The Link between Sub-optimal Diet and Physical Inactivity with Non-communicable Diseases

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INTRODUCTION

Non-communicable diseases (NCDs), also known as chronic diseases, are medical conditions linked with genetic, physiological, behavioral, and environmental factors among others. NCDs are the leading cause of death worldwide, equivalent to 71% of all deaths globally (WHO, 2021). The NCDs with the highest numbers of deaths globally are cardiovascular diseases (CVDs) followed by cancers, respiratory diseases, and diabetes mellitus (DM). Other health problems included under the umbrella of NCDs are obesity, hypertension, gastrointestinal diseases, liver, and renal disorders. Although nothing can be done about non-modifiable risk factors such as age, gender, genetic factors, race, and ethnicity, most of these disorders could be prevented if behavioral and metabolic changes are achieved (Budreviciute et al., 2020). Key metabolic changes that increase the risk of NCDs include hypertension, overweight/obesity, hyperglycemia, and hyperlipidemia (WHO, 2021). The main modifiable behavioral risk factors involve unhealthy diets (i.e., specific nutrients, foods, and food groups as well as dietary patterns) physical inactivity, tobacco use, and alcohol abuse. In 2017, a sub-optimal diet was responsible for more deaths than any other risks globally, including tobacco smoking: 11 million deaths and 255 million disability-adjusted life-years (DALYs; 22% of all deaths and 15% of all DALYs in adults aged 25 years or older) (**Figure 1.1**) (Murray et al., 2020).

With regards to nutrients, high sodium intake (defined by WHO [World Health Organization] as >2 g/day, equivalent to 5 g salt/day) ranks first for mortality worldwide (Murray et al., 2020). High sodium intake contributes to high blood pressure and increases the overall risk for stroke and heart disease. Moreover, the low intake of whole grains and fruit along with high sodium intake constitute more than half of all diet-related deaths and two-thirds of diet-related DALYs (Forouhi & Unwin, 2019). Sub-optimal intake of fruits and vegetables increases the risk for ischemic heart disease, stroke, and gastrointestinal cancers. Also, a high consumption of processed meat is associated with increased all-cause mortality as well as several types of cancer, DM and CVD mortality.

Prevention and Management of Cardiovascular and Metabolic Disease: Diet, Physical Activity and Healthy Aging, First Edition. Christina N. Katsagoni, Peter Kokkinos, and Labros S. Sidossis.

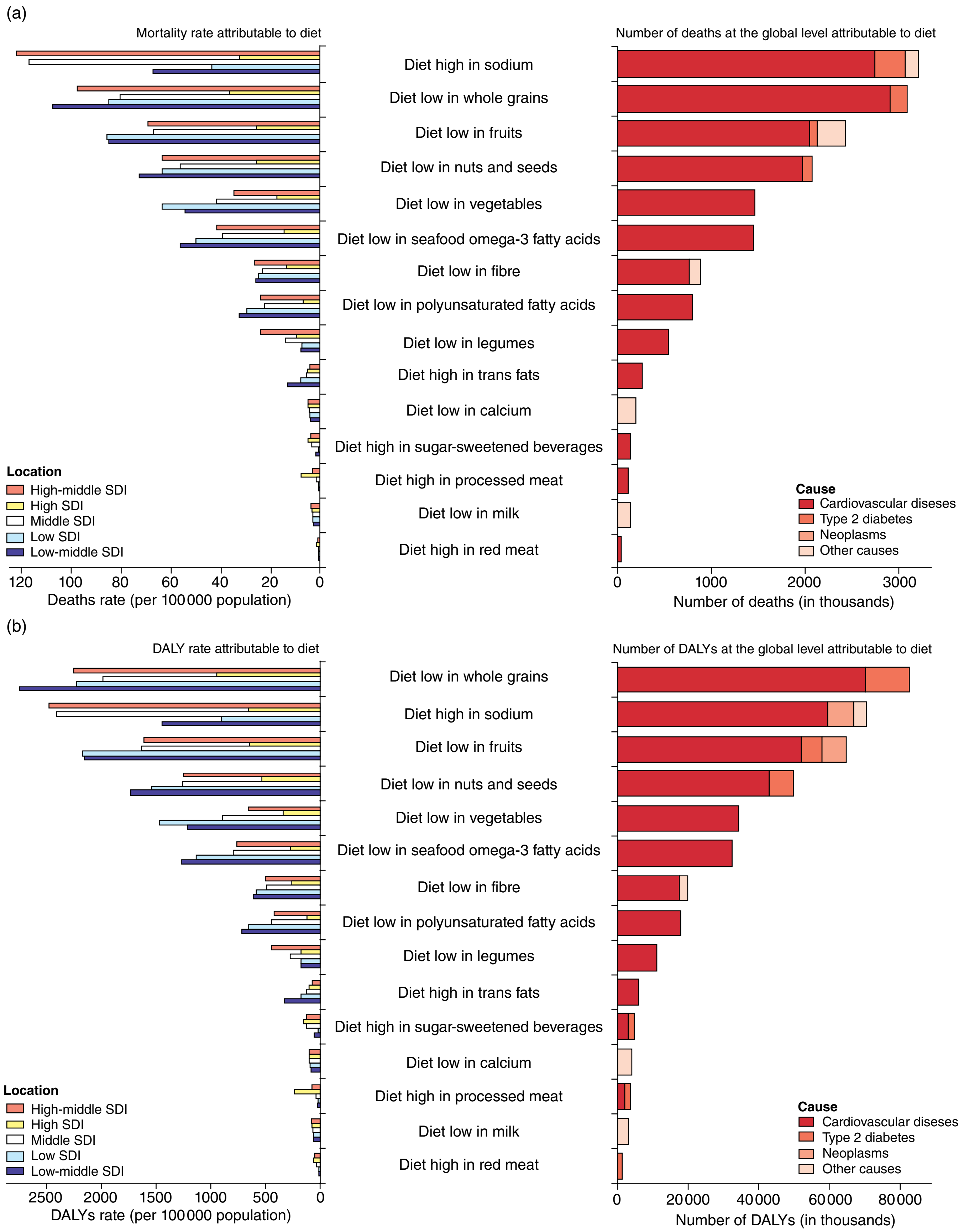

FIGURE 1.1 (a) Number of deaths and DALYs and (b) age-standardized mortality rate and DALY rate (per 100 000 population) attributable to individual dietary risks at the global and SDI level in 2017. DALY = disability-adjusted life-year. SDI = Socio-demographic Index. Source: Adapted from (Afshin et al., 2019).

Along with sub-optimal diet, according to a 2010 WHO report (WHO, 2010), insufficient physical activity was the fourth leading risk factor for mortality, leading to 3.2 million deaths and 32.1 million DALYs (about 2.1% of global DALYs) annually. In 2016, 27.5% of adults globally were insufficiently physically active.

In the following paragraphs, we will focus on the link between a sub-optimal diet and physical inactivity with NCDs.

SUB-OPTIMAL DIET IN TERMS OF NUTRIENTS

LOW DIETARY FIBER INTAKE

Based on a 2017 Global Burden of Disease (GBD) report, in the European Union (EU), the deaths and DALYs attributable to a diet low in fiber (defined as an average daily consumption of <23.5 g/day) account for approximately 97000 deaths and more than 1440000 DALYs, mainly ischemic heart disease as well as colon and rectal cancer (European Commission. Health Promotion and Disease Prevention Knowledge Gateway; Stanaway et al., 2018).

