Adherence to the Nordic Nutrition Recommendations in a Nordic population with metabolic syndrome: high salt consumption and low dietary fibre intake (The SYSDIET study)

Svandis Erna Jonsdottir1*, Lea Brader2, Ingibjorg Gunnarsdottir1, Ola Kally Magnusdottir1, Ursula Schwab3,4,5, Marjukka Kolehmainen3, Ulf Risérus6, Karl-Heinz Herzig7,8, Lieselotte Cloetens9, Hannah Helgegren9,10, Anna Johansson-Persson9, Janne Hukkanen11,12, Kaisa Poutanen3,13, Matti Uusitupa3,4, Kjeld Hermansen2 and Inga Thorsdottir1

1Unit for Nutrition Research, Landspitali – The National University Hospital of Iceland and Faculty of Food Science and Nutrition, University of Iceland, Reykjavik, Iceland; 2Department of Medicine and Endocrinology MEA, Aarhus University Hospital, Aarhus, Denmark; 3School of Medicine, Institute of Public Health and Clinical Nutrition, University of Eastern Finland, Kuopio Campus, Kuopio, Finland; 4Research Unit, Kuopio University Hospital, Kuopio, Finland; 5Institute of Clinical Medicine, Internal Medicine, Kuopio University Hospital, Kuopio, Finland; 6Department of Public Health and Caring Sciences, Clinical Nutrition and Metabolism, Uppsala University, Uppsala, Sweden; 7Department of Physiology, Institute of Biomedicine and Biocenter of Oulu, University of Oulu, Oulu, Finland; 8Department of Psychiatry, Kuopio University Hospital, Kuopio, Finland; 9Biomedical Nutrition, Pure and Applied Biochemistry, Lund University, Lund, Sweden; 10Department of Clinical Nutrition, Skåne University Hospital, Lund, Sweden; 11Department of Internal Medicine, Institute of Clinical Medicine, University of Oulu, and Biocenter Oulu, Oulu, Finland; 12Oulu University Hospital, Oulu, Finland; 13VTT Technical Research Centre of Finland, Espoo, Finland

Abstract

Background: The Nordic countries collaborate in setting recommendations for intake of nutrients by publishing the Nordic Nutrition Recommendations (NNR). Studies exploring how well the Nordic population adheres to the NNR are limited and none are available for the metabolic syndrome (MetS) subgroup. Individuals with MetS are a large part of the adult Nordic population and their diet’s nutritional quality is of great importance as it can affect the progression of MetS.

Objective: To evaluate nutritional intake in a cohort of Nordic adults with MetS or MetS risk factors and their adherence to the NNR.

Design: A multi-centre study was carried out in six centres in four Nordic countries (SYSDIET CoE). Participants (n = 175) were 30–65 years of age, with BMI 27–38 kg/m² and had at least two criteria for MetS. The NNR was used to evaluate the baseline nutrient intake calculated from the participants’ 4-day food diaries using national nutrient databases.

Results: Less than 20% of participants consumed ≤10 E% from saturated fat as recommended in the NNR. Recommended intake (RI) of polyunsaturated fat was met by approximately one-third of participants. Only 20% of men and 26% of women met the RI of dietary fibre. Intake below the defined lower intake level of 2.5 µg/day for vitamin D was observed in nearly 20% of participants. The daily median intake of salt was 8.8 g for men and 6.7 g for women.

Conclusion: Dietary quality of this Nordic population with MetS or MetS risk factors is unsatisfactory and characterised by high intakes of SFA and sodium and low intakes of PUFA and dietary fibre. Vitamin D...
intake was below RI level in a large part of the population. Authorities in the Nordic countries are encouraged to develop intervention programmes for high-risk groups.

Keywords: diet records; dietary fibre; guideline adherence; metabolic syndrome; multicenter study; sodium; dietary
fasting triglycerides > 3.0 mmol/l, total cholesterol > 6.5 mmol/l, and blood pressure > 160/100 mmHg. Despite of the BMI criteria, few study participants with BMI between 38 and < 40 kg/m\(^2\) were accepted due to high commitment to the trial. The intervention protocol, including the inclusion and exclusion criteria, has been described previously (23). Figure 1 illustrates the participant flow for the present study. Completed diet records were returned by 175 participants – 60 men and 115 women.

**Dietary assessment**

Dietary assessment was conducted in the run-in period of the SYSDIET study, where participants were instructed to maintain their usual diet. Diet and nutrient intake were assessed by diet records where participants were instructed to record all food and drink consumed for four consecutive days, including one weekend day. Food intake was reported either as weight or portion size. Supplementation and plant stanol/steol containing products intake if any, was to be discontinued at least 4 weeks prior to entering the study, with the exception that Icelandic participants could continue intake of vitamin D supplements providing they kept it unchanged. The vitamin D supplementation was not included in the nutrient calculations. Participants received both written and oral instructions on how to fill in the diet records and were provided with electronic household scales or valid standardised household measure information on how to give information about the amount of food consumed.

