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The association between nutritional conditions during World War II and childhood anthropometric variables in the Nordic countries

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Summary. *Background*: The purpose of the study was to examine the height and weight in Nordic children during the years around World War II (WWII), and compare them with the nutritional situation during the same period.
Methods: Information on food consumption and energy intake were obtained from the literature. Anthropometric data were collected from the Nordic capitals and cover the period from 1930 to 1960 for ages 7–13 years.
Results: The greatest energy restriction took place in Norway (20%), followed by Finland (17%), while Sweden and Denmark had a restriction of 4–7% compared to pre-war levels. The most pronounced effect of WWII on height and weight is seen in Norwegian children, while some effect is observed for the youngest children in Finland. Little or no effect is seen in Sweden and Denmark.
Conclusion: The Nordic children were affected by WWII in terms of a transient reduction in temporal trends in height and weight, and the magnitude of this decrease was associated with the severity of the energy restriction prevailing in the respective country during the war. These findings warrant further studies of the chronic diseases associated with height and weight for cohorts being in their growth periods during WWII.

1. Introduction

Anthropometric variables (height and weight) at birth and during childhood have been convincingly related to the risk of many non-communicable diseases, such as cancer (Tibblin *et al.* 1995, Michels *et al.* 1996, Hilakivi-Clarke *et al.* 2001), coronary heart disease (Leon *et al.* 1998, Eriksson *et al.* 1999, Barker *et al.* 2002), and type 2 diabetes (Lithell *et al.* 1996). Body height is affected by hereditary factors, nutrition and socio-economic factors during the developmental growth phase, while current weight is associated with the existing diet of the individual. Weight is rapidly affected by changes in energy intake, whereas height is only affected by profound illness or persisting under-nutrition during the growth phase.

Human postnatal linear growth can be divided into three stages, i.e. infant, childhood and pubertal growth (Karlberg 1989). Data from both humans and transgenic

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animal models indicate that the hormones and receptors within the growth hormone–insulin-like growth factors (IGFs) axis play a part in infant growth. However, alternations in dietary intake have the greatest impact on the growth hormone–IGF axis and thus on growth performance in this period (Clayton and Gill 2001). In childhood, growth hormone is the major determinant of growth, whereas the concerted action of growth hormone and sex hormones is necessary for normal pubertal growth. Adequate energy intake during development is required to fulfil the growth potential of the individual. Normal growth, however, is also dependent upon an adequate intake of essential amino acids, essential fatty acids, vitamins and minerals (Clayton and Gill 2001). Energy restriction may well affect growth because protein degradation is increased to compensate for the lack of energy. The growth hormone synthesis may also be affected, as evidenced by decreased levels of IGF-I, a growth factor released by stimulation of growth hormone, during energy restriction (Holly 1998).

During and a few years after World War II (WWII), in the years from 1939 to the late 1940s, there were various restrictions in food supply in the Nordic countries. Norway had the largest restriction during the war due to a cessation of import; the country was strongly dependent on import, estimated to more than 50% of the energy consumed (US Department of Agriculture 1946). Sweden and Denmark had satisfactory average food consumption during the war, with minor restrictions only (US Department of Agriculture 1946). Agricultural production and import were affected in Finland, and the food consumption levels steadily declined during the war years, and were worst in 1942 (US Department of Agriculture 1946, Roine 1948). Natural 'experiments', like WWII, provide valuable information of the association between environmental factors and early growth, and enable us to study how nutritional conditions affect growth.

A previous Norwegian study has shown a significant drop in height and weight for all cohorts of schoolchildren in the capital Oslo measured during WWII (Brundtland *et al*. 1980). Thus, the food restriction in Norway during WWII was large enough to affect important anthropometric indices. Corresponding data from the other Nordic countries (i.e. Sweden, Denmark, Finland and Iceland) during WWII have not previously been published. The purpose of this study was to compare the Nordic countries with respect to anthropometric indices during the years prior to and during WWII, together with an examination of the nutritional conditions during the same period.

2. Methods

2.1. Food consumption and energy intake

Data on the nutritional situation in the Nordic countries prior to and during WWII were obtained from the literature. Emphasis was placed on searching for dietary studies among the inhabitants of the capitals of the Nordic countries, or alternatively data representative for the whole country.

2.2. Anthropometric status

Data on the average height and weight for children measured prior to and during WWII were collected from the Nordic countries. All data were from the respective capitals, and data between 1930 and 1960 for ages 7–13 years were requested. Iceland was excluded, as there were no measurements available for children during WWII.

The Norwegian data were from the city of Oslo, conducted every fifth year by the school health system between 1920 and 1976, and encompassed all school children aged 8–18 years. The numbers in each age and gender group vary between 1000 and 3000. These data are previously published (Brundtland *et al.* 1980), and are reproduced with permission. Schooling has been compulsory in Norway since 1918, thus the measurement covers the total population of Oslo children from 7 to 13 years.

