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ASSESSMENT OF THE EVOLUTION OF ANTHROPOMETRIC INDICATORS IN Students WITH SPORTS PROGRAM

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ABSTRACT. Anthropometric measurements are noninvasive methods that allow assessment of growth and development status and predicting the health of the body. The study was undertaken on 200 students aged 11-16 years. It studied the dynamics of stature and nutritional status in athletes.The results lead to the following conclusions: all the indicators studied increased in range between 11 years and 16 years; the somatic development is influenced by age, sex and sports activities.

Keywords: students, unsports group, sports group, anthropometric indicators

INTRODUCTION

Pre-puberty begins in both sexes at the age of 10-11 years and it takes on average two years at girls, up to 12-13 years and at boys four years, up to 14-15 years. Somatic development during puberty is the influence of internal and external factors that give faster and more evident quantitative and qualitative changes in several of the somatic studies. Most of the studies performed so far in this area have focused on quantitative growth, giving a large number of data on morphological changes of the soma.

This paper aims to assess the somatic development of students from sports school compared with control groups, based on somatic parameters determined at one year interval. The study addresses two aspects: a quantitative assessment of growth and development of somatic parameters measured by comparing with previous results and qualitative assessment of growth and development process by calculating the proportion of indices using measured parameters and comparing them with previous results.

MATERIALS AND METHODS

The analytical study was conducted on 200 students, with ages ranging between 11 years and 16 years, divided in two groups, one group consisted of students who practice sport and the second one was the control group. Each group consisted of 100 subjects. Within each group analyses were performed separately between the sexes. The student selection was based on their health status. Initial testing was done in December and final testing in the same month after a year. Anthropometric examination was done at 8 AM, after a rest of at least 12 hours after the last training. For this study we used the standard form (biometric sheet).

Recommended procedures for anthropometric measurements are subjects in orthostatic procedure with light clothing. Measurements were performed after the procedures recommended by Lohman et al. (1988). The variables studied were: height ((Iv-sol), body mass (weight), biacromial and bitrohanterian diameters. The waist has been measured using a stadiometre. Biacromial and bitrohanterian diameters were measured using an anthropometric compass and results were expressed in centimeters.

The appreciation of harmonious development was done by calculating the proportion of the belts for height using the formula:

Biacromial index = (biacromial diameter/height) x 100
Bitrohanterian index = (bitrohanterian diameter/height) x 100

Fat percentage was calculated using the following formula:

Child body fat% = (1.51 x BMI) - (0.70 x age) - (3.6 x gender) + 1.4

Where: IMB = body mass index; male gender = 1; female gender = 0 (Deurenberg et al. 1991).

The skin fold measurement was performed using a Holtain caliper type. In assessing the nutritional status the body mass index (BMI) was used. It is the ratio of weight expressed in kilograms and height in centimeter square. It was calculated using the BMI Calculator Excel (www.cdc.gov/healthy weight/BMI).

Body water content was calculated separately between the sexes, according to the following formula:

Total water (male) = 0.184 x G + 0.345 x T-35.270
Total water (female) = 0.295 x G + 0.195 x T-14.013

Where T = height, G = weight (Nicolescu et al., 2006).

The muscle mass is calculated using the formula:

Muscle mass = (water total/73) x 100.

The data collected from the two assessments was centralized in an Excel database.

The data processing was done by various mathematical methods. In some cases frequencies were calculated and in other cases were processed statistically by Student aid test. The outliers were removed after Chavenet criterion (Snedecor and Cochram 1978; Weber, 1980). The statistical interpretation of data was performed separately for the two groups and sexes. Statistical processing was performed using Microsoft Office Excel 2003. The correlation was performed using Pearson correlation coefficient (Badea and Georgescu, 2003; Jaba and Grama, 2004).

RESULTS AND DISCUSSIONS

Somatic indicators (size and body mass) increase in the pre-pubertal period (12-15 years at girls and 12-17 years at boys) with 6-10 cm/year size and 3-4 kg/year weight (Heger et al., 2008). During puberty (15-17 years at girls and 17-19 years at boys) the size increases between 1-2 cm/year and the weight by 2-3 kg/year.

Table 1 represents the average values and the statistical estimation on body mass and size of the groups that were studied.