Local nutrient calculating programmes, supported by the national databases (Table 1) were used to estimate energy and nutrient intake. The nutrient databases are comparable, use EuroFIR definitions for chemicals (24), determine dietary fibres by the AOAC methods and define added sugar as refined or industrially manufactured sucrose and other sugars, eventually in the form of an ingredient in a food (25–28). The same energy conversion factors of energy-providing nutrients were used in all four databases: 4 kcal/g for protein and (available) carbohydrates, 2 kcal/g for dietary fibre, 9 kcal/g for fat, and 7 kcal/g for alcohol. Sodium was transformed to salt by multiplying by 2.54.

The Nordic reference values (NRVs) for energy intake (EI) and recommended macronutrient intake for adults were used to evaluate the dietary intake. Intake of four vitamins (vitamins C, D, E, and folate) and four minerals (calcium, magnesium, potassium, and sodium) was estimated and compared to the recommended intake (RI) (22). These micronutrients were chosen by the SYSDIET management team and considered to be especially relevant for the Nordic diet. Furthermore, the Nordic nutrient databases were considered to give adequate and comparable information on these selected micronutrients. For nutrients with established estimates of average requirement (AR) (vitamins C, E, and folate), AR was used to assess the risk of inadequate intake. Proportion of the population not meeting the lower level of intake (LI) of micronutrients or exceeding the upper intake level (UL) was also assessed (22).

**Low-energy reporting**

Height of participants was measured in a standing position in the morning to the nearest 0.5 cm. Body weight was recorded to one decimal place, using calibrated electronic scales while the subject wore light indoor clothing without shoes. Low-energy reporting was evaluated using the Goldberg cut-off 2 (29, 30), comparing the ratio of mean EI and calculated basal metabolic rate (BMR). Harris–Benedict (HB) equations (31) were used to estimate BMR. Ideal body weight (IBW) was calculated using the method proposed by
Biochemical measurements and body composition

Biochemical measurements were all completed locally at each centre, except for fasting plasma insulin, which was analysed at the Aarhus University Hospital using the ELISA method. Automated clinical chemistry analysers and routine clinical chemistry methods were used to measure concentrations of fasting plasma glucose and fasting serum triglycerides, total cholesterol and HDL-cholesterol. Fasting LDL-cholesterol levels were calculated (37). Blood pressure was measured by trained personnel using automatic blood pressure devices. Where possible, blood pressure was measured on the right arm of participants after 10 min rest in a sitting position. The average blood pressure of two or three measurements was recorded with the accuracy of 1 mm Hg. Waist circumference was measured midway between the lower rib and iliac crest. Body composition was determined by bioelectrical impedance analysis. Staff at each centre was trained to perform the measurements according to the standard operational procedures agreed by all centres. Clinical and biochemical measurements have been previously described (23).

The SYSDIET questionnaire on socio-demographic factors and lifestyle habits

Participants answered questionnaires on socio-demographic factors, health status, physical exercise, and other lifestyle habits. They were asked about age, marital status, education, profession, and their subjective health status (good, average, or poor). They were provided with a list of diseases and asked to mark (yes/no) if they had been diagnosed with them. They were also asked to provide detailed information about all regular medication. Participants were asked questions on PA at work, commuting and during leisure time. One PA question focused on how many times per week the participants performed fitness training for ≥30 min (≥4 times/week; 2–3 times/week; 1 time/week; 2–3 times/month; <2 times/month). These questions have been used previously to assess PA (38–41), especially in evaluating if PA is held constant among participants during an intervention study.

Data pooling and analysis

All SYSDIET centres entered their data into Microsoft Office Excel 2007 (Windows) prior to pooling the data in a joint centralised database maintained by VTT Technical Research Centre of Finland. Data were exported from the database and imported to SPSS (Statistical Package for the Social Sciences) for Windows, version 20.0 (SPSS Inc., Chicago, IL) for statistical analyses.

Normality of variables was checked by visual inspection and by using the Kolmogorov-Smirnov test. Variables are described as means and standard deviations (SD) or medians and interquartile range (IQR).

Independent sample t-tests were used to compare anthropometric and biochemical data and nutrient intake between genders and adequate reporters versus low-energy reporters when variables were normally distributed, whereas Mann–Whitney’s U test was applied if variables had non-normal distribution. Pearson’s Chi-square test or Fisher’s exact test (if expected frequencies <5), were used to test for differences in frequency distributions between genders, and also between low-energy reporting men/women versus adequately reporting men/women, in relation to marital status (cohabitation or not), education (university level vs. lower education), profession (manual labour vs. sedentary work), smoking habits (never smoked/ceased smoking vs. smoke regularly/occasionally), blood lipid-lowering medication, hypertension treatment or antidepressant medication (taking medication vs. not) and PA (participants exercising ≥4 times a week for ≥30 min vs. less PA). P <0.05 was regarded as significant in all analysis.