The Swedish data were from the city of Stockholm, conducted every 5 years by the school health service between 1933 and 1953, and stored in the City Archives. All children attending school, except for private and national special schools (ca 3.5%), were included. Some measurements existed annually from 1947 to 1953. All children aged 7, 10 and 13 years were measured, with more than 2000 cases per group. A random sample of 100 was taken from each age and gender group. There was only one measurement for children aged 13 years during this period, therefore this group was excluded. Some of these data have been published previously (Cernerud and Lindgren 1991).

The Danish data were obtained from the school health services records for the city of Copenhagen for children born 1930 or later. The measurements were conducted annually in the Copenhagen municipality until 1983, encompassing all children aged 7–13 years. The numbers in each age and gender group vary between 2000 and 6000 children. Some of these data have been published previously (Thomsen *et al.* 1999).

The Finnish data were sampled from the school health care records for children in the city of Helsinki. Data from 1931 to 1957 for children aged 7–13 years were available. For each age and gender group, a sample between 130 and 800 records were obtained. The data collection is described elsewhere (Eriksson *et al.* 1999), and only children who were born in Helsinki, and living in Finland in 1971, were sampled.

The data were graphed separately for each gender by height and weight by year of measurement for the various age groups available.

3. Results

3.1. Food consumption and energy intake

The literature search obtained eight studies, two for each country, looking at the nutritional status in the Nordic countries around WWII. In Norway, two studies described nutritional investigations in Oslo prior to and during WWII (Galtung Hansen 1947, Strom 1948). In Finland, Denmark and Sweden, only one of the studies in each country described the nutritional status prior to WWII, thus only these were included (Statistics Denmark 1949, Amark 1952, Heikkinen 1996). In these three countries, the investigation was a national assessment of per capita food supplies and dietary intakes, all using food balance information.

Table 1 shows the change in food consumption and energy intake in the Nordic countries, comparing the WWII and pre-war levels, based on the references in the previous paragraph. The percentage change is calculated as the change in energy intake between the two periods divided by energy intake prior to the war. As the basis of the source of energy intake vary, and the national intake variables are not directly comparable, the comparison is limited to the percentage change rounded to the nearest 5%.

Table 1. Percentage change in food consumption and energy intake in the Nordic countries, comparing the WWII levels with pre-war levels.

	Norway	Finland	Sweden	Denmark
Food consumption*				
Meat	−60	−15	−10	−10
Fish	+200	–	–	–
Vegetables	+100	+30	+15	+20
Potatoes	+120	+5	+20	+20
Milk	−40	−30	+20	–
Fruit	−60	−65	−20	–
Sugar	−50	−50	−30	−20
Butter/margarine	−40	−20	−5	−20
Energy intake	−20	−17	− 4	−7
Intake of energy-yielding nutrients*				
Fat	−40	−20	−10	−10
Protein	−10	−15	–	–
Carbohydrate	+10	−15	–	–

* All rounded to the nearest 5% value.

Food consumption changed in a uniform way in all the Nordic countries in that consumption of meat, sugar and fats decreased, while that of vegetable and potato increased in the period of interest. Even though the change was uniform, its magnitude varied markedly. This is illustrated by the vegetable intake, which varied between 15% increase in Sweden (Amark 1952) and 100% increase in Norway (Galtung Hansen 1947). The milk consumption, however, showed a diverging pattern. In Norway and Finland, the consumption of milk went down (Galtung Hansen 1947, Heikkinen 1996), whereas it was constant in Denmark (Statistics Denmark 1949), and increased in Sweden (Amark 1952). Fish consumption remained constant for all Nordic countries except Norway, where it reached a two-fold increase.

It was evident that Norway had the largest reduction; two studies observing families in the capital Oslo found a 20% reduction in energy intake compared to the pre-war level (Galtung Hansen 1947, Strøm 1948). Reports from Finland vary, but energy intake calculations based on food supply data showed a decrease of about 17% (Heikkinen 1996). Even though the comprehensive calculations on energy supply are lacking in Sweden and Denmark, there is evidence that both these countries fared well during the war, with an energy reduction of maximum 4% and 7%, respectively (Statistics Denmark 1949, Amark 1952). Among the energy-yielding nutrients, the greatest change was seen in fat intake, which decreased 10–40% from the pre-war intake level.

3.2. Anthropometric status

Figures 1 and 2 present the average height for boys and girls, respectively, measured between 1930 and 1960, while figures 3 and 4 show the average weight during the same time period.

The strongest effect of WWII on height and weight was seen among the Norwegian children (Brundtland *et al.* 1980 (reproduced with permission)). Both boys and girls of all ages had a decrease in height of an average 1.5 cm during the war years. For weight, an average decrease of 2 kg was seen for all ages and both genders during the same period. The standard error of the mean (SEM) for height and weight was 0.15 cm and 0.15 kg, respectively (Brundtland *et al.* 1980).