Fiber, according to the US Food and Drug Administration (FDA), is the edible part(s) of plants that are resistant to digestion and absorption in the human small intestine. Good fiber sources are whole grains, vegetables, pulses, and some fruits. Based on their physicochemical characteristics, namely their solubility in water (i.e., they dissolve in water), their viscosity (i.e., the degree of resistance to flow), and their fermentation in the colon, they are categorized as soluble (fermentable)—like pectin, gum, mucilage, β-glucan and polydextrose—and insoluble (non-fermentable)—like cellulose, resistance starches, chitosan, hemicellulose, and lignin—fibers (**Figure 1.2**) (Gill, Rossi, Bajka, & Whelan, 2021). Fiber, like carbohydrates, fats, and proteins, is a source of metabolic energy for the human body and provides, on average, 2 kcal/g (European Commission. Health Promotion and Disease Prevention Knowledge Gateway).

Dietary fiber is considered a protective nutrient against the risk of NCDs, namely type 2 diabetes (T2D), CVDs, and colorectal cancer as well as a reduced risk of gaining weight. This is because high fiber intake improves gut microbiome diversity while increasing the production of short-chain fatty acids (SCFAs) and reduces the risk of obesity and other diseases such as DM and inflammation.

In an umbrella review of systematic reviews with 18 meta-analyses (that included 298 prospective observational studies), the highest versus the lowest quantile of dietary fiber intake was associated with a lower risk of CVD (i.e., coronary artery disease and CVD-related death). Evidence also associate the highest category of dietary fiber intake compared to the lowest with a lower risk of several cancers (e.g., pancreatic, gastric, esophageal adenocarcinoma, colon, endometrial, breast, and renal), stroke, and T2D (Veronese et al., 2018).

According to the Dietary Reference Intakes (DRIs) recommended by the United States Department of Agriculture (USDA), the adequate daily intake of fiber from all sources including fruits, vegetables, grains, legumes, and pulses is 14 g per 1,000 kcal, which is approximately 25 g/day for women and 38 g/day for men (European Commission. Health Promotion and Disease Prevention Knowledge Gateway).

HIGH DIETARY SODIUM INTAKE

Although the global age-standardized rates of deaths and DALYs attributable to high sodium intake decreased for both sexes between 1990 and 2019, the total absolute number of deaths and

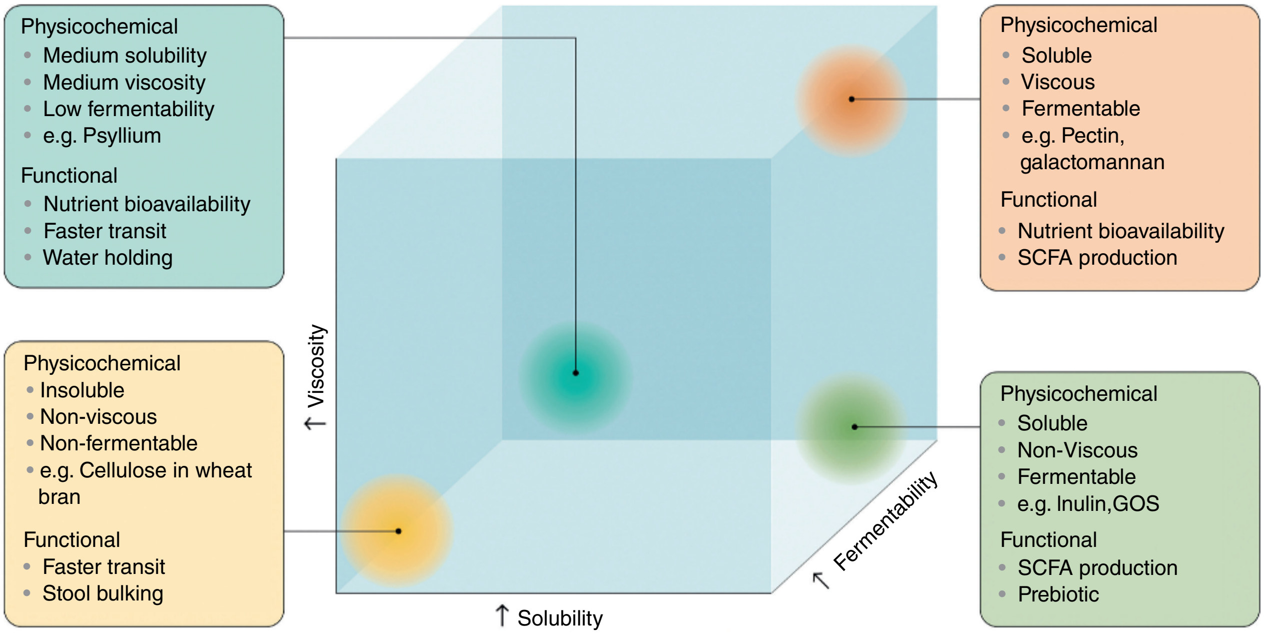

FIGURE 1.2 Spectrum of the physicochemical characteristics of dietary fiber. The physicochemical characteristics of fiber (solubility, viscosity, and fermentability) form a continuum and work in concert to determine its functional properties in the gastrointestinal tract. The combination of these three physicochemical characteristics determines the functional effects of fiber in the gut. Source: (Gill et al., 2020).

DALYs have increased due to population growth and aging (Chen, Du, Wu, Cao, & Sun, 2021). As most of the diseases associated with high sodium intake are age-related, the burden is expected to increase. Indeed, there is a long-standing association between high dietary sodium intake and hypertension as well as CVD (Rhee, 2015). This is related to water retention, systemic peripheral resistance increase, changes in the endothelial function, changes within the structure and function of large elastic arteries, altered activity of the sympathetic system, and altered autonomic neuronal modulation of the cardiovascular system (Grillo, Salvi, Coruzzi, Salvi, & Parati, 2019). High sodium intake is also associated with an increased risk of kidney disease and stomach cancer (Chen et al., 2021).

Numerous meta-analyses have indicated the positive association, either linear or U-shaped, between CVD risk and high sodium intake. In a 2020 meta-analysis of 36 cohort studies that included 616 905 participants, researchers identified a linear relationship between dietary sodium intake and CVD risk, with an increase in risk up to 6% for every 1 g increase in sodium intake per day (Y.-J. Wang, Yeh, Shih, Tu, & Chien, 2020). The U-shaped association was supported in another meta-analysis of cohort studies in which participants with both low (<115 mmol) and high (>215 mmol) sodium intakes had higher mortality compared to participants with a recommended dietary sodium intake (115–215 mmol) (Graudal, Jürgens, Baslund, & Alderman, 2014).