Table 1

Average values and the statistical estimation on size and body mass

Distribution by gender	Groups	X ± Es	Body mass (kg) 1	Body mass (kg) 2	Size (cm) 1	Size (cm) 2
Boys	Unsport	X ± Es	56.08 ± 2.37	66.31 ± 2.43	164.20 ± 0.02	174.84 ± 1.37
	Sports	X ± Es	54.57 ± 1.82	62.26 ± 1.60	163.30 ± 0.02	167.80 ± 1.37
Girls	Unsport	X ± Es	53.98 ± 1.01	55.59 ± 1.08	162.10 ± 0.08	166.10 ± 1.42
	Sports	X ± Es	45.93 ± 1.42	53.52 ± 2.44	157.20 ± 0.01	158.97 ± 1.20

The explanation of the table: X ± SE average and the statistical estimation; 1 - determinations made in 2010, 2 - determinations made in 2011.

Body mass is a sensitive and significant metabolic function and ability to fix or lose body reserves of nutrients. The girls had the body mass values between 45.93 ± 1.42 kg (experimental group) and 53.98 ± 1.01 kg (control group). After one year body mass was 53.52 ± 2.44 kg in the experimental group compared to 55.59 ± 1.08 kg in the control group. For boys the body mass was between 54.57 ± 1.82 kg (experimental group) and 56.08 ± 2.37 kg (control group) and then values reached 62.26 ± 1.60 kg (experimental group) and 66.31 ± 2.43 kg (control group). The body mass of the students in the control increased with 1.61 ± 0.07 kg for girls and it increased with 10.23 ± 0.06 kg for boys as for the experimental group increases were between 7.69 ± 0.22 kg (boys) and 7.59 ± 1.02 kg (girls).

In general, the height characterized fairly well the size of individual development that can relate to all other anthropometric measurements. The boys size was ranged between 164.20 ± 0.02 cm (control group) and 163.30±0.02 cm (experimental group). After one year the results were between 174.84 ± 1.37 cm (control group) and 167.80 ± 1.37 cm (experimental group). After the initial Rainer scale, boys had short stature for a year after that they were framed in medium size. Girls size was between 157.20 ± 0.01 cm (sports group) and 162.10 ± 0.08 cm (control group). After one year the values reached to 158.97 ± 1.20 cm (experimental group) and 166.10 ± 1.42 cm (control group). After Rainer girls have medium size.

Data from the literature supports the existence of a growth rate of four periods. The initial period of fast growth is up to 5 - 6 years for both boys and girls, followed by slow growth period up to 10-12 years for boys and 10 years for girls, and then growth is accelerated up to 16-18 years for boys and up to 14-15 years for girls and after that period it slows down.

Size increased by an average of 10.64 ± 1.35 cm for boys and 4.00 ± 1.34 cm for girls in the control group, and in students performing sports the average increased between 4.50 ± 1.35 cm at boys and 1.77 ± 1.35 cm at girls.

The girls from the experimental group of Pearson's correlation coefficient indicates a good association between weight and size (r = +0.52). In the control group of Pearson's correlation the coefficient was r = +0.39. The Pearson correlation coefficient at boys was r = -0.27 (experimental group) and r = +0.55 (control group).

During puberty there is great individual variability in terms of size and weight (Heger et al., 2008). The determinations made after one year showed increased body weight and height. In the group practicing sports the increase of body mass was due to the increase in muscle growth, in the control group may be due to the increased percentage of fat. In the case studied the experimental group consisted of students enrolled in High School Sports program. We must keep in mind that these students are selected in addition when they begin the athletic training at the age of 11 years (fifth grade).

In Table 2 are shown the average ± statistical estimation at body mass index (BMI). BMI is used as test screening assessing overweight and obesity. In the control group, BMI values were between 20.53 ± 0.31 kg/m^2 (girls) and 22.05 ± 0.97 kg/m^2 (boys). For students performing sports BMI was 18.43 ± 0.41 kg/m^2 (girls) and 19.69 ± 0.47 kg/m^2 (boys). The determinations made after a year revealed normal growth because the increased of BMI and the indicators used in calculating the index.

