led to major changes in the understanding, prevention or treatment of anorexia nervosa. In this paper, I review the existing evolutionary hypotheses and introduce a new hypothesis with potential implications for public health policies.

Current adaptive hypotheses

Three evolutionary explanations for anorexia nervosa have been proposed. First, the 'fleeing famine' hypothesis [12] posits that anorexia nervosa is an anachronistic adaptation to ecological conditions that humans have had to endure throughout most of their evolutionary history. The hypothesis argues that historically, when food resources became scarce, it might have been advantageous to ignore hunger, feel energetic and be optimistic. Supposedly, these adaptations made it easier for individuals to withstand harsh situations until they improved, and might have encouraged people to migrate to other areas, and hence 'flee famine'. The hypothesis might explain the hyperactivity, the ability to ignore hunger, and the positive attitude despite evidence to the contrary, but it does not explain one key feature of the disease: its prevalence among young females. Presumably men and women of all ages faced the same conditions of food depletion. In fact, documented instances of severe food shortages indicate that men lose weight and starve to death before women do [13,14]. The hypothesis presents no testable predictions, falls back upon issues related to sexual attractiveness to explain sex differences in anorexia nervosa, and limits clinical implications to the suggestion that awareness of the 'fleeing famine' hypothesis, or evolutionary explanations in general, will help to build a better rapport between patient and clinician [12]. So far, there have not been any tests of the 'fleeing famine' hypothesis.

Second, the 'reproductive suppression' hypothesis [15] proposes that anorexia nervosa is an adaptation that allows pre-pubescent women to delay the onset of menarche when conditions are unfavourable for reproduction and, by extension, by adult women to return their bodies to pre-pubescent conditions. The hypothesis is based on the long-known [16] and well-documented [reviewed by 17] fact that menarche ceases when body fat decreases 10—15% below normal levels, coupled with the equally well-documented fact that many female mammals delay reproduction when conditions are temporarily unsuitable [reviewed by 18]. The delay in reproduction could depend on the female herself (e.g., condition, age), or could include social (e.g., mating status, mate quality, current offspring) or environmental cues (e.g., a late spring).

An immediately apparent difficulty with the hypothesis was that it did not explain why other, simpler and less damaging means of delaying or preventing reproduction should not be used instead, such as abstaining from sex. However, it was soon suggested that the hypothesis only applies to individuals who lack the social support necessary to regulate reproduction via more conventional means [19]. Hence, the 'reproductive suppression' hypothesis differs from all other evolutionary explanations in that it does not consider massive weight loss to be a maladaptation left over from our evolutionary past, but rather as a current adaptation, beneficial to those who are not able to regulate their reproduction via more conventional means. This is a crucial prediction of the hypothesis, and so far there have not been any tests demonstrating the fitness benefits of delaying reproduction by means of massive weight loss, but any benefits seem highly unlikely, given the associated high mortality [20—22].

The 'reproductive suppression' hypothesis argues that the syndromes associated with anorexia nervosa have been selected to delay reproduction, so psychological elements ought to include a desire to decrease sexual attractiveness. Hence, the 'reproductive suppression' hypothesis views weight loss associated with anorexia nervosa as being categorically different from less extreme and more common types of weight loss and dieting, the purpose of which is invariably to increase sexual attractiveness. There have not been any tests demonstrating this categorical divide.

Tests of the 'reproductive suppression' hypothesis have found that 'eating disorder inventory' (EDI) scores [23], which measure body dissatisfaction and propensity to diet unnecessarily, increased for women who were exposed to narratives depicting high levels of female—female competition [24]. Other work by the same group demonstrated that EDI scores were higher among women who did not deem themselves ready to become mothers, either because of lack of social support, or lack of a suitable partner [25]. Unfortunately, in both studies

the participants were not anorectic individuals without adequate social support, but rather ordinary undergraduates. Hence, a more parsimonious explanation would be that weight concerns diminish when sexual competition is perceived to be lower, when social support is present, or when a suitable partner is found; in essence, that weight concerns are caused by factors associated with sexual attractiveness.

Upon publication of this paper, there shall be two evolutionary explanations of anorexia nervosa based on sexual attractiveness. They differ from the two previous hypotheses in that they both link anorexia nervosa with sexual competition among females, and in that they both view all self-induced weight loss as a continuum, with anorexia nervosa at one extreme. To facilitate discussion I shall refer to them as the 'pseudo-nubile' hypothesis [26], explained and discussed next, and the 'age-related obesity' hypothesis, introduced and explained thereafter.