Results

Characteristics of participants returning adequate diet records at baseline (n = 146) are shown in Table 2. Of the 146 participants, all but one man had elevated waist circumference according to the IDF criteria (2). Additionally, 29% had elevated triglyceride, 33% had reduced HDL cholesterol, 57% had elevated blood pressure, and 61% had elevated fasting glucose. Furthermore, 52% were treated for hypertension, 23% were on blood lipid-lowering medication but none were treated for T2D as it was an exclusion criterion. When asked to rate their own health, 115 of the 146 participants responded, with 55% rating their health as good, 44% as average and one individual as poor.

The percentage of low-energy reporters was 17%, 23% for men and 13% women, respectively. Low EI reporting men had significantly higher (P =0.043) BMI than adequate intake reporters (33 kg/m² vs. 31 kg/m²). Low EI reporting women reported more frequent PA than adequately reporting women, with 36% of low EI reporters...
Table 2. Characteristics of participants returning adequate diet records at baseline

| Characteristics       | Men (n = 46) | Women (n = 100) | P       |
|-----------------------|--------------|-----------------|---------|
| Age (years)           | 55.0 (8.5)   | 55.0 (8.3)      | 0.985   |
| Weight (kg)           | 99.9 (10.7)  | 85.9 (11.4)     | <0.001  |
| Waist circumference (cm) | 109.9 (8.3)  | 101.0 (8.5)     | <0.001  |
| BMI (kg/m²)           | 31.1 (2.8)   | 31.9 (3.6)      | 0.130   |
| Body fat (%)          | 31.6 (6.2)   | 43.0 (4.4)      | <0.001  |
| Systolic BP (mm Hg)   | 136 (15)     | 127 (15)        | 0.001   |
| Diastolic BP (mm Hg)  | 84 (11)      | 80 (10)         | 0.053   |
| Total cholesterol (mmol/l) | 5.0 (0.9)   | 5.4 (0.9)       | 0.038   |
| LDL (mmol/l)          | 3.1 (0.8)    | 3.3 (0.9)       | 0.379   |
| HDL (mmol/l)          | 1.2 (0.3)    | 1.5 (0.4)       | <0.001  |
| Triglyceride (mmol/l) | 1.4 (0.8)    | 1.3 (1.0)       | 0.232   |
| Glucose (mmol/l)      | 5.8 (0.7)    | 5.7 (0.6)       | 0.287   |
| Insulin (pmol/l)      | 58.0 (43.0)  | 50.0 (39.0)     | 0.203   |
| Married/cohabitating (%) | 82.5       | 69.7            | 0.126   |
| University education (%) | 25.8       | 13.0            | 0.106   |
| Sedentary work (%)    | 88.4         | 96.7            | 0.110   |
| Smokers (%)           | 10.9         | 10.0            | 1.000   |
| Antidepressants (%)   | 9.8          | 10.6            | 1.000   |

Values are mean (SD) unless otherwise indicated.

BMI, body mass index; BP, blood pressure; LDL, low-density lipoprotein; HDL, high-density lipoprotein.

aMedians and interquartile range. bSmoking regularly or occasionally.

Discussion

The results of the present study of a Nordic adult population with MetS or at risk of developing MetS showed that the intake of SFA and sodium was higher and dietary fibre and PUFA intake was lower than recommended. In fact, >65% of the participants did not meet the recommendations (22) on SFA, PUFA, dietary fibre and sodium. About 20% of the participants had vitamin D intake below LI, possibly putting them at risk for developing diseases attributed to vitamin D deficiency symptoms (43). Another noteworthy result was the relatively high alcohol consumption observed among men and the gender difference in alcohol consumption seen amongst the participants in this cohort.
Vitamin D supplementation is commonly recommended in the Nordic countries due to lack of sun exposure (44, 45). Women planning on becoming pregnant are often recommended folate supplements (22, 45). Supplements were not included in the nutrient calculations and were supposed to be discontinued before the diet recording with the exception of vitamin D supplements in Iceland. Consequently, the total micronutrient intake might be somewhat underestimated in the population studied. In general, baseline nutrient intake in the SYSDIET study is in line with recent national surveys in the participating countries (45/C148).

As the prevalence of MetS is increasing, the present study group is a highly relevant study group of adults in Westernised countries with an elevated risk of developing CVD and T2D. A balanced whole diet of adequate nutrient and food intake is of specific interest and importance in this risk group (49/C151). The decision to develop joint NNR emerged not only from the geographical location of the Nordic countries but also from the similarities shared in dietary habits as well as in the prevalence of diet-related diseases, such as CVD, obesity, and T2D (3, 22).

