Obesity: a disorder of convenience

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Background

Increasing rates of obesity across the world (1) are broadly attributed to environments that are obesogenic (2), against an evolutionary heritage that is maladaptive in these new contexts (3). While obesity is new in human evolutionary history, having been essentially non-existent until about 10 000 years ago (4), extensive emergence and rise of obesity among most of the world's populations indicates that the ability to become obese is universal (5). This review examines obesity from biocultural anthropological perspectives (6).

Evolutionary perspectives

Larger body mass and increased ability to accumulate fat relative to other non-human primates in seasonal environments are two key adaptive features of human life history (7). Compared with apes, humans have a similar proportion of maternal daily non-maintenance energy budget invested in foetal tissue, but a much higher diet quality. This allows both larger brain size and higher body fatness at birth (8). Neonatal fatness is permissive of brain growth by accommodating brain metabolism under conditions of uncertain or unpredictable food supplies, while relatively large body size reduces the energy costs of bodily maintenance per unit of body size (7). Larger body size allowed early humans greater opportunity for increased foraging returns with the greater home range that goes with it, while larger brain size allowed them to forage more smartly, maximising returns while minimizing effort.

Human fatness buffers reproductive effort during pregnancy and lactation from environmental energetic constraints (9) and against mortality risk in infants soon after birth and at weaning (10). Natural selection for body fatness would have favoured traits that promote energy intake and storage and that minimize energy expenditure (11). As all aspects of metabolism are under genetic control, and the expression of obesity phenotypes is much more limited than the expression of proteins that regulate metabolism, natural selection for the capacity to save and store energy is likely to have taken place for different genes with the same phenotypic result (5). It is no surprise, therefore that there are over 600 genes, markers and chromosomal regions identified as being associated with human obesity phenotypes (12). While genes for obesity have been sought for among some populations expressing very high obesity prevalence rates, including Tongans (13), Samoans (14) and Pima Indians in Arizona (15), the 'thrifty genotype' postulated by Neel (16) has yet to be pinned down, largely because of its polygenic and likely variant nature among populations. Environments that allow the expression of these phenotypes have been termed obesogenic (17).

Hayes *et al.* have suggested that humans, prior to the development of efficient tools and agriculture, had a very high physical activity level (PAL, that is, total daily energy expenditure divided by basal metabolic rate) of 3.2 (18), a value no contemporary population can aspire to. Contemporary foraging groups have much lower PALs, ranging from 2.1 to 1.4, while simple agriculturalist societies have PALs that range from 2.3 to 1.5 (19). This compares with

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PAL values ranging between 2.2 and 1.2 among urban populations in industrialized nations (19).

Obesity and the life course

Increases in survivorship and lifespan duration in industrialized nations with high prevalence rates of obesity suggest that human genotypes for obesity are not incompatible with present environments of good food security and sedentary lifestyle (20). This view has been challenged by Olshansky *et al.* who suggested that life expectancy at birth (LEB) in the USA may decline by up to 5 years in the first half of the 21st century unless the rising rates of obesity are controlled (21). American Samoa and the Cook Islands have obesity rates far in excess of the USA (22). However, LEBs of both populations have undergone stasis in the past decade (after more than three decades of increase), while mortality associated with obesity-related chronic diseases among adults of productive age has increased, and mortality among young children has declined (23,24). In the 1990s, 61% and 70% of American Samoan men and women respectively were classified as obese [body mass index (BMI) ≥ 32 kg m^{-2}] (25,26), while a reanalysis of BMI data for adult Cook Islanders (27) identifies 39% of males and 47% of females to be similarly classified by the same cut-off.

Early pubertal development is linked to overweight and obesity in adolescents in the USA (28). In addition, girls exposed to familial distress or living in dysfunctional households have been shown to have earlier age at menarche (29,30), while physical and verbal abuse in childhood has been shown to be associated with adult obesity (31). While body fatness in females is a prerequisite for fertility (9), obesity and the insulin resistance that often accompanies it are associated with reproductive complications, including menstrual dysfunction, anovulation and miscarriage among adults (32). Increased rates of obesity among British adolescents are likely to enhance the biological potential for teenage conceptions into the future, while increased obesity rates among women will reduce fertility rates biologically (32) and by low marriageability (33).

