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WHO Dietary Recommendations and Prevention of Chronic Respiratory Diseases

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Abstract

Diet and nutrition are important factors in the prevention and maintenance of good health throughout the entire life course. Their role as determinants of major chronic Non-Communicable Diseases (NCDs) is well established and they therefore occupy a prominent position in the WHO Global Action Plan for the Prevention and Control of Non-Communicable Diseases. WHO dietary recommendations focused to achieve Population Nutrient Intake Goals (PNG) represent the population average intake that is judged to be consistent with the maintenance of health in a population. Health, in this content, is marked by a low prevalence of diet related diseases in the population. PNG expressed in numeric terms have been recommended based on the evidence linking dietary factors to risk of developing obesity, type 2 diabetes, cardiovascular diseases, cancer, dental diseases and osteoporosis. Despite the enormous global burden caused by Chronic Respiratory Diseases (CRD) - 7% of all causes mortality or more than 4 million annual deaths there is less reliable data available on the effect of diet on CRD. In this article an attempt was made to compare existing PNG for preventing diet related chronic diseases with the available associations between diet and CRD. Existing data demonstrate that PNG for major nutrients may be applied for CRD. More studies are needed to determine optimal balance of n-6 and n-3 Polyunsaturated Fatty Acids (PUFAs) Despite the fact that the level of evidence for dietary factors in developing of CRD is less convincing than for other NCDs the reported associations data in general do not contradict to existing ranges of PNG. Dietary recommendations for the prevention of CRD are generally compatible with existing dietary guidelines for the control of other major NCDs. This is important for the integrated prevention of major NCDs including CRD.

Keywords: Asthma; Chronic Obstructive Pulmonary Disease; Chronic Respiratory Diseases, Fatty Acids; Non-Communicable Diseases; Obesity; Population Nutrient Intake Goals; World Health Organization (WHO)

Abbreviations

The following abbreviations are used in this review

NCDs	:	Noncommunicable diseases
WHO	:	World Health Organization
PNG	:	Population nutrient intake goals
PUFAs	:	Polyunsaturated fatty acids
MUFAs	:	Monounsaturated fatty acids
NSP	:	Non-starch polysaccharides
FAO	:	Food and Agriculture Organization of the United Nations
UNU	:	United Nations University
CRDs	:	Chronic respiratory diseases
GARD	:	Global Alliance against Chronic Respiratory Diseases
LDL	:	Low density lipoprotein
CHD	:	Coronary Heart Disease
SFA	:	Saturated fatty acids
FEV1	:	Forced expiratory volume in one second
CAPS	:	Childhood asthma prevention study
COPD	:	Chronic Obstructive Pulmonary Disease

Introduction

During the past decades, rapid expansion in a number of large population - based epidemiological studies has helped to clarify the role of diet in preventing and controlling morbidity and

premature mortality resulting from Non Communicable Diseases (NCDs) mainly-cardiovascular, certain types of cancer and diabetes mellitus .WHO's assessment of the relationship between diet and the development of chronic diseases is set out in the report produced by a WHO Expert Committee after careful review of the literature [1]. Some of the specific dietary components that increase the probability of occurrence of NCDs in individuals, and interventions to modify their impact, have also been identified. Population Nutrient Intake Goals (PNG) represent the population average intake that is judged to be consistent with the maintenance of health in a population. Health, in this content, is marked by a low prevalence of diet related diseases in the population. PNG expressed in numeric terms have been recommended based on the evidence linking dietary factors to risk of developing obesity, type 2 diabetes, cardiovascular diseases, cancer, dental diseases and osteoporosis (Table 1). PNG have become the background for the development of the WHO Global Strategy on Diet, Physical Activity and Health, where specific reference values for nutrients are important in improving the dietary recommendations for the population and to prevent chronic diseases [2]. Based on this strategy WHO Global NCDs Action Plan provides policy options for member states intended to advance the implementation of the global strategy [3].

