1
The Global Burden of Obesity and Diabetes

John B. Dixon

One could only wonder what aliens who visited Earth briefly 40 years ago and returned today would think of the changes seen in the dominant intelligent life form inhabiting the planet. Large numbers of humans have become quite bloated, sluggish, and many have difficulty getting around. This would appear the most obvious change in the human condition during that period. What has happened? What has gone wrong? What will things be like should our visitors return in another 40 years?

The obesity-diabetes epidemic has rolled out progressively and inexorably since the 1970s, and little has been done globally to prevent it. The causes are poorly understood, and any attempts to change the trends appear piecemeal, tokenistic, and ineffective. Regions of the developing world that appeared to be protected with their economic and lifestyle characteristics are surpassing all expectations, and even those in rural areas of developing countries are running head first into the diabesity epidemic.

Obesity a Global Issue: The global age-standardized prevalence of obesity nearly doubled from 6.4 % in 1980 to 12.0 % in 2008. Half of this rise occurred in the 20 years between 1980 and 2000 and half occurred in the 8 years between 2000 and 2008 [1]. The magnitude of rise has varied with region, country, and gender; however, stabilization of the obesity prevalence is rare, and of great concern, the rise has accelerated globally over the last decade. In 1980, half of the 572 million adults with a BMI >25 kg/m^2 lived in just five countries headed by China 72 million and the USA 70 million. In 2008, countries with the most overweight people were China (241 million) and the USA (158 million). The largest absolute rise in obesity (BMI>30 kg/m^2) occurred in the USA (56 million) and China (42 million), followed by Brazil (20 million) and Mexico (18 million). The region with the highest global prevalence of obesity includes small islands in the Western Pacific such as Nauru, Samoa, Tonga, and the Cook Islands where obesity rates exceed 50 % and for some subgroups 70 % [1].

Of the high-income nations, there were divergent trends for both men and women with greater rises in obesity prevalence in Australasia and North America compared with Western Europe and high-income areas of Asia. Women had greater increases in obesity prevalence than men in sub-Saharan Africa and Latin America and the Caribbean. Men had greater a increase in prevalence throughout Europe and the high-income regions of the Asia-Pacific region [1]. "If the rates of weight gain (in Australia) observed in the first 5 years of this decade are maintained, our findings suggest that normal-weight adults will constitute less than a third of the population by 2025, and the obesity prevalence will have increased by 65 %" [2].

With increasing levels of obesity, we see an exponential rise in class III obesity (BMI>40 kg/m^2). In the USA between 2000 and 2005, the prevalence of obesity increased by 24 %, class III obesity by 50 %, and BMI >50 kg/m^2 by 75 %, two and three times faster, respectively [3]. Similar trends are reported in Australia [4]. The resultant exponential increase in class III obesity and super obesity is an expected trend as the mean BMI for a community steadily increases. There is also an important gender trend with increasing levels of obesity with women more likely to have the more severe forms of obesity Table 1. Scattered reports of a leveling off of obesity prevalence in small subsections of the community, for example, in adolescent and young adult women, should be treated cautiously as levels are still high, and we need to reflect about the weight trajectories of their mothers and grandmothers who at an equivalent age were generally more petite.

For years we have watched as the US CDC state by state obesity levels have risen year by year and reassured ourselves that either our state was not the worst or, better still, we lived outside the USA and were immune to the catastrophe within. But alas, we can now watch similar changes in the Canadian provinces and UK counties, and thanks to the International Association for the Study of Obesity (IASO), we have a global atlas of the emerging trends. Sadly no global area is or will remain immune.

