

Daily Nutrition, Academic Performance and Physical Capacity of 11 - 16-Year-Old Children from Central Poland

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Abstract

Background: The effects of genes and environment on specific cognitive abilities, including school grades, are more or less the same. The new science: nutriepigenomics demonstrated the influence of nutrients on expression of memory-related genes. Almost nothing is known on the influence of everyday diet on school grades.

Objective: Does the daily nutrition affect 1) average school grades of 11-16-year-olds and its change during the semester; 2) their speed and endurance?

Materials and Methods: We surveyed 200 children (109 girls, 91 boys) of two age groups: the younger group (A) i.e. 11- and 12-year-olds attending an elementary school and the older group (B) i.e. 15- and 16-year-olds attending a junior high school from Uniejów (Poland). The respondents completed our own survey questionnaire, involving the mid-year and end-of-previous-form grades of the core subjects. The speed is defined as the time of 60-metre run and endurance as time of 600-m run for girls and 1000-m run for boys. The statistical analysis comprises of the χ^2 test for assessment of relationship significance, the Tschuprow's test for assessment of dependence power.

Results: 1. The average grade and especially an improvement of an average school grade during the semester in both age groups depends significantly on the frequency of having breakfast and eating fast-food. 2. In the younger group (A) there are also many other dependences (from drinking milk, eating fish, vegetables, fruits). 3. There are considerably more dependences of speed/endurance and nutrition in group A than B; most dependences concern the same "elements of diet" which affect the average grade. 4. The significant effects of nutrition elements and habits exist quite often even in case there are no effects of sex, age and body mass index (BMI) whatsoever.

Conclusion: There might be nutriepigenetic effects of "elements of diet" on cognitive abilities (grade improvement) in adolescents; especially in the younger group; which decrease during the peak of puberty. The effects of nutrition on the cognitive abilities and physical capability seem to occur parallelly! (Kalos Kagathos).

Keywords: Diet; Cognitive Abilities; School Grades; Physical Capacity; Questionnaire Estimation of Nutrition

Background

Human health, both in terms of mental and physical efficiency is the most important set of problems ever, especially if it concerns children. In last 25 years one can find relatively few papers dealing with the effects of everyday diet and its particular elements and nutrients on the cognitive (mental) abilities including memory, academic performance so school achievements/grades. Kretchmer, *et al.* in 1995 [1], reported the problems with cognition, memory and learning being most probably caused somehow by general malnutrition and deficits of iodine, iron and polyunsaturated fatty acids. The special role of iron was confirmed later by Falkingham [2]. Taras [3] in 2005 concluded that neither vitamin and mineral supplementation nor iodine therapy shared any progress of school achievements. This was essentially confirmed by Perlman, *et al.* [4] basing upon standardized tests for elementary school children. [Participants were randomized to receive either a standard children's multivitamin/mineral supplement (MVM) or a placebo. MVM or placebo was administered in school only during lunch or snack period by a teacher or study personnel who were blinded to group assignment]. No significant improvements were observed in secondary end points: number of days absent from school, tardiness, or grade point average.

But in fact already in 2000 Schoenthaler, *et al.* [5] reported the lack of effects of supplementation with vitamins and minerals on nonverbal intelligence of children, probably because majority were already adequately nourished.

There were some hints in 1995 [6] and 1998 [7] that omitting (skipping) breakfast interferes with cognition and learning, an effect that was more pronounced in nutritionally at risk children. Kleinman, *et al.* [8], in 2002, showed that eating breakfast distinctly improved academic performance e.g. school grades. Kim, *et al.* [9] reported that academic performance of Korean children was strongly associated especially with regularity of three meals daily. The most cited paper of Rampersaud, *et al.* [10] showed that breakfast consumption might improve cognitive functions (academic performance including the grades) of youngsters, especially if the breakfast was rich in high fibre grains, fruits and dairy products.

Since then the effects of breakfast have become the most interested subject of the total mentioned area. Thus Mahoney, *et al.* [11] suggested the bigger benefits of breakfasts, especially with low glycaemic index on learning and memory were more pronounced in younger children and girls. These data were essentially confirmed by Adolphus, *et al.* [12] and Edefonti, *et al.* [13].

Remaining parts of everyday diet i.e. besides breakfast were poorly studied. Owen, *et al.* [14,15] proved the importance of energetic metabolites and cofactors, as glucose and l-carnitine, on cognitive abilities. Florence, *et al.* [16], just stressed the necessity of taking both sex and age into consideration. Some authors just emphasized role of "good diet" i.e. "healthy New Nordic Diet" [17] or just avoiding "unhealthy" nutrition [18], it seems the well-balanced diet was meant. Kim, *et al.* [19] and De Groot, *et al.* [20] studied the role of eating fish. The only paper stressing the role of meat, animal source foods as a matter of fact, was that of Hulett, *et al.* [21] in 2015 describing problem in Kenyan school children.

The authors mentioned practically did not suggest the mechanisms of observed effects of food on school achievements except some assumptions on possible tissue hormones and neurotransmitters. No one mentioned the possible nutriepigenetic effects. Meanwhile nutriepigenomic studies [22,23] proved that certain nutrients might improve cognitive abilities via epigenetic modifications/mechanisms acting on expression of genes without the changes of their sequence. Choline in diet of pregnant women affects methylation of DNA in the hippocampus of foetal brain [23] and so it does with memory consolidation.

There are very few such studies in the international, *let alone* Polish literature. Several years ago, I began to study the effect of everyday diet on mental life [24]. Hamułka [25], revealed generally poor nutrition of Polish children, e. g. high sodium and low potassium, high phosphorus and low calcium intake, which could account for poor school grades.

Also, the physical capacity is substantially dependent on genes but also on so-called environment involving a broad range of factors, mainly nutrition. Few studies have been published on the subject. Turski, *et al.* [26] demonstrated that the physical capacity, both general capacity and its components (speed, endurance) measured with the Zuchora's test, are directly proportional to the frequency of eating meat, fish, fruit and vegetables. Only recent paper [27] mentioned that aerobic fitness might be linked to academic achievements of Indian school children.

Objective of the Study

High physical and mental capacities are the main signs (markers) of good health and-on the other hand-nutrition is considered the most important decisive factor as far as the population health is concerned. Nevertheless, in the available literature there are no papers on the parallel effect of nutrition/diet on mental and physical capacity.

Thus the main objective of this paper is to perform a (pilot) study on whether and how everyday diet (habits, foods, frequency of eating various foods etc.) affects during the whole year the school achievements (grades) and thus the average grade in the core subjects, especially on the change of grades during the semester.