Conversely, marriage rates influence obesity rates; entry into marriage is associated with weight gain, while exit from marriage results in weight loss, but of a lower magnitude (34). In the USA, getting married adds an additional 3.1 kg body weight across the first decade after marriage relative to the study average, and a further 0.25 kg per decade of marriage subsequently (34). This is equivalent to an increase in BMI of 1.2 kg m^{-2} in the first decade after marriage.

Obesogenic environments

The term 'obesogenic environment' was coined by Swinburn *et al.* who argued that the physical, economic, social and cultural environments of the majority of industrialized nations encourage positive energy balance of their populations (35). Human exposure to such environments is problematic because, while the energy balance equation is simple (energy intake in excess of expenditure equals weight gain), avoidance of exposure is not. Considerable dietary and work seasonality has been removed in industrialized societies and replaced by 7-day schedules of activity and diet that revolve around industrial production. Such industrially scheduled patterns started to become obesogenic when good food security was achieved (at least at the level of the total population), and cheap transport became available to the masses, in the past 40 years or so. The decline in physical activity in industrialized societies is well documented (36,37) and as important as food security. It is, however, discussed elsewhere in this review (see Fox and Hillsdon).

Food security is 'the physical, social and economic access to sufficient, safe and nutritious food that meets the dietary needs and food preferences of a population, for an active and healthy life' (38). Price constrains food choice and purchase among poorer sectors of many industrialized societies, making obesity an issue of food security, and ultimately one of human rights (currently the Office of the United Nations High Commissioner on Human Rights on the Right to Food has its focus on food availability, hunger and malnutrition (39), but given the deterioration of health because of obesity in many nations, malnutrition because of overconsumption is a logical next step). In poorer nations, socioeconomic status and obesity are positively related. In industrialized societies, the relationship is inverted. The latter has been linked to dietary energy density and energy cost of foods (40,41). In the USA, diets that are more energy-dense cost less (42). In recent years, the prices of fresh fruit and vegetables have increased as proportions of disposable income, while those of refined grains, sugars, and fats have declined (43). Class differences in obesity-relevant health behaviours have also been evoked to explain the inverse relationship between socioeconomic status and obesity (44–46). They are not universal explanations because they do not explain the emergence of class-based health behaviour. However, obesity may be a consequence of the psychosocial impact of living in a more hierarchical society. In an ecological study of obesity in 21 developed nations, Pickett *et al.* found income inequality to be positively associated with energy intake and obesity (47).

Time constraint, particularly in relation to female engagement in the workforce, and the demand for convenience in food has seen the emergence and rise in demand for pre-packaged foods with very short preparation times (48), and of food consumption away from the home (49,50). The demand for convenience in food follows trends of increased outsourcing of aspects of the domestic economy in industrializing, industrial and post-industrial society, which also includes parenting (childcare, school and children's activities) and cleaning. The outsourcing of food preparation and demand for convenience has also seen decreased structure of meals and increased snacking in various industrialized nations (51,52). Snack foods are often (but not universally) densely caloric, prepared, processed and packaged foods (53). Snacking often takes place without feeling physically hungry (54,55), especially when distracted by an external stimulus, such as watching television (56). It is also more difficult for humans, when they are distracted, to accurately monitor how much they have eaten (57).

Convenience in food is also expressed in the emergence of fast food. Eating at fast-food restaurants is positively associated with having children, a high-fat diet, and high BMI, but negatively associated with vegetable consumption and physical activity (58). Accessibility of such restaurants is also predictive of their use (58). Bandini *et al.* however, found that obese adolescents in the USA eat no more fast food than non-obese adolescents, emphasizing that excess energy intake may come from a variety of food sources, including snacks (59).

Cultural feasting is something common to all societies, and does not disappear with industrialization or modernisation. Among urban Samoans, obesity has been attributed to adherence to regular traditional cultural feasting practices while living a more sedentary lifestyle (60). In many parts of the world, Christmas has become an event of conspicuous consumption, in which food is central. Christmas feasting has been associated with weight gain in Sweden (61) and Ireland (62).