S.A. Brethauer et al. (eds.), *Minimally Invasive Bariatric Surgery*,
DOI 10.1007/978-1-4939-1637-5_1, © Springer Science+Business Media New York 2015

TABLE 1. Estimates of the proportion of the US adult population with a BMI > 40 kg/m^2

	1960 (%)	1980 (%)	2000 (%)	2010 (%)
Women (USA)	1.4	2.8	6.1	7.4
Men (USA)	0.4	0.8	2.9	4.3

Adapted from the IASO website [5]

Ethnic Differences Risk: Ethnic-Based Action Points

Diabetes as a Global Issue: While it can be often assumed that the emerging epidemic of type 2 diabetes parallels the obesity epidemic, there are a range of other important considerations that influence the global and regional incidence, prevalence, and total burden of type 2 diabetes.

The International Diabetes Federation "World Diabetes Atlas" updated in 2012 provides an excellent overview of the global situation, and there are very important regional considerations. *Globally it is estimated that 371 million live with diabetes, an overall adult prevalence is 8.3 %, and half of these cases are undiagnosed*:

- Countries with the highest prevalence of diabetes are in two regions the Western Pacific Island nations and in the Middle East. Examples of the highest prevalence rates in adults include Federation of Micronesia (37 %), Nauru (31 %), and Marshall Islands (27 %) in the Western Pacific and Kuwait (24 %), Saudi Arabia (23 %), and Qatar (23 %) in the Middle East.
- Countries with the highest absolute numbers in descending order are China (92 million), India (63 million), the USA (24 million), and Brazil (14 million). And the region with the highest numbers is the Western Pacific with 132 million.
- Sub-Saharan Africa is the region with the highest level of undiagnosed diabetes (80 %).

It is the Asian area that now contributes to more than 60 % of the world's population with diabetes where some of the most dramatic increases in diabetes prevalence have occurred over recent decades. All Asian countries have seen major rises as the rapid socioeconomic growth and industrialization interact with populations that have a strong genetic and ethnic risk of diabetes. Asians develop diabetes at a lower threshold of environmental and anthropometric risk (BMI and waist circumference) [6]. Another striking characteristic of diabetes in the Asian region is the striking narrowing of the urban–rural divide in diabetes prevalence. While urbanization and industrialization were thought to drive increased risk of diabetes, it is now clear that the rural areas are following very closely behind. In the Shanghai region of China, urban diabetes prevalence rose from 11.5 to 14.1 % between 2002–2003 and 2009, while the rural diabetes prevalence rose from 6.1 to 9.8 % during the same period [7]. The rapid rise in diabetes numbers in China indicates a major public health problem that has occurred in parallel with the massive changes in development and gross domestic product [8].

A recent review of diabetes prevalence in the rural areas of low- and middle-income countries revealed a quadrupling of prevalence over the last 25 years. Diabetes prevalence increased over time, from 1.8 % in 1985–1989, 5.0 % in 1990–1994, 5.2 % in 1995–1999, 6.4 % in 2000–2004, to 8.6 % for 2005–2010 [9]. However, this is only part of the story as it is estimated that between 2010 and 2013, the number of adults with diabetes will increase by 69 % in developing countries, while the expected increase in developed countries is 20 % [10]. The diabetes burden in developing countries is also troubling as the increase in diabetes prevalence is dominated by the 40–59 age group, a time of productivity and employment, rather than being driven by aging as is the case developed countries (Fig. 1) [10].

Factors influencing the number of people with diabetes also vary considerable between developed and developing countries. If the incidence of diabetes exceeds mortality, then the prevalence rises. The absolute number of people with diabetes will be influenced by a range of factors, and the relative contributions of these factors vary considerably (Fig. 2). An increased prevalence of diabetes is not simply related to an increase incidence. In the period between 1999 and 2004 in Taiwan, the prevalence of diabetes increased 38 % and 24 % in men and women, respectively, but during the same period, incidence dropped 4 % and 13 %, respectively. An increased incidence in younger adults and a reduced incidence in the elderly increased prevalence substantially [11].