Additionally, we wanted to investigate if and how the diet affects parallelly the physical capacity: aerobic (endurance) and anaerobic (speed) of the same children, whose cognitive abilities were studied.

We wanted to verify if there are any (and what type) dependences-and possible correlations-and examine if these effects are the same in 11 - 12-year-olds, who generally do not manifest significant signs of puberty-and in 15 - 16-year-olds-at the peak of adolescence.

Materials and Methods

We surveyed 200 children (109 girls, 91 boys) belonging to two age groups: the younger one (A) i.e. 11- and 12-year-olds attending the 5th and 6th form of the elementary school, as well as the older one (B) i.e. 15- and 16-year-olds attending the 2nd and 3rd form of the junior high school in Uniejów (Lodz Province).

In the younger group, the surveys were conducted at the Heroes of September 1939 Elementary School in Uniejów in the group of 90 pupils (48 girls and 42 boys) attending the 5th form (11-year-olds: 36) and 6th form (12-year-olds: 54) [master thesis]. In the older group, the surveys were conducted at the Archbishop Bogoria Skotnicki Junior High School in Uniejów in a group of 110 youngsters (61 girls, 49 boys) attending the 2nd form (15-year-olds: 53 youngsters) and 3rd form (16-year-olds: 57) [master thesis].

An everyday diet was established with the diagnostic survey method using the authors' own survey questionnaire, an extended version of the survey authored by Piwowarska and Turski [28]. The youngsters fulfilled our questionnaire during a special lesson in presence of the teacher and coauthors of this paper (M. T. And M. Z. respectively, that time the students preparing the master theses). So, they asked on every question of children having any problems with proper answer.

The survey involves basic information (7 questions on age, sex, weight and height) and 47 proper questions, almost inclusively the closed ones. However, only 27 questions (numbered between 9 and 35) dealt with nutrition; actually a subset of 21 questions were analysed in this study. The others-which will be published separately-were related to self-assessment of health, among others: pain perception, leisure time, physical activity etc.

To keep the paper short, we only quote the example questions (and answers)-with their original numbering; they were shown (without answers) in the table 1 summarizing the main results of the paper.

Let us mention the following:

Do you eat after 9 p.m.?

- a) Yes
- b) No
- c) Occasionally

How many litres of fluid do you drink every day (including hot and cold beverages)

- a) 1 - 1.5 litre
- b) 1.5 - 2 litres
- c) 2 - 3 litres
- d) More than 3

When answering the questions (No 11, 14, 24-35), please choose a suitable number on the scale:

- 1. Never
- 2. Seldom (1 - 2 times a month)
- 3. quite frequently (between 2 and 4 times a week) 3-frequently (every day)
- 4. Very frequently (several times a day). Please circle the chosen answer.

How often do you drink milk and eat dairy products (e. g. cheese, curd, yoghurt)?

0 1 2 3 4 etc.

The subjects were asked about their grades received in the core subjects (e.g. Polish, a foreign language-usually English, history, geography, biology, mathematics, physics, chemistry) mid-year and at the end of the previous form. For every respondent, the average grades (actually two average grades) were calculated, as well as the difference between the average grades received mid-year and at the end of the previous form. If the difference (being either a negative or positive number) was less than 0.2, the average grade was considered unchanged.

Body mass index (BMI) was calculated according to formula: $BMI = (\text{body weight in kg}/(\text{body height in m})^2)$.

The speed was estimated as the time of 60-m run and endurance as the time of 600-m runs for girls and 1000-m run for boys. The time was measured with a stopwatch accurate to 1 second (600- and 1000-m runs) or 0.1 second (60-m run).

The statistical analysis comprised of the χ^2 test for significance assessment of variable dependences [29]. If there were more than 20% cells with values of obtained frequency less than five - in the χ^2 test table- the Mann-Whitney U test was used [30].

For the power of dependences, the Tschuprow's test was performed and T coefficient was calculated [29].

The formula for Tschuprow's coefficient:

$$T_{xy} = T_{yx} = \sqrt{\frac{\chi^2}{n * \sqrt{(r-1)(k-1)}}$$

Where

χ^2 -the final result of χ^2 test for variables x and y; n -total number of persons studied

k - number of verses; r-number of columns in test χ^2

The existence of possible Pearson's linear correlations was also verified. All the statistical calculations were performed using the Excel Statistica 10 software.

The dependence or correlation was considered significant if the probability of the null hypothesis was: $p < 0.05$.

Results

More than 100 significant dependences were found in the χ^2 test, including many high-power dependences (Tschuprow's $T > 0.3$ or even > 0.5). The results, i.e. the list of significant dependences-and lack of such dependences-are presented in the table 1.

Let us note that χ^2 dependences (shown in tables and figures) of speed and endurance concern separately boys and girls whereas these of average school grade and its change (during semester) concern total subgroups (i.e. A-younger and/or B- older) together. Another words speed and/or endurance might concern/ belong to four subgroups, whereas the average grade and its change to only two subgroups.

In table 1 are shown:

1. Shortened version of question of our questionnaire i.e. the matter/subject of question.
2. Statistical significance of dependence between the "element of diet" (i.e. above mentioned subject of question) and respective variable e.g. BMI or change of average grade.
0,01 < p < 0,05; **: 0,001 < p < 0,01; ***: p < 0,001
3. The value of Tschuprow's T coefficient, which is the measure of power of statistically significant dependence between two variables e.g. the frequency of eating of meat and the change of average grade (during semester).

If in any cell of table 1 is just a mark "-" it does mean there is not any significant dependence whatsoever.

