Chapter 3

Metabolic Syndrome

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1 Introduction

Since 1958, the leading causes of death in Japan have been malignant neoplasms, heart disease, and cerebrovascular disease. Given that these conditions are linked to lifestyle habits such as diet and exercise, interventions have previously entailed primary prevention in the general population through lifestyle coaching, and secondary prevention in high-risk populations through regular checkups. However, midterm and final assessments for Health Japan 21 (First Term) indicated that these approaches have failed to achieve targets. Accordingly, revised and specific screening protocols and health guidance were formulated in 2008 [1], with metabolic syndrome (hereafter MetS) introduced as a new diagnostic criterion.

MetS is a compendium of abdominal obesity, glucose intolerance, dyslipidemia, hypertension, and others, each of which is a well-known risk factor for cardiovascular disease and type 2 diabetes. Clustering of these conditions in the same patient as a risk factor has also become a focus of research activity. Moreover, visceral adiposity, insulin resistance, and inflammation have attracted attention as underlying states [2, 3]. The World Health Organization (WHO) defined MetS for the first time in 1998, and it has since been variously labeled as Syndrome X and Deadly Quartet. Diagnostic criteria for MetS have also been formulated by the WHO and by other competent authorities, and are now used for clinical and research purposes.

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Based on data from the Japan National Health and Nutrition Survey 2007, 30.3% of men and 11.0% of women aged 40–74 years are suspected to have MetS, with another 25.9% and 8.2%, respectively, suspected to have pre-MetS (i.e., one in two men and one in five women) [4]. These individuals receive special health checkups, specific health guidance, and intensive coaching from physicians, nutritionists, and public health nurses to prevent the onset of lifestyle-related illnesses and to lower the attendant medical costs. However, MetS was found to be driven not only by individual lifestyle factors but also by psychosocial factors such as depression and work environment [5, 6]. Hence, intensified individual health coaching alone is likely to be insufficient.

This chapter reviews the prevalence and incidence of MetS in the context of socioeconomic measures such as education, income, occupational class and childhood socioeconomic environments.

2 Socioeconomic Indices and MetS

Studies conducted in the United Kingdom [7–9], the United States [10–15], France [16], Sweden [17, 18], Finland [19], Denmark [20], Portugal [21], Netherlands, Poland [22], Tunis [23], Suriname [24], Iran [25, 26], Brazil [27–29], Mesoamerican countries [30], China [31, 32], Taiwan, and South Korea [33–36] showed that MetS prevalence decreases with better education [10–12, 17–21, 34, 35, 37], occupational class [7, 8, 16, 21], income [11–13, 16, 33, 35, 38], and wealth [9]. For example, a survey of 7013 civil servants in London who were stratified by salary into six grades found that the prevalence of MetS among men and women in the lowest grade was 2.2 and 2.8 times higher, respectively, than in the highest grade [7]. Similarly, a Finnish cohort of 1909 participants showed that the age-adjusted prevalence of MetS was significantly lower among those with ≥ 16 years of education (21% in men, 14% in women) than among those with ≤ 9 years of education (41% in men, 27% in women) [19]. Longitudinal analysis also demonstrated that the probability of MetS onset increases as the level of education decreases [14, 15, 39, 40]. However, opposing trends were observed in Nigeria, Saudi Arabia, and India; that is, individuals with high socioeconomic status were more likely to have MetS [41–43].

In addition, MetS prevalence was reported to be associated not only with socioeconomic status of the individual, but also with that of the neighborhood socioeconomic status. Indeed, a US study of 12,709 subjects aged 45–64 years revealed a significant correlation between neighborhood-level indices (income, education, occupation, home ownership, etc.) and MetS prevalence in women, independently of individual socioeconomic indices. For example, white women living in medium- or low-status neighborhoods were 1.14 and 1.17 times more likely, respectively, to develop MetS (after adjusting for age, lifestyle habits, and individual socioeconomic status) than white women in high-status neighborhoods [44]. Likewise, an Australian study of 1877 men and women aged 18 years and over found that the proportion of individuals with university education was inversely and significantly associated with the incidence of metabolic syndrome, as measured over 3.6 years of follow-up. This association persisted even after adjustment for individual-level educational attainment [45].