Diabetes incident and prevalence data from Ontario Canada between 1995 and 2005 provides another example of the interactions that lead to prevalence. During this period, the age- and sex-adjusted prevalence of diabetes in the province increased 69 %, from 5.2 % in 1995 to 8.8 % in 2005. The rate of increase in prevalence was greater in a younger population and the mortality of those with diabetes fell by 25 %. Thus, the increased prevalence in diabetes is attributed to both an increased incidence and improved survival [12].

The prevalence of diabetes in the USA is also greatly influenced by an increased survival of those with diabetes. During the period 1997 to 2004, the National Health Interview Survey found that age-adjusted excessive death rates for those with diabetes (compared with those without diabetes) declined by 60 %, from 5.8 additional deaths/1000 to 2.3 additional deaths/1000, for cardiovascular disease, and

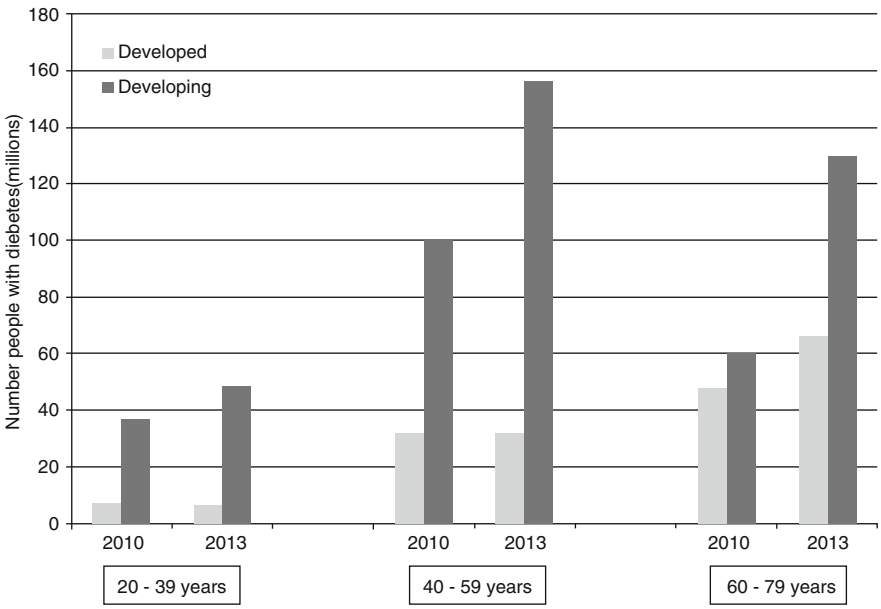

FIG. 1. The predicted number of people with diabetes in 2030 in comparison with 2010 (adapted from: Shaw, J.E. et al., Diabetes Res Clin Pract, (2010). **87**(1): p. 4–14).

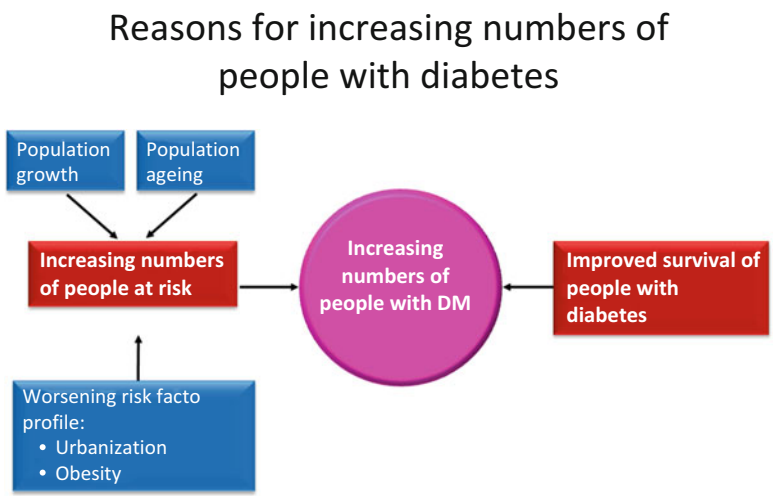

FIG. 2. The reasons associated with an increase in the numbers with diabetes. The relative impact of these population characteristic varies considerably between developed and developing countries.

