

## **Reported food intake and distribution of body fat: A repeated cross-sectional study**

Benno Krachler<sup>1,2,§</sup>, Mats Eliasson<sup>3,4</sup>, Hans Stenlund<sup>5</sup>, Ingegerd Johansson<sup>6</sup>, Göran Hallmans<sup>7</sup>, Bernt Lindahl<sup>2</sup>

<sup>1</sup>Department of Medicine, Kalix Hospital, Kalix, Sweden,

<sup>2</sup>Behavioural Medicine, Public Health and Clinical Medicine, Umeå University, Umeå, Sweden

<sup>3</sup>Department of Medicine, Sunderby Hospital, Luleå, Sweden

<sup>4</sup>Medicine, Public Health and Clinical Medicine, Umeå University, Umeå, Sweden

<sup>5</sup>Epidemiology and Public Health Sciences, Umeå University, Umeå, Sweden

<sup>6</sup>Odontology, Cariology, Umeå University, Umeå, Sweden

<sup>7</sup>Nutrition Research, Public Health and Clinical Medicine, Umeå University, Umeå, Sweden

<sup>§</sup>Corresponding author

Email addresses:

BK: [benno.krachler@medicin.umu.se](mailto:benno.krachler@medicin.umu.se)

ME: [Mats.Eliasson@nll.se](mailto:Mats.Eliasson@nll.se)

HS: [hans.stenlund@epiph.umu.se](mailto:hans.stenlund@epiph.umu.se)

IJ: [Ingegerd.Johansson@odont.umu.se](mailto:Ingegerd.Johansson@odont.umu.se)

GH: [goran.hallmans@nutrires.umu.se](mailto:goran.hallmans@nutrires.umu.se)

BL: [bernt.lindahl@medicin.umu.se](mailto:bernt.lindahl@medicin.umu.se)

## **Abstract**

### **Background**

Body mass, as well as distribution of body fat, are predictors of both diabetes and cardiovascular disease. In Northern Sweden, despite a marked increase in average body mass, prevalence of diabetes was stagnant and myocardial infarctions decreased. A more favourable distribution of body fat is a possible contributing factor. This study investigates the relative importance of individual food items for changes in waist circumference (WC) and hip circumference (HC) on a population level.

### **Methods**

Independent cross-sectional surveys conducted in 1986, 1990, 1994 and 1999 in the two northernmost counties of Sweden with a common population of 250 000. Randomly selected age stratified samples, altogether 2982 men and 3087 women aged 25-64 years. Questionnaires were completed and anthropometric measurements taken. For each food item, associations between frequency of consumption and waist and hip circumferences were estimated. Partial regression coefficients for every level of reported intake were multiplied with differences in proportion of the population reporting the corresponding levels of intake in 1986 and 1999. The sum of these product terms for every food item was the respective estimated impact on mean circumference.

### **Results**

Changes in reported food consumption associated with the more favourable gynoid distribution of adipose tissue were increased use of vegetable oil, pasta and 1.5% fat

Krachler et al: Food intake and body-fat distribution

milk. Changes associated with abdominal obesity were increased consumption of beer in men and higher intake of hamburgers and French fried potatoes in women.

### **Conclusions**

Different food trends as markers of change in body fat distribution have been identified. The method is a complement to conventional approaches to establish associations between food intake and disease risk on a population level.

## Background

The global trend of increasing obesity in the developed world and, even more pronounced in the countries of transition, is associated with an increase in prevalence of all components of the metabolic syndrome. Based on these observations, predictions of a world-wide epidemic of diabetes have been made. Accumulating evidence for effective preventive intervention [1-3] highlights the importance of early indicators for identifying high-risk individuals. Recent studies have shown that the distribution of body-fat, independent of body mass index (BMI) is an important predictive factor for the development of diabetes.

Waist circumference (WC), as a measure of visceral fat, is more closely associated with diabetes and cardiovascular disease and total mortality than adipose tissue in other regions of the body [4-10]. On the contrary, hip circumference (HC) has been found to be independently associated with lower insulin resistance, lower prevalence and incidence of diabetes and lower total mortality [11-15].

In order to identify predictive markers and potential causative mechanisms of diabetes, associations of socio-demographic and lifestyle factors with body-fat distribution have been investigated. High intake of saturated fatty acids and food patterns with a high glycaemic load have been associated with central obesity.

Smoking, a sedentary life-style, and high intake of alcohol are also associated with abdominal obesity whereas physical activity is associated with gynoid fat distribution and higher insulin sensitivity [16-22].

Between 1986 and 1999 body mass in the MONICA population of Northern Sweden increased in both sexes. However, there was no corresponding increase in prevalence

of diabetes and the number of myocardial infarctions decreased. During the same period average hip circumference increased markedly, while waist circumference only increased marginally. Concurrent changes in reported food intake included a less frequent use of 3% fat milk while 1.5% milk, low fat margarine and cooking oil became more important. Consumption of oil as dressing, pasta, beer and convenience foods increased markedly. [23-26].

Our hypothesis is that some of the observed changes in food intake contributed to a more favourable distribution of body-fat, thus compensating for the diabetogenic effects of increased body weight. These changes may also be associated with the sharp decrease of myocardial infarctions in the area. The aim of the present study is to investigate the effect of change in reported intake of individual food items on the redistribution of body-fat measured between 1986 and 1999 on a population level.

## **Methods**

The MONICA project (Multinational Monitoring of Trends and Determinants in Cardiovascular Disease) was initiated by WHO and included 38 populations in 25 countries. Trends in cardiovascular mortality, coronary heart disease and cerebrovascular morbidity were measured in order to assess the extent to which these trends were related to changes in known risk factors, daily living habits and health care [27, 28].

### **Study design**

The Northern Sweden MONICA Project was performed in the counties of Västerbotten and Norrbotten. Descriptions of the survey procedures and quality

assessment of the collected data have been published elsewhere [29, 30]. In short, the surveys were performed in 1986, 1990, 1994 and 1999 in the period of January to April. The samples for the second, third and fourth surveys were selected irrespective of whether individuals had been selected in previous surveys. From a continuously updated population registry, 250 men and 250 women in each of the age groups 25-34, 35-44, 45-54 and 55-64 years were randomly selected and invited to participate. The target population was approximately 265 000 subjects (Fig 1). The participants were invited to the closest health center for a physical examination including anthropometrical measurements and blood sampling. All measurements were performed by specially trained teams of health professionals. Participants were asked to complete a questionnaire on health, socio-economic status and daily living habits. Usual dietary intake over the past year was assessed through a validated, semi-quantitative, self-administered food frequency questionnaire (FFQ) [31]. The questionnaire included 81 items in 1986, 49 items in 1990, and 84 items in 1994 and 1999. 73 items were identical in 1986 and 1999; these are used in the present analysis. Standard portion sizes were used for the estimation of consumed quantities.