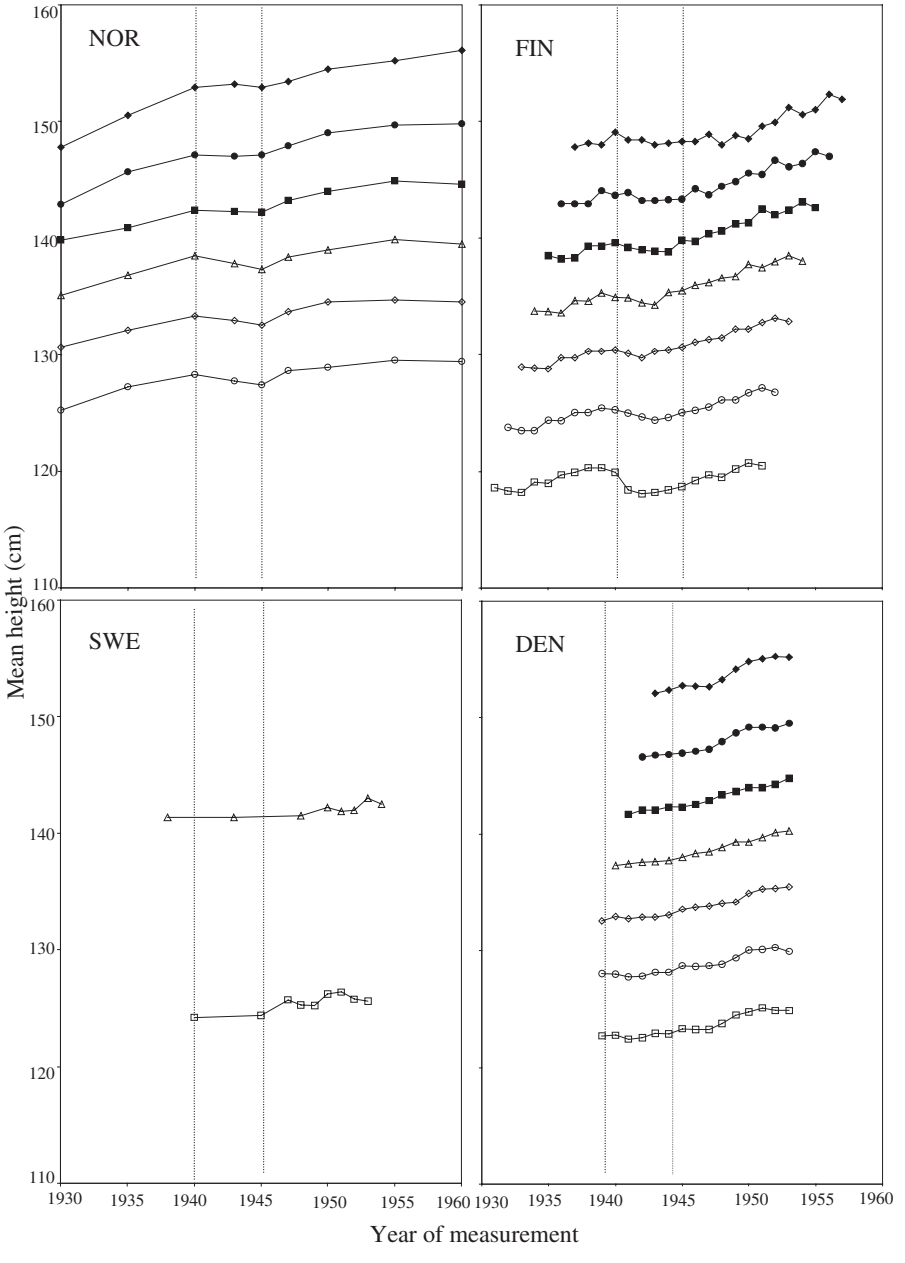

Figure 1. Height in Nordic boys aged 7–13 years from 1930 to 1960 (Norwegian data are reproduced with permission from Brundtland *et al*. 1980). □, 7 years; ○, 8 years; ◇, 9 years; Δ, 10 years; ■, 11 years; ●, 12 years; ◆, 13 years; vertical stippled lines, WWII.

Some effect of WWII was also observed in the Finnish children. For both boys and girls aged 7 years, a decrease was observed in both height and weight of 1.5 cm and 2 kg, respectively. For boys and girls ages 8–13 years, a moderate decrease of 0.5–1 kg was evident in the weight, together with a decrease of maximum 0.5 cm of the height. During the war, the weight and height of both boys and girls