3 Mechanisms Driving the Negative Relationship Between Socioeconomic Status and MetS

Why is MetS more likely to occur as socioeconomic status declines? One possibility is that persons of lower socioeconomic status tend to more easily acquire undesirable lifestyle habits; for example, smoking, drinking, poor diet, and low physical activity. Another reason is that lower socioeconomic status is associated with greater susceptibility to psychosocial stress; for example, workplace stress, depression, fatigue, tension, low social support, and low self-respect [12]. Nevertheless, analyses of lifestyle habits and psychosocial factors yielded only partial explanations for the significant negative relationship between socioeconomic status and MetS [8, 9, 11, 14–16, 18–20, 33–35, 46].

For example, a Danish study [20] of 6038 men and women stratified into five educational levels found that the odds ratio for MetS in the group with the highest educational attainment was significantly lower (0.32 after adjusting for age and gender) than in the group with the lowest educational attainment. The number of smokers also decreased as education rose, while the number of subjects who exercised in their free time increased. However, the percentage of subjects who drank alcohol also increased. On the other hand, the percentage of subjects who felt depression, fatigue, and stress decreased as education rose, as did the percentage of subjects with poor social networks. These lifestyle habits and psychosocial factors were associated with MetS prevalence as expected. However, the relationship remained significant and nearly unchanged at an odds ratio of 0.40, even after controlling for lifestyle habits and psychosocial factors. Furthermore, a survey [8] of 2197 civil servants in London indicated that both lifestyle habits (smoking, exercise, alcohol, diet) and psychosocial factors (job control) explained approximately 50% of the difference in MetS prevalence due to occupational class.

Taken together, these studies confirm that poor lifestyle habits and psychosocial factors contribute to the socioeconomic gap in MetS prevalence, but only to some extent. Additional variables that may explain this gap include the possibility that relatively fewer persons of low socioeconomic status receive health checks and continue treatment following MetS onset, as well as the possibility that such persons are susceptible to harmful neighborhood environments [12, 47] or prevailing environments such as those around fast food [48]. In any case, the studies also show that MetS prevalence is boosted by complex interactions of various factors.

4 Sex Differences

Sex differences are frequently detected in studies of the relationship between socioeconomic status and MetS. In some studies, the socioeconomic gap in MetS is smaller among men than among women, while in others, such a gap is observed among women, but not men. Gender comparisons were possible in 19 of the 24

studies included in this review. “A relationship or strong relationship was observed only among women” [11–14, 21, 34, 35, 40, 49, 50] in 10 of these studies, while “a stronger relationship was observed among men” [7] in 1 study. “Results were mixed” in 5 studies; that is, depending on the socioeconomic indicator tested, relationships were observed among both men and women, or only among women [9, 16, 38, 42, 51]. Finally, “no sex differences were observed” [10, 19, 20] in 3 studies.

In a French study [16] of 3359 men and women, the odds ratios of MetS among participants who paid $\geq$ €2300 in income tax, in comparison to low-income subjects who paid no income tax, were significantly lower only among women: 0.82 for men and 0.38 for women. In a Korean study [35] of 8541 men and women, the likelihood of MetS among women decreased as education or income increased, but tended to increase as education or income increased among men.

In studies of socioeconomic status against laboratory indices of MetS (body mass index, fasting blood glucose, blood pressure), expected relationships between disease and nearly all laboratory indices were observed only among women. Among men, no relationship or reversed relationships were observed [11, 13, 16, 35, 52]. This difference may mask the relationship between MetS and socioeconomic status among men. An identical pattern was reported in the relationship between obesity and socioeconomic status, in which women demonstrated a more consistent negative relationship; that is, susceptibility to obesity increases as socioeconomic status declines [49, 53]. Of note, these sex differences may have some biological basis. For example, men are more susceptible to poor serum lipid status from a young age than women, while childbearing and menopause are more significant drivers of body weight and serum lipid status in women. Another possibility of biological explanation of the sex difference is menopause in women. Indeed, a survey in Korea showed that part-time or full-time employment significantly lowers the odds ratio for MetS (0.67 and 0.66, respectively) only among postmenopausal women, but not among premenopausal women [54]. On the other hand, women face greater societal pressure to be thin (which also affects employment and marriage prospects), while men of low socioeconomic status tend to have jobs that require physical activity; these and other social sex differences may also play a role [11–13, 16, 35, 55].