The 'pseudo-nubile' hypothesis [26] contends that the syndromes associated with anorexia nervosa are maladaptations that are expressed in today's industrialized societies because of unusually high female intrasexual competition. It argues that women have a natural concern for their physical attractiveness, and in contemporary affluent societies, thanks to better medicine, adequate diets, decreased physical labour, and more recently, widespread plastic surgery, older women retain their youthful appearance well past their peak reproductive years. Abed [26] refers to them as 'pseudo-nubile'. The hypothesis argues that the high frequency of 'pseudo-nubile' women increases the level of female intrasexual competition and leads to a super-normal response in some young females' desire to seem more attractive, which is expressed as anorexia nervosa.

The hypothesis' assertion that the presence of 'pseudo-nubile' women increases intrasexual completion is likely based on the concept of operational sex ratio [27], which refers to the number of males relative to the number of females available for mating. The demography of developing, growing populations is often represented visually by the classic age pyramid, with large numbers of young individuals and steadily lower numbers of individuals in older age classes. In contrast, both birth rate and mortality are low in developed societies, which lead to an age distribution resembling a column instead of a pyramid. Even when correcting for propinquity, women tend to mate 'upwards': they usually mate someone who is more educated, taller, wealthier, and most importantly for the purposes of this discussion, a man who is a few years older [28—30]. Consequently, compared to growing populations, in stable populations the operational sex ratio (males:females) is higher, female—female competition is lower, and for women at their peak reproductive years it is actually easier to find slightly older, potentially suitable mates [31]. The apparent youth of a few women in western societies does not compare with the actual youth of masses of women in non-western societies.

In addition to the operational sex ratio, there are several other several methods of quantifying the strength of sexual selection [32], but most of them do not led themselves to comparisons between populations and within one sex. One potentially useful method, however, involves measuring the variance in lifetime reproductive success. In developing societies family size is higher than in developed countries, and infant mortality is higher and more variable; it follows that the variance in reproductive success would also have to be higher. Hence, contrary to a key assumption of the 'pseudo-nubile' hypothesis, again, female intrasexual competition is actually higher in developing countries.

Obesity and sexually selected anorexia nervosa

This paper introduces a fourth evolutionary hypothesis for anorexia nervosa: the age-related obesity hypothesis. The importance of social interactions for humans is compounded by their long life spans, slow maturation, extensive need for parental care, community structure, etc. It is no surprise that we have an uncanny ability to exploit, cajole, manipulate, and persuade each other, skills that depend on our ability to define and gauge our competitors, particularly same-sex competitors, and to react accordingly. For women, youth is a powerful indicator of potential lifetime reproductive success, and hence youth, or the appearance of youth, is a valuable asset in obtaining a high-quality mate. Therefore, women have evolved both the ability to assess the best indicators of youth in their population, and the desire to attain them.

These youth indicators could be morphological, physiological and behavioural, general to all humans or specific to a given culture. Behavioural indicators not only demonstrate culture-specific age-differences, such as fashion or music, but also emphasize physiological differences. For instance, they might take advantage of age-related physiological constraints, such as growing long hair [33,34] or participating in physiologically taxing

or risky activities. Other indicators are more ordinary. Work using standardized composite faces differing only in the quality of their skin demonstrates that homogeneous, youthful skin is more attractive [35], confirming what every woman who wears make up already knows: first apply a smooth foundation.

These tendencies to display youthfulness are most strongly expressed at the age women have historically started to seek their main lifetime partners: their mid-teenage years. Teenage girls tend to find, imitate and sometimes idolize slightly older but nevertheless young female role models. These young role models can be found in the immediate vicinity (older sisters, neighbours, aunts) or in the mass media. Female celebrities are keenly aware that their youth-appeal depends partially on remaining youthful in demeanour and appearance, in remaining 'pseudo-nubile'.

It is often assumed that thinness is an indicator of youth and attractiveness, but the generality of that assumption might be limited. Anderson et al. [36] analysed several societies and concluded that the amount of body fat considered desirable in a culture is inversely correlated with the monetary value of women's work, their degree of political power, and their control over economic resources. In the USA within the 20th century, the preference for curvaceous women has decreased over the past 40 years [37]. In contemporary Europe, Portuguese men prefer 'curvaceous' female figures, whereas Danish men prefer women with smaller hips [38]. Hence, the ideal of female beauty is not constant, and the assumption that thinness is an indicator of youth might be valid only for contemporary western societies, for the simple reason that only in these societies, which also have the highest rates of anorexia nervosa, does weight steadily increase with age among adults.

Over the past 30 years, obesity has become a major source of concern in the western world. For example, in Spain from 1987 to 1997 the prevalence of overweight people in the 25—64 age group increased by 2.2% [39]. In Denmark, from 1982 to 1992 the prevalence of obesity increased from 10% to 13% in men and from 9% to 11% in women [40]. In Norway, over a 10 year span, the prevalence of obesity increased from 7.5 to 14% in men and from 13% to 18% in women [41]. In the USA, mean body weight in adults 20—74-years old increased by 3.6 Kg between the late 70s and the late 80s [42], and the prevalence of obesity went from 12.0% in 1991 to 17.9% in 1998 [43]. The patterns are similar throughout the world's most affluent countries [44,45] and the situation is slowly heading the same direction in developing countries [46—49].