### **Statistical analysis**

A three-step procedure was employed. (i) First, utilizing data from all four surveys, the association between individual food items and waist or hip circumference is estimated, adjusting for age, BMI and survey year. The level of intake reported most frequently in 1986 was chosen as baseline (model 1). In an additional model, smoking status (never/former/current), physical activity (lower/higher), alcohol consumption (quartiles) and education (primary/secondary/university) were added as additional

covariates. Adjustments were also made for the interaction between high reported level of alcohol consumption and low physical activity, high reported level of alcohol consumption and smoking as well as low level of physical activity and smoking (model 2). As food variables are used categorically, coefficients represent the mean difference in each circumference associated with each level of intake vs. the reference category, across all survey years and adjusted for covariates. (ii) Secondly, changes in proportion of the population reporting specific intake levels between the first survey in 1986 and the last one in 1999 are calculated separately for each food item. (iii) Finally, intake-level specific partial regression coefficients for each food item are multiplied with difference in proportions of population reporting that specific level of intake in 1986 and 1999, respectively. The sum of these product terms for each separate food item is the estimated net effect of change in reported food frequency on WC and HC.

- (i) Association circumference – levels of intake: Hip/waist circumference =  $\alpha + \beta_1$  (level 1) +  $\beta_2$  (level 2) + ... +  $\beta_9$  (level 9) + covariates
- (ii) Change in intake levels:  
 $\%$  in level 1 (1999) -  $\%$  in level 1 (1986) =  $\Delta_1$ ;  
 $\%$  in level 2 (1999) -  $\%$  in level 1 (1986) =  $\Delta_2$ ;  
...  
 $\%$  in level 9 (1999) -  $\%$  in level 9 (1986) =  $\Delta_9$
- (iii) Net effect of changes in intake: ( $\Delta_1 * \beta_1 + \Delta_2 * \beta_2 + \dots + \Delta_9 * \beta_9$ )

To estimate the combined effect of food-item associated changes we subtracted change in waist circumference (negatively associated with diabetes and

cardiovascular disease) from change in hip circumference (positively associated).

Positive values will thus indicate risk-lowering changes in body fat distribution.

Significance of association between reported food-intake and WC or HC was estimated by testing the hypothesis that the partial regression coefficients for different levels of reported intake of a food item were equal and equal to zero ( $\beta_{\text{level}_1} = \beta_{\text{level}_2} = \dots = \beta_{\text{level}_9} = 0$ ). To avoid giving a fragmented picture, all food items with large estimated net effects are reported rather than only items with significant estimated associations.

Adjustment for survey year absorbs underlying trends in the population that affect fat distribution. Without that adjustment, changes in measured redistribution of body-fat would (falsely) be attributed to any concurrent change in reported food intake.

However, in food items with a population-wide shift in level of consumption between survey-years (e.g. 3% fat milk and 1.5% fat milk), even item-related effects might be attributed to passage of time, resulting in a conservative estimate of the association.

The Statistical Analysis System (SAS for Windows, version 9.1, SAS Institute, Carry, NC 27513, USA) was used for statistical evaluations.

Non-responders got a second letter of invitation 2 weeks after the date for their initial health examination. Telephone-interviews conducted with non-participants indicate a higher percentage of smokers and a lower (self-reported) body weight in that group [30]. Overall drop-out rate was about 24 % (1931/8000) [26]. In the present study another 152 individuals had to be excluded due to lack of data for estimation of total energy intake (< 90% answers in FFQ) and body mass index. These excluded individuals had a higher mean age in men. There was no significant difference with

remaining study subjects in other parameters. All participants signed an informed consent form. The Research Ethics Committee of Umeå University approved the study.

## Results

Reported energy intake from different sources, sociodemographic and anthropometrical characteristics of the study population are given in **table 1**. The decrease in waist-hip ratio was mainly due to a marked increase in hip circumference in both men and women. Smoking became less common, reported energy intake from saturated fatty acids decreased, and intake of alcohol increased. Higher education became more common.

A complete list of food items that were covered by questionnaires is given in the appendix (**additional file 1: List of items on food-frequency questionnaires**). Out of these, 15 items are shown that were associated with the 10 largest changes in distribution of body fat in either men or women.

**Table 2** summarizes time trends in food consumption associated with the largest changes of waist- and hip circumference for women. Increased use of (vegetable) oil and pasta as well as reduced consumption of fruit creams and 3% fat milk were all associated with reduction of waist circumference. Growing popularity of hamburgers, French fried potatoes and soft drinks were associated with an increase of waist circumference. Increased hip circumference was associated with higher consumption of pasta, vegetable oil as well as cream and 1.5% milk. Time trends for hamburgers and French fried potatoes went along with minor reductions of hip circumference. Adjustment for other lifestyle-factors attenuated the net effect of time trends in

reported food consumption but, did not alter their directions. Only the protective effects of lower consumption of 3% milk and added sugar were reduced markedly. The net effect of increased consumption of 4% beer was reversed.

**Figure 2** illustrates associations of food items with changes in both average hip- and waist-circumference in women. Time trends for vegetable oil, pasta, fruit creams and cream were associated with risk-lowering anthropometric changes, whereas trends for hamburgers and French fried potatoes correlated with risk-increasing changes.

In men, time trends for vegetable oil, pasta and milk were associated with both, largest increase of hip-circumference and largest reduction of waist-circumference (**Table 3, Figure 3**). Increased use of hamburgers and potato chips were associated with an increase of average waist circumference but also a positive effect on hip circumference. Only rising consumption of 4% beer was associated with both, HC decrease and WC increase.

After adjustment for lifestyle-variables (Table 3, model 2) the waist reducing effect of change in pasta consumption disappeared whereas the effect of increased consumption of wine was reversed. The negative net-effect of French fried potatoes could also be explained by associated lifestyle.

In general, waist circumference was more responsive in women whereas hip and waist circumferences were equally affected in men.

## Discussion

### Method

This way of analyzing data derived from food frequency questionnaires is not entirely new. Changes in food habits over time have been expressed in change of waist circumference, before [22]. However, the use of this method in a repeated cross-sectional context is new. The hypothesis that inspired the somewhat cumbersome methodology of this study is: Reported level of intake of a food item is a marker of lifestyle, rather than a measurement of nutrient intake. Therefore, every level of reported intake had to be utilized as a separate variable. This avoids issues of non-linearity that might arise when categorical variables are converted into continuous ones. The results reflect the association between a marker (reported frequency of intake for one single food item) and objective measurements (waist/hip circumferences) adjusted for other objective measurements (sex, age, BMI, survey year). In the crude model no other food-related markers, such as total reported food intake or reported intake of other food items, are introduced. Thus, adding up different markers (food groups) or adjusting one marker for another (adjusting for reported intake of other foods) – common procedures in similar studies that introduce uncontrollable biases - is avoided (model 1). However, in a separate model lifestyle-markers such as, self reported physical activity, education, smoking status and alcohol consumption are considered as additional explanatory variables (model 2).

