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Supplements

Growth, development, and physical fitness of Flemish vegetarian children, adolescents, and young adults^{1,2}

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► ABSTRACT

This study was designed to assess average daily dietary intakes of energy in 82 vegetarian children (group A: 6–9-y-old girls and 6–11-y-old boys), adolescents (group B: 10–15-y-old girls and 12–17-y-old boys), and young adults (group C: 16–30-y-old females and 18–30-y-old males) and included determination of height and weight; triceps, suprailiac, and calf skinfold thicknesses; puberty ratings; and physical fitness. Dietary energy intake was lower than recommended values in all 3 groups. Height and weight did not differ significantly from the reference data except in group B, which had significantly lower heights and weights and lower body mass indexes ($P < 0.05$). Triceps and suprailiac skinfold thicknesses were lower in all age groups, whereas the calf skinfold thickness was only significantly lower in the 10–15-y-old girls ($P < 0.05$). The vegetarian children were as physically fit as the reference group. The vegetarian adolescent boys and

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girls and the young adults scored significantly lower on the standing long jump and 30-s sit-up ($P < 0.05$). The vegetarian subjects of groups B and C recovered significantly faster from the step test ($P < 0.05$). Puberty ratings plotted on percentile graphs showed that all vegetarian subjects, except for 1 girl, were within the normal developmental range. We conclude that, within the limits of this study, vegetarian subjects have lower relative body weights and skinfold thicknesses in adolescence than do nonvegetarians. They scored lower on the strength tests and better on the cardiorespiratory test when compared with reference values. The growth and maturation status of the vegetarian population were within the normal range.

Key Words: Growth • development • physical fitness • vegetarian children • adolescents • young adults • Belgium

► INTRODUCTION

Recent polls revealed that in the United Kingdom, 5% of the electors claim to be vegetarian (1). In Germany, the Allensbach Institute released a figure of 5% for the proportion of vegetarians in the population (2), and in Netherlands figures of 3% (3) and 4.2% (4) were given for the adult vegetarian population in 1989. In the United Kingdom, ≈8% of people aged 11–18 y are vegetarian (5), but no figures on young people are available from other European countries. In Western Europe today, an increasing number of children and young people espouse a vegetarian diet either because they are raised in a vegetarian family or because they have decided themselves to become vegetarian. However, no specific estimates were found of the current numbers of vegetarians <18 y of age in Europe.

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Concern has been expressed that nutrient deficiencies may affect the growth and development of vegetarian children and adolescents, especially those reared on vegan (6) and macrobiotic (7) diets. Nutritional adequacy in lactoovovegetarian children was reviewed extensively by Jacobs and Dwyer (8), by Dwyer et al (9), and more recently by Sanders and Reddy (10). Most of the studies have focused on health aspects of vegetarianism of preschool children (11, 12); few have investigated the physical growth, body composition, maturation, and physical fitness of vegetarian school-age children and adolescents. In Britain, a cross-sectional study of 3 cohorts of Asian vegetarian girls (Urdu, Gujarati, and Punjabi) showed that only 1 cohort (Urdu girls) was significantly shorter than the omnivorous reference group (13). In the Farm Study, O'Connell et al (14) found that the height of children ≤10 y of age raised in a vegetarian commune was consistently below US reference values. During the past decade, several growth studies have been carried out in children of Seventh-day Adventists (SDAs), who largely follow a vegetarian lifestyle. In a small sample ($n = 17$) of lactoovovegetarian SDA children 10–12 y of age, Tayter and Stanek (15) found no significant differences in group mean heights, weights, midarm circumferences, triceps skinfold thicknesses, and weight-for-length indexes when compared with a group of omnivores of the same age and sex.

Sabaté et al (16, 17) collected height and weight data from a 2-y longitudinal survey of 2272 children

aged 6–18 y of whom 1090 were SDA and most followed a lactoovovegetarian diet. Age-adjusted regression analysis showed that SDA school boys were taller (1.6 cm) than public school boys, but there were no significant differences in height for girls. After height was controlled for, boys and girls in the SDA school were found to be leaner than their public school peers.