In western societies, moderate age-related weight gain is considered normal [50], and the increase can even occur among individuals with relatively active lifestyles. For example, an analysis of recreational runners over a three year span concluded that to compensate for the expected weight gain associated with normal aging, men would have to increase their runs by 4 km/week every year, and women by 6.2 km [51]. The solution to the obesity problem is intractably complex, but the essence of the problem is shockingly simple: energy intake is higher than energy expenditure [52]. Any long-term imbalance will invariably lead to changes in body weight over the years, and even small gains of a couple of Kg per year will, in due time, lead to obesity [53,54]. In populations in which obesity is increasing, age-related weight gains are no longer merely 'moderate'.

The concomitant increases in obesity and anorexia in the industrialized world might not be coincidental. The 'age-related obesity' hypothesis of anorexia nervosa posits that an age-related increase in obesity, or more generally, weight in a population, such as is occurring in most western societies, sets the stage for thinness to become a powerful and simple indicator of youth. The otherwise normal tendencies to seem youthful and hence more attractive to the opposite sex are occasionally taken to extreme and unhealthy levels by certain highly competitive young females, leading to anorexia nervosa. The hypothesis explains the increasing prevalence of the disease in western societies, the differences between the sexes, the age at which it is most prevalent, its association with high achievement and optimism, and its high prevalence, at least historically, among the most competitive and affluent social groups.

Assumptions and predictions

The power of the evolutionary paradigm can also be a weakness, for it allows the formulation of perfectly reasonable and compelling explanations that do not seem to require further testing. However, before any such hypotheses are applied to problems in clinical medicine, they must be thoroughly tested, not only by the hypotheses' originator(s) but also by disinterested third parties.

Any evolutionary explanation, adaptive or maladaptive, comes with three implicit assumptions that follow directly from the basic premises of natural selection. The first one is that the trait must be variable, which is true in this case: some individuals develop anorexia nervosa and others do not. The second assumption is that there must

be a heritable component to the trait, which is also true. Studies examining anorexia nervosa's heritability, which is the degree to which variance in a trait in a population is due to additive genetic effects, put the estimates at about 70% [55—57]. The third assumption is that if the trait is adaptive, it must increase the fitness of the individuals having it, and if it is maladaptive, it must have increased the organism's fitness at some point in its evolutionary history, even if it no longer does. Aside from the 'reproductive suppression' hypothesis, all other evolutionary hypothesis for anorexia nervosa concur that it is a maladaptation, but disagree about the conditions that cause it.

The 'age-related obesity' hypothesis predicts that anorexia nervosa should be more prevalent in populations in which thinness is a good indicator of youth. The hypothesis was partially based on the observation that there is a positive correlation between the prevalence of anorexia nervosa and obesity across populations, but it might nevertheless be useful to formally confirm this premise. More specifically, the hypothesis predicts that the prevalence of anorexia nervosa should be positively correlated to the slope of the weight vs. age relationship for adult females in a population. As usual, care must be taken to identify the appropriate populations and sub-populations, and where differences occur [58], the hypothesis also predicts that they are related to the degree of non-assortative mating, or dating. That is, young women should identify the population against which they will be compared and pay particular attention to the best indicators of youth in that population. This prediction is in stark contrast to that of the 'pseudo-nubile' hypothesis, which is based on the premise that women are able to retain their youthful appearance despite their age, and would therefore predict that anorexia nervosa should be more prevalent in populations in which thinness is not associated with age.

Second, the 'age-related obesity' hypothesis could be tested by examining individuals' perceptions of the weight-age relationship. Han et al. [59] asked a panel of 362 judges consisting of British men and women aged 28—77 (mean: 53 years) to estimate the age of women's silhouettes. By using silhouettes, the authors precluded the use of other cues that can be used to estimate age. The results were striking: age estimates went up by one year for every 1 cm increase in waist circumference. The 'age-related obesity' hypothesis predicts that the perceived relationship between weight and age should be stronger in populations in which anorexia is more prevalent. If I may, the first seed that led to this paper occurred while I worked in South Korea and realized that I had difficulty aging people from afar because I could not apply the main cue I normally used in North America: girth.

Third, the 'age-related' obesity hypothesis predicts that, compared to the rest of the population, anorectic individuals would perceive an even stronger relationship between weight and age. Should this prediction be supported, it might be used as a basis for pre-screening high-risk individuals. In contrast, the 'pseudo-nubile' hypothesis would predict that the awareness and/or perception of the weight-age relationship would be weaker in populations in which anorexia nervosa is most prevalent, and in anorectic individuals.