This is an ecological study, with all design-related strengths and limitations as compared to trials on individual level. In this study, associations are based on currently representative samples of a population rather than one single sample that was representative at baseline – 13 years earlier. Unlike prospective cohort studies,

risk markers derived from repeated cross-sectional surveys rest on the assumption of stable causative mechanisms – including biases - during the whole study period.

Adjustment of associations for survey year should neutralize effects of most changes in underlying causes. One possible exception is social desirability bias, due to its potential to not only change the strength of an association but also its direction. In our population with its sharp increase in average level of education a concurrent increase in tendency to report in accordance with social norms might have reduced some of the associations observed.

Thus, the calculated association may represent more than the effect of a single food item: Related food habits, and possibly a connected general lifestyle have to be considered as potential causative factors.

## **Results**

Main trends in reported food consumption associated with a more favourable distribution of body fat were increased use of (vegetable) oil, pasta, 1,5% milk and reduced consumption of 3% milk. Changes associated with high-risk fat distribution were increased consumption of hamburgers and soft drinks.

To our knowledge, this is the first study of association between change in reported intake of individual food items and waist- and hip- circumferences on a population level. Previous studies were either focussed on macronutrients [32, 33] or food patterns [34, 35], or did not address differential effects on hip- and waist circumferences. Moreover, this study gives a comprehensive picture of a geographically defined population. Thus, our results may complement data derived from cohorts selected by age or profession. In contrast to many other studies, all anthropometrical measurements were made by personnel trained according to standardized criteria.

Most changes in mean reported intake are small, 80% ranging between one and four intakes per month. Some results apparently contradict each other from a biological point of view. For example, a lower intake of 3% fat milk and increased use of cream were both associated with an increase in hip circumference even after adjustment for lifestyle-variables. This highlights the marker-value of reported food intake, indicating the presence of unknown or inadequately measured causative factors that are disregarded by converting reported intake of foods into estimated nutrient intake. Only few of the underlying associations reached statistical significance reflecting the fact that reported frequency of food intake is a weak predictor of waist- and hip circumference compared to covariates such as BMI and age. The lower number of items on the food frequency questionnaire in 1990 might have introduced a bias in the estimated associations between reported intake and circumferences. However, adjustment for survey year should remove systematic errors. Moreover, when comparing level-specific associations between survey-years we did not find more differences than expected by chance.

A mechanistic interpretation of our results would suggest an association between fat intake and abdominal obesity. Increased use of convenience foods (hamburgers, French fried potatoes), generally considered as markers of a diet high in fatty acids, was associated with an increase in WC. A number of changes associated with a reduction of WC (less 3% fat milk, more vegetable oil) mark a reduced intake of saturated fatty acids. The latter findings are in accordance with reports that highlight the importance of fat quality rather than total amount of dietary fat, although the question of the role of fat intake in the causation of obesity, diabetes and cardiovascular disease is still unresolved [36-42].

Further, our results support evidence suggesting that a diet high in low-fat dairy products and low in fast food and soft drinks is associated with smaller gains in BMI and waist circumference [17, 43, 44]. Previous findings of a negative association between intake of potatoes and WC [45] could not be confirmed in our population.

## **Conclusions**

In this study, reported food intake is interpreted as marker for a general lifestyle. Any intervention targeted at individuals defined as high risk by the findings in this study, would therefore have to simultaneously aim at these lifestyle factors, rather than only try to modify consumption of a selected food item.

## **Abbreviations**

BMI      body mass index

FFQ      food frequency questionnaire

HC      hip circumference

MONICA Monitoring of Trends and Determinants in Cardiovascular Disease [27, 28]

WC      waist circumference

## **Competing interests**

The authors declare that they have no competing interests.

## **Authors' contributions**

BK was responsible for the design of the study, performed the statistical analysis and drafted the manuscript. ME contributed in its design and contributed to the manuscript. HS contributed to design and statistical analysis. IJ participated in data collection and validation. GH participated in data collection and validation and contributed to the manuscript. BL participated in study design, data analysis, writing of the manuscript and to the securing of funding. All authors read and approved the final manuscript.

## **Acknowledgements**

We are indebted to a previous anonymous reviewer for valuable suggestions. This study was supported by the Joint Committee of the local county councils of Jämtland, Norrbotten, Västernorrland, Västerbotten (“Visare Norr”) and a grant by Norrbottensakademin. The Northern Sweden MONICA Project has been supported by grants from Norrbotten and Västerbotten counties, by the Joint Committee of Northern Sweden Health Care Region, the Swedish Public Health, the Swedish Medical Research Council (MFR), the Heart and Chest Foundation, the Stroke Fund, King Gustaf V’s and Queen Victoria’s foundation, Vårdalstiftelsen, the Social Sciences Research Council.

Krachler et al: Food intake and body-fat distribution

None of the above-mentioned funding bodies had any influence on study design, data collection, analysis or interpretation; writing or decision to submit the manuscript for publication.

## References

1. J Tuomilehto, J Lindstrom, JG Eriksson, TT Valle, H Hamalainen, P Ilanne-Parikka, S Keinanen-Kiukaanniemi, M Laakso, A Louheranta, M Rastas, et al: **Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance.** *N Engl J Med* 2001, **344**:1343-50.
2. RE Ratner: **An update on the Diabetes Prevention Program.** *Endocr Pract* 2006, **12 Suppl 1**:20-4.
3. L Serra-Majem, B Roman, R Estruch: **Scientific evidence of interventions using the Mediterranean diet: a systematic review.** *Nutr Rev* 2006, **64**:S27-47.
4. JC Seidell, L Perusse, JP Despres, C Bouchard: **Waist and hip circumferences have independent and opposite effects on cardiovascular disease risk factors: the Quebec Family Study.** *Am J Clin Nutr* 2001, **74**:315-21.
5. O Bosello, M Zamboni: **Visceral obesity and metabolic syndrome.** *Obes Rev* 2000, **1**:47-56.
6. T Rankinen, SY Kim, L Perusse, JP Despres, C Bouchard: **The prediction of abdominal visceral fat level from body composition and anthropometry: ROC analysis.** *Int J Obes Relat Metab Disord* 1999, **23**:801-9.
7. I Janssen, PT Katzmarzyk, R Ross: **Waist circumference and not body mass index explains obesity-related health risk.** *Am J Clin Nutr* 2004, **79**:379-84.
8. Y Wang, EB Rimm, MJ Stampfer, WC Willett, FB Hu: **Comparison of abdominal adiposity and overall obesity in predicting risk of type 2 diabetes among men.** *Am J Clin Nutr* 2005, **81**:555-63.
9. CP Sanchez-Castillo, O Velasquez-Monroy, A Lara-Esqueda, A Berber, J Sepulveda, R Tapia-Conyer, WP James: **Diabetes and hypertension increases in a society with abdominal obesity: results of the Mexican National Health Survey 2000.** *Public Health Nutr* 2005, **8**:53-60.
10. RP Wildman, D Gu, K Reynolds, X Duan, X Wu, J He: **Are waist circumference and body mass index independently associated with cardiovascular disease risk in Chinese adults?** *Am J Clin Nutr* 2005, **82**:1195-202.
11. JC Seidell, TS Han, EJ Feskens, ME Lean: **Narrow hips and broad waist circumferences independently contribute to increased risk of non-insulin-dependent diabetes mellitus.** *J Intern Med* 1997, **242**:401-6.
12. L Lissner, C Bjorkelund, BL Heitmann, JC Seidell, C Bengtsson: **Larger hip circumference independently predicts health and longevity in a Swedish female cohort.** *Obes Res* 2001, **9**:644-6.
13. MB Snijder, JM Dekker, M Visser, LM Bouter, CD Stehouwer, PJ Kostense, JS Yudkin, RJ Heine, G Nijpels, JC Seidell: **Associations of hip and thigh circumferences independent of waist circumference with the incidence of type 2 diabetes: the Hoorn Study.** *Am J Clin Nutr* 2003, **77**:1192-7.
14. MB Snijder, PZ Zimmet, M Visser, JM Dekker, JC Seidell, JE Shaw: **Independent and opposite associations of waist and hip circumferences with diabetes, hypertension and dyslipidemia: the AusDiab Study.** *Int J Obes Relat Metab Disord* 2004, **28**:402-9.