In the control group the body mass index increased after a year with 1.69±0.43 kg/m^2 at boys and 1.72±0.18 kg/m^2 at girls. In the experimental group after one year increases were higher by 2.09 ± 0.33 kg/m^2 at boys and 2.17 ± 0.12 kg/m^2 at girls.

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Table 2

Body mass index (BMI) values at the studied groups

Distribution by gender	Groups	X ± Es	BMI (kg/m^2) 1	BMI (kg/m^2) 2
Boys	Unsports	X ± Es	22.05 ± 0.97	23.74 ± 0.54
	Sports	X ± Es	19.69 ± 0.47	21.78 ± 0.80
Girls	Unsports	X ± Es	20.53 ± 0.31	22.25 ± 0.49
	Sports	X ± Es	18.43 ± 0.41	20.60 ± 0.53

Explication at Table 1.

In Table 3 the body mass indices are grouped into four categories: underweight, normal, overweight and obesity. Overweight is indicated by a BMI equal to, or higher than 25 and less than 30. In boys overweight is present in a proportion of 9.52% in the experimental group compared to 13.51% in the control group.

After one year the percentage increased at the control group (14.81%) and the experimental group (12.12%). The overweight girls in the control group were at a rate of 7.69%, while the experimental group had a percentage of 4.34%.

Measurements performed in year 2011 showed growth rates both in the control group (10.81%) and the experimental group (7.89%). Data from the literature claims that overweight is due to increasing body weight due to muscle and/or accumulation of excess fat. The overweight in adolescents is associated with obesity in adulthood. Obesity corresponds to a BMI equal to or greater than 30 kg/m^2. From epidemiological perspective, however, there is evidence that this is associated with increased cardiovascular risk. The increase the circumference waist/hip (marker of abdominal obesity) is correlated with the increased cardiovascular risk (Dubbert et al., 2002; Hu et al. 2004; Huxley et al., 2010; Khoury et. al, 2012; Torrance et al., 2007; Wang, 2003).

If BMI is less than 18.5 kg/m^2 we can discuss about malnutrition. Underweight is commonly associated with low dietary intake, excessive energy expenditure, and frequent attacks of respiratory and gastrointestinal infections, anemia (iron deficiency) as well as slow recovery from illness. School children have poor school performance and low attendance (Ramzan et al. 2008). Malnutrition was highlighted in a high percentage for students who practiced sport. Percentages were between 42.85% (boys) and 52.17% (girls). Dynamic changes in somatic development indices showed lower percentage of students who experienced malnutrition both in the control group and experimental group.

In subjects investigated were observed increasing the percentage of students who have normal BMI. In the control group the percentage increased with 14.61% at boys and with 3.79% at girls while in the experimental group the growth was between 18.27% (boys) and 22.31% (girls).

Numerous studies have been interested in this future obesity because it is responsible for the occurrence of complications such as diabetes, heart diseases and vascular diseases, hypertension, sleep apnea, impaired mobility (Boo et al. 2010; Ramzan et al., 2008). In the occurrence of obesity there are many factors involved, namely the individual (genetic – see Popa et al., 2011, nervous, mental, behavioral, drugs, metabolic, endocrine, age) and environmental factors (Nemeş and Cosman, 2011). Literature reveals a doubling of the prevalence of obesity in children in the last 30 years, both in industrialized countries and in the developing ones (Wang and Lobstein, 2006**)**.

Transversal studies in Romania, on children aged between 11-15 years have shown increasing prevalence of overweight and obesity with 14.7% at girls and with 8.7% at boys (International Association for the Study of Obesity). Inactivity, lack of sport and exercise are factors predisposing to obesity. The predominant etiologic factor in obesity is the excessive food intake and physical inactivity (Jelea and Jelea, 2009a, b; Jelea et al., 2010; Khoury et al, 2012; Tiruneh, 2009; Parsons et al. 2006). Obesity first degree was initially evidenced on boys. The prevalence of obesity first degree was raised in the experimental group (8.11%). Contrary to expectations, after one year, the prevalence of obesity increased in the experimental group (2.64% at girls and 4.55% at boys). Obesity is the most common cause of abnormal growth acceleration in childhood.