Dietary factor	Goal (% of total energy, unless otherwise stated)
Total fat	15 - 30%
Saturated fatty acids	<10%
Polyunsaturated Fatty Acids (PUFAs)	6 - 10%
n-6 Polyunsaturated Fatty Acids (PUFAs)	5 - 8%
n-3 Polyunsaturated Fatty Acids (PUFAs)	1 - 2%
Trans fatty acids	<1%
Monounsaturated Fatty Acids (MUFAs)	By difference[a]
Total carbohydrate	55 - 75%[b]
Free sugars[c]	<10%
Protein	10 - 15%[d]
Cholesterol	<300 mg per day
Sodium chloride (sodium)[e]	<5 g per day (<2 g per day)
Fruits and vegetables	≥400 g per day
Total dietary fibre	From foods
Non-starch polysaccharides (NSP)	From foods

[a] This is calculated as: total fat - (saturated fatty acids + polyunsaturated fatty acids + trans fatty acids).
[b] The percentage of total energy available after taking into account that consumed as protein and fat, hence the wide range.
[c] The term "free sugars" refers to all monosaccharides and disaccharides added to foods by the manufacturer, cook or consumer, plus sugars naturally present in honey, syrups and fruit juices.
[d] The suggested range should be seen in the light of the Joint WHO/FAO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition, held in Geneva from 9 to 16 April 2002.
[e] Salt should be iodized appropriately. The need to adjust salt iodization, depending on observed sodium intake and surveillance of iodine status of the population, should be recognized.

Table 1: Ranges of population nutrient intake goals*. *WHO PNG, from [1] and http://www.who.int/nutrition/topics/5_population_nutrient/en/index.html

Chronic respiratory diseases are a group of NCDs affecting the airways, lungs and related structures. According to the International Classification of Diseases, ICD-10 [4], common CRDs include asthma, bronchiectasis, Chronic Obstructive Pulmonary Disease (COPD), occupational lung diseases, rhinitis, chronic rhinosinusitis, sleep apnea syndrome and pulmonary hypertension. Over one billion people suffer from CRDs (Table 2). Many patients experience considerable adverse impact upon their quality of life, and costs are incurred for the society [5,6].

Asthma	334 million
COPD	210 million
Rhinitis (excluding asthma)	400 million
Sleep disordered breathing	> 100 million
Other CRDs	> 50 million

Table 2: Estimated prevalence of chronic respiratory diseases.

According to WHO more than 4 million annual deaths or 7 % of all causes mortality are due to CRD. By this indicator CRD are on the third place among all NCDs after cardiovascular diseases and cancer. Asthma and COPD are responsible for almost 80% of all CRD deaths [7]. WHO has launched the Global Alliance against Chronic Respiratory Diseases (GARD) to address this issue at the global scale. GARD is a voluntary alliance of national and international organizations, medical and scientific societies, institutions and agencies all working with the common

goal of reducing the global burden of CRDs [8]. Despite the enormous burden caused by CRD and an important role of diet in the prevention of chronic diseases there is less reliable data available on the effect of diet on CRD. This concerns fatty acids consumption where a good balance between pro-inflammatory effect of n-6 PUFAs and anti-inflammatory effect of n-3 PUFAs should be found [9-12] taking into account the role of systemic inflammation in major NCDs [13]. Since diet plays a key role in the population-based prevention of NCDs a comparative analysis of the existing data is one of the major targets of this review.

Methods

WHO meeting reports, consultations and Technical Report Series have been mainly used for preparation of this review as well as Pub Med search.

Methodology of Dietary Assessment and CRD

Regretfully there is no ideal method which could provide a quick, cheap and reliable assessment of the individual dietary intake. Lack of data is also caused by different definitions of CRD for epidemiological studies, lack of standardization of different aspects of the dietary surveys (interviewers, questionnaires, food composition tables etc.) and different approaches for the assessment of a long time nutritional intake which should be typical to reflect a habitual diet [14]. Often the results of one study could not be confirmed by other investigators due to different methodologies used for nutrients assessments. For instance, semi-quantitative analysis (food frequency questionnaire), which is widely used, may give less precise estimates for some foods and nutrients than the diary methods [15]. Dietary assessment methods can be separated into assessment of intake over a short, immediate period of time (e.g. 24-h recall) or a long period of time (e.g. dietary records, food frequency questionnaire) or their combination [16]. To provide more accurate quantitative data a weighted 7-day food record is often treated as the reference method [17].

In this case a chemical analysis of the remaining pieces of food could be made. However, in the majority of cases the nutrients analysis is made by using food composition tables which should be regularly updated due to new foods appearance on the market. Validation of dietary assessment is important issue while analyzing the dietary impact on the health status of the individual and the role of individual nutrients in this process. External objective reference parameters such as biological markers of intake are often needed to evaluate the validity of dietary assessment. At present only, few nutrients have biological markers that respond to changes in dietary intake with sufficient sensitivity. For instance, fatty acid composition in adipose tissue is a reflection of long-term dietary fat intake. Biochemical measurements of nutrients in blood and urine well correlate with a short-term intake of lipids, vitamins, sodium and potassium [18].