15. A Esmailzadeh, P Mirmiran, L Azadbakht, P Amiri, F Azizi: **Independent and inverse association of hip circumference with metabolic risk factors in Tehranian adult men.** *Prev Med* 2006, **42**:354-7.
16. K Samaras, LV Campbell: **The non-genetic determinants of central adiposity.** *Int J Obes Relat Metab Disord* 1997, **21**:839-45.
17. PK Newby, D Muller, J Hallfrisch, N Qiao, R Andres, KL Tucker: **Dietary patterns and changes in body mass index and waist circumference in adults.** *Am J Clin Nutr* 2003, **77**:1417-25.
18. HS Kahn, LM Tatham, CW Heath, Jr.: **Contrasting factors associated with abdominal and peripheral weight gain among adult women.** *Int J Obes Relat Metab Disord* 1997, **21**:903-11.
19. AH Harding, DE Williams, SH Hennings, J Mitchell, NJ Wareham: **Is the association between dietary fat intake and insulin resistance modified by physical activity?** *Metabolism* 2001, **50**:1186-92.
20. I Janssen, PT Katzmarzyk, R Ross, AS Leon, JS Skinner, DC Rao, JH Wilmore, T Rankinen, C Bouchard: **Fitness alters the associations of BMI and waist circumference with total and abdominal fat.** *Obes Res* 2004, **12**:525-37.
21. CA Holcomb, DL Heim, TM Loughin: **Physical activity minimizes the association of body fatness with abdominal obesity in white, premenopausal women: results from the Third National Health and Nutrition Examination Survey.** *J Am Diet Assoc* 2004, **104**:1859-62.
22. P Koh-Banerjee, NF Chu, D Spiegelman, B Rosner, G Colditz, W Willett, E Rimm: **Prospective study of the association of changes in dietary intake, physical activity, alcohol consumption, and smoking with 9-y gain in waist circumference among 16 587 US men.** *Am J Clin Nutr* 2003, **78**:719-27.
23. M Eliasson, B Lindahl, V Lundberg, B Stegmayr: **No increase in the prevalence of known diabetes between 1986 and 1999 in subjects 25-64 years of age in northern Sweden.** *Diabet Med* 2002, **19**:874-80.
24. M Eliasson, B Lindahl, V Lundberg, B Stegmayr: **Diabetes and obesity in Northern Sweden: occurrence and risk factors for stroke and myocardial infarction.** *Scand J Public Health* 2003, **Suppl 61**:70-7.
25. B Lindahl, B Stegmayr, I Johansson, L Weinehall, G Hallmans: **Trends in lifestyle 1986-99 in a 25- to 64-year-old population of the Northern Sweden MONICA project.** *Scand J Public Health* 2003, **Suppl 61**:31-7.
26. B Krachler, MC Eliasson, I Johansson, G Hallmans, B Lindahl: **Trends in food intakes in Swedish adults 1986-1999: findings from the Northern Sweden MONICA (Monitoring of Trends and Determinants in Cardiovascular Disease) Study.** *Public Health Nutr* 2005, **8**:628-35.
27. H Tunstall-Pedoe, D Vanuzzo, M Hobbs, M Mahonen, Z Cepaitis, K Kuulasmaa, U Keil: **Estimation of contribution of changes in coronary care to improving survival, event rates, and coronary heart disease mortality across the WHO MONICA Project populations.** *Lancet* 2000, **355**:688-700.
28. K Kuulasmaa, H Tunstall-Pedoe, A Dobson, S Fortmann, S Sans, H Tolonen, A Evans, M Ferrario, J Tuomilehto: **Estimation of contribution of changes in classic risk factors to trends in coronary-event rates across the WHO MONICA Project populations.** *Lancet* 2000, **355**:675-87.
29. B Stegmayr, V Lundberg, K Asplund: **The events registration and survey procedures in the Northern Sweden MONICA Project.** *Scand J Public Health* 2003, **Suppl 61**:9-17.