for all-cause age-adjusted mortality a decline of 44 % from 10.8 to 6.1 deaths/1000. The declines were similar in both men and women [13]. Similar declines in mortality have been reported in other developed countries including Canada, Norway, and Finland. These encouraging findings have been attributed to a range of advances including systematic improvements in the quality and organization of care, improved models of chronic disease management, and the active promotion of self-care behaviors. More intensive pharmacotherapy targeting optimal levels of blood pressure [14] and cholesterol [15] has been shown to reduce morbidity and mortality, while the targets for glucose control remain more controversial [16]. There have also been reductions in smoking, limb amputations, and visual loss associated with retinopathy.

It becomes clear that while increasing levels of obesity play a major role in the increasing global population with diabetes, there are other major contributing determinants. The contrast in these determinants in developing compared with developed nations is presented in Table 2.

Causes Are Complex: The global biological determinants for the obesity-diabetes epidemic appear complex and poorly understood. They extend well beyond the global marketing of Westernized energy dense foods and the obligatory reduction in human movement that a developed society delivers. The interaction with the environment is far more complex, and a large number of additional conditions also appear to contribute to the evolving catastrophe. This complexity may partly explain the impotence of current preventative measures. Early life and metabolic programming appear to be very

TABLE 2. The differing determinants of the increasing population with diabetes in developing compared with developed countries

	Developed	Developing
Population growth	+	++
Population aging	+	+++
Increasing high-risk ethnicities	++	–
Increased incidence	+	++
Falling mortality	++	–

important factors contributing to obesity and may include genetics, maternal age, assertive mating, childhood infections, the pattern of established gut microbiota, and epigenetic programming changes to the ovum, the fetus, and the infant during the early years of life [17, 18]. The most important 4 years that influence a person's weight throughout the life cycle may well occur before the 3rd birthday. Early life programming sets an organism up for the environment that the organism is likely to encounter for living. To be programmed for a lean nutritional environment and being born into the "land of plenty" is aberrant representing a clear programming-environmental mismatch. One only has to look at the obesity and metabolic plight of indigenous populations globally when confronted with Western living conditions. It may not surprise that people of European origin fare best in "a land of plenty" and indeed may be the global exceptions in their resistance to developing diabetes and other metabolic disturbance associated with obesity.

Other environmental conditions are also likely to contribute to the obesity emidemic: sleep time over the decades has been reduced and is partly replaced with screen time; temperature-controlled environments reduce our energy expenditure in both heating and cooling our bodies; endocrine disrupters are widely dispersed within our environment and some contribute to weight gain; antibiotics and other factors have been designed to grow our food supply rapidly and efficiently may also change or gut microbiome to encourage weight gain; and iatrogenic contributions to weight gain through medications to treat mental illness, epilepsy, chronic autoimmune and inflammatory disease, and diabetes [17].

Obesity and Its Influence on Diabetes

The risk of developing type 2 diabetes at any given BMI is strongly related to ethnicity, and the World Health Organization and the International Diabetes Federation recommend modified action points for interventions based on ethnicity (Table 3).

Obesity also has additional influences on the number of people with diabetes for reasons beyond increased incidence.

Obesity is leading to an onset of type 2 diabetes in younger age groups. There is a negative relationship between BMI and the age of onset of type 2 diabetes [19, 20], and this is clearly associated with a longer period living with diabetes. Life expectancy for diabetes diagnosed at 30 years is quite different to that of 70 years.

In those with diabetes, overweight and obesity appears to be associated with lower age-adjusted mortality. A series of recent population assessments raise a very relevant issue with respect to diabetes, BMI, and mortality. All are different populations, but there are consistent findings and all would raise substantive questions about the value of weight loss in the overweight and class I obese BMI ranges.