Using different methods associations have been reported between CRD and the intake of different nutrients and food [5]. Obesity which is a major risk factor for NCDs [3] has also been associated with the increased risk of asthma and lower lung function [5,19]. In this article an attempt was made to compare existing PNG for preventing diet related chronic diseases with the available associations between diet and CRD to consider a dietary approach for the prevention of CRD which would be compatible with the existing dietary approaches for the prevention and control of major NCDs. It's important from the viewpoint of the WHO Global Action Plan for the Prevention and Control of NCDs where reduction of the major shared modifiable risk factors for NCDs -tobacco use, unhealthy diet, physical inactivity and harmful use of alcohol is one of the major objectives [3].

Literature Review

Consumption of Individual Nutrients or Food and CRDs

Fat and Fatty Acids

There is no data that total fat consumption within WHO PNG 15-30% (Table 1) has negative effect on CRD as well as reduction of Saturated Fatty Acids (SFA) intake less than 10%. Polyunsaturated Fatty Acids (PUFAs) intake 6-10% needs special discussion. PUFAs consist of n-6 PUFAs and n-3 PUFAs or Ω6 and Ω3 PUFAs. The most important n-6 PUFA is linoleic acid, this is abundant especially in soybean and sunflower oils. The most important n-3 PUFAs are eicosapentaenoic acid and docosahexaenoic acid found in fatty fish and sea animals, and α-linolenic acid found in plant foods. N-6 PUFAs lower total plasma Low Density Lipoprotein (LDL) cholesterol concentrations [20] and have beneficial effect on mortality from CHD [21], while biological effects of n-3 PUFAs are wide ranging from beneficial: powerful lowering of serum triglycerides, lowering of blood pressure, improvement of cardiac function, arterial compliance, endothelial function, vascular reactivity and potent anti-platelet and anti-inflammatory effects, to the harmful- they raise serum LDL cholesterol [22,23]. Systematic review and meta-analysis of 20 studies found that omega-3 PUSA supplementation was not associated with lower risk of all-cause mortality, cardiac death, sudden death, myocardial infarction or stroke based on relative and absolute measures of association [24]. An optimal balance between n-6 and n-3 PUFAs is considered as 5-8% and 1-2% respectively (Table 1).

From the CRD point of view n-6 PUFAs (including arachidonic fatty acid) are considered to be pro-inflammatory due to higher levels of inflammatory mediators (prostaglandins PGE2 and leukotrienes LTB4). In a representative sample of more than 13,000 Dutch adults; high intake of several n-6 fatty acids was associated with significant reduction in FEV1, particularly in smokers [9]. This proinflammatory effect theoretically should be also balanced

by anti-inflammatory effect of n-3 PUFAs [10-12]. This area needs further investigation considering the role of systemic inflammation in major NCDs [13]. Childhood Asthma Prevention Study (CAPS) initiated as the first randomized controlled trial tested the effectiveness of n-3 fatty acid supplementation in reducing the incidence of asthma and allergic sensitization in Australian children [25]. 616 children were enrolled as participants using weighted food records along with food frequency questionnaire. The median ratios of n-3 fatty acids to n-6 fatty acids in the control diet group were 1:7.2, 1:7.7 and 1:7.4 at 18 months, three years and five years, respectively and in the active diet group the median ratios were 1:4.9, 1:5.9 and 1:5.8 respectively [26]. No beneficial effect was found in the study. Recent meta-analysis of 23 studies on fish intake in association with childhood asthma suggests that introduction of fish early in life (6-8 months) and regular consumption of all fish (at least once a week) reduces asthma and wheeze in children up to 4,5 years old, while fatty fish intake may be beneficial in older children up to 14 years of age [27] More studies are still needed to find the appropriate balance between n-6 and n-3 PUFAs to protect against CRD.

Trans fatty acids appear during the process of partial hydrogenation of PUFAs. This process creates trans fatty acids and also removes the critical double bonds in essential fatty acids necessary for the action. Most trans fatty acids are contributed by industrially hardened oils, deep fried fast foods and baked goods [28]. Several large cohort studies have found that intake of trans fatty acids increase the risk of coronary heart disease, central adiposity and diabetes [29,30]. However, these acids are slowly disappearing from the American diet [31]. There is only very limited data about the association between consumption of trans fatty acids and asthma. In cross sectional studies higher prevalence of asthma is observed in those countries that have higher levels of trans-fatty acids intake [32]. Higher levels of margarine consumption are also associated with the increased risk of asthma [33,34]. Two large prospective studies in US demonstrated an increased risk of development COPD in men and women associated with diet rich in desserts and French fries [35,36]. In view of this the PNG of trans fatty acids consumption (less than 1% of total energy) is not harmful for CRD. Thus, goal was then restated in the WHO Scientific Update on trans fatty acids with the recommendation to minimize their intake [37] up to eliminating of trans fats in the food supply chain and 6 countries in Europe (Denmark, Norway, Iceland, Hungary, Austria, Switzerland) now have legislative limits in place that virtually eliminate trans-fat from the food supply [38]. Now trans-fat issue is part of the Global Policy on unhealthy diet reduction measures [39]. Nevertheless, more studies and in particular those where the trans fatty acids consumption could be validated by fatty acid composition in adipose tissue are needed.