30. M Eriksson, B Stegmayr, V Lundberg: **MONICA quality assessments.** *Scand J Public Health* 2003, **Suppl 61**:25-30.
31. I Johansson, G Hallmans, A Wikman, C Biessy, E Riboli, R Kaaks: **Validation and calibration of food-frequency questionnaire measurements in the Northern Sweden Health and Disease cohort.** *Public Health Nutr* 2002, **5**:487-96.
32. CA Gonzalez, G Pera, JR Quiros, C Lasheras, MJ Tormo, M Rodriguez, C Navarro, C Martinez, M Dorronsoro, MD Chirlaque, et al: **Types of fat intake and body mass index in a Mediterranean country.** *Public Health Nutr* 2000, **3**:329-36.
33. K Samaras, PJ Kelly, MN Chiano, N Arden, TD Spector, LV Campbell: **Genes versus environment. The relationship between dietary fat and total and central abdominal fat.** *Diabetes Care* 1998, **21**:2069-76.
34. E Wirfalt, B Hedblad, B Gullberg, I Mattisson, C Andren, U Rosander, L Janzon, G Berglund: **Food patterns and components of the metabolic syndrome in men and women: a cross-sectional study within the Malmö Diet and Cancer cohort.** *Am J Epidemiol* 2001, **154**:1150-9.
35. FB Hu, EB Rimm, MJ Stampfer, A Ascherio, D Spiegelman, WC Willett: **Prospective study of major dietary patterns and risk of coronary heart disease in men.** *Am J Clin Nutr* 2000, **72**:912-21.
36. WC Willett: **Dietary fat plays a major role in obesity: no.** *Obes Rev* 2002, **3**:59-68.
37. A Astrup: **Dietary fat is a major player in obesity--but not the only one.** *Obes Rev* 2002, **3**:57-8.
38. JA Marshall, DH Bessesen: **Dietary fat and the development of type 2 diabetes.** *Diabetes Care* 2002, **25**:620-2.
39. EJ Feskens: **Can diabetes be prevented by vegetable fat?** *Diabetes Care* 2001, **24**:1517-8.
40. FB Hu, MJ Stampfer, JE Manson, A Ascherio, GA Colditz, FE Speizer, CH Hennekens, WC Willett: **Dietary saturated fats and their food sources in relation to the risk of coronary heart disease in women.** *Am J Clin Nutr* 1999, **70**:1001-8.
41. KA Meyer, LH Kushi, DR Jacobs, Jr., AR Folsom: **Dietary fat and incidence of type 2 diabetes in older Iowa women.** *Diabetes Care* 2001, **24**:1528-35.
42. B Vessby: **Dietary fat and insulin action in humans.** *Br J Nutr* 2000, **83 Suppl 1**:S91-6.
43. PK Newby, D Muller, J Hallfrisch, R Andres, KL Tucker: **Food patterns measured by factor analysis and anthropometric changes in adults.** *Am J Clin Nutr* 2004, **80**:504-13.
44. V Drapeau, V Provencher, S Lemieux, JP Despres, C Bouchard, A Tremblay: **Do 6-y changes in eating behaviors predict changes in body weight? Results from the Quebec Family Study.** *Int J Obes Relat Metab Disord* 2003, **27**:808-14.
45. J Halkjaer, TI Sorensen, A Tjonneland, P Togo, C Holst, BL Heitmann: **Food and drinking patterns as predictors of 6-year BMI-adjusted changes in waist circumference.** *Br J Nutr* 2004, **92**:735-48.

## Figures

### Figure 1 - Study design

<sup>1</sup> Counties of Norrbotten and Västerbotten, population register of inhabitants aged 25-64 on January 1<sup>st</sup> of the survey-year.

<sup>2</sup> Randomly selected samples of 250 in age strata 25-34, 35-44, 45-54, 55-64 years.

<sup>3</sup> Number of individuals who appeared at the health centers for measurements and completed FFQ.

<sup>4</sup> Number of individuals with complete anthropometrical data and at least 90% answers in FFQ.

### Figure 2 - Estimated effect of change in reported food intake 1986-1999 on average waist- and hip-circumference in women

10 items with the largest estimated effect on distribution of body fat in women. Sort order is the sum of effects from largest reduction to highest increase of risk for diabetes. The underlying associations between food intake and waist- and hip-circumferences were adjusted for age, body-mass and survey year (model 1)

### Figure 3 - Estimated effect of change in reported food intake 1986-1999 on average waist- and hip-circumference in men

10 items with the largest estimated effect on distribution of body fat in men. Sort order is the sum of effects from largest reduction to highest increase of risk for diabetes. The underlying associations between food intake and waist- and hip-circumferences were adjusted for age, body-mass and survey year (model 1)

## Tables

### **Table 1 - Characteristics of study population 1986 vs. 1999.**

<sup>1</sup> Counties of Norrbotten and Västerbotten, population register of inhabitants aged 25-64 on January 1<sup>st</sup> of the survey-year.

<sup>2</sup> Randomly selected samples of 250 in age strata 25-34, 35-44, 45-54, 55-64 years.

<sup>3</sup> Number of individuals who appeared at the health centers for measurements and completed FFQ.

<sup>4</sup> Number of individuals with complete anthropometrical data and at least 90% answers in FFQ.

### **Table 2 - Food items with largest associated changes of waist- and hip-circumference in women.**

<sup>1</sup> Estimate of total effect on diabetes risk: Hip-change (negatively associated with DM) - Waist-change (positively associated with DM)

<sup>2</sup> Model 1: regression of change in reported food frequency on waist/hip circumference adjusted for BMI, age and survey-year.

<sup>3</sup> Model 2: all variables are adjusted for BMI, age, survey-year, smoking-status (never/ex-/current), level of reported physical activity (lower/higher), educational level (primary school/secondary school/college), level of reported alcohol (quartiles) intake as well as interaction between smoking and low physical activity, smoking and high alcohol intake, low physical activity and high alcohol intake.

<sup>4</sup> number of reported intakes per month

<sup>5</sup> relative changes in % of mean reported intake 1986

<sup>6</sup> estimated net effects of reported changes on mean waist/hip circumference.

<sup>7</sup> probabilities that partial regression coefficients for different levels of intake are equal to zero at 95% level

### **Table 3 - Food items with largest associated changes of waist- and hip-circumference in men.**

<sup>1</sup> Estimate of total effect on diabetes risk: Hip-change (negatively associated with DM) - Waist-change (positively associated with DM)

<sup>2</sup> Model 1: regression of change in reported food frequency on waist/hip circumference adjusted for BMI, age and survey-year.

<sup>3</sup> Model 2: all variables are adjusted for BMI, age, survey-year, smoking-status (never/ex-/current), level of reported physical activity (lower/higher), educational level (primary school/secondary school/college), level of reported alcohol (quartiles) intake as well as interaction between smoking and low physical activity, smoking and high alcohol intake, low physical activity and high alcohol intake.

<sup>4</sup> number of reported intakes per month

<sup>5</sup> relative changes in % of mean reported intake 1986

<sup>6</sup> estimated net effects of reported changes on mean waist/hip circumference

<sup>7</sup> probabilities that partial regression coefficients for different levels of intake are equal to zero at 95% level

	Men			Women		
	1986 (n=784)	1999 (n=632)	P <sup>1</sup>	1986 (n=757)	1999 (n=692)	P <sup>1</sup>
Age (y)	45.0±11	45.7±11	0.25	44.6±11	45.7±11	0.07
Primary education only (%) <sup>2</sup>	58	22	<0.001	54	18	<0.001
Sedentary (%) <sup>2,3</sup>	59	66	0.01	56	78	<0.001
Smokers (%) <sup>2,4</sup>	34	18	<0.001	31	24	0.003
Intake of alcohol (g/d)	2.7±2.6	3.7±5.4	<0.001	1.3±1.4	2.0±1.6	<0.001
BMI (kg/m <sup>2</sup> )	25.6±3.5	26.6±3.4	<0.001	25.0±4.4	25.9±4.5	<0.001
Waist circumference (cm)	93.0±9.6	94.9±9.8	<0.001	85.3±12.4	84.0±12.0	<0.004
Hip circumference (cm)	97.9±6.1	103.1±6.5	<0.001	98.5±8.8	103.0±8.6	<0.001
Waist-to-hip ratio	0.95±0.06	0.92±0.07	<0.001	0.86±0.07	0.81±0.07	<0.001
Energy from alcohol (%)	1.1±1.1	1.5±1.4	<0.001	0.6±0.7	0.8±0.7	<0.001
Energy from fat (%)	38.5±5.7	37.0±6.0	<0.001	37.8±5.7	36.2±6.1	<0.001
Energy from saturated fat (%)	17.3±3.2	15.4±3.1	<0.001	16.7±3.1	14.6±3.2	<0.001
NSP intake (g/MJ) <sup>5</sup>	2.2±0.5	2.3±0.6	0.06	2.4±0.6	2.5±0.7	<0.002
Reported intake (MJ/d)	7.6±2.4	7.5±2.5	0.80	7.0±2.1	7.4±2.0	<0.003