Table 3

Classification of body mass index in subjects investigated

Distribution by gender	Groups	Malnutrition (%)		Normal (%)		Overweight (%)		Obesity first degree (%)		Obesity second degree (%)	
		1	2	1	2	1	2	1	2	1	2
Boys	Unsports	13.51	11.12	59.46	74.07	13.51	14.81	8.11	-	5.41	-
	Sports	42.18	18.18	46.88	65.15	9.38	12.12	1.56	4.55	-	-
Girls	Unsports	20.31	10.81	71.88	75.67	7.81	10.81	-	2.71	-	-
	Sports	52.17	23.68	43.48	65.79	4.35	7.89	-	2.64	-	-

Explication at Table 1.

Appreciation of harmonious development trunk belt is made by calculating the proportion for height. The experimental group boys biacromial diameter was between 32 cm and 45 cm with an average 37.10 cm (r = +0.87) for the next determination diameter was between 34 cm and 46 cm. In this case the average was 39 cm (r = +0.089). For subjects in the control group had values biacromial diameter between 28 cm and 42 cm with an average of 35.15 cm (r = +0.88), after a year had limitations diameter between 33 cm and 43 cm, and the average was 40.05 cm (r = -0.21).

Biacromial diameter was used to calculate the biacromial index. In Table 4 are shown the average values of the biacromial indices from the boys studied.

Table 4

Average values of the biachromial and bitrohanterian indices for the studied boys

Years	Unsports Boys				Sports Boys			
old	Biachr. index (%) 1	Biachr. index (%) 2	Bitroch. index (%) 1	Bitroch. index (%) 2	Biachr. index (%) 1	Biachro. index (%) 2	Bitroch. index(%) 1	Bitroch. index (%) 2
11	21.54	21.90	16.92	17.80	22.77	23.24	17.13	18.07
12	21.47	22.59	17.12	17.50	22.51	23.25	17.38	17.65
13	22.22	22.91	18.75	19.75	22.67	23.80	17.09	18.86
14	20.09	23.12	18.26	18.39	22.30	23.25	17.66	18.02
15	23.38	23.76	17.56	18.22	22.61	23.01	17.47	17.52
16	23.80	23.90	17.98	18.98	22.69	23.51	17.89	18.19
Media	**22.08**	**23.03**	**17.76**	**18.44**	**22.59**	**23.34**	**17.43**	**18.05**

In the experimental group these indices increased between the two determinations from an average of 22.59% (year 2010) to 23.34% (year 2011). Growth rates were between 0.47% and 1.41%. In the experimental group the diameter increased with 0.75% and in the control group with 0.95%.

The bitrohanterian diameter is smaller than the biacromial one with 4-5 cm. Boys from the experimental group had the bitrohanterian diameter between 24.50 cm and 34 cm with an average of 29.73 cm (r=0.81). After a year the diameter ranged between 25 cm and 36 cm and the average 30.17 (r=-0.16). The bitrohanterian diameter in the control group was between 22 cm and 31 cm with an average of 27.94 cm (r=+0.84), after a year the values were between 23 cm and 35 cm with an average of 29.53 cm (r=-0.398). The biacromial diameter increased between 0.44 cm (experimental group) and 1.59 cm (control group).

In order to evaluate the harmonious development of the trunk we calculated the bitrochanterian index (Table 4). In the case of the students who did not practice any sport the average values of the index was between 16.92% (11 years old) and 17.98% (16 years old). The determinations made after one year showed the growth of the index (17.80% at 11 years and 18.98% at 16 years).

In the case of students who practiced high sport performance the bitrohanterian index was between 17.09% (13 years old) and 17.89% (16 years old). To make the comparison between the bitrohanterian indices we made an arithmetical mean at sports and unsports. This was 17.76% (unsports) and 17.43% (sports). After one year the average was 18.44% (control group) and 18.05% (experimental group). The bitrochanterian index has the values between 18% and 19% in the height for men. In the case of those who practiced sports, it is recommended that this index to be low.

The biacromial diameter at the girls in the experimental group, was between 29 cm and 38 cm with an average of 34.78 cm (r=+0.79). The following year the diameter increased, the values were between 33 cm and 40 cm, and the average of 36.15 cm (r=+0.087). In the control group the biacromial diameter ranged between 33 cm and 40.50 cm, and the average of 35.59 cm (r=+0.58), later the limits were between 33 - 43 cm and the average of 40.05 cm (r=-0.132).