A fourth approach to testing the 'age-related obesity' hypothesis might be to manipulate the perceptions of the weight-age relationship in a laboratory setting. For example, Salmon et al. [24] were able to affect EDI scores by simply exposing subjects to narratives depicting different levels of female—female competition. Such methods have also been used to examine the causes of body dissatisfaction [60]. Similarly, it would be possible to manipulate the perception of the weight-age relationship and then quantify its effect on weight concerns. The prediction would be that the more cognisant individuals are of the weight-age relationship, the higher their weight concerns would become. In contrast, the 'pseudo-nubile' hypothesis predicts weight concerns should be highest among women who (are led to) believe that weight and other attributes do not increase with age, that women remain 'pseudo-nubile'.

Implications and conclusions

The hypothesis proposed herein links the rise in anorexia nervosa in western society with the increase in obesity. Whereas individuals who might be afflicted by anorexia nervosa probably exist in all populations, the disease is more likely to develop in environments in which thinness is a reliable indicator of youth. Most women have a natural desire to seem young, but the pressure is strongest among teenagers, an age at which historically they were the most motivated and best equipped to find a long-term, high-quality mate. In the past 30 years, as the relationship between weight and age became stronger in western societies, thinness became a reliable indicator of youth. Some individuals, who likely have a pre-disposition for the disease, go beyond merely maintaining a nubile physique and develop anorexia nervosa.

Numerous studies have found correlations between eating disorders and the portrayal of

beautiful, young and thin women in the media [61,62], but the causality's direction and strength of the effect are difficult to ascertain [63,9]. It is generally accepted that young women's body satisfaction decreases when they are exposed to images of thin, young, beautiful women, and it has been reasonably well-documented that anorectic or 'at-risk' individuals are more easily affected [60,64,65]. Some authors take a judicious approach and conclude the mass media might be one of the many causes that might precipitate the disease in high-risk individuals [63,9], but other authors take a prosecutorial demeanour, declaring 'that mass media promulgate a slender ideal that elicits body dissatisfaction' [65], and set forth to 'implicate the mass media in the promotion of this standard' (of beauty) [66].

Ironically, the mass media are more likely to pick up and disseminate these latter views, which are sometimes translated into public policy. Some examples over the past two years that caught international headlines include slim models who were barred from the runways during Milan's and Madrid's fashion weeks, and Australian cheerleaders who were ordered to change uniforms because their midriff revealing outfits supposedly put undue pressure on young girls to lose weight. In the context of eating disorders, the question of why young women expose themselves to such media images has been examined [67], but the motivation behind the media's use of these images has not. The reason might be that the answer is obvious. The media are not dominated by a secret group intent on causing eating disorders and body dissatisfaction in women. The media's aim is simply to sell a product, and the depiction of beautiful women helps in accomplishing that goal. It just happens that beauty has always been equated with youth, and in western societies, due to the rise in obesity of recent decades, youth is now equated with slimness. Hence, the mass media's 'obsession' with thinness might not be the cause of anorexia nervosa, but rather the collective expression of the same problem.

Several assumptions and testable predictions of the 'age-related obesity' hypothesis of anorexia nervosa are presented in this paper, and researchers will surely devise more elegant and innovative tests. If the hypothesis is supported, public health policies should be aimed at the purported cause of the disease, and eliminate the weight-age relationship in the population. If age-related weight increases are eliminated in a population, thinness would cease to be an indicator of youth and anorexia rates would drop. These policies would still include encouraging healthy diets and active lifestyles, but public health officials would also have to formulate integrative and comprehensive policies, instead of focusing solely on one end of the weight distribution, or the other, independently.

Richard Morton offered the first medical description of anorexia nervosa in 1689, and Sir William Gull coined the term in 1874 [68], but the disease was rare until the 1970s. There have always been individuals who might have been pre-disposed to the disease, but never before have these pre-dispositions been expressed in such large numbers. When anorexia nervosa was first described it afflicted young women as they approached sexual maturity, just like it does today, but back then sexual maturity took a few more years, and it affected women aged 17—24. Without undermining biomedical, psychological, physiological, or genetic approaches, which certainly identify individuals at risk, provide potential treatments, and uncover the disease's physiological mechanisms, it is apparent that the epidemiology of anorexia nervosa is sensitive to socioeconomic changes. Our society has drastically changed in the last 30 to 40 years and some factor, or factors, have led to an increase in anorexia nervosa and obesity. So far, the two problems have been considered and treated independently from each other. The 'age-related obesity' hypothesis postulates the two diseases are inextricably linked.

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