In a 1-y longitudinal, observational matched-pairs study of 50 pescovegetarian children aged 7–11 y, Nathan et al (18) found that of all anthropometric measurements examined, the predicted height increment of the vegetarian cohort was slightly (0.47 cm) but significantly greater than that of the omnivorous cohort. There was a nonsignificant tendency for vegetarians to be leaner than omnivores.

It is apparent that there have been few if any studies on the growth and development of vegetarian children and adolescents that have taken into consideration body-composition variables, maturation indicators, and physical fitness. The present study, therefore, was designed to assess daily intakes of energy and to determine selected anthropometric measurements, puberty ratings, and physical fitness measures of vegetarian children, adolescents, and young adults and to compare these variables with reference data.

► SUBJECTS AND METHODS

Subjects

The children, adolescents, and young adults were recruited in the Flemish region of Belgium by advertising in health food shops and by contacting vegetarian-oriented societies. Criteria for selection were that the subjects were healthy, aged 6–30 y, and had followed a lactoovovegetarian diet for ≥ 3 y. The final sample comprised 82 subjects of whom 72% ($n = 59$) were vegetarian since birth and 28% ($n = 23$) had been vegetarian for ≥ 3 y. "Healthy" was defined as having no history of any illness considered likely to affect growth. On the basis of the reported medical information, none of the subjects had to be excluded from the study because of the latter criterion. Informed consent from the parents of the children and adolescents and from the young adults was obtained before data collection. The subjects were grouped into 3 cohorts: group A, prepubertal children, 6–9-y-old girls ($n = 9$) and 6–11-y-old boys ($n = 9$); group B, adolescents, 10–15-y-old girls ($n = 10$) and 12–17-y-old boys ($n = 10$); group C, young adults, 16–30-y-old females ($n = 31$) and 18–30-y-old males ($n = 13$).

Because of time restraints and local circumstances, not all subjects could be measured and tested. Seventy-eight subjects provided dietary data and 48 subjects were measured and underwent physical fitness tests.

Food energy intake

Dietary information was obtained by using a 7-d food-frequency questionnaire that was completed by the mothers of the prepubertal children (group A) and was self-administered by all adolescents and young adults (groups B and C). The results of the dietary analyses together with a hematologic study

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will be reported in a forthcoming publication. The food energy intake was calculated by using the computerized Dutch Food Composition Table and compared with the recommended daily energy intake (19).

Anthropometric measures and maturation ratings

Anthropometric measures included weight, height, and triceps, suprailiac, and calf skinfold thicknesses measured by using standardized techniques described by Lohman et al (20). Comparisons for groups A and B were made with reference data from a recent representative study (stratified random sample of 2837) of 6–18-y-old Flemish youth (21), whereas for group C, reference data were used from an anthropometric and physical fitness study of young adults based on a representative random sample ($n = 99$) of Flemish physical education and physiotherapy students (J Borms, unpublished observations, 1993).

Data concerning a restricted number of sexual maturation characteristics were collected according to criteria formulated by Tanner (22) and extended by a sixth stage for pubic hair (23). Ratings were made of pubic hair and development of genitalia in boys and of pubic hair, breast development, and age at menarche in girls.

All anthropometric measurements were performed by a trained anthropometrist (quality-control coefficient for inter- and intraobserver reliability >0.90) and sexual maturation by self-assessment techniques (24–26) using Roede and Van Wieringen's (27) standard color photographs. Age at menarche was determined by the retrospective method using questions regarding date of onset of menarche (28, 29).

Physical fitness

Fitness assessment included hand dynamometry, a standing long jump, a 30-s sit-up, and the Queen's College Step Test, as measures of hand grip strength, leg explosive strength, abdominal dynamic muscular endurance, and cardiorespiratory endurance, respectively.