Monounsaturated Fatty Acids (MUFAs) are beneficial for cardiovascular diseases by lowering plasma total and LDL cholesterol [40]. There is little evidence on the effect of MUFAs on CRD. There are some data on the harmful effect of MUFAs which promote allergic sensitization [41,42] and hay fever [41,43] while SFA from dairy products have been associated with reduced asthma risk [44]. The only nutritionally important MUFA is oleic acid, which is abundant in olive and canola oils and also in nuts. The recommendation to calculate MUFAs by difference: total fat - (SFA+ PUFAs + trans fatty acids) when applied for CRD should consider adequate consumption of n-3 PUFAs along with the presence of SFA preferably within the recommended amounts. However, more studies in this area are needed.

Carbohydrates and Dietary Cholesterol

Since fruits and vegetables besides carbohydrates contain other nutrients it's difficult to interpret the role of total carbohydrates in the development of CRD. On the other hand, the limited consumption of free sugars (less than 10% of total energy) will allow better controlling obesity and overweight taking into account the role of sugar in promoting obesity [1] which is associated with higher prevalence of asthma [5]. There is no data on the impact of dietary cholesterol on CRD. However, within the "western" pattern diet linked with the development of CRD [35,36] dietary cholesterol should be considered. The western dietary pattern is heavy loaded by high consumption of refined grains, cured and red meats, desserts and sweets, French fries, eggs and high- fat dairy products. Consumption of cholesterol as well as free sugars within this pattern is no doubt higher than the recommended WHO range for these nutrients.

Sodium Chloride

More data exists on sodium chloride and fruits and vegetables impact on CRD. In some population based cross-sectional studies the association between salt intake, bronchial symptoms [45] and asthma was found in children [46]. There where an improvement in pulmonary function with low salt diet [47] and promising results of trials on reduction of salt in exercise induced asthma [48]. Limitation of dietary sodium intake to less than 5 grams per day (Table 1) should take into account total sodium intake from all dietary sources, for example additives such as monosodium glutamate and preservatives. It's a difficult task to achieve since current salt consumption for instance in England is between 9-12 grams per day [49] however salt reduction policy is a key element of the WHO NCD Action Plan [3], practical recommendations for salt reduction technique [50] and part of the Fiscal Policies for diet and prevention of NCDs [51].

Fruits and Vegetables

Consumption of fruits and vegetable ≥ 400 g per day (Table 1) could be also justified for prevention of CRD possibly due to antioxidants/vitamins presence in fresh fruits and vegetables. A beneficial effect of fresh fruit consumption on symptoms,

lung function or asthma control has been observed in children and adults by several epidemiological studies [52-56]. The relationships between dietary patterns and lung function and Spiro metrically defined COPD were investigated in a cross-sectional study of 1,551 males and 1,391 females in UK. It was shown that a "Prudent" dietary pattern (high consumption of fruit, vegetables, oily fish and whole meal cereals) may protect against impaired lung function and COPD, especially in male smokers [57]. Almost 16 years follow up study of 72 043 US women (Nurse's Health Study) have demonstrated a negative association between a diet rich in fruit, vegetables and fish with the risk of COPD, whereas a positive association was found between a diet rich in refined grains, cured and red meats, desserts, and French fries [35].

Data collected from a large prospective cohort of 42,197 US men (Health Professionals Follow-up Study) have shown a negative association of the risk of newly diagnosed during 12 years COPD and diet rich in fruits, vegetables and fish. Diet rich in refined grains, cured and red meats, desserts and French fries may increase the risk of COPD [36]. 20 years follow up study in three European countries (Finland, Italy and The Netherlands) have demonstrated a protective effect of fruit against COPD among 2917 men aged 50-69 at baseline. A 100gramme increase in fruit intake was associated with 24% lower mortality risk [58] Statistical analysis of these long-term prospective studies has adjusted multiple risk factors, including smoking to demonstrate independent role of dietary factors in developing of COPD. These results also suggest that dietary antioxidants may modify the development of CRD in susceptible individuals. The low intake of dietary antioxidant vitamin C, validated by plasma level of vitamin C appears to be primarily associated with a diet deficient in fruit (citrus fruit) and significantly correlated with the number of cases of symptomatic asthma [15]. Dietary supplementation with vitamin C also significantly improves asthma control, pulmonary function and pulmonary inflammatory markers in children with moderate persistent asthma [59].

