OBESITY EPIDEMIC IN INDIA

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Abstract : *Urbanization and economic growth in India has brought in its wake, the problem of obesity among the young and children. Indians are prone to central obesity which is a risk factor for metabolic and vascular complications even at a lower Body Mass Index. A BMI of >23 kg/m2 has been shown to be associated with increased risk of diabetes. Indians have a higher visceral fat mass than white Caucasians and African Americans. Fat cells form a metabolically and hormonally active organ which function as both endocrine and paracrine organ in the body. Adipocyte secretes a range of molecules that affect metabolism, vascular function, appetite and the immune and haemostatic systems. The prevalence of obesity correlates directly with socioeconomic class and is higher among women. Though excess intake of calories is related to obesity but repeated episodes of malnutrition, followed by nutritional rehabilitation, alter the body composition and increase the risk of obesity during childhood. Malnutrition causes impaired linear growth and favors adiposity. National Nutrition Monitoring Bureau has reported that pattern of food consumption in India , shows increased intake of animal products, sugars and fat since 1971.Increased caloric intake coupled with reduced physical activity have contributed significantly to the obesity epidemic The demographic and epidemiological transition, the forces of internal migration and urbanization, have led to changes in food consumption patterns and physical activity patterns. Genetic influences though not proven probably do play an important role in concert with environmental factors. Globalization of trade has encouraged people to grow cash crops for export thereby reducing the availability of these nutrients for the local population. The movement of population into urban area has significantly altered the work related physical activity and the inculcation of westernized type dietary habits have compounded the epidemic of obesity in India.*

INTRODUCTION

Over last few years, India has undergone rapid economic development. But this development has brought the increasing burden of no communicable diseases. Obesity is one of the preventable risk factor for no communicable diseases which has emerged as a major health problem both in developed and underdeveloped countries[1,2]. Obesity can be defined on the basis of body mass index BMI, weight (kg)/height (m^2)[3] and can be used to assess individual and community nutritional status[4]. Today whole world is facing epidemic of obesity.[5] Developed countries had paid attention to the epidemic, but developing countries were not able to give attention to such extent. One reason is the presence of communicable diseases and other being financial problems. India has controlled under nutrition to a large extent, but is now facing an epidemic of obesity. This epidemic is assuming serious proportions in cities and is particularly affecting young adults and children.

Previously nutrition research in India had focused on undernutrition related to nutrient deficit and high rates of infection. Data from the National Family Health Survey 1998/99 (NFHS 2), however shown that the 12% of the women can be classified as overweight (BMI > 25 kg/m2) and 2% are obese (BMI > 30 kg/m^2). Furthermore, in the large cities where 4% of the samples live, 37% of women are overweight or obese, while in the rural areas where 74% reside, 43% have a low BMI. Socioeconomic status is an important predictor of both over and underweight.

As rates of overweight and obesity rise, India is beginning to experience the burden of associated chronic diseases, particularly cardiovascular disease and adult onset diabetes[5, 6]. WHO estimate that diabetes in India will increase from 19.4 million in 1995 to 57.2 million in 2025[5].

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DEFINITION OF OBESITY AND APPLICABILITY OF INTERNATIONAL CRITERIA TO INDIAN

World Health Organization (2000) recommended BMI as cut-offs for the diagnosis of obesity in developed countries (kg/m^2): preobese 25.00–29.99, obese class I 30.00–34.99, obese class II 35.00–39.99, obese class III 40.00[7].

Over last few years it has been observed that the distribution of fat is also an important determinant of morbidity and mortality, and that 'central' obesity may be more pathological than generalized obesity (measured as BMI).

Recommendations have come for the diagnosis of central obesity for **men and women** respectively:

WORLD HEALTH ORGANIZATION (2000):
Waist: hip ratio
>1.0; >0.85; Waist circumference (mm) ; Moderate risk 940, 800 ; Severe risk 1020, 880

Research over the last few years has recognized fat cells as metabolically and hormonally active organ which function as both endocrine and paracrine organ in the body. Adipocyte secretes a range of molecules that affect metabolism, vascular function, appetite and the immune and haemostatic systems[8, 9]. Research so far have suggested that deranged adipocyte function may be involved in the pathogenesis of insulin resistance syndrome, type 2 diabetes and atherosclerosis[9].