Table 1. Thus:

1. There are a lot of significant dependences between the average school grades -in both age groups - and the frequency of eating after 09:00 p.m., frequency of having breakfast, type of foods eaten for breakfast and brunch, type of beverage that the subjects drank most often, frequency of drinking/eating milk and milk products and eating fast-food.
2. In the younger group (11 - 12-year-olds) there are even more significant dependences of the average grade, [15 while only 10 in older group-per 21 questions where statistically significant dependencies appear] among others from the frequency of eating fish, eggs, vegetables, fruit, sweets and preferred type of meat and total daily volume of ingested fluids (both cold and hot beverages).
3. More dependences $\uparrow\uparrow$ (i.e. changes "from lack of dependence to their appearance")-and often much more evident \uparrow (i.e. changes with an elevation of power of dependence, so an increase of value of T Tschuprow's coefficient)-are found not for the average grade itself but for its change during the semester (deterioration, no change, improvement). [In fact there are 16 dependencies - per 21 possibilities as there are 21 questions- not for the average grade itself but for its change during the semester. However additionally for 8 questions dependences are more evident i.e. power of statistical dependence of "Change of average grade during semester"

is respectively higher ↑ than “Average grade” itself, whereas only in one case is lower ↓]. Therefore, the influence of diet on such change of the average grade was considered as the main parameter of the study. Generally, significant dependence of this change is observed for the same survey questions (i.e. the same elements of diet) as for the effects on the average grade itself. However, there are many exceptions (See table 1). In 6 cases/questions the dependences [statistically significant] disappear in/for younger group [only in 2 cases for older group], but in 7 another questions new dependences become evident in/for younger group [6 cases for older group]; the significant dependence is often observed for the change of the average grade and not for the average grade itself ↑↑ (or the power of dependence is more substantial for the change of mean ↑). This is for effects of frequency of eating whole-grain foods, meat and cold cuts, milk and fish, vegetables and legumes and number of meals daily in the younger group, preferred meat and the meat that the participants eat most often, the frequency of eating meat and cold cuts-in the younger group and frequency of eating eggs and generally brunch in the older group and fruits and the type of meat that is eaten most often-for both age groups.

4. As the respondent age increases, a number of the following dependences concerning the change of the average grades disappears or diminishes (becomes less evident: from the frequency of eating of meat and cold cuts but also fish, milk, whole-grain products, vegetables, fruit, legumes and total volume of fluids per day. However, less often in older children compared to the younger ones, new dependences appear (or increase): from the frequency of eating after 09:00 p.m., having breakfast, foods eaten for breakfast and brunch and frequency of eating fast-food. Summarizing roughly the same effects/dependencies exist in both age groups in 7 cases [per 10 - 15] for “Average grade” and in 10 cases [per 14 - 16] for “Change of average grade during semester”.
5. In the younger group, compared to the older group, there are considerably much less significant dependences of diet (e.g. the frequency of eating X or Y) from sex, age and BMI. Just let me stress that in younger group there are only 3 dependencies [for 16 totally] from sex for “Change of average grade during semester”. At the same time there is 9 dependencies [for 14 existing] in older group, where is dependence from sex. We must emphasize that if we note “effect of sex” it means the interdependence of sex and given “element of nutrition” [the answer on given questionnaire question] is found to happen e.g. effect of sex [male/female] on the frequency of eating brunch. In any case there is no effect of sex on “Change of average grade during semester” itself. But of course some indirect impact might be considered. In younger group there are only 2 cases where both the effect of age and effect on “Change of average grade during semester” are visible [5 for older group]. For BMI as the possible source of an indirect impact there are quite a lot of cases [7 for younger and 11 for older group]. However usually the power of dependence between “given element of nutrition” and “Change of average grade during semester” is much bigger than that for dependence between BMI and “given element of nutrition” [see questions 10, 11, 16 and 31 in table 1].
6. There are many dependences between given “element of diet” on one hand and speed and endurance on the other, more often in the younger group. In subgroup of girls of younger group dependencies exist in 14 questions for speed and 12 questions for endurance [respectively for older group: 7 and 9]. In subgroup of boys of younger group dependencies exist in 10 questions (speed) and 12 (endurance), whereas for older boys there are 12 dependencies for endurance but only two dependencies for speed.

Usually dependencies of speed and endurance exist for the same kind of meals (i.e. the same answers on the questions in the diet questionnaire) which influenced the average grade and especially its change during the semester. This is more clearly visible for older group where almost all [for older girls just all] the dependencies of speed and endurance existing are about the same as dependencies of change of average grade during semester - except of endurance of older boys where “only” 9 [from 12 total] dependencies are about the same. For younger group there is a bit less such parallel effects [9 per 14 for speed and 8 per 12 for endurance in subgroup of girls and only 5 per 10 for speed and 6 per 11 for endurance in subgroup of younger boys.

Summarizing comparison between older and younger group: per 21 questions in 10 cases there are about the same effects in both groups for “Change of average grade during semester” and only 5 for endurance of both girls and boys and 3 for girls’ and 2 for boys speed.

The table 1 demonstrates the areas and power of dependences (shown within χ^2 test to be significant: $p < 0,05$), however, without further details the adequate interpretation is difficult to perform. Therefore, the most significant/interesting data (or the ones being an example of interpretation in the remaining cases) will be presented on figures 1-4 and in table 2-5.

In any further table or figure are just data, usually % of given subgroup, which are bound each other within the statistically significant dependence shown in table 1. So, we do not repeat measures of significance e.g. **as it was shown in table 1.

We presented [in figures] some data using graphs showing the change of dependent variables i.e. the change of average mean (during semester) or the endurance i.e. the time of run on 600-1000m (see Methods) with growing other variable i.e. usually the frequency of consumption of “diet elements” (compare table 1 and related remarks). In fact the same mode but without graphs has been applied in table 2-4 (for interpretation compare in Discussion chapter).