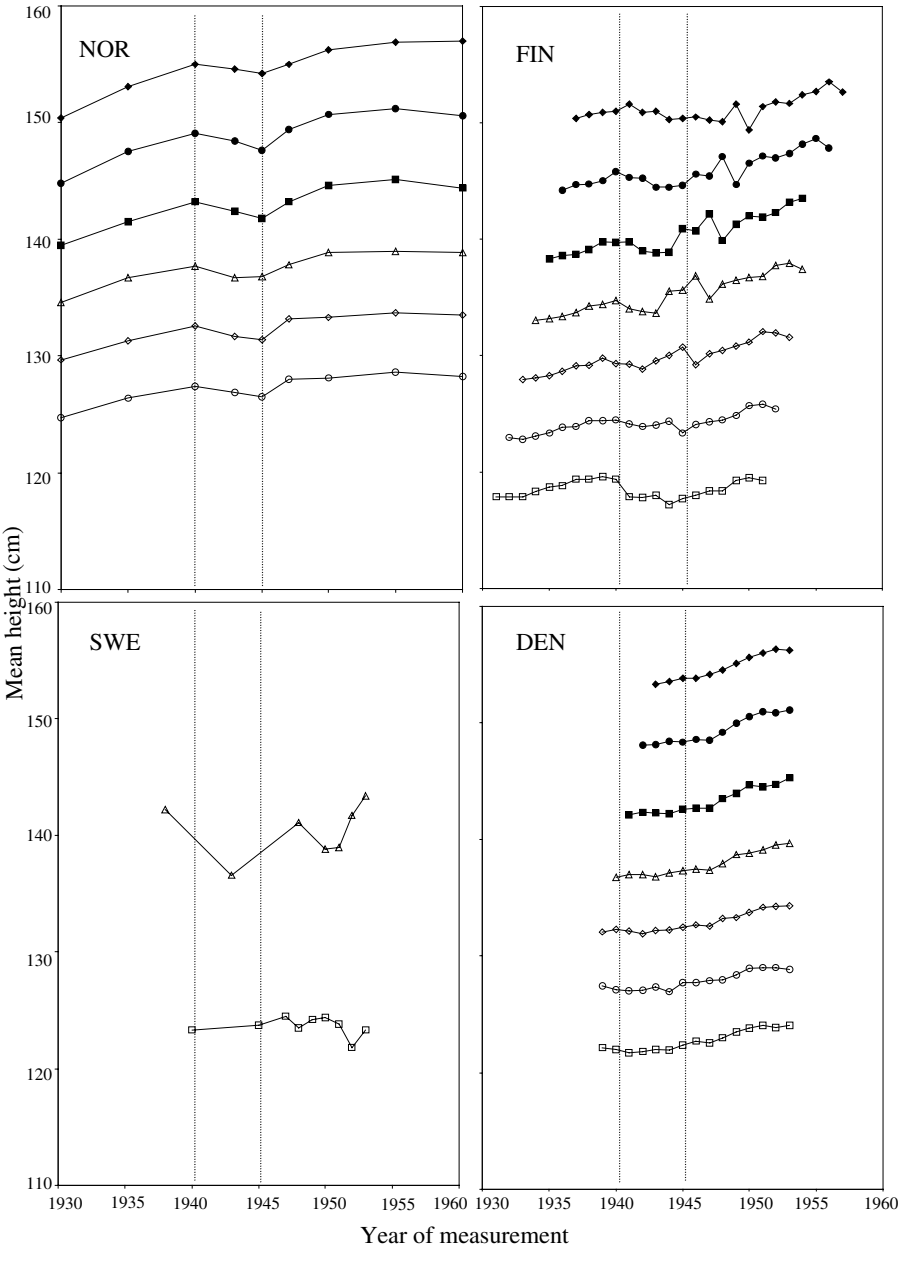

Figure 2. Height in Nordic girls aged 7–13 years from 1930 to 1960 (Norwegian data are reproduced with permission from Brundtland *et al*. 1980). □, 7 years; ○, 8 years; ◇, 9 years; Δ, 10 years; ■, 11 years; ●, 12 years; ◆, 13 years; vertical stippled lines, WWII.

aged 9–11 years increased to over pre-war levels. Finnish children were at a lower height and weight than the other Nordic children before WWII. The SEM ranged from 0.2 to 0.7 cm for height, and from 0.1 to 0.5 kg for weight.

For Swedish boys, no effect of the war was seen for either height or weight in any ages. For Swedish girls during the war, no effect was seen for girls aged 7 years,