In Table 5 are presented the values of biacromial and bitrohanterian indices at girls, by age group. Literature data indicates values between 18-20% of height. In the experimental group average percentages were 21.67 $\pm$ 0.66% (year 2010) and 22.62$\pm$0.54% (year 2011). For students practicing sports the average percentages were between 22.11$\pm$0.05% (first determination) and 22.70 $\pm$ 0.11% (at the second measurement). Generally speaking for sports index is even better if it is higher.

Regarding the control group, the bitrohanterian index was 17.00 $\pm$ 0.38% (the first determination) and second determination 18.29 $\pm$ 0.41%. In the experimental group, at the first measurement the results were 17.51 $\pm$ 0.24%, and at the second measurement 18.84 $\pm$ 0.25%. Data from the literature (Duma, 2006) indicate decreased of the index to athletes.

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Table 5

Average values of the biachromial and bitrohanterian indices for the studied girls

Years	Unsports Girls				Sports Girls			
	Biachr. index (%)	Biachr. index (%)	Bitroch. Index (%)	Bitroch. Index (%)	Biachr. index (%)	Biachro. index (%)	Bitroch. Index (%)	Bitroch. index (%)
old	1	2	1	2	1	2	1	2
11	20.12	20.69	16.46	16.66	22.04	22.76	17.42	18.79
12	21.98	22.20	17.45	17.65	22.30	22.83	16.99	19.44
13	21.80	22.37	17.80	18.18	21.87	22.87	17.71	19.68
14	21.89	24.69	18.40	19.06	22.13	22.50	16.67	18.00
15	22.08	23.35	18.92	19.12	22.24	23.05	18.08	18.76
16	22.20	22.43	18.92	19.12	22.10	22.21	18.23	18.37
Media	**21.67**	**22.62**	**17.99**	**18.29**	**22.11**	**22.70**	**17.51**	**18.84**

In Table 6 are shown the average values and statistical estimation on abdominal skin fold and body fat percentage. In boys abdominal skin fold increase was observed with values ranging between 0.05 ± 0.11 cm (experimental group) and 0.08 ± 0.08 cm (control group). Abdominal skin folds in girls increased by values between 0.05 ± 0.03 cm (experimental group) and 0.14 ± 0.34 cm (control group).

Table 6

Average values and statistical estimation on adipose tissue in the groups studied

Distribution by gender	Groups	X ± Es	Mean skin fold (cm) 1	Mean skin fold (cm) 2	Adipose tissue (%) 1	Adipose tissue (%) 2
Boys	Unsports	X ± Es	1.48 ± 0.09	1.56 ± 0.01	21.12 ± 3.09	21.58 ± 0.67
	Sports	X ± Es	1.59 ± 0.12	1.64 ± 0.01	18.28 ± 0.36	19.74 ± 0.56
Girls	Unsports	X ± Es	2.01 ± 0.35	2.15 ± 0.01	21.72 ± 0.72	21.77 ± 0.50
	Sports	X ± Es	1.67 ± 0.04	1.72 ± 0.01	20.50 ± 1.19	22.16 ± 4.56

Explication at Table 1.

The adipose tissue was calculated according to the body mass index, age and sex of the subjects. In Table 6 are shown the average values and the statistical estimation. Determinations made after one year showed increased percentage of fat. This increase for the experimental group was between 1.46 ± 0.80% (boys) and 1.66 ± 3.37% (girls), and in the control group was 0.46 ± 2.42% (boys) and 0.05 ± 0.22% (girls).

The optimum level of body fat in adults is 12-18% unsportsmanlike (10-25%) for men and 16-25% (18-30%) for women (Wilmore et al., 1986). Athletes have lower values of body fat. The percentage of fat for athletes varies widely depending on the type of sport and 6-13% in men and 12-19% in women. Exercises can induce favorable changes in body composition. Physical activity has an effect on body composition and fat characteristics only when exercises are sustained over a period of time and has a high intensity.

Total water content and muscle are presented in Table 7. In 10-16 years time water accumulates in the body in different amounts depending on sex (Nicolescu et al., 2006). Our new results have revealed enhanced water content in the control group with 9.15 ± 2.64 l (boys) respectively 4.09 ± 1.00 l (girls). In the experimental group, the water content increased between 5.93 ± 2.32 l (boys) and 2.7 ± 0.07 l (girls).