Perceptions of body size and obesity

Across history and to the present day, individuals and groups of privilege have been able to display embodied wealth by way of above-average body size, including weight and fatness (63,64). In a cross-cultural comparison of appropriate body size in different traditional societies, Brown found that the vast majority of them favoured plumpness as being attractive (65). A number of societies in which the prevalence rate of obesity has risen in recent decades and that previously were shown to desire and/or accept larger bodies and obesity now show a preference for thinner bodies. These include majority populations in the USA (66) and the European Union (67), as well as among African–American girls (68), Pacific Islanders (69–72) and urban Native American youth (73). Among Europeans, the desire for thinner body size is increasingly observed in children and adolescents and is not confined to females of upper socioeconomic status (68,74–76). While high cultural valuation of body fatness might contribute to the emergence of obesity, it may cease to do so in subsequent generations in populations with high levels of obesity.

Conclusions

It is almost inevitable that obesity should have emerged as a major human biological phenomenon in the environments that have been constructed in industrialized nations during the past 60 years, and which have been transferred across the world with industrialization and modernisation since. It is a disorder of convenience, as the needs of humanity in industrialized nations are served with ever more convenient work, leisure and food-getting. Because of the diverse contexts in which obesity has emerged and the complex environments in which it persists, it is unlikely that there will be a ubiquitous reversal in the trends of obesity prevalence in the near future. Indeed, the ceiling on the potential for obesity in the majority of the worlds' populations is far from having been reached. However, obesity is also an outcome of cultural and symbolic overvaluation of food in the context of plenty; and such overvaluation declines among subsequent generations born into times of plenty.

Conflict of Interest Statement

No conflict of interest was declared.

References

1. Popkin BM, Doak CM. Obesity is a worldwide phenomenon. *Nutr Rev* 1998; **56**: 106–114.
2. Hill JO, Wyatt HR, Reed GW, Peters JC. Obesity and the environment: where do we go from here? *Science* 2003; **299**: 853–835.
3. Neel JV, Weder AB, Julius S. Type II diabetes, essential hypertension, and obesity as 'syndromes of impaired genetic homeostasis': the 'thrifty genotype' hypothesis enters the 21st century. *Perspect Biol Med* 1998; **42**: 44–74.
4. Brown PJ, Krick SV. Culture and ethnicity in the etiology of obesity: diet, television and the illusion of personal choice. In: Johnston FE, Foster G (eds). *Obesity, Physical Growth and Development*. Smith-Gordon: London, 2001, pp. 111–157.
5. Lev-Ran A. Human obesity: an evolutionary approach to understanding our bulging waistline. *Diabetes Metab Res Rev* 2001; **17**: 347–362.
6. Ulijaszek SJ, Lofink H. Obesity in biocultural perspective. *Annu Rev Anthropol* 2006; **35**: 337–360.
7. Aiello LC, Wells JCK. Energetics and the evolution of the genus homo. *Annu Rev Anthropol* 2002; **31**: 323–338.
8. Ulijaszek SJ. The comparative energetics of primate fetal growth. *Am J Hum Biol* 2002; **14**: 603–608.
9. Norgan NG. The beneficial effects of body fat and adipose tissue in humans. *Int J Obes Relat Metab Disord* 1997; **21**: 738–746.
10. Kuzawa CW. Adipose tissue in human infancy and childhood: an evolutionary perspective. *Am J Phys Anthropol* 1998; **27**(Suppl.): 177–209.

This paper was commissioned by the Foresight programme of the Office of Science and Innovation, Department of Trade and Industry