Due to the design and aim of the study, all of the participants were overweight or obese, a large proportion had hypertension and elevated concentrations of plasma glucose. Furthermore, average lipid values were similar to previously reported results for people with MetS (52, 53). Some SYSDIET participants may have received dietary advice due to these elevated risk factors prior to the participation in the study. Thus, it is possible that this resulted in an underestimation of the poor adherence to dietary recommendations observed in this population. The present data may be useful in future Nordic prevention programmes of MetS, for example, identifying those nutrient targets that need special intervention.

This study revealed insufficient dietary fat quality in the study population. The contribution of SFA to total EI was above the RI level in about 80% of the participants. Replacement of SFA with PUFA in particular can improve the risk profile in the MetS (54) and lower the risk of CHD. In a meta-analysis by Mozaffarian et al. (49) researchers found 19% reduced risk of CHD events for intervention groups consuming on average 15% of total energy from PUFA, compared with the control groups with only 5% of total EI from PUFA. Thus, for each 5% increase in the proportion of energy obtained from PUFA when substituting SFA, the risk of CHD events was reduced by 10% (49). Higher intake of dietary fibre has been associated with lower risk for MetS, T2D, and CVD in high-risk populations (55/C158). Two recent studies indicate that improved fat quality and fibre intake through the consumption of healthy Nordic food can play an important role in decreasing the risk of chronic disease (59, 60).

Due to the design and aim of the study, all of the participants were overweight or obese, a large proportion had hypertension and elevated concentrations of plasma glucose. Furthermore, average lipid values were similar to previously reported results for people with MetS (52, 53). Some SYSDIET participants may have received dietary advice due to these elevated risk factors prior to the participation in the study. Thus, it is possible that this resulted in an underestimation of the poor adherence to dietary recommendations observed in this population. The present data may be useful in future Nordic prevention programmes of MetS, for example, identifying those nutrient targets that need special intervention.

This study revealed insufficient dietary fat quality in the study population. The contribution of SFA to total EI was above the RI level in about 80% of the participants. Replacement of SFA with PUFA in particular can improve the risk profile in the MetS (54) and lower the risk of CHD. In a meta-analysis by Mozaffarian et al. (49) researchers found 19% reduced risk of CHD events for intervention groups consuming on average 15% of total energy from PUFA, compared with the control groups with only 5% of total EI from PUFA. Thus, for each 5% increase in the proportion of energy obtained from PUFA when substituting SFA, the risk of CHD events was reduced by 10% (49). Higher intake of dietary fibre has been associated with lower risk for MetS, T2D, and CVD in high-risk populations (55-58). Two recent studies indicate that improved fat quality and fibre intake through the consumption of healthy Nordic food can play an important role in decreasing the risk of chronic disease (59, 60). More than half of the population studied was in treatment for hypertension. Given the known association between sodium (salt) intake and blood pressure, the high sodium intake in the present study is alarming. Lowering salt intake has been shown to decrease blood pressure in MetS subjects (61). Lower salt intake has also been shown to contribute to blood pressure reduction in hypertensive participants receiving the current treatment.
| Micronutrients | RI      | AR      | LI      | Men (n = 46) | Women (n = 100) | P  |
|---------------|---------|---------|---------|--------------|-----------------|----|
|               | Median (IQR) | Below/above R1% | Below AR% | Below LI% | Median (IQR) | Below/above R1% | Below AR% | Below LI% |
| Vitamin C (mg) | 75      | 60/50<sup>b</sup> | 10      | 89.0 (71.0) | 35             | 24           | 2          | 104.0 (78.8) | 28             | 11           | 0 | 0.159 |
| Vitamin D (μg) | 7.5/10<sup>e</sup> | – | 2.5<sup>d</sup> | 5.8 (6.7) | 65             | –           | 17         | 5.0 (5.8)    | 74             | –           | 19 | 0.262 |
| Vitamin E (mg) | 10/8<sup>h,*</sup> | 6/5<sup>h,*</sup> | 4/3<sup>h,*</sup> | 8.8 (4.5) | 65             | 15          | 0          | 8.8 (4.4)    | 40             | 5           | 0 | 0.898 |
| Folate (μg)    | 300/400<sup>f</sup> | 200 | 100     | 289.5 (161.5) | 52             | 13          | 0          | 265.5 (110.3) | 71             | 17          | 0 | 0.272 |
| Calcium (mg)   | 800     | – | 400     | 1061.7 (659.3) | 24             | –           | 0          | 860.5 (430.1) | 42             | –           | 5 | 0.001 |
| Magnesium (mg) | 350/280<sup>b</sup> | – | –       | 385.0 (209.5) | 39             | –           | 0          | 325.8 (125.2) | 26             | –           | – | 0.001 |
| Potassium (mg) | 3500/3100<sup>b</sup> | – | 1600    | 3588.0 (1814.7) | 48             | –           | 0          | 3221.5 (1298.7) | 45             | –           | 0 | 0.003 |
| Sodium (mg)    | <2800/<2400<sup>b</sup> | – | 575     | 3460.2 (1155.4) | 83<sup>a</sup> | –           | 0          | 2624.5 (947.5) | 65<sup>a</sup> | –           | 0 | <0.001 |