Non-Starch Polysaccharides

Wholegrain cereals, fruits and vegetables are the preferred sources of non-starch polysaccharides. Due to lack of data on the effect of dietary fiber on CRD and referring to the above mentioned studies on fruits, vegetable and whole grain associations with CRD we can assume that recommended consumption of fruits, vegetables and wholegrain foods is likely to provide >20g per day of non-starch polysaccharides (>25 g per day of total dietary fiber) [1]. This will probably have a protective effect on CRD.

Protein

High consumption of cured and red meat is typical for the "Western" dietary pattern. This pattern associated with the higher prevalence of COPD assumes a high animal protein diet. On the other hand, "Prudent" dietary pattern heavily loaded by a high consumption of fruits, vegetables, fish, poultry and whole grain products is associated with the lower prevalence of CRD [35,36]. Increasing soy consumption from the soybean products (tofu, natto, bean sprouts and soy milk drinks) was also associated with a decreased risk of COPD and breathlessness [60].

Obesity and Body Mass

Obesity control is a key element of the WHO Global NCDs Action Plan [3]. Classification of obesity, under - and overweight is seen in Table 3.

Classification	BMI (kg/m^2)	
	Principal cut-off points	**Additional cut-off points**
Underweight	**<18.50**	**<18.50**
Severe thinness	<16.00	<16.00
Moderate thinness	16.00 - 16.99	16.00 - 16.99
Mild thinness	17.00 - 18.49	17.00 - 18.49
Normal range	**18.50 - 24.99**	**18.50 - 22.99**
		23.00 - 24.99
Overweight	**≥25.00**	**≥25.00**
Pre-obese	25.00 - 29.99	25.00 - 27.49
		27.50 - 29.99
Obese	**≥30.00**	**≥30.00**
Obese class I	30.00 - 34-99	30.00 - 32.49
		32.50 - 34.99
Obese class II	35.00 - 39.99	35.00 - 37.49
		37.50 - 39.99
Obese class III	≥40.00	≥40.00

Table 3: The International Classification of adult underweight, overweight and obesity according to BMI*. *Body Mass Index (BMI) is a simple index of weight-for-height that is commonly used to classify underweight, overweight and obesity in adults. It is defined as the weight in kilograms divided by the square of the height in metres (kg/m^2). Source: Adapted from WHO, 1995, WHO, 2000 and WHO 2004 [61].

It appears to be associated with the increased prevalence of asthma and lower lung function in developed [62-65] and developing countries as well as in deprived populations [66-67]. Fast food restaurant attendance may be a risk factor for asthma [68]. Moreover, in asthma obesity is a risk factor for dyspnoea [69] and poor control of the disease (70). In COPD obesity is also proposed to be a risk factor for dyspnoea and the severity of the

disease [71]. Although the weight loss problem in the clinical cases of COPD stands beyond the main purpose of this article the population-based PNG could provide a synergistic effect along with the therapeutical management. Healthy diet principles are applied during the clinical treatment of other major NCD like e.g. cardiovascular and diabetes which are frequent co-morbidities of COPD patients [72].

Conclusion

Finally, NCDs mainly cardiovascular diseases, cancers, diabetes and CRD are the world's biggest killers causing an estimated 36 million deaths each year-63% of all deaths globally. Diet and nutrition are important factors in the prevention and maintenance of good health throughout the entire life course. Their role as determinants of major chronic NCDs is well established and they therefore occupy a prominent position in the WHO prevention and control activities [3]. Despite the fact that the role of dietary factors in developing of CRD is less convincing than for other NCDs like cardiovascular diseases, certain types of cancer and diabetes mellitus the reported associations in general do not contradict to existing ranges of the WHO population nutrient intake goals. Limited intake of total fat within the recommended range, restriction of salt consumption, adequate intake of fresh fruits and vegetables, weight control and attention to the processed food which can be recommended for the prevention of CRD are generally compatible with existing dietary recommendations for the control of major NCDs like cardiovascular diseases, certain types of cancer and diabetes mellitus. Nevertheless, more research is needed to better study the relationships between diet and CRD.

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