Question	Group →	Sex	Age	BMI	Grades		Speed		Endurance	
Question No. Subject ↓↓					Average grade	Change of average grade during semester	Girls	Boys	Girls	Boys
9/ Number of meals per day HM	A	—	—	—	—	0.345 ↑↑ ***	—	0.389 *	0.504 ***	0.394 *
	B	0.251 ***	—	0.221 **	0.389 ***	0.250 ↓ + **	0.331 *	—	0.441 + ***	—
10/Frequency of eating after 9 p.m. FE	A	—	0.225 *	—	0.274 **	— ↓↓	0.548 ***	0.461 **	0.407 ***	0.481 ***
	B	0.372 ***	—	0.199 *	0.251 + **	0.455 ↑ ***	0.319 + *	0.354 + *	0.448 + ***	0.360 + *
11/ Frequency of having breakfast FE	A	—	—	—	0.419 ***	— ↓↓	—	0.465 **	0.476 ***	0.446 **
	B	0.388 ***	0.194 *	0.233 **	0.425 + ***	0.432 ◦ ***	0.439 ***	—	0.326 + *	—
13/ Foods eaten for breakfast Wh	A	—	—	—	0.314 **	— ↓↓	—	—	0.581 ***	—
	B	0.359 ***	0.234 *	—	0.316 + ***	0.351 ◦ ***	0.357 *	—	0.420 + ***	—
14/ Frequency of having brunch FE	A	0.205 *	—	0.220 *	0.266 *	0.288 ◦ **	0.382 *	0.364 *	—	0.439 **
	B	0.278 ***	—	0.253 ***	—	0.364 ↑↑ + ***	0.234 + **	0.364 + *	0.332 *	0.324 + *
16/ Foods eaten for brunch Wh	A	0.201 *	0.238 **	0.267 **	0.314 **	0.282 ◦ *	0.395 **	0.482 ***	—	0.446 **
	B	0.331 ***	0.317 ***	0.235 **	0.367 + ***	0.454 ↑ + ***	0.326 + ***	—	0.320 *	0.389 + **
19/ Meat eaten most often Wh	A	—	—	0.323 ***	—	0.379 ↑↑ ***	—	—	—	—
	B	0.199 *	—	0.347 ***	—	0.387 ↑↑ + ***	—	—	—	—
20/ Preferred meat Wh	A	—	—	—	0.255 *	0.445 ↑ ***	—	0.465 **	0.444 ***	—
	B	—	—	—	—	0.313 ↑↑ + ***	—	—	—	0.308 *
22/ Total volume of fluids/day HM	A	0.313 ***	—	0.199 *	0.341 ***	0.420 ↑ ***	—	0.362 *	—	0.439 **
	B	0.424 ***	—	—	—	—	—	—	—	0.455 + ***
23/ Beverage that the subjects drank most often Wh	A	—	—	—	0.280 *	0.347 ↑ ***	—	—	—	—
	B	—	—	0.191 *	0.291 + **	0.296 ◦ + *	—	—	—	0.442 ***
24/ Frequency of eating whole-grain foods FE	A	—	—	—	—	0.566 ↑↑ ***	0.368 *	—	—	—
	B	0.497 ***	0.229 **	0.322 ***	0.351 ***	0.268 ↓ + **	0.392 + ***	—	0.531 ***	0.301 *
25/ Frequency of having milk and milk products FE	A	—	—	0.230 **	0.313 **	0.374 ↑ ***	0.464 ***	—	0.489 ***	—
	B	—	—	0.238 **	0.249 + *	— ↓↓	—	—	—	0.351 *

26/ Frequency of eating meat FE	A	—	—	0.216**	—	0.515 ↑↑ ***	0.373 *	—	0.348 *	—
	B	—	—	—	0.310***	0.239 ↓ + *	—	—	0.306 + *	0.373 **
27/ Frequency of eating cold cuts FE	A	—	—	—	—	0.384 ↑↑ ***	0.492 ***	—	0.541 ***	—
	B	0.254***	—	0.268***	—	—	—	—	—	0.404**
29/ Frequency of eating fish FE	A	—	—	—	0.282**	0.453 ↑ ***	0.354 *	—	0.478 ***	—
	B	—	—	—	—	—	—	—	—	—
30/ Frequency of eating eggs FE	A	—	—	—	0.261*	0.320 ↑ **	0.383 *	0.370 **	0.502 ***	—
	B	—	0.194*	0.223**	—	0.288 ↑↑ + **	—	—	—	0.452 ***
31/ Frequency of eating vegetables FE	A	—	0.202*	0.246**	0.282**	0.456 ↑ ***	0.428 **	—	—	0.492 ***
	B	0.316***	—	—	—	—	—	—	—	—
32/ Frequency of eating fruit FE	A	—	—	—	0.249*	0.438 ↑ ***	0.546 ***	—	—	0.513 ***
	B	—	—	0.317***	—	0.266 ↑↑ + **	—	—	0.303 *	0.389 + **
33/ Frequency of eating legumes	A	—	—	0.265**	—	0.406 ↑↑ ***	0.433 **	—	—	0.509 ***
	B	—	—	—	—	—	—	—	—	—
34/ Frequency of eating sweets FE	A	—	0.248**	0.400***	<i>0.284</i> **	— ↓↓	<i>0.411</i> **	<i>0.385</i> *	<i>0.363</i> *	<i>0.455</i> **
	B	0.214***	0.189*	0.310***	—	—	—	—	—	—
35/ Frequency of eating fast-food FE	A	0.227*	0.271*	0.213*	<i>0.393</i> ***	— ↓↓	<i>0.403</i> **	<i>0.556</i> ***	<i>0.353</i> *	<i>0.548</i> ***
	B	0.275***	0.253***	0.335***	0.281 + **	0.403 ↑ ***	—	—	—	—

Table 1: Summary of the study results.

Significant dependences (and their power) between: daily nutrition and the average grade and their change during the semester, as well as speed and endurance (and sex, age and BMI).

All the numbers within the table eg.0,345 and so on mean the values of Tschuprov coefficient [see Methods] being the measure of power of statistical dependence between answer on given question of our survey questionnaire [e.g. question No 9 on number of meals(main)daily or question 35: frequency of eating fast -food] and given variable [e.g.. BMI, sex or. Average grade of school marks/degrees]. All these dependences were statistically significant [those with *** with $p < 0,001$]. Mark “-” means there is no dependency being statistically significant [so: $p > 0,05$; usually $p > 0,3$].

↑ and ↓ means that power of statistical dependence of “Change of average grade during semester” is respectively higher or lower than “Average grade” itself.

↑↑ and ↓↓ mean the changes of above mentioned data in the same direction but the changes are much more pronounced (drastic i.e. From “-” [lack of dependence] to e.g. 0,288 (↑↑) or inversely: from e.g. 0,393 to “-” [lack of dependence]).

↓ means that power of statistical dependence of “Change of average grade during semester” is practically equal to “Average grade” itself.

+ means the effect is about the same in/for the older group B and in/for the younger group A [qualitatively; not necessarily quantitatively].

Numbers in bold [as “0.345”] mean there is both statistically significant dependence of “Change of average grade during semester” and that marked in bold dependence of speed or /and endurance.

Numbers in italics [as 0.461] mean there is both statistically significant dependence of “Average grade” and that marked in bold dependence of speed or /and endurance [but !! only in case there is no dependence of “Change of average grade during semester”].

FE means the effects of frequency of eating was studied.

- HM means “How many...” (...meals.: question 9) or “How much..(..of fluids.: question22)”
- Wh means “What”.

The figure 1 illustrates the effect of frequency of eating fruits on the change of the average grade and on endurance of boys (based on the time of 1000-m result) in the younger group (with our “new” way of presentation: “broken” lines similar to curves of typical functions- instead the rectangles- compare Discussion).