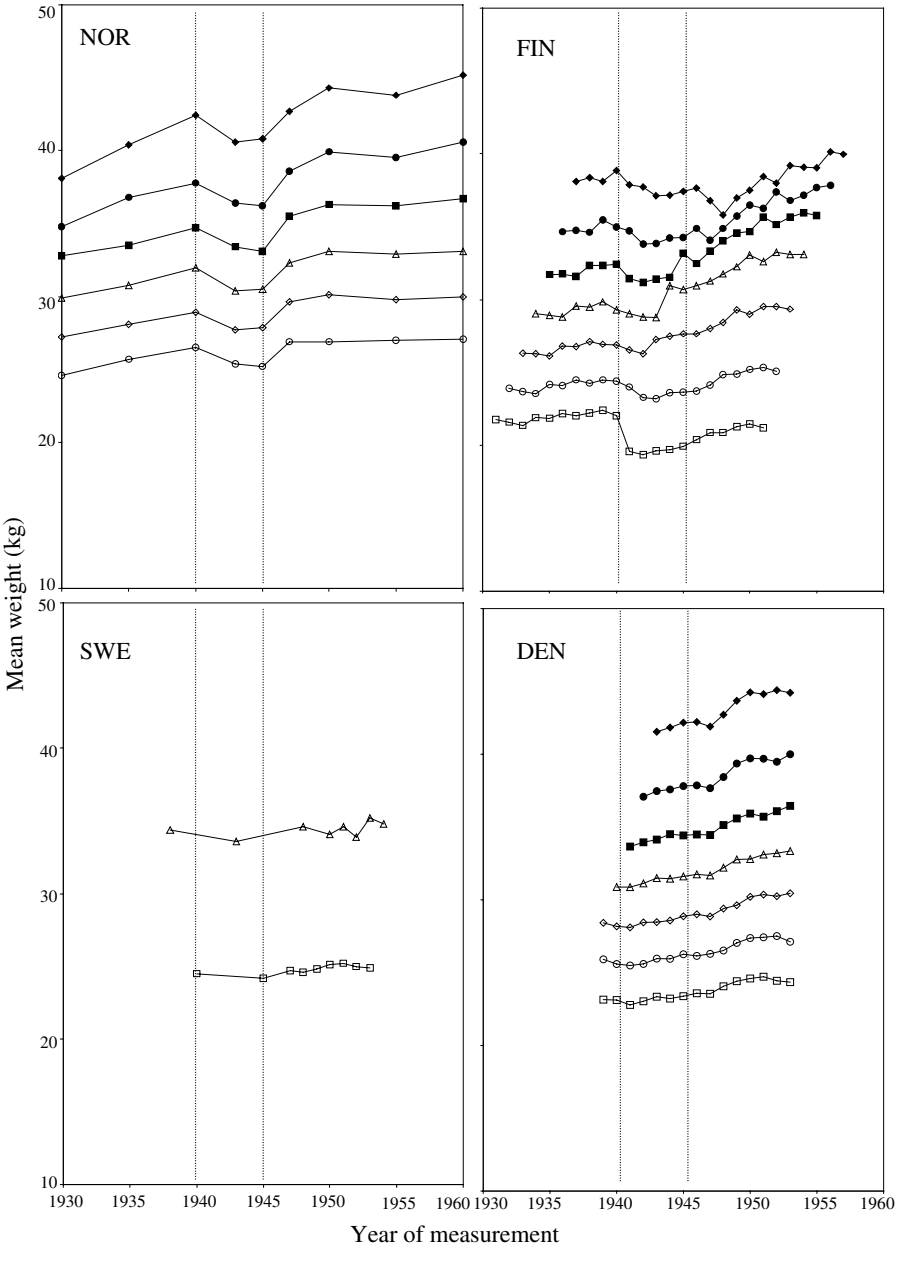

Figure 3. Weight in Nordic boys aged 7–13 years from 1930 to 1960 (Norwegian data are reproduced with permission from Brundtland *et al*. 1980). □, 7 years; ○, 8 years; ◇, 9 years; Δ, 10 years; ■, 11 years; ●, 12 years; ◆, 13 years; vertical stippled lines, WWII.

while a decrease of 5 cm in height and 2 kg in weight was observed for the 11-year-olds. The SEM was 0.6 cm for height, and ranged from 0.3 to 0.6 kg for weight.

The trends in height and weight remained unchanged for Danish children during WWII, with a constant slight increase for all children. The SEM ranged from 0.07 to 0.16 cm for height, and from 0.05 to 0.15 kg for weight.