Muscle mass increased between the two determinations. In the control group increased by 9.09 ± 0.76 kg was at boys and 3.94 kg ± 1.99 kg for girls. Increases in the experimental group were 5.19±2.25 kg at boys and 2.14±0.24 kg at girls.

Table 7

Average values and statistical estimation on total water content and muscle mass in the groups studied

Distribution by gender	Groups	X ± Es	Total water (l) 1	Total water (l) 2	The muscle mass (kg) 1	The muscle mass (kg) 2
Boys	Unsports	X ± Es	27.79 ± 3.48	36.94 ± 0.84	41.50 ± 0.44	50.58 ± 1.20
	Sports	X ± Es	28.73 ± 2.95	34.66 ± 0.63	42.26 ± 3.38	47.45 ± 0.86
Girls	Unsports	X ± Es	29.73 ± 1.11	33.82 ± 0.11	42.93 ± 2.54	46.87 ± 0.55
	Sports	X ± Es	32.36 ± 0.54	35.06 ± 0.61	45.25 ± 1.06	47.39 ± 0.82

Explication at Table 1.

In both groups we found increased water content and muscle mass. As the water content varies strongly related on muscle mass, we noticed a similar evolution of the two indices. In athletes the muscle mass increases through physical activity but it must be regular and at a high level according to the sport practiced.

Sport's favorite constitutional biotype is obtained after conducted training over a period of 4-6 years.

CONCLUSIONS

The study results allowed us to draw those conclusions.

Somatic indicators (body mass and size) had lower values in athletes. Average body mass for the control group were higher than those observed in the experimental group. Body mass increased in the control group between the two measurements, with values between 1.61 ± 0.07 kg (girls) and 10.23 ± 0.06 kg (boys). Increases in the experimental group were 7.69 ± 0.22 kg for boys and 7.59 ± 1.02 kg for girls. This somatic indicator increased in the same rhythm between the sexes. Body mass of an athlete should approach the optimal weight requirements imposed by the sports industry.

The height characterized fairly well the development of the subject according to this report and other anthropometric measurements. Boys size ranged between 164.20 + 0.02 cm (control group) and after a year the results were between 174.84±1.37 cm. In the experimental group, the first measurement of the size was 163.30±0.02 cm and 167.80±1.37 cm in the second. The size increased by 10.64 ± 1.35 cm at boys and 4.00 ± 1.34 cm at girls from the control group. At students who practiced sports increased was between 4.50 ± 1.35 cm at boys and 1.77 ± 1.35 cm at girls. The growth rate is within the values recorded in the literature.

Puberty in both sexes is characterized by a rapid increase in stature and slow growth of body mass. In the study conducted we observed a rapid growth of weight and slow growth of the size in the experimental group. In the control group both indicators have increased in range during the study.

The calculation of body mass index allowed the study of nutrition. First of all, the determinations made initially emphasized a high percentage (42.18% at boys and 52.17% at girls) of malnutrition in the experimental group. Dynamic changes in somatic development indices showed lower percentage of students with malnutrition. Protein caloric malnutrition evident in the experimental group allows us to recommend a high protein, high calorie diet along with an effort aimed at increasing muscle mass.

Experimental group showed lower body mass index values than those found in the control group. As far as overweight and obesity are concerned the percentage increased in students from the control group showing eating disorders. We also noticed the reduction of percentage for students who practiced sport. Physical activity has an effect on body composition and fat characteristics only when exercise is sustained for a period of time and it has high intensity.

The assessment of body harmony development was done by calculating bitrohanterian and biacromial indices. The data obtained showed the growth of both bitrohanterian and biacromial indices in both groups.

The results of the study showed increased percentage of abdominal fat. We found increased water content and muscle mass in both groups. As the water content varies strongly related to muscle mass we noticed a similar trend of these indices. The growth of muscle mass in the experimental group is achieved by physical activity but it must be regular and at a high level depending on the sport practiced the initiation is at around the age of 11 years, and the premises for harmonious development of specific somatic activity in sport is performed between 11 years and 16 years.

A regular monitoring of the somatometric indicators is a method of monitoring health and nutrition.

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