The hand grip strength test, standing long jump, and 30-s sit-up tests were executed according to the protocol of the *Eurofit Handbook* (30) and the results were compared with the reference data for Flemish children and adolescents (31) and Flemish physical education and physiotherapy students (J Borms, unpublished observations, 1993). The Queen's College Step Test (32) is a short step test that can be used to predict maximal oxygen consumption capacity. The test consists of stepping up and down a bleacher step 41 cm high at a rate of 22 steps/min for 3 min. Subjects remain standing after the exercise and a 15-s pulse count is taken beginning 5 s after cessation of exercise. The 15-s count is multiplied by 4 to record the score in beats/min. Comparisons were made for recovery heart rate of the young adults (group C) by using the percentile rankings of college students (32), whereas for the children and adolescents, reference data from a Flemish school population were used (M Hebbelinck, A De Malsche, unpublished data, 1996).

Statistical analysis

Student's t test for small samples was used to compare means of the different vegetarian cohorts with

reference means. Because no SDs of the reference values were available, CIs around the observed means were used. P values < 0.05 were considered statistically significant.

► RESULTS

Food energy intake

Seventy-eight subjects with complete dietary records were studied. Energy intake (**Table 1** [↗](#)) was considerably lower than the mean reference data in all subjects, with particularly marked differences in four 15-y-old boys and three 15-y-old girls, whose intakes were 66% and 51% of the reference values, respectively. Only two 13-y-old boys had intakes that were close (97%) to the reference value.

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View this table: **TABLE 1.** Energy intake of vegetarian children (group A), adolescents (group B), and young adults (group C) compared with reference values¹
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Anthropometric measurements

The mean weight, height, and body mass index (BMI) for each of the 3 groups are reported in **Table 2** [↗](#). When compared by applying t tests, only the vegetarian adolescents (group B), both boys and girls, had significantly lower ($P < 0.05$) body weights than the reference means. Moreover, the vegetarian adolescent boys were 8.5 cm smaller ($P < 0.05$) than the reference mean.

View this table: **TABLE 2.** Mean weight, height, and BMI of vegetarian children (group A), adolescents (group B), and young adults (group C) compared with reference values¹
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The children (group A) and young adults (group C) did not differ significantly from the reference population standards with regard to height and weight. The BMIs were significantly ($P < 0.05$) lower than reference standards in both adolescent girls and boys (group B). Skinfold thicknesses at the triceps, calf, and suprailiac sites are listed in **Table 3** [↗](#). Generally, the skinfold thickness at all sites were lower in all age groups than the reference means. More particularly, significant differences ($P < 0.05$) were shown in the triceps skinfold thickness of the prepubertal girls (group A) and the adolescent boys (group B), the calf skinfold thickness of the adolescent girls, and the suprailiac skinfold thickness of the prepubertal girls as well as of the adolescent girls and boys.

View this table: **TABLE 3.** Triceps, calf, and suprailiac skinfold thicknesses (SKF) of vegetarian children (group A), adolescents (group B), and young adults (group C) compared with reference values¹
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C) compared with reference values¹

Sexual maturation

The ratings of pubic hair development in the boys of group B (12–17 y; $n = 10$) were plotted on percentile curves (23) and are depicted in **Figure 1**. Eight boys scored above the median (50th percentile): 2 (subjects 3 and 9) between the 55th and the 70th percentile, 2 (subjects 1 and 2) between the 70th and the 80th percentile, and 4 (subjects 4, 5, 7, and 10) between the 80th and 90th percentile. Two boys (subjects 6 and 8) scored under the 50th percentile: 1 (subject 6) at the 47th and 1 (subject 8) at the 22nd.

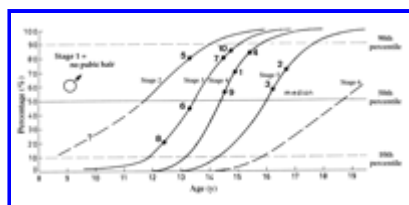


FIGURE 1. Pubic hair ratings of vegetarian adolescent boys ($n = 10$) plotted on cumulative frequency curves. •, Subject number. Data from the Dutch population survey of 1965 (23).

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Ratings of genital development of the boys are shown in **Figure 2**. Seven of the 9 boys had scores well above the median, whereas 2 boys (subjects 5 and 6, aged 13.1 y and 13.2 y, respectively) had not yet attained stage 2 of genital development. The record was missing for 1 boy (subject 8).