Salt (a combination of sodium and chloride) is the major source of sodium in the diet. Classic sources of salt are processed foods, ready-to-eat meals, salt added during food preparation and cooking as well as table salt (Y.-J. Wang et al., 2020) (**Figure 1.3**). The WHO recommends an overall sodium intake of less than 2 000 mg/day of sodium (<5 g of salt/day)

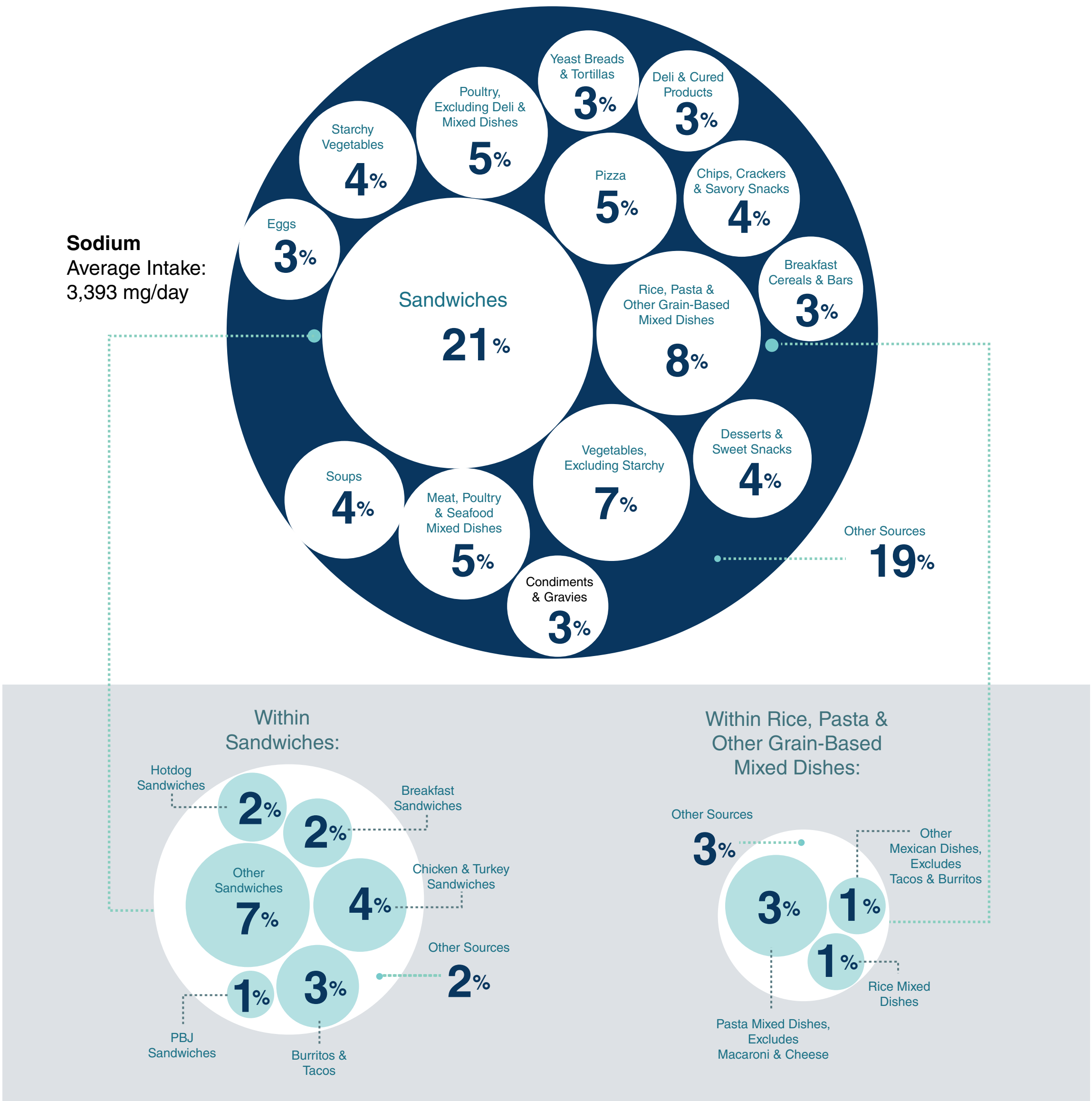

FIGURE 1.3 Source and average intake of sodium for US populations ages 1 and older. Source: (US Department of Agriculture and US Department of Health and Human Services. Dietary Guidelines for Americans, 2020-2025).

(WHO, 2012), whereas the 2020–2025 US Dietary Guidelines for adults recommend limiting sodium intake to 2 300 mg/day (US Department of Agriculture and US Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025). However, the average sodium intake across the US exceeds these recommendations at 3 393 mg/day (range 2000–5000mg/day) for those ages 1 and older (US Department of Agriculture and US Department of Health and Human Services. Dietary Guidelines for Americans, 2020–2025).

A reduction in dietary sodium can reduce blood pressure in both hypertensive and normotensive individuals, regardless of sex and ethnic group, as well as the incidence of hypertension; it was also linked to a reduction in morbidity and mortality from CVDs (Grillo et al., 2019). More details will be discussed in **Chapter 16**.

HIGH SATURATED FATTY ACID INTAKE

Over the last decade, numerous studies have investigated the role of saturated fats on several cardiovascular outcomes, but they fail to demonstrate rigorous evidence that supports continued recommendations to either limit saturated fatty acid (SFA) consumption or replace them with poly-unsaturated fatty acids (PUFAs) like omega-3 (Astrup et al., 2021). However, the 2020–2025 Dietary Guidelines for Americans continued the recommendation to limit SFAs to 10% or less of total energy intake, based on insufficient and inconsistent evidence (Dietary Guidelines Advisory Committee, 2020).

Indeed, results from clinical trials data are inconclusive. Although researchers concluded that reducing dietary saturated fat for at least 2 years could reduce the risk of combined cardiovascular events by 21%, a systematic review of 15 randomized controlled trials (RCTs) with about 59 000 participants, found little or no effect of reducing saturated fat on all-cause mortality or cardiovascular mortality, including non-fatal myocardial infarction, stroke, and coronary heart disease (CHD) events. Little or no effect was also found for cancer diagnoses, DM diagnosis, HDL cholesterol, serum triglycerides, or blood pressure. There were small reductions in weight, serum total cholesterol, LDL cholesterol, and BMI (Hooper et al., 2020).

Similarly, the epidemiological data from several meta-analyses of prospective observational studies have shown no significant associations between SFA consumption and CHD or CVD (Heileson, 2020).

HIGH TRANS FATTY ACIDS INTAKE

Trans fatty acids (TFAs) are unsaturated fatty acids with one or more unconjugated double bonds in the trans configuration. They are present in foods from ruminant animals (i.e., cattle, sheep, goats, and camels), although most are generated during the manufacturing processing of partially hydrogenated vegetable and marine oils, such as margarines, confectionery fats, and fat spreads. The amount of TFAs in partially hydrogenated vegetable oils can be as high as 60%. Foods that commonly contain margarine, such as deep-fried foods, baked goods, and snacks are therefore high in TFAs. Compared to animal fats, hydrogenated vegetable oils are more stable and less likely to become rancid during repeated deep-frying processes. Thus, they are widely used commercially (Oteng & Kersten, 2019).

Collectively, evidence strongly suggests that industrial TFA consumption is associated with increased risk of CHD-related mortality and CVD. Therefore, several countries have passed laws that either restrict or completely ban food companies from incorporating TFAs into their food products. However, there is an ongoing debate as to whether industrially or naturally produced ruminant TFAs exert the same effects on cardiovascular health (Pipoyan et al., 2021).