11. Rosenbaum M, Leibel RL. The physiology of body weight regulation: relevance to the etiology of obesity in children. *Pediatrics* 1998; **101**: 525–539.
12. Perusse L, Rankinen T, Zuberi A, Chagnon YC, Weisnagel SJ, Argyropoulos G, Walts B, Snyder EE, Bouchard C. Human obesity gene map: the 2004 update. *Obes Res* 2005; **13**: 381–490.
13. Duarte NL, Colagiuri S, Palu T, Wang XL, Wilcken DE. A 45-bp insertion/depletion polymorphism of uncoupling protein 2 in relation to obesity in tongans. *Obes Res* 2003; **11**: 512–517.
14. Tsai HJ, Sun G, Smelser D, Viali S, Tufa J, Jin L, Weeks DE, McGarvey ST, Deka R. Distribution of genome-wide linkage disequilibrium based on microsatellite loci in the samoan population. *Hum Genomics* 2004; **1**: 327–334.
15. Kovacs P, Ma L, Hanson RL, Franks P, Stumvoll M, Bogardus C, Baier LJ. Genetic variation in UCP2 (uncoupling protein-2) is associated with energy metabolism in pima Indians. *Diabetologia* 2005; **48**: 2292–2295.
16. Neel J. Diabetes mellitus: a 'thrifty' genotype rendered detrimental by 'progress'? *Am J Hum Genet* 1962; **14**: 353–362.
17. Finkelstein EA, Ruhm CJ, Kosa KM. Economic causes and consequences of obesity. *Annu Rev Public Health* 2005; **26**: 239–257.
18. Hayes M, Chustek M, Heska S, Wang Z, Pietrobelli A, Heymsfield SB. Low physical activity levels of modern homo sapiens among free-ranging mammals. *Int J Obes* 2005; **29**: 151–156.
19. Ulijaszek SJ. Physical activity, lifestyle and health of urban populations. In: Schell LM, Ulijaszek SM (eds). *Urbanism, Health and Human Biology in Industrialised Countries*. Cambridge University Press: Cambridge, 1999, pp. 250–279.
20. Eaton SB, Konner M, Shostak M. Stone agers in the fast lane: chronic degenerative diseases in evolutionary perspective. *Am J Med* 1998; **84**: 739–749.
21. Olshansky SJ, Passaro DJ, Hershow RC, Layden J, Carnes BA, Brody J, Hayflick L, Butler RN, Allison DB, Ludwig DS. A potential decline in life expectancy in the united states in the 21st century. *N Engl J Med* 2005; **352**: 1138–1145.
22. International Obesity Task Force.*Global Prevalence of Obesity*. 2006. [WWW document]. URL http://www.iotf.org/database (accessed October 2006).
23. Kane P, Lucas D. An overview of south pacific population problems. *Asia-Pacific Popul J* 1986; **1**: 3–16.
24. United Nations University.*Globalis – An Interactive World Map. Life Expectancy at Birth*. 2006. [WWW document]. URL http://www.gvu.unu.edu (accessed October 2006).
25. Swinburn BA, Ley SJ, Carmichael HE, Plank LD. Body size and composition of Polynesians. *Int J Obes Relat Metab Disord* 1999; **23**: 1178–1183.
26. Keighley ED, McGarvey ST, Quested C, McCuddin C, Viali S, Maiava T. Nutrition and health in modernizing Samoans: temporal trends and adaptive perspectives. In: Ohtsuka R, Ulijaszek S (eds). *Health Change in the Asia-Pacific Region. Biocultural and Epidemiological Approaches*. Cambridge University Press: Cambridge, 2007 (in press).
27. Ulijaszek SJ. Increasing body size and obesity among cook islanders between 1966 and 1996. *Ann Hum Biol* 2001; **28**: 363–373.
28. Ebling FJP. The neuroendocrine timing of puberty. *Reproduction* 2005; **129**: 675–683.
29. Kim K, Smith PK, Palermiti AL. Conflict in childhood and reproductive development. *Evol Hum Behav* 1997; **18**: 109–142.
30. Hulanicka B. Acceleration of menarcheal age of girls from dysfunctional families. *J Reprod Infant Psychol* 1999; **17**: 119–132.