Reference values not defined in NNR (22).
P values refer to the difference in micronutrient intake between genders.
NRV: Nordic reference values; RI: recommended intake; AR: average requirement; LI: lower level of intake; IQR: interquartile range.
<sup>a</sup>Percentage of participants above the recommendations for sodium.
<sup>b</sup>Reference values for men/women.
<sup>c</sup>The lower RI value for vitamin D applies to people 31–60 years old and the higher RI value applies to people 61–74 years old.
<sup>d</sup>The LI for vitamin D is primarily set for individuals >60 years of age, but percentage and numbers of all men and women below the LI are presented.
<sup*e</sup>α-Tocopherol equivalents (α-TE = 1 mg RRR-α-tocopherol).
<sup>f</sup>Women of reproductive age are recommended an intake of 400 μg folate/day. 300 μg was used as a reference value for all men and women older than 50 years but 400 μg was used as a reference value for women younger than 50 years.
medical therapy (62) and could decrease the risk of stroke and CHD (63).

Of the investigated vitamins and minerals, vitamin D intake was most frequently below RI for both genders with 65% of men and 74% of women not reaching the current RI of 7.5 mg/day. Nearly 20% of participants had an intake below LI for vitamin D. Vitamin D has gained a lot of attention with low levels of intake as well as low serum 25-hydroxyvitamin D being associated with several health risks besides low bone density traditionally related to vitamin D deficiency (64, 65). The fact that a considerable proportion of the participants had calcium intake below RI and 5% of the women had intake below LI, needs special attention in the population studied.

In the present study, the same inclusion criteria and the same method for dietary assessment were used in all six centres in the four Nordic countries. The need for comparable data on nutrient intake across Europe has been recognised as a task hampered by difficulties, complicated by the diverse study methodologies and varying purposes between studies (66). This multi-centre study carried out with comparable methodology is therefore an important step toward this goal. The present study gives novel and valuable information on the nutritional status of this cross-Nordic study group of people with MetS or MetS risk factors.

The NRV are primarily valid to assess intake on a group level. Comparison with reference values can only give some indication on whether the intake is adequate, but this does not mean that the requirements are met for each individual (22). Inherent errors related to the use of nutrient databases are unavoidable (17, 67). Accurate estimation of energy requirements using low-cost solutions like prediction equations are needed, but currently there is no consensus regarding this topic, especially when estimating the energy needs for obese individuals (68). Therefore, the limitations inherent with prediction equations such as HB apply here (68, 69). However, it is unlikely that application of other equations for the estimation of low-energy reporting would change our main findings and conclusions of considerably higher than recommended salt intake and low dietary fibre intake. The gender division in the current study is about one-third males and two-thirds females. In recent Finnish and Swedish population-based studies, the MetS prevalence was somewhat higher in men than women (9, 70). For better representativeness of our study population, a higher ratio of men would have been preferable. Higher numbers of participants and the addition of participants from the other Nordic countries would have given these results further value and generalisability to the remainder of the Nordic MetS population. However, there is no reason to assume that the nutritional intake of individuals with MetS would have been much different in other areas in the Nordic countries.

In conclusion, the dietary quality of this Nordic population with Mets or MetS risk factors is unsatisfactory and is characterised by high intakes of SFA and sodium and low intakes of PUFA and dietary fibre. Vitamin D intake estimated from the diet records was below RI level in a large part of the population. The low adherence to nutrition recommendations is likely to further perpetuate these high-risk individuals in developing T2D and CVD. Health providers should pay special attention to dietary assessments and should adequately educate these risk groups about the potential consequences of their nutritional intake toward the development of T2D and CVD. Authorities in the Nordic countries are encouraged to develop intervention programmes for high-risk groups. It seems relevant to