Data from 5 pooled analyses of 5 large US longitudinal cohort studies were examined for incident diabetes in men and women over the age of 40 years and subsequent cardiovascular and all-cause mortality. After adjusting for demographics and established cardiovascular risk factors, those who were overweight and obese had a reduced all-cause and cardiovascular mortality [21].

Similar and very confronting data has been reported from Taiwan where a national diabetes registry is active [22]. Almost 90,000 diabetic patients were recruited after 1995 and the national death registry examined at the end of 2006 when 30 % had died. The adjusted analysis found that increasing body mass index was associated with progressive reduction in all-cause mortality. The effect was statistically significant for all causes of mortality other than cancer deaths. Those with a BMI >30 (which is uncommon in Taiwan) had the lowest mortality. This is one example of the obesity survival paradox.

A third study in Scotland examined BMI at the time of diabetes diagnosis in over 100,000 patients and mortality. There were 9,631 deaths between 2001 and 2007. BMI at the time of diagnosis was associated in a U-shaped mortality with the lowest index mortality in the overweight group. The authors question if weight loss interventions reduce mortality [23].

Black and Caucasian men followed by the USA VA medical centers also demonstrate an inverse relationship between BMI and diabetes mortality. The obese men, even those with a BMI > 35, have a lower mortality than normal-weight men [24].

These data add important contributions to the metabolic surgery—type 2 diabetes debate and raise issues about intentional weight loss in those not in the BMI > 35 category. This emerging data, combined with the issues with the large Sibutramine SCOUT study [25] and the premature cessation of the Look Ahead study for lack of hard end-point efficacy, all raise questions about any value in intentional weight loss in the overweight and class I obese BMI range in those with diabetes. It is becoming clear that bariatric-metabolic surgery will need to provide hard all-cause mortality, cardiovascular mortality, and suicide outcomes [26] data before it could be a broadly acceptable therapy for overweight and class I obese individual with diabetes. The same pattern has emerged for the approval of pharmacotherapy for weight loss and diabetes although it is easier to stop drug therapy than reverse bariatric procedures.

In summary, diabetes and obesity prevalence continues to rise, especially in the young and in developing countries.

TABLE 3. The classification of weight category by BMI

	BMI (kg/m^2)	
Classification	Principal cutoff points	Cutoff points for Asians
Normal range	18.5–24.9	18.5–22.9
		23.0–24.9
Pre-obese	25.0–29.9	25.0–27.4
		27.5–29.9
Obese class I	30.0–34.9	30.0–32.4
		32.5–34.9
Obese class II	35.0–39.9	35.0–37.4
		37.5–39.9
Obese class III	≥40.0	≥40.0

For Asian populations, classifications remain the same as the international classification, but public health action points for interventions are set at 23, 27.5, 32.5, and 37.5 [27]
We address eligibility and prioritization for bariatric surgery within the colored zones above
Source: Adapted from WHO 2004 [28]

Increasing obesity and its associated increase in incident diabetes do not explain all the increase in diabetes prevalence, and the determinants of prevalence vary considerably in developing countries when compared with developed. The morbidity and mortality associated with diabetes has decreased substantially in developed countries where the major increase in diabetes is likely to occur in those over 60 years. In contrast in developing countries, the obesity-diabetes epidemic burden will impact those of working age. Longitudinal epidemiological data indicates that overweight and obesity may be associated with improved survival in those with diabetes and that the benefits of intentional weight loss are unclear.

The burden of obesity and diabetes remains high globally, and national and regional obesity-diabetes prevention and management strategies are essential.

Acknowledgment: I would like to thank Professor Jonathan Shaw, at the Baker IDI Heart and Diabetes Institute, Melbourne, for sharing figures and data that I have used in the preparation of this chapter.

Review Questions and Answers

Question 1

What is the expected change in the proportion of people with severe obesity (class II, III, and BMI>50) as the prevalence of obesity rises in a community?