31. Williamson DF, Thompson TJ, Anda RF, Dietz WH, Felitti V. Body weight and obesity in adults and self-reported abuse in childhood source. *Int J Obes* 2002; **26**: 1075–1082;Aug 2002.
32. Mitchell M, Armstrong DT, Robker RL, Norman RJ. Adipokines: implications for female fertility and obesity. *Reproduction* 2005; **130**: 583–597.
33. Harper B. Beauty, stature and the labour market: a British cohort study. *Oxford Bull Econ Stat* 2000; **62**: 771–800.
34. Sobal J, Rauschenback B, Frongillo EA. Marital status changes and body weight changes: a US longitudinal analysis. *Soc Sci Med* 2003; **56**: 1543–1555.
35. Swinburn BA, Egger G, Raza F. Dissecting obesogenic environments: the development and application of a framework for identifying and prioritizing environmental interventions for obesity. *Prev Med* 1999; **29**: 563–570.
36. Erlichman J, Kerbey AL, James WPT. Physical activity and its impact on health outcomes. Paper 2: prevention of unhealthy weight gain and obesity by physical activity: an analysis of the evidence. *Obes Rev* 2002; **3**: 273–287.
37. Ferro-Luzzi A, Martino L. Obesity and physical activity. In: Chadwick DJ (ed.). *The Origins and Consequences of Obesity*. Ciba Foundation Symposium 201. Wiley: Chichester, 1996, pp. 207–277.
38. Food and Agriculture Organization. *Committee on World Food Security, Twenty-fourth session. Guidelines for National Food Insecurity and Vulnerability Information and Mapping Systems (FIVIMS): Background and Principles*. Food and Agriculture Organization of the United Nations: Rome, 1998.
39. Office of the United Nations High Commissioner on Human Rights on the Right to Food.*Special Rapporteur of the Commission on Human Rights on the Right to Food*. 2006. [WWW document]. URL http://www.ohchr.org/english/issues/food/issues.htm (Accessed October 2006).
40. Darmon N, Ferguson EL, Briend A. A cost constraint alone has adverse effects on food selection and nutrient density: an analysis of human diets by linear programming. *J Nutr* 2002; **132**: 3764–3771.
41. French SA. Pricing effects on food choice. *J Nutr* 2003; **133**: 841S–843S.
42. Drewnowski A, Darmon N. The economics of obesity: dietary energy density and energy cost. *Am J Clin Nutr* 2005; **82**: 265S–273S.
43. Sturm R. Childhood obesity: what we can learn from existing data on societal trends, part 2. *Prev Chronic Dis* 2005; **2**: A20.
44. Jeffrey RW, French SA, Firster JL, Spry VM. Socioeconomic status differences in health behaviors related to obesity: the healthy worker project. *Int J Obes* 1991; **15**: 689–696.
45. Molarius A. The contribution of lifestyle factors to socioeconomic differences in obesity in men and women: a population-based study in Sweden. *Eur J Epidemiol* 2003; **18**: 227–234.
46. Stamatakis E, Primatesta P, Chinn S, Rona R, Falascheti E. Overweight and obesity trends from 1974 to 2003 in English children: what is the role of socioeconomic factors? *Arch Dis Child* 2005; **90**: 999–1004.
47. Pickett KE, Kelly S, Brunner E, Lobstein T, Wilkinson RG. Wider income gaps, wider waistbands? an ecological study of obesity and income inequality. *J Epidemiol Community Health* 2005; **59**: 670–674.
48. Schluter G, Lee C. Changing good consumption patterns: their effects on the US Food System, 1972–92. *Food Rev* 1999; **22**: 35–37.
49. Lin B, Guthrie J, Blaylock JR. The diets of America's children: influences on dining out, household characteristics, and nutritional knowledge. *Agric Econ Rep* 1996; **746**: 1–37.