### Table 5. Baseline nutrient density of micronutrients compared to the recommended nutrient density given in NNR

| Energy density of micronutrients | Men (n = 46) | Women (n = 100) | P | Recommended nutrient densitya |
|----------------------------------|-------------|-----------------|---|-------------------------------|
| Vitamin C (mg/MJ)b               | 9.3 (8.1)   | 13.0 (11.3)     | 0.001 | 8                             |
| Vitamin D (µg/MJ)b               | 0.6 (0.6)   | 0.6 (0.7)       | 0.768 | 1.0                           |
| Vitamin E (mg/MJ)                | 0.9 (0.3)   | 1.1 (0.4)       | <0.001 | 0.9                           |
| Folate (µg/MJ)b                  | 29.2 (14.7) | 32.9 (12.4)     | 0.030 | 45                            |
| Calcium (mg/MJ)                  | 114.7 (45.4)| 110.0 (40.1)    | 0.528 | 100                           |
| Magnesium (mg/MJ)                | 40.0 (11.3) | 41.5 (10.5)     | 0.443 | 35                            |
| Potassium (mg/MJ)                | 393.4 (112.4)| 415.0 (118.9)   | 0.302 | 350                           |
| Sodium (mg/MJ)                   | 353.9 (81.0)| 330.9 (72.7)    | 0.090 | –                             |

Reference value not defined in the Nordic Nutrition Recommendations (NNR) (22).
P values refer to the difference in energy density of micronutrient intake between genders.

aRecommended nutrient density in NNR (22), to be used for planning diets for groups of individuals 6–60 years of age with heterogeneous age and sex distribution.

bMedians and interquartile range.
implement programmes of guidelines and tests of their effects for people with Mets or MetS risk factors in the Nordic countries.

Acknowledgements

The authors express gratitude to the participants taking part in the study.

The authors thank Cindy Mari Imai for proofreading the article.

Conflict of interest and funding

The SYSDIET study was one of three projects in the Nordic Centre of Excellence Programme on Food, Nutrition and Health funded by NordForsk for years 2007–2012 (no: 070014). This study was also funded by the Academy of Finland, Danish Diabetes Research Foundation, The Sigrid Juselius Foundation, and EVO funding from Kuopio University Hospital (Finland); the Druvan Foundation, ESPEN, Skåne County Council Research and Development Foundation, Swedish Council for Working Life and Social Research, The Heart–Lung Foundation, Diabetesfonden and Foundation Cerealia (Sweden); The Danish Obesity Research Centre (DanORC, www.danorc.dk), The Danish Council for Strategic Research (DairyHealth, BioFunCarb) (Denmark); and The Agricultural Productivity Fund (Iceland).