In developing countries, metabolic and vascular risks for 'obesity' manifest at a lower BMI compared with those in developed countries. Thus, the BMI classification of obesity based on large-framed European populations may be inappropriate for Indians (and other Asians) having a small body frame[10]. For a given BMI Indians have a higher percentage body fat than white Caucasians and African Americans[11,12,13]. Indians have a higher visceral fat mass than white Caucasians and African Americans as shown by various studies in India

[14, 15,16,17,19] ,UK[18, 20] and the USA. [11, 13, 21] Magnetic resonance imaging has shown that the visceral adiposity in Indians is accompanied by higher central subcutaneous adiposity i.e. higher sub scapular, triceps skin fold thickness as well as higher posterior subcutaneous fat thickness.[11] Visceral fat is primarily responsible for the various metabolic consequences of central obesity. The metabolic effects of subcutaneous adiposity need to be studied further. Higher risk of diabetes and impairment of glucose tolerance at lower BMI in Indians has been highlighted in a small prospective study. The 10-year risk of developing impairment of glucose tolerance or diabetes in normal glucose-tolerant middle-aged men and women (n-191) is 2.4 times higher in subjects with a BMI of >23 kg/m^2 compared with those with a lower BMI.[22] In a large cross-sectional study of glucose tolerance in six cities in India (National Urban Diabetes Survey), a BMI of >23 kg/m^2 has been shown to be associated with increased risk of diabetes.[17] Preliminary analysis of bioimpedance measurements has shown that BMI substantially underestimates adiposity in Indian men.[23,24] Thus, in rural men with a mean BMI of 21 kg/m^2, one-third are adipose (body fat >25%), while 80% of the urban middle-class men are adipose at a mean BMI of 24.1 kg/m^2. Only 7% of these urban men would be classified as obese by the World Health Organization (2000) criteria (BMI >30 kg/m^2). Thus Indians are considerably adipose at a relatively lower BMI. On the basis of these data World Health Organization Expert Consultation (2004) has reduced the 'obesity-related action point' in the Asians to 23 kg/m^2. [25]

CAUSES OF THE EPIDEMIC

Urbanization is strongest risk factor for obesity.[26] Obesity is three times more common in urban areas comparing to rural areas, although it is increasing rapidly even in villages because traditional villages are also becoming urbanized in their habits. Another related risk factor is higher socio-economic status.

Weight gain occurs when energy intake by an individual exceeds energy expenditure over a period of time. Changing patterns of food intake and physical activity contribute to the positive energy balance. Genetic as well as non-genetic determinants affect an individual's response to energy intake as well as physical activity, and therefore influence the balance between the two factors. [27]

It is possible that a **'thrifty genotype'** may have helped man survive famine conditions by successfully depositing fat. However, in the current situation of excess food and reduced activity, this genotype may lead to obesity.

Presently the contribution of genetic factors to obesity is not clear at the population level. However, a number of rare syndromes of extreme obesity have been related to specific mutations in genes.[28] Studies in twins also favor a role for genetic factors in the etiology of obesity. [29, 30] It is possible that like other chronic polygenic disorders (diabetes and hypertension); the expression of obesity is influenced by environmental condition.

ORIGIN OF ADIPOSITY IN INDIA

Obesity is now increasingly reported in young Indian adults and even in children. According to the World Health Organization [31], India has a preschool childhood obesity prevalence of about 1%. Repeated episodes of malnutrition, followed by nutritional rehabilitation, are known to alter body composition and increase the risk of obesity.[32] The discordance between linear growth and adipocyte development will enhance adipocyte development when linear growth is affected by malnutrition. It is likely that these factors will contribute to increasing problem of obesity in India, given the enormous number of stunted children which is estimated at between 52.0% and 63.0%.[33]

Childhood obesity increases the risk of obesity in adulthood and parental obesity interacts quite strongly to alter this risk, and there are several interactive factors contributing to the increased prevalence of obesity in childhood.

India, which is rapidly urbanizing, demonstrates increases in calorie intake, increases in fat intake, and increased levels of sedentary habits. Lifestyle changes resulting in physical inactivity and sedentary behaviors are important in contributing to obesity in children. This is exemplified by more time in a day spent by children in physically passive behaviors such as TV viewing, working or playing games on a computer, talking on the telephone etc.