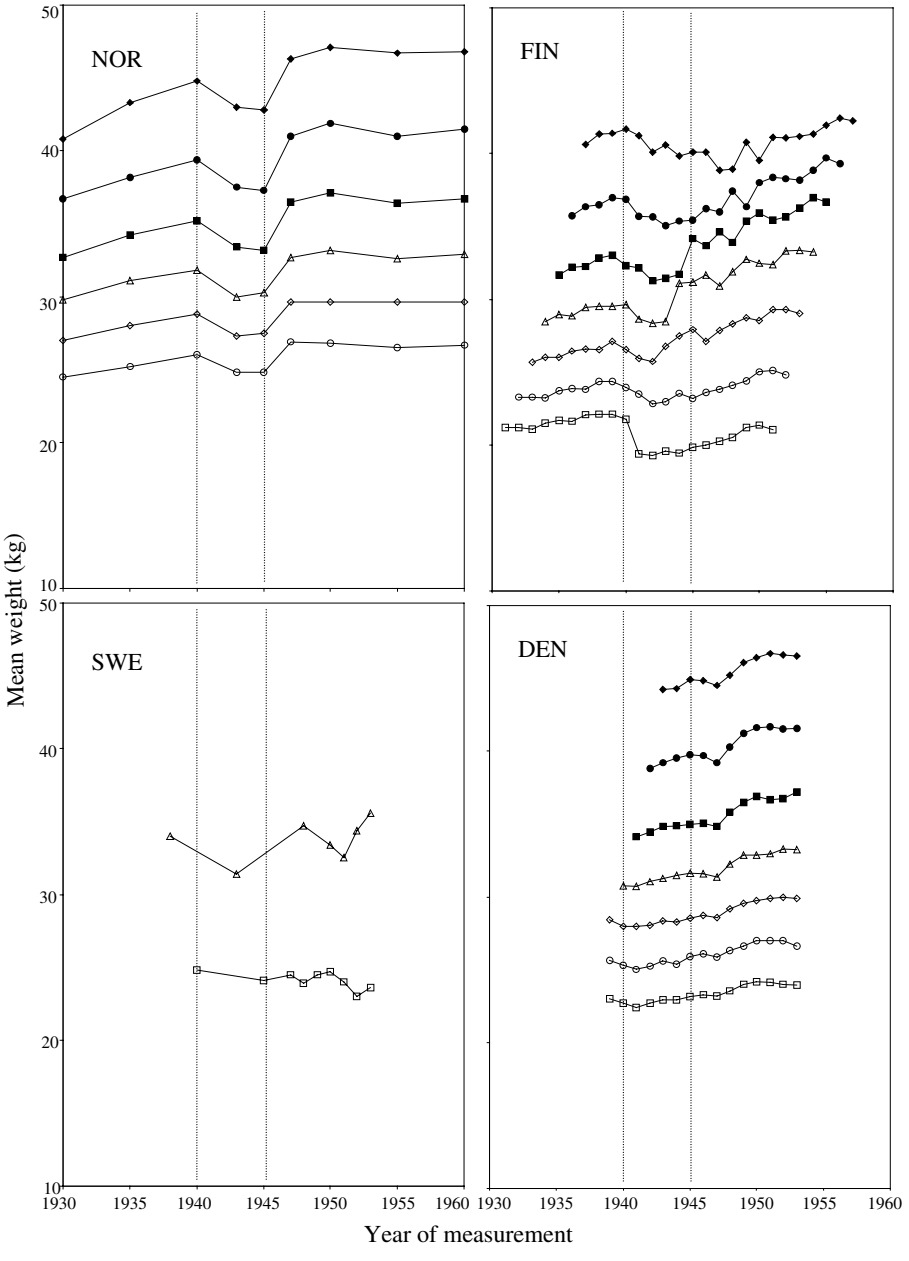

Figure 4. Weight in Nordic girls aged 7–13 years from 1930 to 1960 (Norwegian data are reproduced with permission from Brundtland *et al.* 1980). □, 7 years; ○, 8 years; ◇, 9 years; Δ, 10 years; ■, 11 years; ●, 12 years; ◆, 13 years; vertical stippled lines, WWII.

4. Discussion

The principal findings of the present study are that Nordic children were more or less affected by WWII in terms of a transient reduction in time trends in height and weight, and that the magnitude of this decrease was associated with the severity of the energy restriction prevailing in the respective country during the war. The most

consistent impairment in the anthropometric variables and the largest energy restriction were observed in Norway, followed by Finland. Even though there were few measurements prior to the war in Sweden and Denmark, the trends show that little or no effect on height and weight was observed, together with a modest energy restriction. Our data are in keeping with other lines of evidence, such as that from the Netherlands where men exposed to the Dutch hunger winter famine during last trimester of gestation and first 6 months of life had lower risk of obesity at age 19 years (Ravelli *et al.* 1976), suggesting that severe energy deprivation may have a long-term effect on anthropometric variables.

Several precautions pertaining to this ecological study need to be taken into consideration when interpreting the causal implications of these results. First, only aggregated measurements are available both for the anthropometric variables and for the dietary energy intake within each country. Thus, even though it seems plausible that the relationship between energy restriction and impaired growth holds at a population level, it is uncertain to what extent this is valid at an individual level. A British cohort study, however, supports a similar relationship at an individual level (Frankel *et al.* 1998).

Second, heterogeneity within the population, together with a lack of ability to control for potential confounding factors such as socio-economic conditions (Cernerud and Elfing 1995, Silventoinen *et al.* 1999), make it appropriate to be cautious whether the association between WWII-imposed energy restriction and impaired height and weight development is causal. Norwegian data, however, report that all socio-economic classes were well off regarding their financial status, and that dietary intake was probably determined more by food availability than income during WWII (Strøm 1948). Another source of potential bias is introduced from the use of aggregated family data or food supply data on energy restriction. It is unclear how the energy intake is distributed within the family, but there are reasons to believe that the children suffered from the prevailing restriction.

There has been some controversy about the findings from the Dutch hunger winter, because the women who actually were able to get pregnant and deliver a live born baby were different from the women who did not conceive under these circumstances. Thus, a possible selection bias might also arise in the present study regarding fertility and infant mortality levels. In the Nordic countries, however, the energy restriction was not as severe as in the Dutch hunger winter, and data from Norway, with the largest food restriction, do not show any effect on either fertility or infant mortality (Statistics Norway 1994).

To reduce possible bias, data from the various countries have been gathered from sources as comparable as possible. All anthropometric data in the present study stem from the school health service from the respective capital in each country, thus making the areas reasonably comparable in terms of food supply. The advantage of using data from cities is that the possible effects of food shortage during wartime are likely to be more pronounced in these non-food producing areas (urban) compared with the food producing areas (rural) (Statistics Norway 1946, Roine 1948). It is only for Norway, however, that data regarding food intake per family exist for the capital, and thus allowing for a direct comparison with anthropometric variables. In the other countries, food consumption and energy intake are based on national food consumption statistics. As mentioned above, the effect of food shortage is likely to be more pronounced in the city, thus the percentage change in energy intake for the urban population is likely to be underestimated for Denmark, Sweden and Finland.