A meta-analysis of RCTs that explored naturally occurring or industrially produced TFAs and plasma LDL-to-HDL ratios revealed that, independent of their source, all TFAs could lead to an increase in the LDL-to-HDL ratio. However, a systematic review and meta-analysis of prospective studies found that industrially produced, but not naturally occurring TFAs, are associated with an increased risk of CHD. Interestingly, new evidence supports that specific animal-derived TFAs do not have detrimental health effects but may be beneficial for human health (Pipoyan et al., 2021). In a 2016 systematic review and meta-analysis authorized by the WHO, replacing total or industrial TFAs with either cis-MUFA or cis-PUFA improved lipid and lipoprotein profiles, which further lead to a reduction of CVD risk.

According to a 2020 review, mechanistically, in vivo and in vitro studies show that industrial TFAs might promote inflammation, endoplasmic reticulum (ER) stress, and fat storage in the liver instead of adipose tissue, compared with cis-unsaturated fatty acids and SFAs (Oteng & Kersten, 2020).

Therefore, in 2018, the WHO published an action package to reduce the TFA use in the global food supply called the 'REPLACE action package' (**Figure 1.4**). Based on a six-step strategy, each country should implement actions to eliminate industrially produced TFAs.

SUB-OPTIMAL DIET IN TERMS OF FOODS AND FOOD GROUPS

LOW CONSUMPTION OF FRUITS AND VEGETABLES

The low consumption of fruit and vegetables is associated with an increased risk of CVD, T2D, and cancer. The WHO recommends eating five portions of fruit and vegetables per day (equivalent to 400 g).

According to a meta-analysis of 27 prospective cohort studies as well as the results from the Nurses' Health Study (1984–2014, 66 719 women) and the Health Professionals Follow-up Study (1986–2014, 42 016 men), fruit and vegetable intake was inversely associated with with total mortality and cause-specific mortality attributable to cancer, CVD, and respiratory disease. Interestingly, consuming about 5 servings/day of fruit and vegetables, or two fruit servings and three vegetable servings, was associated with the lowest mortality, without additional risk reduction at higher intakes (D. D. Wang et al., 2021).

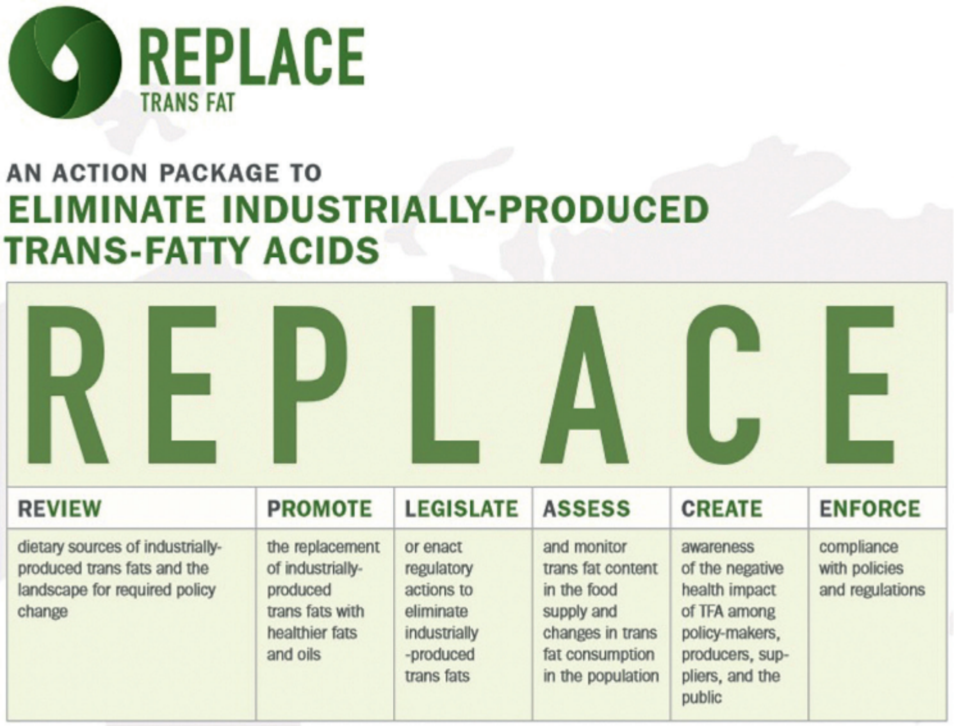

FIGURE 1.4 The 'REPLACE' action package developed by the WHO to reduce trans fatty acids from the global food supply. Source: [https://www.who.int/teams/nutrition-and-food-safety/replace-trans-fat (accessed 3 May 2022)].

LOW CONSUMPTION OF WHOLE-GRAIN PRODUCTS

In 2017, the Healthy Grain Forum (Ross et al., 2017) in accordance with the International Carbohydrate Quality Consortium (ICQC) Scientific Consensus on Whole Grains, published a definition for whole-grain foods. According to this definition, a food might be labeled as whole grain "if it contains at least 30% whole-grain ingredients in the overall product and more whole grain than refined grain ingredients, both on a dry-weight basis" (Ross et al., 2017).

A low consumption of whole-grain food products usually leads to a low fiber intake (especially insoluble fractions) as well as B vitamins, minerals, and phytochemicals with antioxidant properties, all of which are linked to many health benefits.

Epidemiological data support that the high intake of whole grains is correlated with decreased mortality from CVD as well as the prevention and management of T2D (Tieri et al., 2020). Moreover, whole grains are considered an important factor for maintaining a healthy body weight and reducing the risk of obesity (Tieri et al., 2020).

Despite the health benefits from high consumption, the intake of whole grains globally is lower than general recommendations, which increases the risk for mortality associated with chronic disease (Tieri et al., 2020). With regards to morbidity, low whole-grain intake is associated with the highest number of DALYs (Murray et al., 2020).

There are several recommendations for the daily consumption of whole grains; in the USA, it is recommended to consume at least 85 g/day (Arnold, Harding, & Conley, 2021), while in European countries, such as Denmark, it is 75 g or 10 megajoules (MJ, 2 388 kcal) per day (Frølich, Åman, & Tetens, 2013).

HIGH INTAKE OF ADDED/FREE SUGAR AND SWEETENED BEVERAGES

The WHO defines added/free sugar as "monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook, or consumer, and sugars naturally present in honey, syrups, fruit juices, and fruit juice concentrates" (WHO, 2015).

In many high-income countries, sugar-sweetened beverages and added/free sugars are consumed above the recommended daily limits (**Table 1.1**), while it is on the rise in low- and middle-income countries.

This is a major problem for public health, as there is a strong association between a high sugar diet and obesity, which was stated in 2015 reports from both the WHO (WHO, 2015) and the UK's Scientific Advisory Committee on Nutrition (SACN) (Carbohydrates and Health Report, 2015). Added/free sugars, particularly those coming from sugar-sweetened beverages (SSBs), increase overall energy intake while lowering the intake of nutritional foods, leading to an unhealthy diet, weight gain, and increased risk of NCDs (WHO, 2015). A major concern is also the positive association between free sugar intake and dental caries. Similarly, results from prospective cohort studies have linked SSBs to an increased risk of T2D (Moore & Fielding, 2016). Both obesity and T2D are important risk factors for cardio-metabolic diseases, which supports the evidence that a very high sugar diet could also be associated with CVD mortality (Moore & Fielding, 2016).

Table 1.1 Recently published recommendations on the consumption of dietary sugars.