There are reports from urban parts of India, which provide some insight into the problem. A study in Bombay revealed that the prevalence of obesity among young adult males varied from **10.7% to 53.1%**[34], while another from Delhi, showed an overall prevalence of **27.8%.**[35] and it is higher in females than males (**33.4% vs. 21.3%)**. A study conducted in Kashmir showed the obesity prevalence to be **15.0%;** females having a prevalence of **23.7%** compared with **7.0%** among males.[36] Prevalence of obesity varies with socio-economic status in urban India as shown by data from the **Nutrition Foundation of India.** [37] Upper strata is having higher prevalence rates (32.2% among males, 50% among females) than the middle classes (16.2% males, 30.3% females), followed by the lower socio-economic groups (7.0% males, 27.8% females) and the poor in urban slums with the lowest (1.0% males, 4.0% females). But these **reports are not truly representative of the problem** in the country as they used a body mass index (BMI) cut-off of 25.0 kg per m^2 which include both overweight and obesity beginning at a BMI of 30.0 kg per m^2 and above[31]. Surveys conducted by the **Food and Nutrition Board** (i.e. District Nutrition Profiles survey)[33], is the only representative survey which have reported prevalence of 0.3% and 0.7% in rural and 0.4% and 0.7% in urban men and women, respectively, using a BMI cut-off of 30.0 kg per m^2. **National Family Health Survey** showed a prevalence rate of 2.2% for women aged 15–49 years using BMI. 30.0 kg/m^2. [38] It varied depending on residence (urban. 5.8% vs. rural. 0.9%), increasing with educational achievement from 0.9% for illiterate to 6.5% for those with secondary education. However, it is increasingly evident that, in populations from the Indian sub-continent, BMI does not provide a good indicator of body fat (i.e. that body fat content is higher) for any given BMI among Indians[39]. Increasing BMI is associated with central

adiposity and higher waist/hip ratios along with risk of NCDs appearing at much lower BMI (25.0 kg/m^2) than among other population groups[40].

DIETARY CONSUMPTION AND LIFESTYLE CHANGES DURING THE NUTRITION TRANSITION IN INDIA

Rapid quantitative changes in dietary intake in developing countries indicate an increase in per capita availability of food and are also accompanied by qualitative changes in the diet. Food balance data from the Food and Agriculture Organization (FAO) show that the change in energy intake in Asian countries has been small, but there have been large changes in consumption of **animal products, sugars and fats**[41]**.** The net effect has been a marked shift in the diet with **energy from fat (both animal and vegetable) increasing each year.** Data from India show that higher-income groups consumed a diet with 32% of the energy from fat while the lower-income groups consumed only 17% energy from fat. More recent dietary surveys in Delhi also confirm that the upper income groups in urban India currently consume higher levels of energy from fat as compared with the urban poor or rural populations.

TRENDS AND PATTERNS IN FOOD CONSUMPTION IN INDIA

There have been many nationally representative surveys on diet, nutrition and food consumption patterns in India since the 1970s. They include:

1. National Nutrition Monitoring Bureau (NNMB) surveys of diet and nutrition on a continuous basis in 10 states in India since 1971. On some occasions, these NNMB surveys have been linked with the National Sample Survey Organization (NSSO) and the National Council of Applied Economic Research (NCAER);
2. National Family Health Survey (NFHS) conducted by the Ministry of Health and Family Welfare and coordinated by the International Institute for Population Sciences, Bombay. The NFHS surveys cover 24 states and provide anthropometric data on women aged 15 to 49 years;
3. District Nutrition Profiles survey organized by the Food and Nutrition Board, Department of Women and Child Development, Government of India.

The data from several of these surveys have been collected and are summarized below.