This limitation, however, is not a major concern, given that the underestimation can be estimated to maximum 3–4% based on data given in Heikkinen (1996).

Weaknesses of the present study are the sparse data for Sweden, and the lack of multiple measurements prior to WWII for both Denmark and Sweden. This makes formal statistical assessment of the secular trends difficult. We believe, however, that the effect of WWII on the anthropometric variables is convincingly demonstrated by the graphical illustrations. The shortcoming in the completeness of the data must be judged in light of the large difficulties in providing these kinds of data from the original sources, the old archives. Given this perspective, in our opinion it is justified to present and interpret the data with a less stringent approach than otherwise would have been preferred.

Even though we have chosen to present the data as cross-sectional data, it is possible to follow data longitudinally by birth cohort, for example in the Finnish cohort, where the same children are followed with repeated measurements. Here a possible cohort effect on height and weight can be observed, being most pronounced for girls, starting for those aged 7 years in 1944 and followed until the final measurement at 13 years. The reason for this inflection is unknown, but it is possible to postulate this could be due to harsh nutritional conditions affecting particularly those born in 1937.

In Finland, only the younger children were retarded in their growth during WWII. This pattern is quite consistent throughout the war period and is based on a sample size of at least 150 children (average 400), and is thus not likely to represent an artefact. It is, however, unclear to us why those aged 7 years of age would respond differently to any given energy restriction than the older age groups. The most likely explanation is therefore simply that the food deprivation in Helsinki was larger among the youngest children than the older ones.

The measurements performed in Stockholm during the war are scarce, unfortunately. The height and weight reduction among 10-year-old girls in Sweden during WWII is based on only one measurement and a small sample size of 100, which make this finding prone to random variation. Data published earlier, with access to the complete health records, published a height of 137.5 cm for girls aged 10 years measured in 1943, and 139.0 cm for 1953 (Cernerud and Lindgren 1991). Our corresponding figures were 136.5 and 143.5 cm. Thus, it seems plausible that the height and weight reduction observed in our sample of Swedish girls during WWII may be due to random variation.

The consumption of fat, cereals, vegetables and meat changed in a uniform way in the Nordic countries during WWII, although it showed a certain variation in the magnitude of change. There was, however, some heterogeneity in the fish and milk consumption, with an increase in fish intake in Norway, while the intake was constant in Sweden, Finland and Denmark. There are no known hypotheses being able to explain how these changes in food composition could have any effect on the anthropometric variables, since the amounts of the essential amino acids and fatty acids were reported to be sufficient (Strom 1948). The dietary change resulted in lower net energy intake, which is the most plausible explanation for the observed effect on height and weight, rather than the modest diversity with respect to dietary composition (Mohan and Rao 1983, Clayton and Gill 2001).

Studies on conscripts in the Netherlands noted that boys who were around the maximum growth spurt in puberty (around 14 years) during the Dutch hunger winter had an interruption in the secular trend towards increasing height

(Van Wieringen 1978). For boys aged around 18 years this trend was not interrupted, suggesting that long-term effect of famine is only apparent when the exposure happens prior to the pubertal growth spurt. Unfortunately, there are no measurements of anthropometric status of these Nordic children in adulthood to investigate whether this effect of WWII is temporary or not.

The diseases that are positively associated with adult body height are the non-smoking related cancers, such as those of the breast, colon and testis, while the diseases that are inversely associated are cardiovascular disease, type 2 diabetes, stroke and stomach cancer (Davey Smith *et al*. 2000). Poor nutrition during childhood can affect growth and contribute to short stature in adult life (Silventoinen *et al*. 1999), thus, effects on the anthropometric variables in childhood may affect the risk for diseases later in life. Previously published data have demonstrated a decreased risk in the birth cohorts born during WWII on the incidence of testicular cancer in Norway, Sweden and Denmark (Wanderas *et al*. 1995, Bergstrom *et al*. 1996) (there were too few cases to observe any trend for Finland) and of colorectal cancer in Norway (Svensson *et al*. 2002). Furthermore, the breast cancer risk was lower than expected for women who experienced their puberty during WWII in Norway (Tretli and Gaard 1996), especially in non-food producing (urban) areas (Robsahm and Tretli 2002). No studies have, to our knowledge, investigated the effect of WWII in childhood on the risk of coronary heart disease, diabetes or stroke. There is, however, evidence that height and weight during childhood may affect later risk of coronary heart disease and insulin resistance (Lithell *et al*. 1996, Gunnell *et al*. 1998). This implies that the nutritional conditions during the war may have modified the risk factors for these diseases later in life.

In conclusion, it is plausible that the observed transient reduction in the anthropometric variables is attributable to the energy restriction that took place in various degrees in the Nordic countries during WWII. These findings warrant further studies, including assessment of the impact on incidence, and possibly survival, of the chronic diseases associated with height and weight for the cohorts who were in their sensitive periods early in life during WWII. Further studies with a life course perspective, such as those on the Dutch hunger winter on breast, prostate and colon cancer (Dirx *et al*. 1999, 2001, 2003), should be conducted in the Nordic countries, where a wide range of energy restriction, and subsequent effects on the anthropometric variables, was observed for childhood cohorts during WWII.