Organization (year)	Recommendations
2020–2025 Dietary Guidelines for Americans (US Department of Agriculture and US Department of Health and Human Services. Dietary Guidelines for Americans, 2020)	Consume less than 10% of calories per day from added sugars.
World Health Organization (2015) (WHO, 2015)	The intake of free sugars should be reduced to less than 10% of total energy intake in both adults and children.
UK Scientific Advisory Committee on Nutrition (SACN) (2015) (Carbohydrates and Health Report, 2015)	The average population intake of free sugars should not exceed 5% of the total dietary energy for age groups from 2 years onward.
2015–2020 Dietary Guidelines for Americans (2015) (US Department of Health and Human Services and US Department of Agriculture, 2015)	Consume less than 10% of calories per day from added sugars.
Australian National Health and Medical Research Council (2013) (Australian Guidelines, 2013)	Limit intake of foods and drinks containing added sugars such as confectionery; sugar-sweetened soft drinks and cordials; fruit drinks; vitamin waters; energy and sport drinks.
European Food Safety Authority (2010) (EFSA Panel on Dietetic Products & Allergies, 2010)	The available evidence is insufficient to set an upper limit for the intake of (added) sugars based on their effects on body weight or a risk reduction of dental caries.

Source: (Moore and Fielding, 2016).

The harmful association between SSBs and several health outcomes may reflect a general unhealthy lifestyle whereby individuals with greater SSB intake are more likely to have a poorer diet quality, higher caloric intake, and a sedentary lifestyle (Semnani-Azad et al., 2020). The pathophysiology behind the high amounts of sugar consumption via SSBs and ultra-processed foods is that the latter may lead to the production of high reactive oxygen-carbons (ROCs), which further increases the possibility of atherosclerosis, hypertension, peripheral vascular disease, coronary artery disease, cardiomyopathy, heart failure, and cardiac arrhythmia (Haque et al., 2020).

Based on the aforementioned evidence, most scientific organizations, in order to limit the rising trends of obesity and related metabolic diseases, suggest reducing total dietary intake of added/free sugars to 5% to 10% of total energy intake (**Table 1.1**).

Nevertheless, the effect of specific dietary sugars, e.g., glucose, fructose and others, on metabolism and human health is less clear (Moore & Fielding, 2016). Especially when considering that the postprandial glucose response, commonly known as the glycemic index used to measure the blood glucose-raising potential of foods, varies between people, as it is affected by several factors such as the gut microbiome, anthropometric data, physical activity, and blood lipids (Zeevi et al., 2015).

However, it seems that the effects of total sugars, added sugars or specific dietary sugars in human health depends on the consumed amount. In a systematic review and dose-response meta-analysis of 10 prospective cohort studies, including 624 128 individuals with 11 856 cases of CVD incidence and 12 224 cases of CVD mortality (Khan et al., 2019), authors investigated the relation of total and added fructose-containing sugars with CVD risk. A harmful association of total sugars, fructose, and added sugars with CVD mortality was found for intakes above 133 g (26% energy) of total sugars, 58 g (11% energy) of fructose, and 65 g (13% energy) of added sugars. No harmful association was found with lower intake of these sugars or at any dose for sucrose (Khan et al., 2019).

Attention should be given to other major food sources of fructose-containing sugars such as yogurt, fruit, 100% fruit juice, and mixed-fruit juice, as the latest data support the notion of a possible, even protective role, of those foods with cardio-metabolic conditions such as metabolic syndrome. In a systematic review and meta-analysis of 13 prospective cohort studies (including 49 591 participants and 14 205 metabolic syndrome cases), although a positive association was found between SSBs and the risk of metabolic syndrome incidence, an L-shaped protective dose-response association was observed for yogurt and fruit with metabolic syndrome (Semnani-Azad et al., 2020). Regarding fruit juices (mixed and 100%), a U-shaped dose-response association was found, suggesting a protective association between 75 and 150 mL/d but an adverse association for more than 175 to 200 mL/d. Yogurt, fruit, and 100% fruit juices are highly nutritious food groups.

FOODS AND FOOD GROUPS RICH IN SATURATED FATTY ACIDS

Whole-fat dairy products, unprocessed meat, eggs, and dark chocolate were thought to increase the risk of CVD due to their high SFA content. However, it is now apparent that the relationship or effect of any food cannot be predicted by its nutrient content without considering the overall macronutrient distribution (**Figure 1.5**) (Astrup et al., 2020).

Robust evidence from prospective and clinical trial studies show no increase, or even a small benefit, in CVD risk from full-fat dairy consumption (Giosuè, Calabrese, Vitale, Riccardi, & Vaccaro, 2022). Based on an umbrella review of observational studies, there is also convincing and probable evidence of a decreased risk of colorectal cancer, hypertension, elevated blood pressure, and fatal stroke as well as a possible decreased risk of breast cancer, metabolic syndrome, stroke, and T2D (Godos et al., 2020). The potential mechanisms of the attenuating effects of dairy foods remain to be fully elaborated, but seem to involve food matrix effects on fat bioavailability and changes in the gut microbiome as well as glucose, insulin, and other hormonal responses (Giosuè et al., 2022).

Eggs are rich in SFAs. However, they provide important nutrients such as high-quality protein, iron, other minerals, vitamins, and carotenoids. Several meta-analyses of prospective studies have concluded that higher egg consumption is not associated with CHD risk and may be associated with a lower

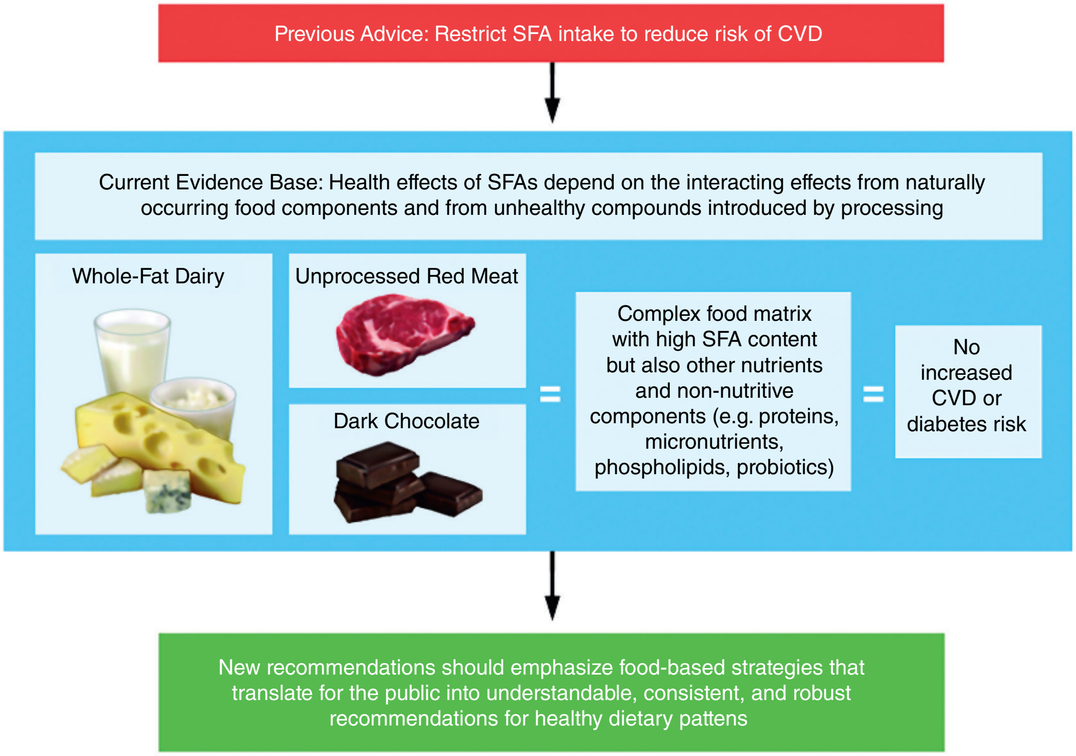

FIGURE 1.5 Previous and current evidence regarding the health effects of high SFA content foods (e.g., whole-fat dairy, unprocessed red meat, and dark chocolate) and CVD risk. Source: (Astrup et al., 2020 / with permission of Elsevier).