NNMB survey in India has shown adequacy in calorie intake during the 1970s and up to the early 1980s. There is gradual improvement in caloric intake per head, typified by an increase in consumption of cereal grains, while the intake of most other food items such as milk, oil, sugar, etc. remained largely unchanged. Many of these surveys revealed disparities in the intakes of most foods between rural and urban populations and between different socio-economic groups. There is gradual reduction in cereal grain consumption between 1975 and 1995 that has not affected the average energy intake. This is largely the result of a progressive increase in the intake of protein, and probably fats. The latter is due to a phenomenal increase in the consumption of milk and milk products and an increase in the intake of animal products (designated flesh foods) and fats and oils. The production of pulses and legumes is a concern and consequently their cost and consumption have fallen dramatically. This is a cause for much concern since pulses and legumes are a very important source of vegetable proteins in the habitual Indian diet. Trends in the changes in consumption of urban populations are not readily available, although the surveys conducted between the late 1970s and the 1990s show wide differences between the socio-economic strata in an urban environment. Recent data from the District Nutrition Profiles survey[33], have shown differences in the intakes of vegetables and fruits and fats and oils between urban and rural populations. The National Family Health Survey[38] provides information on the consumption of specific and selected foods once a week at least and demonstrates, for instance, that the percentage of women consuming meat/ chicken/fish once a week is higher in urban than rural locations

INTAKE OF FAT IN THE DIET

There is progressive increase in the intake of fat over last few years as shown by analyses carried out by the FAO. When the dietary energy supply increases, the fat calorie ratio (i.e. the contribution of fat to energy) increases mainly due to the increase in consumption of animal products. Food balance data from the FAO show India at the bottom of the group of countries with a fat calorie ratio over 15% (15.3%) with a total fat intake at 37.8 g per day and a 27.5% animal fat to total fat ratio.41Trends based on food balance sheet data show that the per capita supply of animal products has increased from 7.0 g in 1965 to 12.9 g in 1999, thus contributing almost twice the energy content (increased from 104 to 192 kcal per capita per day).

Estimates from the NNMB helped to assess the fat intake from Indian dietary components. It has now been recognized that components of the Indian diet such as cereals, pulses, tubers and vegetables have 'invisible fat', in addition to the obviously visible fats consumed in the daily diet. It has been computed that 10–15% of the daily energy in the diet can come from this invisible component and this level is adequate to meet the essential fatty acid requirements for both linoleic acid and alpha linolenic acid. Dietary fat intake, based on household surveys, suggests that the visible fat in poor rural diets is largely vegetable-based with negligible animal fats. The differences in the dietary fat intake between rural and urban and lower and higher socio-economic groups are largely due to large differences in the intakes of visible fats, except in the highest income group where much of it is from animal sources, with the invisible fat intake being similar among these groups.[42]

CONSUMPTION OF FRUITS AND VEGETABLES AND DIETARY FIBER

Horticultural products are good sources of vitamins, minerals and fiber as well as bioactive compounds like phytochemicals. Horticulture has shown dramatic improvement over last few

years in India, as the area under cultivation and the horticultural outputs have increased. India has a prominent share in the global production of fruits and vegetables.[43]

But much of this does not seem to be reflected in increases in the consumption of fruits and vegetables – perhaps largely the result of their production as cash crops for export and sale. This can lead to a considerable loss of soil and micronutrients that are not beneficial to the local population. However, economic development seems to lead to improvements in intakes of legumes and vegetables (as well as animal products) and these changes may be beneficial. But these changes with socio-economic status are also often associated with reduced intakes of coarse cereal grains and increased reliance on highly polished varieties that may reduce the intakes of dietary fiber.

CHANGES IN PHYSICAL ACTIVITY PATTERNS

Physical activity has declined in the world as a result of increasing mechanization[43]. Time in a day or week dedicated to paid work has declined in several countries as a result of shorter work shifts, shorter weeks and longer vacations. Concurrent to this, increased urbanization, universal use of motor cars, mechanization of most manual jobs outside the occupational sphere and increasing leisure time have aggravated this trend. Increased leisure time is most often dedicated to sedentary activities like television viewing, thus altering the structure of leisure time and encroaching on time normally allocated to other activities including weekday sleep.

CONCLUSION

The important determinants that characterize the epidemic of obesity in India are: the demographic and epidemiological transition, the forces of internal migration and urbanization, the changes in food consumption patterns and physical activity patterns that in turn are contributing to increasing sedentary life style, and of other non communicable diseases.

Globalization of trade encourages cash crops for export and the resultant movement of important micronutrients, which are now not available to the local population. This results in the inculcation of imbalanced and excessive calorie Western-type diet, together with the widening of economic inequalities in the society. Changes in lifestyles will further fuel this.