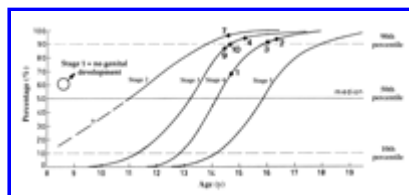


FIGURE 2. Genital development ratings of vegetarian adolescent boys ($n = 10$) plotted on cumulative frequency curves. •, Subject number. Data from the Dutch population survey of 1965 (23).

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Ratings of pubic hair development of the girls in group B (10–15 y of age; $n = 10$) were plotted on percentile curves (23) and depicted in **Figure 3**. Six of the 10 girls had pubic hair ratings above the median: 3 (subjects 1, 6, and 10) scored between the 50th and 70th percentile and 3 (subjects 2, 4, and 7) scored above the 90th percentile. Two girls (subjects 8 and 9) had low ratings (8th and 6th percentile) of pubic hair development and 2 (subjects 3 and 5, aged 10.6 y and 12.0 y, respectively) did not show any pubic hair development.

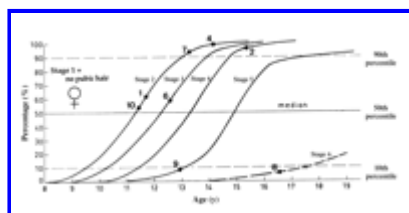


FIGURE 3. Pubic hair ratings of vegetarian adolescent girls ($n = 10$) plotted on cumulative frequency curves. •, Subject number. Data from the Dutch population survey of 1965 (23).

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The ratings of breast development are shown in **Figure 4**. Four girls (subjects 2, 4, 7, and 8) scored at the 65th percentile or above, 5 (subjects 1, 3, 6, 9, and 10) rated breast development between the 10th and 40th percentile, and 1 (subject 5, aged 12.0 y) had not started breast development. With use of the method of retrospective collection with the vegetarian adolescent girls and female young adults ($n = 32$), mean age at menarche was 13.2 ± 1.4 y, ranging from 11 to 16 y.

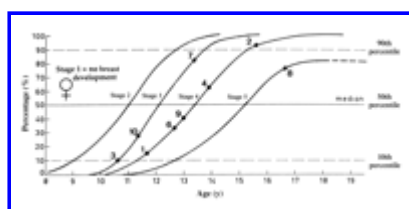


FIGURE 4. Genital development ratings of vegetarian adolescent girls ($n = 10$) plotted on cumulative frequency curves. •, Subject number. Data from the Dutch population survey of 1965 (23).

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Physical fitness

The results of the 4 physical fitness tests are reported in **Table 4**. The vegetarian children (group A) did not differ from the reference population. Hand grip strength of the vegetarian subjects in all 3 age groups did not differ significantly from the reference values, except for the females in group C, who scored significantly lower on this item than did the reference group of physical education students (J Borms, unpublished observations, 1993).

View this table: **TABLE 4.** Physical fitness test scores of vegetarian children (group A), adolescents (group B), and young adults (group C) compared with reference values
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The vegetarian adolescents in group B and young adults in group C scored significantly ($P < 0.05$) lower in the standing long jump and 30-s sit-up tests than did the reference populations. In contrast, the same 2 groups of vegetarian subjects had significantly lower recovery heart rates than did the reference populations.

► DISCUSSION

Children who follow certain vegetarian diets, particularly vegan diets, that are rich in bulk are reported to have difficulty acquiring adequate energy intake (6, 8, 18). This observation is corroborated by the present findings in which energy intakes of the vegetarian children, adolescents, and young adults were well below the reference values (19). The greatest differences were in 15-y-old boys ($n = 4$) and girls ($n = 3$), 11-y-old girls ($n = 3$), and male young adults ($n = 13$), who were attaining 66%, 51%, 71%, and 68% of the reference energy intakes, respectively.

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Although the energy intakes tended to be low, the vegetarian subjects had attained normal height but they were leaner, had lower skinfold thicknesses and lower BMIs in several of the age groups. Taking into account the fact that lighter persons require proportionately less energy per unit of time for activities that involve displacement of mass, it is clear that energy allowances must be adjusted for the variation in requirements that result from these differences in body size and body composition. The relative leanness of the vegetarian subjects, particularly in adolescence and young adulthood, may explain why they had low energy intakes. Moreover, for groups, recommended energy allowances represent averages and should be regarded as empirically derived estimates.