This paper was commissioned by the Foresight programme of the Office of Science and Innovation, Department of Trade and Industry

50. McCrory MA, Fuss PJ, Hays NP, Vinken AG, Greenberg AS, Roberts SB. Overeating in America. Association between restaurant food consumption and body fatness in healthy adult men and women ages 19–80. *Obes Res* 1999; **7**: 564–571.
51. Samuelson G. Dietary habits and nutritional status in adolescents over Europe. An overview of current studies in the Nordic countries. *Eur J Clin Nutr* 2000; **54**(Suppl. 1) **:** S21–S28.
52. Jahns L, Siega-Riz AM, Popkin BM. The increasing prevalence of snacking among US children from 1977 to 1996. *J Pediatr* 2001; **138**: 493–498.
53. Nielsen SJ, Siega-Riz AM, Popkin BM. Trends in energy intake in US between 1977 and 1996: similar shifts seen across age groups. *Obes Res* 2002; **10**: 370–378.
54. Jeffrey RE, French SA. Epidemic obesity in the United States: are fast foods and television viewing contributing? *Am J Pub Health* 1998; **88**: 277–280.
55. Dietz WH, Gortmaker SL. Do we fatten our children at the television set? Obesity and television viewing in children and adolescents. *Pediatrics* 1985; **75**: 807–812.
56. Stroebele N, de Castro JM. Television viewing is associated with an increase in meal frequency in humans. *Appetite* 2004; **42**: 111–113.
57. Wansink B. Environmental factors that increase the food intake and consumption volume of unknowing consumers. *Annu Rev Nutr* 2004; **24**: 455–479.
58. Jeffrey RW, Baxter J, McGuire M, Linde J. Are fast food restaurants an environmental risk factor for obesity? *Int J Behav Nutr Phys Act* 2006; **3**: 2.
59. Bandini LG, Vu D, Must A, Cyr H, Goldberg A, Dietz WH. Comparison of high-calorie, low-nutrient-dense food consumption among obese and non-obese adolescents. *Obes Res* 1999; **7**: 438–443.
60. Pelletier D. The relationship of energy intake and expenditure to body fatness in Western Samoan men. *Ecol Food Nutr* 1987; **19**: 185–199.
61. Andersson I, Rossner S. The Christmas factor in obesity therapy. *Int J Obes* 1992; **16**: 1013–1015.
62. Munnelly P, Feehan S. An obesity clinic model. *Proc Nutr Soc* 2002; **61**: 9–10.
63. De Garine I, Pollock N (eds). *Social Aspects of Obesity and Fatness*. Gordon and Breach: New York, 1995.
64. Brown PJ, Konner M. An anthropological perspective of obesity. *Ann N Y Acad Sci* 1987; **499**: 29–46.
65. Brown PJ. Culture and the evolution of obesity. *Hum Nat* 1991; **2**: 31–57.
66. Anderson LA, Eyler AA, Galuska DA, Brown DR, Brownson RC. Relationship of satisfaction with body size and trying to lose weight in a national survey of overweight and obese women aged 40 and older, United States. *Prev Med* 2002; **35**: 390–396.
67. Madrigal H, Sanchez-Villegas A, Martinez-Gonzalez MA, Kearney J, Gibney MJ, Irala J. Underestimation of body mass index through perceived body image as compared to self-reported body mass index in the European Union. *Public Health* 2000; **114**: 468–473.
68. Katz ML, Gorden-Larsen P, Bentley ME, Kelsey K, Shields K, Ammerman A. 'Does skinny mean healthy?' perceived ideal, current, and healthy body sizes among African-American girls and their female caregiver. *Ethn Dis* 2004; **14**: 533–541.
69. Craig P, Swinburn B, Matenga-Smith T, Matangi H, Vaughan F. Do Polynesians still believe that big is beautiful? Comparison of body size perceptions and preferences of Cook Islands, Maori and Australians. *N Z Med J* 1996; **14**: 200–203.
70. Wilkinson J, Ben-Tovim D, Walker M. An insight into the personal significance of weight and shape in large samoan women. *Int J Obes Relat Metab Disord* 1994; **18**: 602–606.
71. Brewis AA, McGarvey ST, Jones J, Swinburn BA. Perceptions of body size in Pacific Islanders. *Int J Obes Relat Metab Disord* 1998; **22**: 185–189.
72. Becker AE, Gilman SE, Burwell RA. Changes in prevalence of overweight and in body image among Fijian women between 1989 and 1998. *Obes Res* 2005; **13**: 110–117.
73. Rinderknecht K, Smith C. Body-image perceptions among urban native American youth. *Obes Res* 2002; **10**: 315–327.
74. Canpolat BI, Orsel S, Akdemir A, Ozbay MH. The relationship between dieting and body image, body ideal, self-perception, and body mass index in Turkish adolescents. *Int J Eat Disord* 2005; **37**: 150–155.
75. Story M, French SA, Resnick MD, Blum RW. Ethnic/racial and socioeconomic differences in dieting behaviors and body image perceptions in adolescents. *Int J Eat Disord* 1995; **18**: 173–179.
76. Lee K, Sohn H, Lee S, Lee J. Weight and BMI over 6 years in Korean children: relationships to body image and weight loss efforts. *Obes Res* 2004; **13**: 1959–1966.

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