**Table 1 - Characteristics of study population, 1986 vs. 1999.**

<sup>1</sup> Education, physical activity and smoking status: Chi-square test for categories, all other two tailed t-test for difference between means

<sup>2</sup> Education, physical activity and smoking status as percentage of same-sex population, all other values are  $x \pm SD$

<sup>3</sup> Less than 1 hour of strenuous physical activity per week

<sup>4</sup> Including recent (< 6month) ex-smokers, since FFQ covered past 12 months

<sup>5</sup> Non-Starch-Polysaccharides = dietary fibre

Women Food item <sup>3</sup>	Intake change 1986-99		Waist change				Hip change				Combined <sup>1</sup>	
	/mo <sup>4</sup>	/'86 <sup>5</sup>	Model 1 <sup>2</sup>		Model 2 <sup>3</sup>		Model 1 <sup>2</sup>		Model 2 <sup>3</sup>		1 <sup>2</sup>	2 <sup>3</sup>
			mm <sup>6</sup>	p <sup>7</sup>	mm <sup>6</sup>	p <sup>7</sup>	mm <sup>6</sup>	p <sup>7</sup>	mm <sup>6</sup>	p <sup>7</sup>	mm <sup>6</sup>	mm <sup>6</sup>
beer, 4% alcohol	0.6	153 %	-1.10	0.60	-0.92	0.83	-0.68	0.59	-1.24	0.36	0.42	-0.32
bread, crisp	-13.4	-27 %	-0.31	0.21	-0.37	0.26	0.06	0.65	-0.09	0.64	0.37	0.28
cream/crème fraîche/sour cream	1.4	40 %	-1.27	0.26	-0.94	0.32	1.38	0.01	0.99	0.09	2.65	1.93
fruit soups/fruit creams	-1.3	-36 %	-3.24	0.01	-3.13	0.02	-0.07	0.58	-0.25	0.67	3.17	2.88
hamburger	0.8	73 %	3.21	0.07	2.94	0.13	-0.66	0.47	-0.41	0.67	-3.87	-3.34
milk, 1.5% fat	18.0	331 %	-1.11	0.02	-0.76	0.03	1.24	0.48	0.98	0.45	2.35	1.75
milk, 3% fat	-21.8	-84 %	-1.47	0.25	-0.75	0.38	-0.05	0.44	-0.74	0.55	1.42	0.01
oil, cooking	8.7	693 %	-6.18	<.01	-4.86	<.01	1.35	0.40	0.23	0.75	7.53	5.09
oil, dressing	3.3	210 %	-2.54	0.07	-1.96	0.17	0.50	0.73	0.03	0.79	3.04	1.99
pasta	4.2	132 %	-2.21	0.25	-1.47	0.45	2.14	0.09	1.61	0.15	4.35	3.09
potato chips/popcorn/salted nuts	1.5	188 %	-0.78	0.44	-0.24	0.45	1.15	0.59	1.14	0.53	1.94	1.38
potatoes, French fried	0.9	95 %	2.11	0.14	1.90	0.13	-0.42	0.05	0.04	0.13	-2.52	-1.86
soft drinks	1.9	93 %	2.11	0.19	2.00	0.23	0.31	0.91	0.57	0.77	-1.81	-1.43
sugar/honey in tea/coffee	-10.4	-36 %	-0.30	0.39	0.02	0.41	0.13	0.68	-0.05	0.83	0.44	-0.08
wine	0.7	65 %	-1.03	0.05	-0.83	0.08	1.08	0.15	1.67	0.22	2.11	2.51

**Table 2 - Food items with largest associated changes of waist- and hip-circumference in women.**

<sup>1</sup> Estimate of combined effect on diabetes risk: Hip-change (negatively associated with DM) - Waist-change (positively associated with DM)

<sup>2</sup> Model 1: regression of change in reported food frequency on waist/hip circumference adjusted for BMI, age and survey-year.

<sup>3</sup> Model 2: all variables are adjusted for BMI, age, survey-year, smoking-status (never/ex-/current), level of reported physical activity (lower/higher), educational level (primary school/secondary school/college), level of reported alcohol (quartiles) intake as well as interaction between smoking and low physical activity, smoking and high alcohol intake, low physical activity and high alcohol intake.

<sup>4</sup> number of reported intakes per month <sup>5</sup> relative change in % of mean reported intake 1986

<sup>6</sup> estimated net effects of reported changes on mean waist/hip circumference

<sup>7</sup> probabilities that partial regression coefficients for different levels of intake are equal to zero at 95% level

Men Food item <sup>3</sup>	Intake change 1986-99		Waist change				Hip change				Combined <sup>1</sup>	
	/mo <sup>4</sup>	/'86 <sup>5</sup>	Model 1 <sup>2</sup>		Model 2 <sup>3</sup>		Model 1 <sup>2</sup>		Model 2 <sup>3</sup>		1 <sup>2</sup>	2 <sup>3</sup>
			mm <sup>6</sup>	p <sup>7</sup>	mm <sup>6</sup>	p <sup>7</sup>	mm <sup>6</sup>	p <sup>7</sup>	mm <sup>6</sup>	p <sup>7</sup>	mm <sup>6</sup>	mm <sup>6</sup>
beer, 4% alcohol	1.0	97 %	1.41	0.35	0.26	0.75	-0.63	0.48	-1.03	0.48	-2.04	-1.29
bread, crisp	-15.3	-28 %	1.21	0.01	1.10	0.01	0.76	0.62	0.56	0.79	-0.45	-0.54
cream/crème fraîche/sour cream	1.4	48 %	0.41	0.62	0.33	0.58	1.98	<.01	1.62	<.01	1.57	1.29
fruit soups/fruit creams	-0.9	-25 %	0.56	0.73	0.11	0.76	-0.26	0.31	-0.24	0.29	-0.82	-0.35
hamburger	1.0	68 %	2.65	<.01	1.93	0.02	0.75	0.03	0.61	0.03	-1.90	-1.32
milk, 1.5% fat	21.0	403 %	-1.20	0.70	-0.76	0.70	2.95	<.01	2.67	<.01	4.15	3.43
milk, 3% fat	-30.3	-81 %	-1.41	0.80	-1.58	0.73	1.85	0.01	1.19	0.02	3.26	2.77
oil, cooking	7.3	557 %	-1.65	0.71	-1.45	0.65	2.68	0.35	1.80	0.56	4.33	3.25
oil, dressing	1.8	97 %	-0.14	0.78	-0.37	0.69	0.33	0.99	0.03	0.99	0.47	0.40
pasta	3.7	110 %	-0.90	0.02	<.01	0.10	1.93	0.01	1.59	0.02	2.83	1.59
potato chips/popcorn/salted nuts	1.6	146 %	1.65	0.64	1.23	0.71	0.64	0.96	0.43	0.90	-1.02	-0.81
potatoes, French fried	1.2	96 %	-0.42	0.91	-1.17	0.66	-0.70	0.58	-0.89	0.44	-0.28	0.29
soft drinks	3.9	114 %	0.78	0.21	0.65	0.16	-0.01	0.25	0.06	0.38	-0.79	-0.59
sugar/honey in tea/coffee	-24.0	-44 %	0.67	0.77	0.97	0.68	1.19	0.25	0.94	0.56	0.52	-0.03
wine	0.8	65 %	0.25	<.01	-0.34	<.01	0.53	0.03	0.48	0.13	0.28	0.82