Furthermore, it is commonly believed that people tend to underreport items such as seasonings (eg, fats, oils, and sweeteners), which may affect reported energy intake (33). Underreporting food intake could be a plausible explanation for the lower energy intakes, particularly with the vegetarian subjects who may have been trying to give an impression of following a healthier diet (40).

Except for the group of adolescent boys, height was normal in these vegetarian children, adolescent girls, and young adults. There was a marked tendency for all age groups and both sexes to be lighter in proportion to their height than the reference values. The smaller mean height of the group of adolescent boys may be ascribed to the fact that 2 brothers in this group were markedly shorter than the rest of the group. The extent to which vegetarian diet had influenced body height cannot be identified because genetic and social factors may have influenced growth as well (34). When weight was controlled for height, vegetarian boys and girls were shown to be leaner, corroborating the present findings (15, 16). The age distributions of the secondary sex characteristics were within the 3rd to 97th percentile range of the Dutch population survey of 1965 (23). The question of whether these sexual maturation indicators have undergone secular changes has been studied by Roede and Van Wieringen (27), who found that median values of stages of sexual maturation shifted to an earlier age varying in boys from 1 mo (genitalia stage 3) to 1 y (pubic hair stage 5), and in girls from 5 mo (breast stage 3) to 1 y (breast stage 5). Taking into account that these secular changes may also have taken place in the Flemish population, we found that, except for 1 girl, the adolescent vegetarian boys and girls reached sexual maturation within the normal range. Note that several subjects had ratings of puberty characteristics well above the median reference values.

Age at menarche is considered to be one of the strongest indicators of timing of sexual maturation and is related to the health and nutritional status of the individual. The median menarcheal age of 13.2 y in the present study is identical to the most recent figure for Flemish girls (35) and does not support the hypothesis of delayed menarche in vegetarian girls (36–38) in this particular population.

There is growing interest in the physical fitness of present-day youth (39). Because the health and fitness of a child are related to his or her eating patterns and exercise habits, it is important to determine the level of physical fitness. The results of the physical fitness tests in the present study indicate that in the 3 strength-related tests, ie, hand grip strength (static strength), standing long jump (explosive strength), and 30-s sit-up (abdominal strength), the vegetarian subjects scored at or below the average level of performance of their respective reference age groups. Although no reference data were available on a general population of young adults (group C), we made our comparison with a reference group of physical education and physiotherapy students, who were in a good physical condition. However, both the vegetarian male and female adolescents and young adults performed better in the step test than did the reference group. This latter finding suggests that the vegetarian subjects had better cardiorespiratory endurance. In this respect, a contributing factor may be the pattern of sporting activity of the vegetarian population studied; most played endurance sports rather than strength-related sports (40). Moreover, the relatively low body mass and the skinfold thickness data may have been a part of the better cardiorespiratory endurance of the vegetarians. To date, no similar study of the physical fitness status of vegetarian youth has been performed, and therefore, no comparisons can be made.

Finally, we note that self selection could not be avoided in this study. Because there was no attempt to determine the specific reason for participating in the study, it is impossible to estimate the degree of self selection. Regardless of this limitation, this is one of the few epidemiologic studies to focus on different aspects of the growth and developmental status of vegetarian youth such as body composition (skinfold thicknesses), sexual maturation, and physical fitness.

In conclusion, the results of this study support the view that a lactoovovegetarian diet sustains adequate physical growth and maturation. Some of the vegetarian subjects, however, appear to have had difficulty meeting the energy requirements. (Analysis of the diet together with a hematologic study of this population will be reported in a forthcoming study.) Furthermore, in comparison with reference values, the vegetarian youngsters studied are lean and scored low on strength tests but high on cardiorespiratory endurance tests. Even though the present study supports previous findings that normal growth and development can be achieved in relatively young vegetarian populations (8), longitudinal studies that actually link the vegetarian diet with various aspects of health and fitness during growth into adulthood are needed.

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