risk of stroke (Drouin-Chartier et al., 2020; Geiker, Larsen, Dyerberg, Stender, & Astrup, 2018). Moreover, results from RCTs show neutral or beneficial effects on cardio-metabolic risk markers in people with prediabetes and T2D (Fuller et al., 2018).

Dark chocolate has a high SFA content but also contains stearic acid, which is considered of neutral effect on CVD risk. Moreover, epidemiological and experimental data suggest that dark chocolate has anti-oxidative, antihypertensive, anti-inflammatory, anti-atherogenic, and anti-thrombotic properties, which have preventive effects against CVD and T2D (Astrup et al., 2020).

Likewise, evidence regarding the association of unprocessed meat with all-cause mortality, CVD, CHD, and T2D risk is low to very low compared to processed meat that shows increased risks. The results from a meta-analysis of RCTs found no differences in blood lipids, lipoproteins, or blood pressure between groups of individuals consuming more, or fewer, than 0.5 daily servings of meat (O'Connor, Kim, & Campbell, 2017). In the same meta-analysis, processed meat raised the risk of T2D to 19%, but red-meat consumption was not significantly associated with DM (O'Connor et al., 2017).

In a meta-analysis of RCTs that compared diets with red meat with diets that replaced red meat with a high-quality plant protein sources, animal sources (i.e., chicken/poultry/fish; fish only; poultry only), mixed-animal protein sources (including dairy); and carbohydrates found no significant differences between red meat and all the comparison diets combined in the blood concentrations of total, low-density lipoprotein, high-density lipoprotein cholesterol, apolipoproteins A1 and B, or blood pressure. However, relative to the combined comparison diets, red-meat intake resulted in lower decreases in triglyceride levels (Guasch-Ferré et al., 2019).

Although the evidence regarding red-meat consumption is inconclusive regarding cardio-metabolic diseases, there is strong evidence that consuming either red or processed meat is positively associated with colorectal cancer (Huang et al., 2021), as it will be further discussed in **Chapter 21**.

HIGH PROCESSED-MEAT CONSUMPTION

As mentioned in the previous section, a high consumption of processed meat like bacon, sausages, salami, or other cold cuts, may increase the risk for chronic diseases, namely T2D (Yang et al., 2020) and certain cancers, e.g., colorectal and esophageal cancer.

Indeed, in an umbrella review including 72 meta-analysis of both cohort and case-control studies, 100g/day increments of red meat and 50 g/day increments of processed meat were associated with 11% to 51% and 8% to 72% increased risk of multiple cancers, respectively (Huang et al., 2021). During the high-temperature cooking process of red meat, several potential carcinogens, such as polycyclic aromatic hydrocarbons and heterocyclic amines are formed, which increases the possibility of cancer risk.

Also, the high sodium content of processed meat increases the risk of developing hypertension and vascular stiffness. However, the magnitude of association of processed meat consumption with adverse cardio-metabolic outcomes is very small and the evidence is low (Zeraatkar et al., 2020).

SUB-OPTIMAL DIET IN TERMS OF DIETARY PATTERNS

Beyond single nutrients, foods, and food groups, in the last decades there is a shift in nutrition research to more holistic dietary patterns. The assessment of whole dietary patterns either *a priori* or *a posteriori* is likely to provide a better explanation of diet–health interactions as it takes into consideration combinations of different foods and beverages. To this context, sub-optimal, unhealthy or Western dietary patterns increase the risk of CVD, obesity, metabolic syndrome, T2D (Fung, Schulze, Manson, Willett, & Hu, 2004; Walsh, Jacka, Butterworth, Anstey, & Cherbuin, 2017), and cancer. However, according to a 2020 umbrella systematic review (Jayedi, Soltani, Abdolshahi, & Shab-Bidar, 2020) that evaluated the evidence obtained by published meta-analyses of prospective cohort studies on the association between empirically derived unhealthy dietary patterns and the risk of NCDs, found a very low to moderate quality of evidence. Notably, positive associations between unhealthy dietary patterns and the risk of NCDs were confirmed only for all-cause mortality, colorectal adenoma, T2D, and metabolic syndrome but not CVD or CHD mortality (Jayedi et al., 2020).

THE WESTERN DIETARY PATTERN

The Western pattern is characterized by a high intake of processed meat, red meat, butter, eggs, refined grains, fast food, SSBs, sweets, and desserts while it is low in fruit and vegetables. Therefore, Western-type diets are enriched in total fat, animal proteins, n-6 PUFAs, and added sugars, while they are low in fiber (Hu, 2002).

Numerous cohort (Oikonomou et al., 2018), such as the ATTICA study (Panagiotakos et al., 2009), and case-control studies, such as the INTERHEART study (Iqbal et al., 2008), have shown statistically significant associations between unhealthy dietary patterns and increased odds or risk for developing CVD. However, the pooled estimation from several meta-analyses assessing the associations of unhealthy dietary patterns with CVD has not always revealed statistical results (Li et al., 2015; Rodríguez-Monforte, Flores-Mateo, & Sánchez, 2015). This is because an unhealthy pattern is not always synonymous with developing CVD as those patterns do not necessarily represent food choices that pose the highest CVD risk rather than a mix of food choices including those with a protective role.

Regarding metabolic syndrome and T2D, evidence is more constant and clearer. Data from observational cohort studies show that the adherence to the highest compared to the lowest category of Western diet is associated with an increased risk of metabolic syndrome, general and central obesity, higher BMI, and waist circumference in several countries (Rodríguez-Monforte, Sánchez, Barrio, Costa, & Flores-Mateo, 2017). Also, a large body of evidence from meta-analyses of prospective cohort studies (Alhazmi, Stojanovski, McEvoy, & Garg, 2014; Jannasch, Kröger, & Schulze, 2017) suggest that an unhealthy dietary pattern characterized by red and processed meats, high-fat dairy, and refined grains may also increase the risk of T2D incidence by almost 30% (Maghsoudi, Ghiasvand, & Salehi-Abargouei, 2016) through exacerbated insulin secretion and insulin resistance.

The proposed mechanisms behind the harmful associations between Western-type diets and health include the increased production of reactive-oxygen species, low-grade inflammation, abnormal activation of the sympathetic nervous and renin-angiotensin-systems (Kopp, 2019). There is also evidence that as well as alterations in the structure and diversity of gut microbiome affect both systemic and mucosal immune responses (Statovci, Aguilera, MacSharry, & Melgar, 2017), all of which play a pivotal role in the development of NCDs.