5 Childhood Socioeconomic Environment and MetS in Adulthood

Protections against adult diseases are said to begin in childhood (or, in some cases, possibly before birth). Similarly, factors that predispose an individual to MetS are believed to form as early as childhood. The syndrome gradually progresses as a result of the complex effects of genetic factors [56], the uterine environment [57], lifestyle habits in childhood, the home environment [58], and other factors [59, 60].

In studies on the relationship between childhood socioeconomic status and MetS, indicators of childhood socioeconomic status, including the father’s occupation

during childhood [9, 10, 21, 55, 61, 62], the education level of both parents [63], birth weight [62], age at menarche [21], and height [21], were previously surveyed to assess potential links to MetS in adulthood, controlling for adulthood socioeconomic status (due to the strong correlation between childhood and adulthood socioeconomic status). However, the results of these studies were contradictory, with significant association observed in some [9, 55, 62, 63], but not in others [10, 21, 61]. Nevertheless, we note that even in studies that found no association between childhood socioeconomic status and MetS, associations were often observed with individual laboratory indices of MetS.

In two British studies [9, 55], a significant relationship between childhood socioeconomic status and adulthood MetS was observed only among women. For example, tracking a group of participants born in 1946 revealed that, among women, the father's occupation during childhood, as well as the participant's own occupation and education, are significantly and independently related to MetS. Among men, however, only the participant's education was relevant [55]. Another British survey [62] also showed that birth weight, postnatal weight gain, living environment, and the father's occupation during childhood explain about 11.9% and 4.6% of adulthood MetS in men and women, respectively [62].

Why then is childhood socioeconomic status linked to MetS in adulthood? First of all, it was demonstrated that low birth weight and a subsequent growth spurt, which reflect poor nutrition before birth, elicit insulin resistance and other factors that predispose individuals to adult diseases in adulthood. Low parental socioeconomic status at birth is also considered as a risk factor. In addition, low socioeconomic status in childhood may have harmful consequences on lifestyle habits in adulthood. For example, one study showed that, independent of a person's own socioeconomic status, low socioeconomic status in the father is significantly associated with smoking in adulthood [46]. In addition, low parental socioeconomic status is associated with poor childhood home environment that may include child abuse, among other factors. Another pathway has been suggested in which poor childhood home environment is associated with MetS through poor psychosocial status in adulthood (depression and poor social support) [63]. Thus, childhood experiences associated with low socioeconomic status may adversely affect psychosocial functioning in adulthood, and may easily cause MetS because of factors such as low stress tolerance. Furthermore, a survey of adolescents found that MetS was more prevalent in less reputable high schools than in well-regarded high schools [64], implying that socioeconomic status may begin to influence MetS onset prior to adulthood.

6 Summary

As noted, individual interventions such as special health checks and lifestyle coaching are aimed at reducing MetS, heart disease, and type 2 diabetes. Lifestyle habits such as diet and exercise are unquestionably important. However, the link between

MetS and social factors such as socioeconomic status is poorly understood, as demonstrated here, and is, perhaps for this reason, not investigated often.

Lifestyle coaching alone may not reduce MetS as expected. However, overall reduction of MetS could potentially be achieved with, for example, concurrent measures that target psychological issues often faced by persons of low socioeconomic status, such as economic uncertainty, work stress, depression, and low self-esteem. This reduction may also be achieved by programs tailored to the needs of persons in lower socioeconomic classes whose lifestyle habits and living conditions are otherwise difficult to change. Other social interventions, including in infrastructure and social capital, may also enhance reduction of MetS, although further research is needed.

The independent effect of childhood socioeconomic status on MetS suggests that factors in childhood and adolescence may predispose individuals to MetS in adulthood. For example, persons born to parents of low socioeconomic status are more likely to stay in a similar status as adults, regardless of one's own efforts or intentions, thus increasing the risk of MetS. Therefore, measures against MetS require not only an emphasis on individual effort and personal responsibility, but also multi-generational insight into one's life course.

Up to 2009, most studies focused on social disparities in MetS prevalence in Europe and North America. After 2010, more and more studies emerged from the Middle-East, Asia, Africa, Mesoamerica, and Latin America. Also, studies investigating mechanisms related to life course have dramatically increased recently, along with studies of genetic and contextual or built environments. Accordingly, frameworks and implementation programs to improve MetS are evolving.

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