References

1. Astrup A. Healthy lifestyles in Europe: prevention of obesity and type II diabetes by diet and physical activity. Public Health Nutr 2001; 4: 499–515.
2. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. Circulation 2009; 120: 1640–5.
3. OECD. Health at a glance: Europe 2012: OECD Publishing. http://ec.europa.eu/health/reports/docs/health_glance_2012_en.pdf [cited 3 January 2013].
4. Aspélund T, Gudnason V, Magnusdottir BT, Andersen K, Sigurdsson G, Thorsson B, et al. Analysing the Large Decline in Coronary Heart Disease Mortality in the Icelandic Population Aged 25–74 between the Years 1981 and 2006. PLoS One 2010; 5: e13957.
5. Hildrum B, Myklebust A, Hole T, Midthjell K, Dahl AA. Age-specific prevalence of the metabolic syndrome defined by the International Diabetes Federation and the National Cholesterol Education Program: the Norwegian HUNT 2 study. BMC Public Health 2007; 7: 220.
6. Sundstrom J, Riserus U, Byberg L, Zethelius B, Lithell H, Lind L. Clinical value of the metabolic syndrome for long term prediction of total and cardiovascular mortality: prospective, population-based cohort study. BMJ 2006; 332: 878–82.
7. Miettola J, Nykanen I, Kumpusalo E. Health views and metabolic syndrome in a Finnish rural community: a cross-sectional population study. Can J Rural Med 2012; 17: 10–6.
8. Stensvold D, Nauman J, Nilsen TIL, Wisloff U, Slordahl SA, Vatten L. Even low level of physical activity is associated with reduced mortality among people with metabolic syndrome, a population based study (the HUNT 2 study, Norway). BMC Med 2011; 9. http://www.biomedcentral.com/content/pdf/1741-7015-9-109.pdf.
9. Pajunen P, Rissanen H, Harkanen T, Jula A, Reunanen A, Salomaa V. The metabolic syndrome as a predictor of incident diabetes and cardiovascular events in the Health 2000 Study. Diabetes Metab 2010; 36: 395–401.
10. Ezzati M, Lopez AD, Rodgers A, Vander Hoorn S, Murray CJ. Selected major risk factors and global and regional burden of disease. Lancet 2002; 360: 1347–60.
11. World Health Organization (2009). 2008–2013 action plan for the global strategy for the prevention and control of noncommunicable diseases. Geneva: World Health Organization.
12. World Health Organization (WHO). Cardiovascular diseases (CVDs). Fact sheet N°317. Geneva: World Health Organization. http://www.who.int/mediacentre/factsheets/fs317/en/; 2011 [cited 4 January 2013].
13. Khaw KT, Wareham N, Bingham S, Welch A, Luben R, Day N. Combined impact of health behaviours and mortality in men and women: the EPIC-Norfolk prospective population study. PLoS Med 2008; 5: e12.
14. World Health Organization (2003). Diet, nutrition, and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation. Geneva. World Health Organ Tech Rep Ser 916: i–viii, 1–149.
15. Jonsdottir S, Hughes R, Thorsdottir I, Yngve A. Consensus on the competencies required for public health nutrition workforce development in Europe – the JobNut project. Public Health Nutr 2011; 14: 1439–49.
16. Jonsdottir S, Thorsdottir I, Kugelberg S, Yngve A, Kennedy NP, Hughes R. Core functions for the public health nutrition workforce in Europe: a consensus study. Public Health Nutr 2012; 15: 1999–2004.
17. Slimani N, Deharveng G, Unwin I, Southgate DA, Vignat J, Skrie G, et al. The EPIC nutrient database project (ENDB): a first attempt to standardize nutrient databases across the 10 European countries participating in the EPIC study. Eur J Clin Nutr 2007; 61: 1037–56.
18. Brussaard JH, Lowik MR, Steingrimsdottir L, Moller A, Kearney J, De Henauw S, et al. A European food consumption survey method – conclusions and recommendations. Eur J Clin Nutr 2002; 56(Suppl 2): 889–94.
19. Ramel A, Martinez JA, Kiely M, Bandarra NM, Thorsdottir I. Moderate consumption of fatty fish reduces diastolic blood pressure in overweight and obese European young adults during energy restriction. Nutrition 2010; 26: 168–74.
20. Kyro C, Skeie G, Dragsted LO, Christensen J, Overvad K, Hallmans G, et al. Intake of whole grain in Scandinavia: intake, sources and compliance with new national recommendations. Scand J Public Health 2012; 40: 76–84.
21. Zamora-Ros R, Knaze V, Lujan-Barroso L, Kuhle GG, Mulligan AA, Toullaud M, et al. Dietary intakes and food sources of phytoestrogens in the European Prospective Investigation into Cancer and Nutrition (EPIC) 24-hour dietary recall cohort. Eur J Clin Nutr 2012; 66: 932–41.
22. Nordic Nutrition Recommendations 2004: integrating nutrition and physical activity. 4th ed. Copenhagen: Nordic Council of Ministers; 2004.
23. Uusitupa M, Hermansen K, Savolainen MJ, Schwab U, Kolehmainen M, Brader L, et al. Effects of an isocaloric healthy Nordic diet on insulin sensitivity, lipid profile and inflammation markers in metabolic syndrome – a randomized study (SYS-DIET). J Intern Med 2013; 274: 52–66.
24. European Food Information Resource (EuroFIR). http://www.eurofir.eu; [cited 19 January 2013].
25. The Icelandic Food Composition Database (ISGEM). http://www.matix.is/ISGEM/en/; [cited 19 January 2013].
26. National Food Institute – Technical University of Denmark (DTU). Danish Food Composition Database – version 7.1. March 2009. http://www.foodcomp.dk/v7/foodb_default.asp; [cited 19 January 2013].
27. Livsmedelsverket – the National Food Agency. Livsmedelsdatabasen. http://www.slv.se/en-gb; [cited 19 January 2013].
28. National Institute for Health and Welfare. Fineli – Finnish Food Composition Database. http://www.fineli.fi; [cited 19 January 2013].
29. National Institute for Health and Welfare. Fineli – Finnish Food Composition Database. http://www.fineli.fi; [cited 19 January 2013].
30. Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Harris JA, Benedict FG. A biometric study of human basal metabolism. Proc Natl Acad Sci USA 1918; 4: 370.
31. Goldberg GR, Black AE, Jebb SA, Cole TJ, Murgatroyd PR, Coward WA, et al. Critical-evaluation of energy-intake data using fundamental principles of energy physiology: 1. Derivation of cutoff limits to identify under-recording. Eur J Clin Nutr 1991; 45: 569-81.
32. Harris IA, Benedict FG. A biometric study of human basal metabolism.Proc Natl Acad Sci USA 1918; 4: 370-3.
33. Hamwi GJ. Therapy: changing dietary concepts. In: Danowski TS, ed. Diabetes mellitus: diagnosis and treatment. New York: American Diabetes Association; 1964, 73-8.
34. Black AE, Coward WA, Cole TJ, Prentice AM. Human energy expenditure in affluent societies: an analysis of 574 doubly-labelled water measurements. Eur J Clin Nutr 1996; 50: 72-92.
35. Black AE. Critical evaluation of energy intake using the Goldberg cut-off for energy intake: basal metabolic rate. A practical guide to its calculation, use and limitations. Int J Obes Relat Metab Disord 2000; 24: 1119-30.
36. Luhrmann PM, Herbert BM, Neuhauser-Berthold M. Under-reporting of energy intake in an elderly German population. Nutrition 2001; 17: 912-6.
37. Friedewald WT, Levy RI, Fredrickson DS. Estimation of the Goldberg cut-off for energy intake: basal metabolic rate. A practical guide to its calculation, use and limitations. Int J Obes Relat Metab Disord 2000; 24: 1119-30.
38. Lankinen M, Schwab U, Kolehmainen M, Paananen J, Poutanen K, Mykkanen H, et al. Whole grain products, fish and bilberries alter glucose and lipid metabolism in a randomized controlled trial. The Nordic Diet Study. PLoS Med 2011; 8: e1000252.
39. Pork General Nutrition Council. Dietary fiber and nutrient density are inversely associated with the metabolic syndrome in US adolescents. J Am Diet Assoc 2011; 111: 1688-95.
40. Pork General Nutrition Council. Dietary fiber in the prevention and treatment of metabolic syndrome: a review. Crit Rev Food Sci Nutr 2008; 48: 905-12.
41. Pajunen P, Kotronen A, Korpi-Hyovalti E, Keinanen-Kiukaanniemi S, Oksa H, Niskanen L, et al. Metabolically healthy and unhealthy obesity phenotypes in the general population: the FIN-D2D Survey. BMC Public Health 2011; 11: 754.
42. Pork General Nutrition Council. Eating behavior in the prevention and treatment of metabolic syndrome: a review. Crit Rev Food Sci Nutr 2008; 48: 905-12.
43. Pork General Nutrition Council. Eating behavior in the prevention and treatment of metabolic syndrome: a review. Crit Rev Food Sci Nutr 2008; 48: 905-12.
58. Weickert MO, Pfeiffer AF. Metabolic effects of dietary fiber consumption and prevention of diabetes. J Nutr 2008; 138: 439-42.