**Table 3 - Food items with largest associated changes of waist- and hip-circumference in men.**

<sup>1</sup> Estimate of combined effect on diabetes risk: Hip-change (negatively associated with DM) - Waist-change (positively associated with DM)

<sup>2</sup> Model 1: regression of change in reported food frequency on waist/hip circumference adjusted for BMI, age and survey-year.

<sup>3</sup> Model 2: all variables are adjusted for BMI, age, survey-year, smoking-status (never/ex-/current), level of reported physical activity (lower/higher), educational level (primary school/secondary school/college), level of reported alcohol (quartiles) intake as well as interaction between smoking and low physical activity, smoking and high alcohol intake, low physical activity and high alcohol intake.

<sup>4</sup> number of reported intakes per month <sup>5</sup> relative change in % of mean reported intake 1986

<sup>6</sup> estimated net effects of reported changes on mean waist/hip circumference

<sup>7</sup> probabilities that partial regression coefficients for different levels of intake are equal to zero at 95% level



## **Additional files**

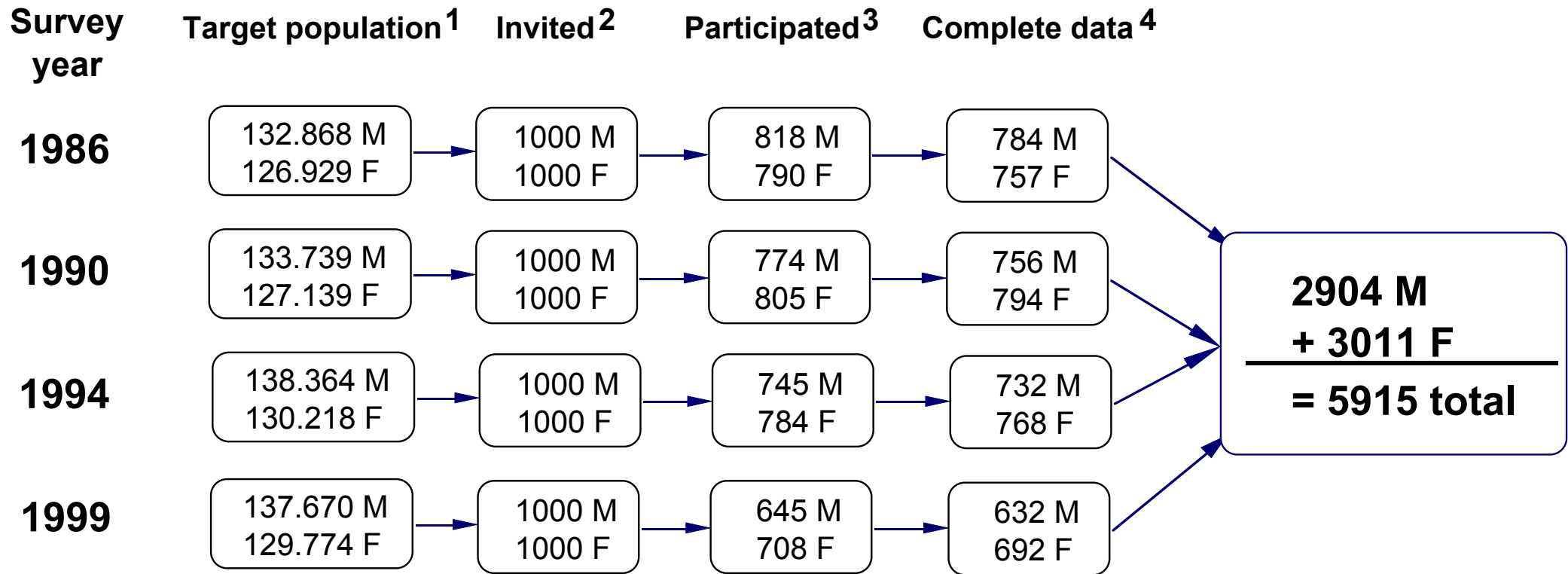
### **Additional file 1**

File name: Krachler et al Additional file\_1.doc

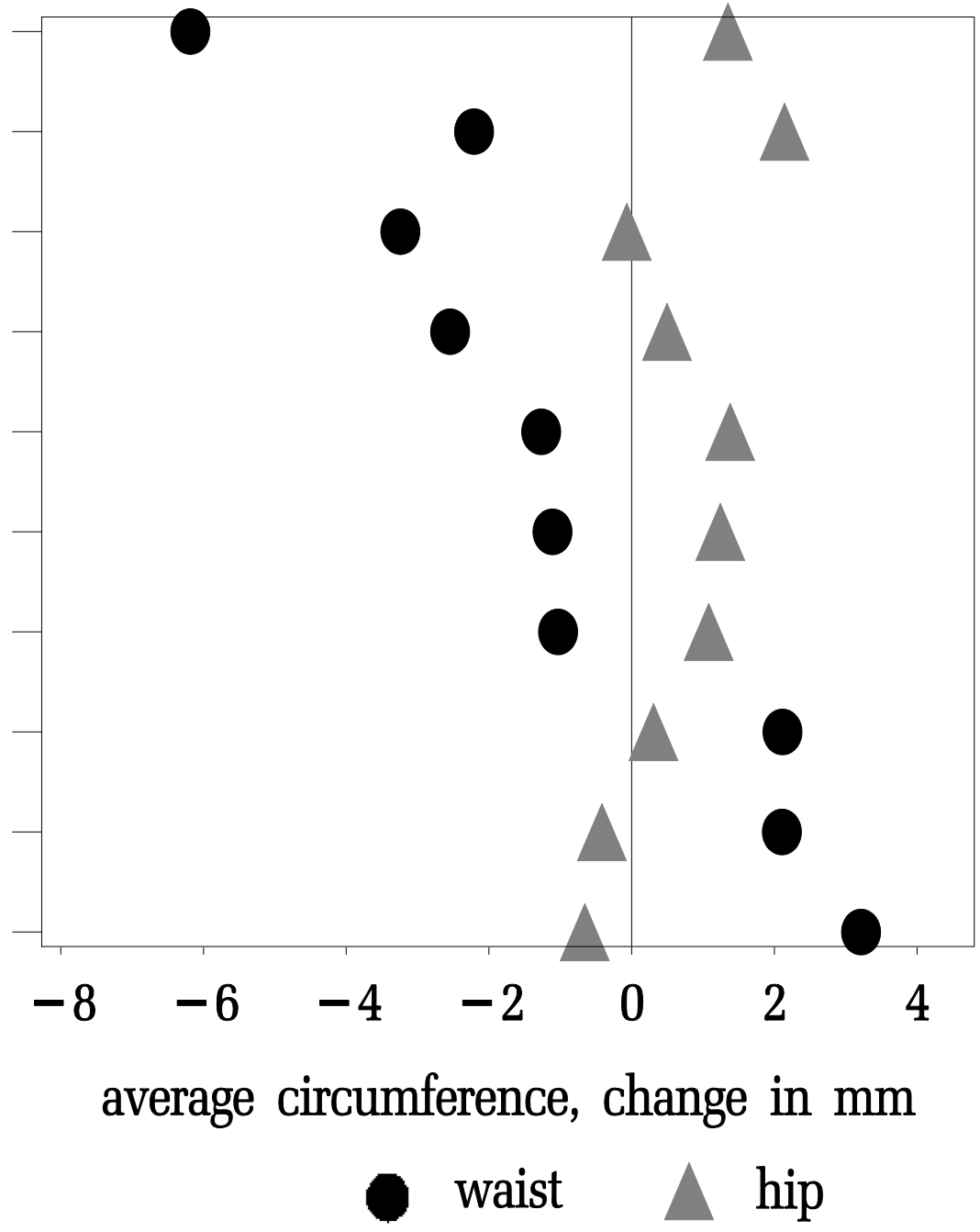
File format: word 2003

Titel of data: Additional file 1 – List of items on food-frequency questionnaires

Descriptions: Complete list of all items on food frequency questionnaires in 1986.  
1990, 1994 and 1999



oil, cooking  
pasta  
fruit soups/fruit creams  
oil, dressing  
cream/crème fraîche/sour cream  
milk, 1.5% fat  
wine  
soft drinks  
potatoes, french fried  
hamburger



oil, cooking

milk, 1.5% fat

milk, 3% fat

pasta

bread, crisp

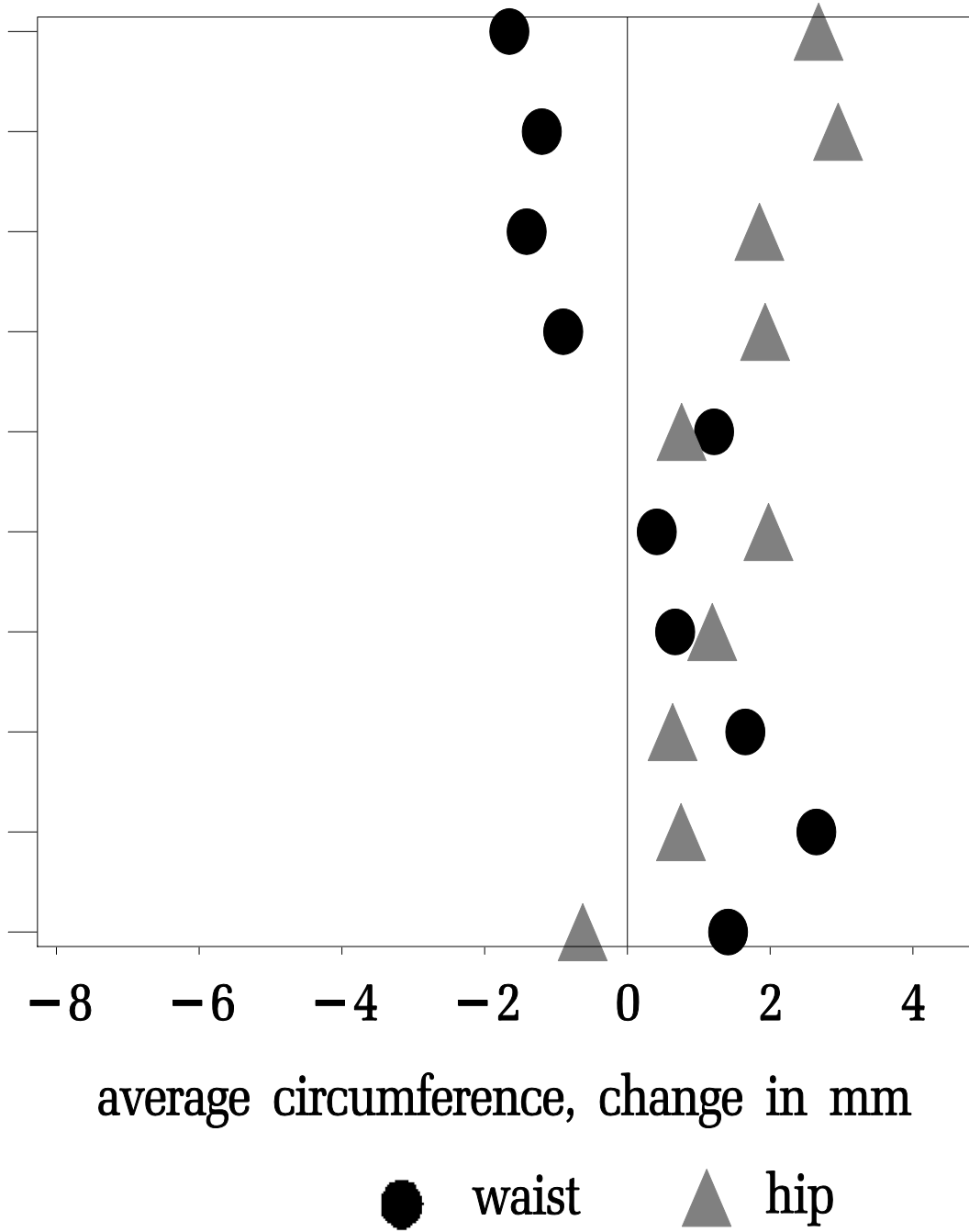
cream/crème fraîche/sour cream

sugar/honey in tea/coffee

potato chips/popcorn/salted nuts

hamburger

beer, 4% alcohol



**Additional files provided with this submission:**

Additional file 1 : Krachler et al Additional file\_1.doc : 154Kb

<http://www.nutritionj.com/imedia/1644513882116034/sup1.DOC>