(a) The rise in the prevalence of obesity leads to the same proportional rise in higher levels of obesity.
(b) The proportional rise in severe forms of obesity is less than expected because limited numbers have the propensity to become severely and super obese.
(c) The proportional (or percentage) rises far more rapid and becomes more so with higher BMI. The proportion of super obese (BMI >50) is rising rapidly.
(d) There is insufficient data to know how many in our communities have the more severe forms of obesity.

The answer is C.

Question 2

The increasing prevalence of diabetes in developed countries such as the USA is related to:
(a) Increased aging
(b) Increased overweight and obesity rates
(c) Increased survival of those with diabetes
(d) Increased proportion within the population with a high ethnic risk
(e) All of the above

The answer is E.

Question 3

Which of the following is true about diabetes prevalence in developing countries?
(a) Diabetes rates are much lower than in developed countries.
(b) Diabetes rates are only rising in urban regions.
(c) The expected increase in diabetes will have its greatest impact in the working years of middle age rather than the elderly.
(d) The expected increase in diabetes will have its greatest impact in elderly.
(e) Diabetes is not a major health issue in developing countries as it is in the developed.

The answer is C.

References

1. Stevens GA, Singh GM, Lu Y, Danaei G, Lin JK, Finucane MM, Bahalim AN, McIntire RK, Gutierrez HR, Cowan M, Paciorek CJ, Farzadfar F, Riley L, Ezzati M. National, regional, and global trends in adult overweight and obesity prevalences. Popul Health Metr. 2012;10:22.
2. Walls HL, Magliano DJ, Stevenson CE, Backholer K, Mannan HR, Shaw JE, Peeters A. Projected progression of the prevalence of obesity in Australia. Obesity (Silver Spring). 2012;20:872–8.
3. Sturm R. Increases in morbid obesity in the USA: 2000-2005. Public Health. 2007;121:492–6.
4. Walls HL, Wolfe R, Haby MM, Magliano DJ, de Courten M, Reid CM, McNeil JJ, Shaw J, Peeters A. Trends in BMI of urban Australian adults. Public Health Nutr. 1980–2000;2009:1–8.
5. IASO. USA prevalence of morbid obesity—adapted from the IASO website; 2013.
6. Ramachandran A, Snehalatha C, Shetty AS, Nanditha A. Trends in prevalence of diabetes in Asian countries. World J Diabetes. 2012;3:110–7.
7. Li R, Lu W, Jiang QW, Li YY, Zhao GM, Shi L, Yang QD, Ruan Y, Jiang J, Zhang SN, Xu WH, Zhong WJ. Increasing prevalence of type 2 diabetes in Chinese adults in Shanghai. Diabetes Care. 2012;35:1028–30.
8. Yang W, Lu J, Weng J, Jia W, Ji L, Xiao J, Shan Z, Liu J, Tian H, Ji Q, Zhu D, Ge J, Lin L, Chen L, Guo X, Zhao Z, Li Q, Zhou Z, Shan