PHYSICAL INACTIVITY

Physical activity is a widely accepted global public health issue. Data regarding physical inactivity worldwide is disappointing. More than a quarter of all adults globally (27.5%) were physically inactive in 2016, putting more than 1.4 billion adults at risk for developing diseases associated with physical inactivity such as CVD (Guthold, Stevens, Riley, & Bull, 2018). Women were less active than men (31.7% woman versus 23.4% men) (**Figure 1.6**), as were older adults compared to younger adults. High-income countries showed almost a double prevalence of inactivity (36.8%) compared with low-income countries (16%) (Guthold et al., 2018).

Globally, in 2022, physical inactivity was deemed responsible for 7.2% and 7.6% of all-cause and CVD deaths, respectively (Katzmarzyk, Friedenreich, Shiroma, & Lee, 2022). Regarding the proportions of all NCDs attributable to physical inactivity, these varied from 5% for CHD, 4.5% for T2D, 7.2% of renal cancer, and 8.1% for dementia (Katzmarzyk et al., 2022). Moreover, despite the high prevalence-based population attributable risks in high-income countries, 69% of total deaths and 74% of CVD deaths associated with physical inactivity occurred in middle-income countries due to the greater populations of these countries (Katzmarzyk et al., 2022). The high levels of physical inactivity in wealthier countries might be attributed to more sedentary occupations and personal motorized transportation, while more activity is undertaken at work and for transport in low-income countries (Guthold et al., 2018).

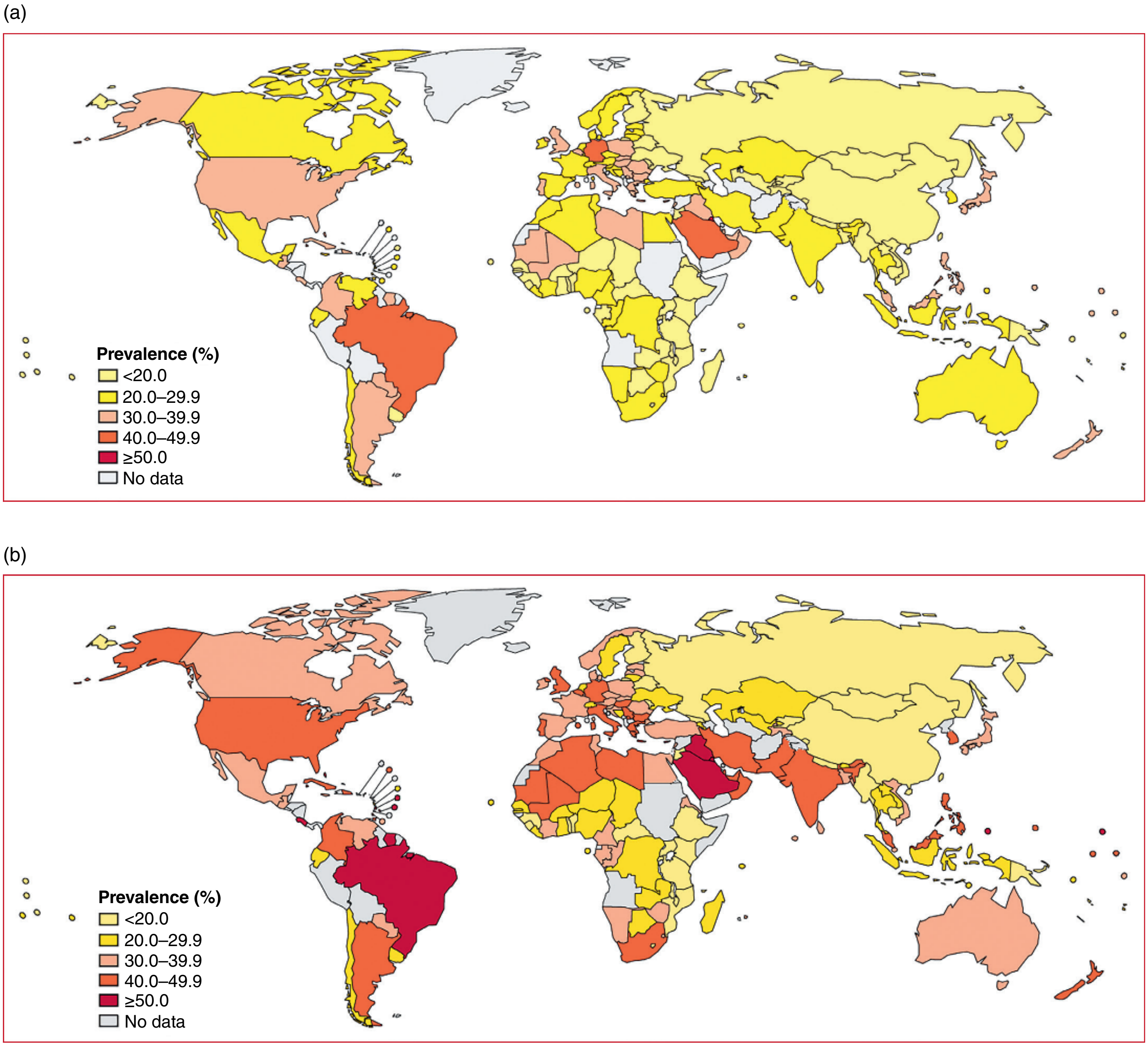

FIGURE 1.6 Country prevalence of insufficient physical activity in (a) men and (b) women in 2016. Women were less active than men (31.7% versus 23.4%). Source: (Guthold et al., 2018 / Elsevier / CC BY 3.0 IGO).

Globally, reasons for insufficient participation in physical activity include the increased use of technology, alterations in transportation patterns, and economic development in many countries (Kohl et al., 2012). According to the US Centers for Disease Control and Protection (CDC), people report lack of time and safety issues as common barriers, while other reasons cited are a lack of self-motivation; confidence in the capability to be physically active; encouragement, support, or companionship during exercise; feeling inconvenienced by exercise; or feeling bored during or not enjoying, exercise. Moreover, several environmental factors may influence individuals' participation in physical activity in all domains, such as an increase in violence, high-density traffic, and air pollution as well as a lack of parks, sidewalks, and sports/recreation facilities. In both middle aged (50 to 64) and older (65 to 70 years old) adults, environmental factors, and resources as well as social influences and beliefs about being capable of exercising seem to be among the most frequently identified barriers (Spiteri et al., 2019).

According to 2020 WHO guidelines on physical activity and sedentary behavior (WHO, 2020), physical inactivity is defined as individuals' inability to follow their current age group recommendations regarding weekly levels of physical activity.

More information will be given in **Unit 2**. Briefly, for children and youth aged 5 to 17, guidelines recommend at least 60 minutes of moderate- to vigorous-intensity physical activity daily, preferably aerobic and performed as play. For adults, recommendations suggest at least 150 minutes of moderate-intensity aerobic physical activity per week or at least 75 minutes of vigorous-intensity aerobic physical activity throughout the week, or an equivalent combination of moderate- and vigorous-intensity activity (WHO, 2020).