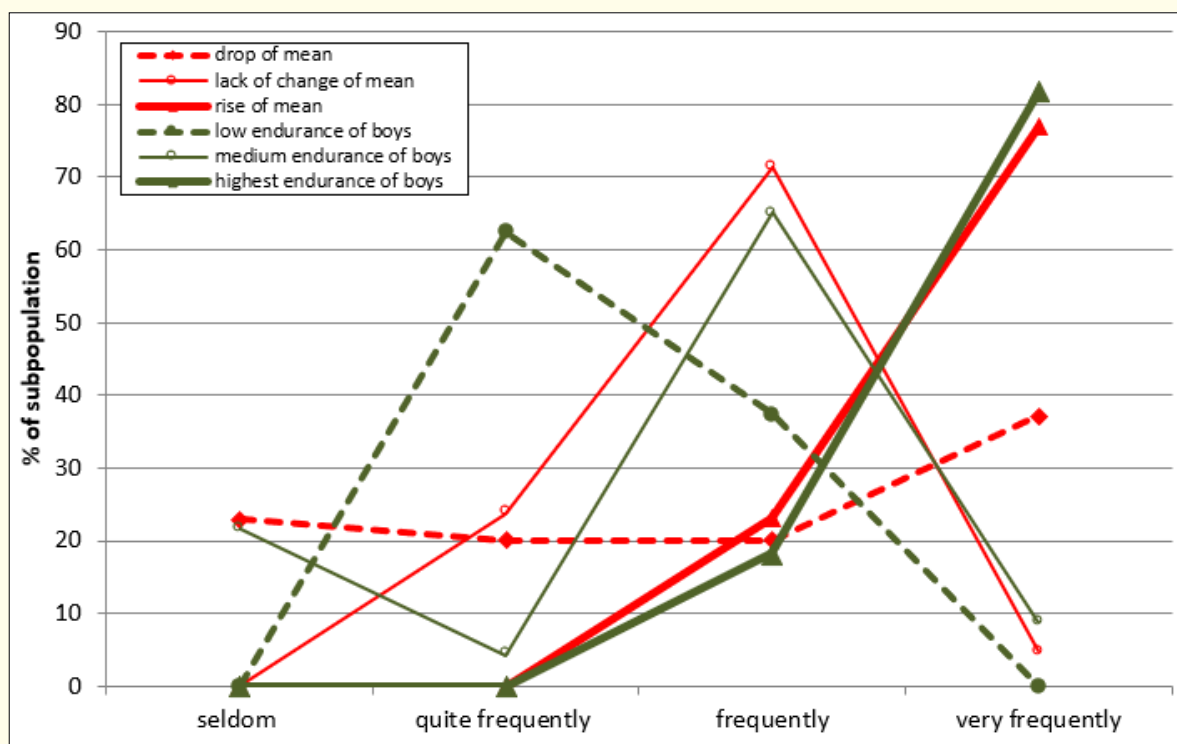


Figure 1: The frequency of consumption of fruits within the group of younger children.

A) The change of the mean of school achievements during the semester (the change of mean).

B) The endurance of boys.

On axis y there is % in given subpopulation i.e. those respondents which have chosen given answer e.g. very frequently (“I eat fruits very frequently i.e. several times everyday”) e.g. there were all 42 younger children whose mean of school achievements did not change during semester, whereas 30 of them ate fruits frequently.

Thus, it is: $30/42 \times 100\% = 71,4\%$ and so on.

On axis x there is frequency of eating (consumption) of fruits exactly as table 6 (left side).

Please note (Figure 1) that for the same x-axis value, a bit similar changes of both studied, absolutely different, variables are observed. Thus for the same points on x-axis (the scale is arbitrary) there is both either: a/% of persons with deteriorated average grade and % of persons (boys in this case) with low endurance or b/as above but respectively with lack of change of mean and medium endurance and c/ with rise of mean and highest endurance.

It is clearly visible that when the frequency of eating fruits increases, the number of persons with improved average grade but also endurance (in boys) increase.

However, the details vary: as many as 2/3 of boys with low endurance eat fruit approximately once everyday; as for the 11-12-year-olds with grade deterioration during the semester, only 1/5 of them do so.

The figure 2 (the same mode of presentation as in figure 1) illustrates the effect of frequency of eating after 09:00 p.m. (late supper another words) in the older group on the change of the average grade and endurance of girls (600-m run). The results are less unequivocal, however evidently the improvement of endurance in girls is accompanied by decreased frequency of eating late supper (“inversely proportional effect”). A similar effect concerns the improvement of the average grade (strictly speaking the change from deterioration to improvement of the average grade).

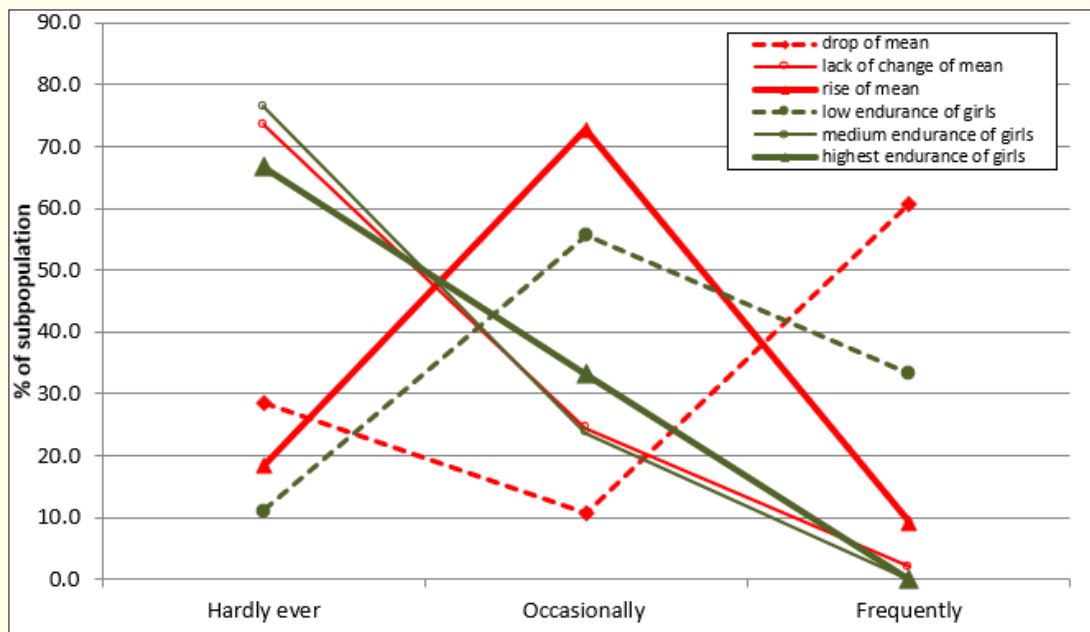


Figure 2: The effects of the frequency of taking the supper after 9 pm – within the group of older children on the: A) The change of the mean of school achievements during the semester (the change of mean). B) The endurance of boys. The data come from the answers on the question No 10 (See table 1). Values of % on y axis were calculated analogically as was exemplified under figure 1.