G, He J. Prevalence of diabetes among men and women in China. N Engl J Med. 2010;362:1090–101.
9. Hwang CK, Han PV, Zabetian A, Ali MK, Narayan KM. Rural diabetes prevalence quintuples over twenty-five years in low- and middle-income countries: a systematic review and meta-analysis. Diabetes Res Clin Pract. 2012;96:271–85.
10. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes Res Clin Pract. 2010;87:4–14.
11. Chang CH, Shau WY, Jiang YD, Li HY, Chang TJ, Sheu WH, Kwok CF, Ho LT, Chuang LM. Type 2 diabetes prevalence and incidence among adults in Taiwan during 1999-2004: a national health insurance data set study. Diabet Med. 2010;27:636–43.
12. Lipscombe LL, Hux JE. Trends in diabetes prevalence, incidence, and mortality in Ontario, Canada 1995-2005: a population-based study. Lancet. 2007;369:750–6.
13. Gregg EW, Cheng YJ, Saydah S, Cowie C, Garfield S, Geiss L, Barker L. Trends in death rates among U.S. adults with and without diabetes between 1997 and 2006: findings from the national health interview survey. Diabetes Care. 2012;35:1252–7.
14. UK Prospective Diabetes Study Group. Tight blood pressure control and risk of macrovascular and microvascular complications in type 2 diabetes: UKPDS 38. BMJ. 1998;317:703–13 [see comments] [published erratum appears in BMJ 1999 Jan 2;318(7175):29].
15. Colhoun HM, Betteridge DJ, Durrington PN, Hitman GA, Neil HA, Livingstone SJ, Thomason MJ, Mackness MI, Charlton-Menys V, Fuller JH. Primary prevention of cardiovascular disease with atorvastatin in type 2 diabetes in the collaborative atorvastatin diabetes study (cards): multicentre randomised placebo-controlled trial. Lancet. 2004;364:685–96.
16. Currie CJ, Peters JR, Tynan A, Evans M, Heine RJ, Bracco OL, Zagar T, Poole CD. Survival as a function of HbA(1c) in people with type 2 diabetes: a retrospective cohort study. Lancet. 2010;375:481–9.
17. McAllister EJ, Dhurandhar NV, Keith SW, Aronne LJ, Barger J, Baskin M, Benca RM, Biggio J, Boggiano MM, Eisenmann JC, Elobeid M, Fontaine KR, Gluckman P, Hanlon EC, Katzmarzyk P, Pietrobelli A, Redden DT, Ruden DM, Wang C, Waterland RA, Wright SM, Allison DB. Ten putative contributors to the obesity epidemic. Crit Rev Food Sci Nutr. 2009;49:868–913.
18. Gluckman PD, Hanson MA. Developmental and epigenetic pathways to obesity: an evolutionary-developmental perspective. Int J Obes (Lond). 2008;32 Suppl 7:S62–71.
19. Hillier TA, Pedula KL. Characteristics of an adult population with newly diagnosed type 2 diabetes: the relation of obesity and age of onset. Diabetes Care. 2001;24:1522–7.
20. Durand ZW. Age of onset of obesity, diabetes and hypertension in Yap State, Federated States of Micronesia. Pac Health Dialog. 2007;14:165–9.
21. Carnethon MR, De Chavez PJ, Biggs ML, Lewis CE, Pankow JS, Bertoni AG, Golden SH, Liu K, Mukamal KJ, Campbell-Jenkins B, Dyer AR. Association of weight status with mortality in adults with incident diabetes. JAMA. 2012;308:581–90.
22. Tseng CH. Obesity paradox: differential effects on cancer and non-cancer mortality in patients with type 2 diabetes mellitus. Atherosclerosis. 2013;226:186–92.
23. Logue J, Walker JJ, Leese G, Lindsay R, McKnight J, Morris A, Philip S, Wild S, Sattar N. The association between BMI measured within a year after diagnosis of type 2 diabetes and mortality. Diabetes Care. 2013;36(4):887–93.
24. Kokkinos P, Myers J, Faselis C, Doumas M, Kheirbek R, Nylen E. BMI-mortality paradox and fitness in African American and Caucasian men with type 2 diabetes. Diabetes Care. 2012;35:1021–7.
25. James WP, Caterson ID, Coutinho W, Finer N, Van Gaal LF, Maggioni AP, Torp-Pedersen C, Sharma AM, Shepherd GM, Rode RA, Renz CL. Effect of sibutramine on cardiovascular outcomes in overweight and obese subjects. N Engl J Med. 2010;363:905–17.
26. Adams TD, Gress RE, Smith SC, Halverson RC, Simper SC, Rosamond WD, Lamonte MJ, Stroup AM, Hunt SC. Long-term mortality after gastric bypass surgery. N Engl J Med. 2007;357:753–61.
27. WHO. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. Lancet. 2004;363:157–63.
28. WHO. Obesity: preventing and managing the global epidemic. Report of a who consultation. World Health Organ Tech Rep Ser. 2000;894:1–253.