59. Adamsson V, Reumark A, Fredriksson IB, Hammarstrom E, Vessby B, Johansson G, et al. Effects of a healthy Nordic diet on cardiovascular risk factors in hypercholesterolaemic subjects: a randomized controlled trial (NORDIET). J Intern Med 2011; 269: 150-9.

60. Olsen A, Egeberg R, Halkjaer J, Christensen J, Overvad K, Tjonneland A. Healthy aspects of the Nordic diet are related to lower total mortality. J Nutr 2011; 141: 639-44.

61. Chen J, Gu D, Huang J, Rao DC, Jaquish CE, Hixson JE, et al. Metabolic syndrome and salt sensitivity of blood pressure in non-diabetic people in China: a dietary intervention study. Lancet 2009; 373: 829-35.

62. Frisoli TM, Schmieder RE, Grodzicki T, Messerli FH. Salt and hypertension: is salt dietary reduction worth the effort? Am J Med 2012; 125: 433-9.

63. Mozaffarian D, Appel LJ, Van Horn L. Components of a cardioprotective diet: new insights. Circulation 2011; 123: 2870-91.

64. Heaney RP. Vitamin D in health and disease. Clin J Am Soc Nephrol 2008; 3: 1535-41.

65. Holick MF, Chen TC. Vitamin D deficiency: a worldwide problem with health consequences. Am J Clin Nutr 2008; 87: 1080S-6S.

66. Vinas BR, Barba LR, Ngo J, Gurinovic M, Novakovic R, Cavelaars A, et al. Projected prevalence of inadequate nutrient intakes in Europe. Ann Nutr Metab 2011; 59: 84-95.

67. Poslusna K, Ruprich J, de Vries JHM, Jakubikova M, van’t Veer P. Misreporting of energy and micronutrient intake estimated by food records and 24 hour recalls, control and adjustment methods in practice. Brit J Nutr 2009; 101: S73-85.

68. Frankenfield D, Roth-Yousey L, Compler C. Comparison of predictive equations for resting metabolic rate in healthy nonobese and obese adults: a systematic review. J Am Diet Assoc 2005; 105: 775-89.

69. Elizabeth Weekes C. Controversies in the determination of energy requirements. Proc Nutr Soc 2007; 66: 367-77.

70. Novak M, Bjorck L, Welin L, Welin C, Manhem K, Rosengren A. Gender differences in the prevalence of metabolic syndrome in 50-year-old Swedish men and women with hypertension born in 1953. J Hum Hypertens 2013; 27: 56-61.

*Svandis Erna Jonsdottir*
Unit for Nutrition Research
Landspitali – The National University Hospital of Iceland
Eiríksgata 29
IS-101 Reykjavik, Iceland
Tel: +354 543 8410
Fax: +354 543 4824
Email: svandjo@landspitali.is