However, the lowest frequency of eating late supper is found in the 15-16-year-olds with unchanged average grade, not in those with improvement of the average grade during the semester.

The figure 3 compares the influence of frequency of eating vegetables in both age groups. The improving effect on the rise of an average mean is evident in the younger A group.

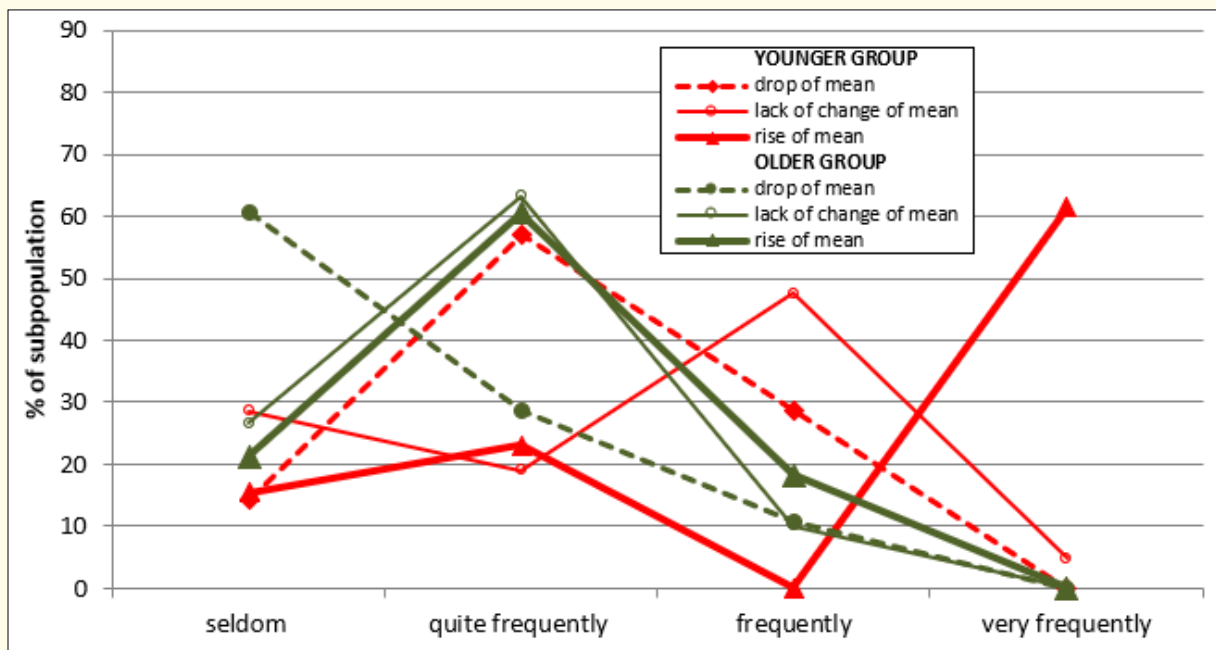


Figure 3: The effects of the frequency of consumption of vegetables on the change of the mean of school achievements during semester (the change of mean) in two groups of children: A) younger B) older. The data come from the answers on the question No 31 (See table 1). For meaning of expressions below x axis and values of % on y axis compare the text below figure 1.

The figure 4 compares the effect of frequency of having breakfast on the change of the average grade in both age groups. Here the effect was more evident in the older group; in the younger group, e.g. the highest ratio of children having breakfast every day is observed not in the group with improvement of the average grade but rather in the group with no change. Possibly some very good students fail to have breakfast every day because of hastiness (“being so engrossed in school work”).

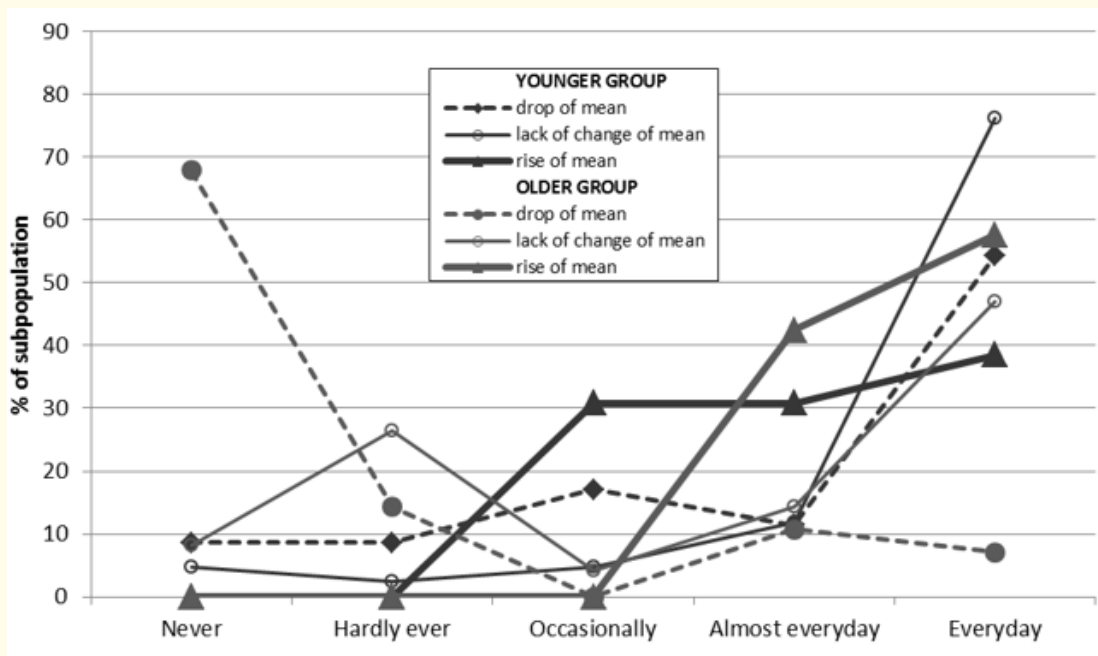


Figure 4: The effect of the frequency of having breakfast on the change of school achievements during semester in two groups of children: A) younger B) older.

The data come from the answers on the question No 11 (See table 1). For meaning of expressions below x axis and values of % on y axis compare the text below figure 1.