KEY POINTS

- Non-communicable diseases (NCDs), also known as chronic diseases, are medical conditions linked with several factors such as genetic, physiological, behavioral, and environmental factors.
- The NCDs with the highest numbers of deaths globally are cardiovascular diseases (CVDs) followed by cancers, respiratory diseases, and DM. Other health problems included under the umbrella of NCDs are obesity, hypertension, gastrointestinal diseases, and liver and renal disorders.
- A diet low in fiber is defined as an average daily consumption of less than 23.5 g of fiber per day.
- The adequate daily intake of fiber from all sources including fruits, vegetables, grains, legumes, and pulses is 14 g per 1 000 kcal, which is approximately 25 g/day for women and 38 g/day for men.
- High sodium intake (defined by WHO as >2 g /day, equivalent to 5 g salt/day) ranks first for mortality worldwide.
- Salt (a combination of sodium and chloride) is the major source of sodium in the diet. Classic sources of salt are processed foods, ready-to-eat meals, salt added during food preparation and cooking as well as table salt.
- The WHO recommends an overall sodium intake of less than 2 000 mg/day of sodium (<5 g salt/day), whereas the 2020–2025 US Dietary Guidelines for adults recommend limiting sodium intake to 2 300 mg/day.
- Numerous studies have failed to demonstrate rigorous evidence supporting continued recommendations either to limit the consumption of saturated fatty acids (SFAs) or replace them with poly-unsaturated fatty acids (PUFAs) like omega-3.
- The 2020–2025 Dietary Guidelines for Americans continues the recommendation to limit SFAs to 10% or less of total energy intake, based on insufficient and inconsistent evidence.
- Evidence strongly suggest that industrial trans fatty acid (TFA) consumption is associated with an increased risk of CHD, related mortality, and CVD.
- The WHO published an action package to reduce TFA using the global food supply called the 'REPLACE action package'.
- The low consumption of fruit and vegetables has been associated with increased risk of CVD, T2D and cancer. WHO recommends eating five portions of fruit and vegetables per day (equivalent to 400 g).
- A low consumption of whole-grain food products leads to a low fiber intake (especially insoluble fractions) in addition to B vitamins, minerals, and phytochemicals with antioxidant properties, all of which are components linked to many health benefits.
- There are several recommendations for the daily consumption of whole grains; in the USA, at least 85 g/day is recommended, while in European countries, such as Denmark, the recommendation is 75 g/10 megajoules (MJ, 2 388 kcal) per day.
- Added/free sugars, particularly those from sugar-sweetened beverages (SSBs) increase overall energy intake and lowers the intake of nutritional foods, which leads to an unhealthy diet, weight gain, and increased risk of NCDs.
- The postprandial glucose response, commonly known as the glycemic index used to measure the blood glucose-raising potential of foods, varies between people, as it is affected by several factors such as the gut microbiome, anthropometric data, physical activity, and blood lipids.
- It seems that the effects of total sugars, added sugars, or specific dietary sugars on human health depends on the consumed amount.
- Attention should be given to other major food sources of fructose-containing sugars such as yogurt, fruit, 100% fruit juice, and mixed-fruit juice, as the latest data support a potentially protective role of those foods against cardio-metabolic conditions such as metabolic syndrome.
- Whole-fat dairy products, unprocessed meat, eggs, and dark chocolate were thought to increase the risk of CVD due to their high SFA content. However, it is now apparent that the relationship or effect of any food cannot be predicted by its nutrient content without considering the overall macronutrient distribution.
- During the high-temperature cooking process of red meat, several potential carcinogens, such as polycyclic aromatic hydrocarbons and heterocyclic amines are formed, increasing cancer risk.
- The assessment of whole dietary patterns either *a priori or a posteriori* is likely to provide a better explanation of diet–health interactions as it considers the combination of different foods and beverages.
- The proposed mechanisms behind the harmful associations between Western-type diets and health include (i) the increased production of reactive-oxygen species, (ii) low-grade inflammation, (iii) abnormal activation of the sympathetic nervous and renin-angiotensin systems as well as (iv) alterations in the structure and diversity of the gut microbiome, which affects both systemic and mucosal immune responses, all of whom have a pivotal role in the development of NCDs.
- Data regarding physical inactivity worldwide is disappointing. More than a quarter of all adults globally (27.5%) were physically inactive in 2016, putting more than 1.4 billion adults at risk for developing diseases associated with physical inactivity.
- The high levels of physical inactivity in wealthier countries might be attributed to more sedentary occupations and personal motorized transportation, while more activity is undertaken at work and for transport in low-income countries

SELF-ASSESSMENT QUESTIONS

1. Indicate whether the following statements are true or false:

   (a) A low in fiber diet is defined as an average daily fiber consumption of less than 23.5 g per day.

   (b) A low in fiber diet is defined as an average daily fiber consumption of less than 25 g per day.

   (c) A low in fiber diet is defined as an average daily fiber consumption of less than 15.0 g per day.

   (d) All the above answers are incorrect.

2. Fill in the blanks:

   (a) A high sodium intake is considered as and equivalent to according to WHO.

   (b) The physicochemical characteristics of fibers include their ___________, ____________, and ___________ in the gut.

   (c) The 2020–2025 Dietary Guidelines for Americans recommend limiting saturated fatty acids to of total energy intake.

   (d) WHO recommends eating of fruit and vegetables per day (equivalent to____________).

   (e) Most scientific organizations, to limit the rising trends of obesity and the related metabolic diseases, suggest reducing total dietary intake of added/free sugars to.

   (f) The Western type diets are enriched in __________, ______________, n-6 poly-unsaturated fatty acids and, while they are low in.

3. Through what mechanisms do trans fatty acids act to affect human health?

4. Provide the WHO definition for added/free sugars.

5. Provide the WHO definition for physical inactivity.

6. Children should perform:

   (a) 30 minutes or more per day of moderate- to vigorous-intensity physical activity.

   (b) 60 minutes or more per day of moderate- to vigorous-intensity physical activity.

   (c) 90 minutes or more per day of moderate- to vigorous-intensity physical activity.

   (d) 150 minutes or more per day of moderate- to vigorous-intensity physical activity.

7. What is the physical activity recommendation for adults?

8. Are unhealthy dietary patterns always synonymous with developing CVD?

9. What is the pathophysiology of high amounts of sugar via sugar--sweetened beverages?

10. Fill in the blanks:

    (a) There is a long-standing association between high dietary sodium intake and _________ as well as ______________.

    (b) The 2020–2025 US Dietary Guidelines for adults recommend limiting sodium intake to___________.

    (c) ______________ is the major source of sodium in the diet.

    (d) Classic sources of salt are_________, _________, ________, and________ as well as ______________.

    (e) A reduction in dietary sodium reduces regardless of sex and ethnic group.

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FURTHER READING

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Links

- https://www.who.int/news-room/fact-sheets/detail/noncommunicable-diseases
- www.fda.gov/nutritioneducation
- https://www.gov.uk/government/groups/scientific-advisory-committee-on-nutrition
- https://www.cdc.gov/chronicdisease/resources/publications/factsheets/physical-activity.htm
- wholegrainscouncil.org
- carbquality.org
- https://www1.nyc.gov/site/doh/health/health-topics/national-salt-sugar-reduction-initiative.page
- sweeteners.org
- nutrition.gov
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- https://www.fao.org/home/en
- https://www.who.int/teams/nutrition-and-food-safety/replace-trans-fat