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Zusammenfassung. *Hintergrund*: Studienziel war die Beschreibung der Körperhöhe und des Gewichtes bei Skandinavischen Kindern während der Jahre um den Zweiten Weltkrieg, und der Vergleich mit der Ernährungssituation in derselben Periode.
Methoden: Informationen über Nahrungsmittelkonsum und Energieaufnahme wurden der Literatur entnommen. Aus dem Zeitraum von 1930 bis 1960 wurden für die Altersgruppe 7 bis 13 Jahre anthropometrische Daten aus den Skandinavischen Hauptstädten gesammelt.
Ergebnisse: Die größte kalorische Beschränkung der Nahrungsmittelversorgung herrschte in Norwegen (20%), gefolgt von Finnland (17%), während die Beschränkung in Schweden und Dänemark nur 4–7% gegenüber der Vorkriegszeit ausmachte. Der stärkste kriegsbedingte Effekt auf Körperhöhe und Gewicht ist bei Norwegischen Kindern zu sehen, während ein gemäßigter Effekt bei den jüngsten Finnischen Kindern zu beobachten ist. In Schweden und Dänemark ist der Effekt geringfügig oder nicht nachweisbar.
Zusammenfassung: Skandinavische Kinder zeigten während des Zweiten Weltkriegs eine vorübergehende Verringerung ihrer Körperhöhen- und Gewichtszunahme. Das Ausmaß dieser Verringerung war mit dem Schweregrad der kriegsbedingten kalorischen Beschränkung der Nahrungsmittelversorgung in den jeweiligen Ländern assoziiert. Die Ergebnisse rechtfertigen weitere Studien auch hinsichtlich chronische Erkrankungen und ihren Einfluß auf Körperhöhe und Gewicht in Jahrgängen, die während des Zweiten Weltkriegs aufgewachsen sind.

Résumé. *Arrière-plan*: Cette étude a pour objet d'examiner la stature et le poids des enfants nordiques dans les années de la seconde guerre mondiale et de les mettre en rapport avec la situation nutritionnelle pendant la même période.
Méthode: L'information sur les consommations alimentaires et l'apport énergétique ont été tirées de la littérature. Des données anthropométriques ont été collectées dans les capitales nordiques, elles couvrent la période de 1930 à 1960 pour les âges de 7 à 13 ans.
Résultats: La plus forte restriction énergétique s'est produite en Norvège (20%) suivie par la Finlande (17%), alors que la Suède et le Danemark ne connurent qu'une restriction de 4,7% par rapport aux niveaux d'avant-guerre. L'effet le plus marqué du second conflit mondial sur la taille et le poids se note chez les enfants norvégiens, tandis qu'un effet apparaît chez les enfants finlandais les plus jeunes. La Suède et le Danemark ne montrent que peu ou pas d'effet de la période de guerre.
Conclusion: Les enfants nordiques ont été affectés par la seconde guerre mondiale sous la forme d'une réduction transitoire de la tendance séculaire d'augmentation de la stature et du poids et l'importance de cette réduction a été fonction de la sévérité des restrictions énergétiques affectant chaque nation pendant la durée de la guerre. Ces résultats fournissent un cadre de référence, pour de futures études portant sur les maladies chroniques associées au poids et à la stature chez les cohortes d'enfants ayant leur croissance pendant la période de la seconde guerre mondiale.

Resumen. *Antecedentes*: El propósito del estudio fue examinar la estatura y el peso en los niños nórdicos durante los años en torno a la II Guerra Mundial, y compararlos con la situación nutricional durante el mismo periodo.
Métodos: La información sobre el consumo de alimentos y la ingesta energética se obtuvo de la literatura. Los datos antropométricos se recogieron en las capitales nórdicas y cubren el periodo comprendido entre 1930 y 1960, para edades entre los 7 y los 13 años.
Resultados: La mayor restricción energética tuvo lugar en Noruega (20%), seguida por Finlandia (17%), mientras que Suecia y Dinamarca tuvieron una restricción del 4–7% respecto a los niveles pre-bélicos. El efecto más pronunciado de la II Guerra Mundial sobre la estatura y el peso se observó en los niños noruegos, mientras que se percibió un cierto efecto en los niños más jóvenes de Finlandia. En Suecia y Dinamarca se observó un efecto pequeño o nulo.
Conclusión: Los niños nórdicos se vieron afectados por la II Guerra Mundial en términos de una reducción transitoria de las tendencias temporales en la estatura y el peso, y la magnitud de esta reducción estaba asociada con la severidad de la restricción energética predominante en los respectivos países durante la guerra. Estos resultados demandan posteriores estudios de las enfermedades crónicas asociadas con la estatura y el peso para las cohortes que se encontraban en sus periodos de crecimiento durante la II Guerra Mundial.