REFERENCES

1. **WHO. Diet, nutrition and prevention of chronic diseases.** *WHO Tech Report Series No 797. Geneva: World Health Organization, 1990.*
2. **WHO. Obesity: preventing and managing the global epidemic.** *Report of WHO consultation on Obesity, Geneva June 5–7 1997. Geneva: World Health Organization, 1998*
3 **Garrow JS** *Obesity and related diseases. Edinburgh: Churchill Livingstone, 1988.*
4 **Bailey KV, Ferro-Luzzi A.** *Use of body mass index of adults in assessing individual and community nutritional status. Bull World Health Organ 1995; 73:673–80*
5. **King, H., Aubert, R. E. & Herman, W. H.** *Global burden of diabetes. Diabetes Care (1998) 21: 1414–1431.*
6. **Reddy, K. S. & Yusuf, S.** *(1998) The emerging epidemic of cardiovascular disease in developing countries. Circulation 97: 596–601.*
7 . **World Health Organization** *The problem of overweight and obesity. In Obesity: Preventing and Managing the Global Epidemic.WHO Technical Report Series no. 894, pp. 5–15. WHO: Geneva(2000) .*
8 . **Mohamed-Ali V, Pinkney JH & Coppack SW** *Adipose tissue as an endocrine and paracrine organ. Journal of Obesity and Related Metabolic Disorders (1998) 22, 1145–1158.*
9 **Gema F, Javier G, Francisco J & Mary´a A** *The adipocyte: a model for integration of endocrine and metabolic signaling in energy metabolism regulation. American Journal of Physiology (2001) 280, E827–E847.*
10. **James WPT, Chunming C & Inoue S** *Appropriate Asian body mass indices? Obesity Reviews (2002) 3, 139.*
11. **Chandalia M, Abate N, Garg A, Stray-Gundersen J & Grundy SM** *Relationship between generalized and upper body obesity to insulin resistance in Asian Indian men. Journal of Clinical Endocrinology and Metabolism(1999) 84, 2329–2335.*
12. **Chowdhury B, Lantz H & Sjostrom L** *Computed tomography determined body composition in relation to cardiovascular risk factors in Indian and matched Swedish males. Metabolism (1996) 45, 634–644.*
13. **Banerji MA, Faridi N, Atluri R, Rochelle L & Lebovitz HE** *Body composition, visceral fat, leptin, and insulin resistance in Asian Indian men. Journal of Clinical Endocrinology and Metabolism (1999) 84, 137–144.*
14. **Ramachandran A, Snehalatha C, Dharmaraj D & Vishwanathan M** *Prevalance of glucose intolerance in Asian Indians: urban-rural difference and significance of upper body adiposity. Diabetes Care (1992) 15, 1348–1355.*
15. **Shelgikar KM, Hockaday TDR & Yajnik CS** *Central rather than generalised obesity is associated with hyperglycaemia in Indians. Diabetic Medicine (1991) 8, 712–717.*
16. **Misra A, Pandey RM, Devi R, Sharma R, Vikram NK & Khanna N** *High prevalence of diabetes, obesity and dyslipidaemia in urban slum population in northern India. International Journal of Obesity (2001) 25, 1722–1729.*
17. **Snehalatha C, Viswanathan V & Ramachandran A** *Cutoff values for normal anthropometric variables in Asian Indian adults. Diabetes Care (2003) 26, 1380–1384.*
18. **McKeigue PM, Shah B & Marmot MG** *Relation of central obesity and insulin resistance with high diabetes prevalence and cardiovascular risk in South Asians. Lancet (1991) 337, 971–973.*
19. **Snehalatha C, Ramachandran A, Vallabi K, et.al.** *Computed axial tomographic scan measurement of abdominal fat distribution and its correlation with anthropometry and insulin secretion in healthy Asian Indians. Metabolism (1997) 46, 1220–1224.*
20. **Forouhi NG, Jenkinson G, Thomas EL, Mullick S, et.al.** *Relation of triglyceride stores in skeletal muscle cells to central obesity and insulin sensitivity in European and South Asian men. Diabetologia (1999) 42, 932–935.*
21. **Raji A, Seely EW, Arky RA & Simonson DC** *Body fat distribution and insulin resistance in healthy Asian Indians and Caucasians. Journal of Clinical Endocrinology and Metabolism (2001) 86, 5366–5371.*