The table 2 illustrates that the children of the younger group who prefer poultry tend to improve the average grade, the opposite effect is found for pork.

No	The most preferred meat dishes ↓	% of respondents		
		The change of mean		
		Drop	No change	Rise
1	Beef	28,6	4,8	7,7
2	Pork	60,0	21,4	0,0
3	Poultry	11,4	71,4	69,2
4	Mutton	0,0	2,4	0,0
5	Veal	0,0	0,0	23,1
	Together	100,0	100,0	100,0

Table 2: The effects of the most preferred kind of meat dishes on the change of mean of school achievements within the younger group of children (A total).

The data come from the answers on the question No 20 in our survey (see Table 1) Values of % shown in table 2 were calculated e.g. There were all 42 younger children whose mean of school achievements did not change during semester, whereas 9 of them reported the pork is the most preferred meat for them. Thus it is: $9/42 \times 100\% = 21,4\%$ and so on.

The table 3 illustrates that drinking more still mineral water promotes improvement of the average grade of older group whereas drinking more carbonated sweetened, Fanta- and Cola-type, beverages is detrimental for both age groups). So, from the point of view of an official dietetics the effects for both groups (subgroups) are consistent but the details vary to the great extent.

No	The most frequent beverage	% of					
		The change of mean					
		The younger group			The older group		
		Drop	No change	Rise	Drop	No change	Rise
1	Mineral water non sparkling	8,6	0,0	7,7	14,4	36,7	48,4
2	Fruit juice	22,8	19,1	15,4	7,1	0,0	15,1
3	Sparkling sweet drinks (e.g. Fanta)	45,7	19,0	0,0	46,4	53,1	18,2
4	Milk/ yoghurt	0,0	4,8	38,5	0,0	0,0	0,0
5	Tea	22,9	57,1	38,5	32,1	10,2	6,1
6	Coffee	0,0	0,0	0,0	0,0	0,0	12,2
	Together	100,0	100,0	100,0	100,0	100,0	100,0

Table 3: The effects of the most frequently drunk kind of beverage on the change of mean of school achievements within the younger and older group of children. The data come from the answers on the question No 23 (See table 1). The calculation of values of % shown in the table 3 was analogical as shown below table 2.

The table 4 shows the strong effects of frequency of consumption of both eggs and sweets on the change of average mean of school grades of younger (A) group of children. The details substantially vary but what is the most important the effects seem to be contradictory/ hardly with “direct correlation” in a sense both sweets and fruits apparently improve (statistically) the school achievements but after the attaining some level of frequency of consumption further increase of frequency results in decrease of school grades.

No	Consumption of →	% of respondents					
		EGGS			Sweets		
		The change of mean					
		Drop	No change	Rise	Drop	No change	Rise
1	Seldom (at least 2 times a month)	51,5	14,3	15,4	5,7	19,1	0,0
2	Quite frequently (2-3 times a week)	14,3	66,7	46,2	40,0	21,4	23,1
3	Frequently (once every day)	28,6	11,9	30,8	37,1	31,0	46,2
4	Very frequently (several times every day)	5,7	7,1	7,7	17,1	28,6	30,8
	Together	100,1	100,0	100,1	99,9	100,1	100,1
	Together	100,0	100,0	100,0	100,0	100,0	100,0

Table 4: The effects of the frequency of the consumption of: a) eggs and b) sweets on the change of mean of school achievements within the younger group of children (A total). The data come from the answers on the questions No30 (eggs) and No 34 (sweets); see table 1. For calculation of and see below table 2.

Additionally we proved (Table 5) that practically only in the 11-12-year-olds-both girls and boys-significant but inconspicuous positive correlations take place between the average grade (of core subjects) and speed, as well as between speed and endurance; in boys of this age group there is also a low positive correlation between the average grade and endurance. In older group above presented Pearson correlations disappear or somehow reveal as negative ones (we do not discuss them); only the correlation between the average grade and speed pertain in groups of older girls.

The correlation between ↓	Girls		Boys	
	Younger (A)	Older (B)	Younger (A)	Older (B)
Speed and the mean of school → achievements	[- 0,250]* slight positive	[- 0,230]* slight positive	[- 0,208]* slight positive	[- 0, 07] lack
Endurance and the mean of school → achievements	[- 0,106] lack	[0,250]* small negative	[- 0,217]* slight positive	[- 0,07] lack
Speed and endurance →	[0,324]** distinct positive	[- 0,170]* lack	[0,278] * slight positive	[- 0,270]* slight negative

Table 5: The linear Pearson correlations between the different abilities within two groups of children. The values of R x/y coefficient. The mark +/- does not necessarily mean the positive or negative correlation as it does depend on the units and thus the speed and endurance are the results in the race (60m or 600/ 1000 m) in seconds. So the speed/endurance “apparently decreases” with the time in the race growing. For remaining explanations see “Methods”.

There seems to happen the significant although rather weak positive linear correlation between speed and endurance, it might look incredible as people think [and it is essentially confirmed with scientific papers] that quite another types of muscle fibers are responsible on speed in short runs [sprints] and long but much weaker efforts [aerobic]. But in fact probably for majority of people, including children, endurance and speed might be parallel, whereas extremities of speed and endurance might go in opposite directions compared to the straight line [of linear dependence of a positive correlation of speed and endurance - what would be the case for average people].

Discussion

Although the survey questionnaire by Piwowska and Turski [28] used in the present study is not a standardized tool-which is also true for most of the surveys conducted in Poland-nevertheless has been used in over 60 Master Theses and over 20 publications concerning various groups of children, adolescents and adults in Poland; therefore it proved useful as a research tool of over 8000 participants of studies on the everyday diet.

Our study examined the diet of children of various sex, age and BMI. Therefore, it might be asked to what extent the observed effects, e.g. of the particular element of diet on the average grade, are really influenced by sex, age and BMI. There are relatively few dependences of sex and BMI on the frequency of consumption of “the elements of diet” (and the dependences of age are even more scarce) and they are generally weak (the Tchuprow’s T coefficient < 0.25) with the exception of dependence of sex on the total daily fluid intake and frequency of eating whole-grain products-both in the older children group.

The poor effects of sex, age and BMI suggest that the observed dependences (influences) of the “elements of diet” on the studied capacities are not caused by sex hormones (sex but also age come into play because as the children grow older, the puberty peak occurs). However, these effects are more numerous in the older group [9 effects of sex in older group with only 3 effects within the younger group]. What is more, certain effects of diet on mental or/and physical capacity decrease with age (or, less likely, they become more evident). So, it looks like the effects of certain elements of diet (or their components) might be somehow “antagonistic” to the effects of certain sex hormones in some cases and “synergistic” in the others.