22. **Yajnik CS, Shelgikar KM, Naik SS, et.al.** *Impairment of glucose tolerance over 10 yr in normal glucose tolerant Indians. Diabetes Care (2003c) 26, 2212–2213.*
23. **Lubree HG, Rege SS, Bhat DS, et.al.** *Body fat and cardiovascular risk factors in Indian men in three geographical locations. Food and Nutrition Bulletin (2002) 23, 146–149.*
24. **Joglekar AA, Yajnik CS, Lubree HG, et.al.** *Body fat and metabolic syndrome in men from rural and urban India. In Proceedings of the 18th Congress of the International Diabetes Federation, Abstr. no. 1395; available at http:// www.idfparis2003.org (2003)*
25. **World Health Organization Expert Consultation** *Appropriate Body Mass Index (BMI) for Asian Populations and its Implication for Policy and Intervention Strategies. Lancet (2004)363, 157–163.*
26. **Fall CHD** *Non-industrialized countries and affluence. In type 2 diabetes: the thrifty phenotype. British Medical Bulletin (2001) 60, 33–50.*
27. **Prentice A** *Obesity and its potential mechanistic basis. In type 2 diabetes: the thrifty phenotype. British Medical Bulletin (2001) 60, 51–67.*
28. **Barsh GS, Farooqi IS & O'Rahilly S** *Genetics of bodyweight regulation. Nature (2000) 404, 644–651.*
29. **Bouchard A, Tremblay J, Deapres A, et.al.** *The response to long-term overfeeding in identical twins. New England Journal of Medicine(1990) 322, 1477–1482.*
30. **Sims EAH** *Destiny rides again as twins overeat. New England Journal of Medicine (1990) 322, 1522–1523.*
31. **World Health Organizations (WHO).** *Obesity: Preventing and Managing the Global Epidemic. Report of a WHO consultation. WHO Technical Report Series No. 894.Geneva: WHO, 2000.*
32. **Shetty PS.** *Diet and life-style and chronic non-communicable diseases: what determines the epidemic in developing societies? In: Krishnaswami K, ed. Nutrition Research: Current Scenario and Future Trends. New Delhi: Oxford & IBH Publishing Co., 2000; 153–67.*
33. **Government of India. India** *Nutrition Profile. New Delhi: Department of Women and Child Development, Ministry of Human Resources, Government of India, 1998.*
34. **Dhurandhar NV, Kulkarni PR.** *Prevalence of obesity in Bomaby. Int. J. Obes. Relat. Metab. Disord. 1992; 16: 367–75.*
35. **Gopinath N, Chadha SL, Jain P, Shekawat S, Tandon R.** *An epidemiological study of obesity in adults in the urban population of Delhi. J. Assoc. Physicians India 1994; 42:212–5.*
36. **Zargar AM, Masoodi SR, Laway BA, Khan AK, Wani AI, Bashir MI, Akthar S.** *Prevalence of obesity in adults – an epidemiological study from Kashmir valley of Indian Subcontinent. J. Assoc. Physicians India 2000; 48: 1170–4*
37. **Gopalan C.** *Obesity in the urban middle class. NFI Bull. 1998; 19: 1–4.*
38. **National Family Health Survey. India Main Report,** *1991. Chapter 7: Nutrition and the prevalence of anaemia [Online]. Accessed 31 August 2001.*
39. **Dudeja V, Misra A, Pandey RM, Devina G, Kumar G, Vikram NK.** *BMI does not accurately predict overweight in Asians in northern India. Br. J. Nutr. 2001; 86: 105–12.*
40. **Yajnik CS.** *The insulin resistance epidemic in India: fetal origins, later lifestyle, or both? Nutr. Rev. 2001; 59: 1–9.*
41. **Food and Agriculture Organization (FAO)/World Health Organization (WHO)**. *Fats and Oils in Human Nutrition. Report of a joint expert consultation. FAO Food & Nutrition Papers, Vol. 57. Rome: FAO, 1994; 1–147.*
42. **Ghafoorunisa. Fats in Indian diets.** *NFI Bull. 1989; 10: 1–5.*
43. **Kaul GL. Fruit and vegetable production in India.** *NFI Bull. 1998; 19: 5–8.*
43 . **Ferro-Luzzi A, Martino L.** *Obesity and physical activity. In: The Origins and Consequences of Obesity. Ciba Foundation Symposium, Vol. 201. Chichester: John Wiley & Sons, 1996; 228–46.*