But the most interesting seem to be our findings on the effect of given “element of diet” on our main variable i.e. the change of mean of an average grade in the case where there were not any significant dependence between given “element of diet” and sex, age and BMI. Such a situation exists in younger group A (11 - 12 year-olds)with the number of meals per day {9}, frequency of eating breakfast {11}, products eaten for breakfast {13}, frequency of eating whole-grain products {24}, fish {29}, fruit {32}, legumes and cold cuts {27}. In some cases there is no effects of sex and age, but there is a weak dependence between consumption of say Z and BMI. This takes place with frequency of eating meat {26}, legumes {33}, eggs {30}and dairy products {25} and the most frequently eaten meat {19}. The number in parentheses in this paragraph mean the number of question in our survey shown in table 1.

We can also deduce from data in table 1 that the effects mentioned are in most cases for both average mean itself and its change during semester. Besides, such effects being apparently independent on sex and age exist in most of above mentioned cases also for the physical capacity, mostly for girls, both for speed (anaerobic efforts) and endurance (aerobic).

In accessible literature one can find only one paper [27] which to some extent confirms our data on parallel effect of “elements of diet” on both school achievements and aerobic fitness, so endurance. In fact linear Pearson correlation between mentioned variables (Table 5) does exist what strongly advocates above mentioned parallel effects of diet.

Of course further scrupulous studies are needed to show if there might be the an additivity of negligible effects related with sex, age (and BMI) e.g. hormones thus resulting in almost complete invalidation of effect of “element of diet” itself (whatever it means) let alone the mechanisms of such action.

We previously showed that in older group B more effects of sex, age and BMI takes place. Nevertheless, there are questions (Table 1) where these effects do not exist but apparently the effect of given “element of diet” on change of average mean (or physical capacity) pertains. Such a story takes place for the most frequent beverage and frequency of eating meat and to some extent (still effect of BMI) for frequency of eating fruit and dairy products. As far as BMI is taken into consideration we have to remind paper of Baxter, *et al.* [31] who found that there is no relationship between academic achievements and BMI. However there was found relationship of these achievements with socioeconomic status of families. In our group of Polish children there were practically no any striking differences within socioeconomic status of families of these children.

We must say some our observations seem to be relatively novel in comparison with the accessible literature. It concerns preferred and most frequently eaten meat, frequency of eating meat and cold cuts, legumes, whole-grain products and eggs. So, does with the most frequently drunk beverage.

Our data concerning frequency of eating breakfast and kind of breakfast (Rampersaud), frequency of consumption of milk and dairy products [8], fruits [10] and fish [19,20], apparently confirm the data of mentioned authors. Lazzeri, *et al.* [32] found simply that adolescents who ate breakfast irregularly intook fruit with a lower frequency. It seems such a link does not exist as a rule in our studied group.

Problem of role and effects of number of meals per day seems to be controversial. Some authors mentioned the effects of meals of animal origin [21], but it does not change that we are first who found the relationship of school achievements i.e. average mean of grades and its change with the frequency of eating meat and role of kind of meat eaten most frequently. The above mentioned paper [21] proved the group eating at school local plant - based stew with meat showed significant improvement in arithmetic, English, local language and geography in comparison with children not eating the mentioned meat in school. In case meat was replaced with milk then instead arithmetic grades from so called science (biology) improved. The authors supposed that effects might be owing to folate, vitamin B₁₂ and available iron.

It was demonstrated (see e.g. figures 1, 3, 4 and table 2) that the mental capacity (the average grade and its change) and physical capacity (speed and endurance) are promoted by increased frequency of eating fruits and vegetables, as well as bigger number of meals per day, having breakfast and brunch every day, bigger volume of ingested fluids, especially still mineral water.

On the other hand (see e.g. figure 2) higher ratio of eating after 9 p.m., higher frequency of eating fast-food decreases the mental and physical capacity (in a sense as it was explained earlier).

However, we often observed contradictory effects of a given food (or maybe of its components-suppose for example cholesterol and ω -3 unsaturated fatty acids) on the “mental capacity”, as the influence of eating eggs and sweets (Table 5); see also some “curves” on figures 2-4. Our above concept on contradictory effect of mentioned fat components was described (independently) by Zhang, *et al* [33].

Consequently, on the graph illustrating the dependence (y: % of members of the subpopulation sharing the same trait, e.g. those who improved their average grade during the semester-from x: frequency of eating a given food Z), instead of a line -joining the points -and extending uniformly upwards or downwards (a straight line or hyperbola with “upper” or “lower” plateau) there is (a sort of) parabola with a maximum or minimum. In other words, the highest or lowest % of respondents eating the given food P is observed in the group with the average, not the lowest or highest whatever capacity.

Our observation(s) confirm - to some extent- data of de Groot, *et al.* [20] who found there was inverted U-shape association between fish consumption and cognitive performance and academic achievements in Dutch adolescents. The higher fish intake was associated with higher term grades. However, eating more i.e. above some level (norm) seemed no longer beneficial; on the contrary it might even deteriorate school achievements.

The thing is, we showed that such phenomenon exists with not just fish but many other “diet elements”; compare table 3 and 4 and figures 2-4 in some parts.

And yet each graph is an “echo” of existing mathematical dependences, e.g. dependence of the reaction speed on the enzyme, substrate or inhibitor concentration. However, these dependences (between the mental and physical capacity and the “elements” of diet i.e. nutrients - and frequency of consumption of them- are very far from being even slightly determined and their mechanisms are still completely unknown.

To a certain extent, such contradictory effects would give grounds to the very existence of the nutritional norms: we observe that a given “diet element” X has an “activating” effect below a certain concentration and an “inhibitory” effect in higher concentrations.

Are the observed differences [under the influence of nutrition i.e. its ingredients] significant? Absolutely yes - they are the source/cause of the existence of statistically significant relationships observed, often highly significant [$p < 0.001^{***}$]. But how should one understand the real sense that the value of Tschuprow’s T coefficient [and these values are the main figures in table 1, i.e. the most important set

Based on the formula for Tschuprow’s T [see ‘Materials and methods’], it can easily be calculated assuming an equal number of all fields of the distribution table [to calculate χ^2] that the average difference in number in a given subgroup may change under the influence of a specific change in nutrition (e. g. eating meat daily, not every 2 - 3 days) by about 35% (for $T = 0.25$) to about 79.2%% (for $T = 0.56$). Below we present a shortened calculation [for example] to show the values indicated above:

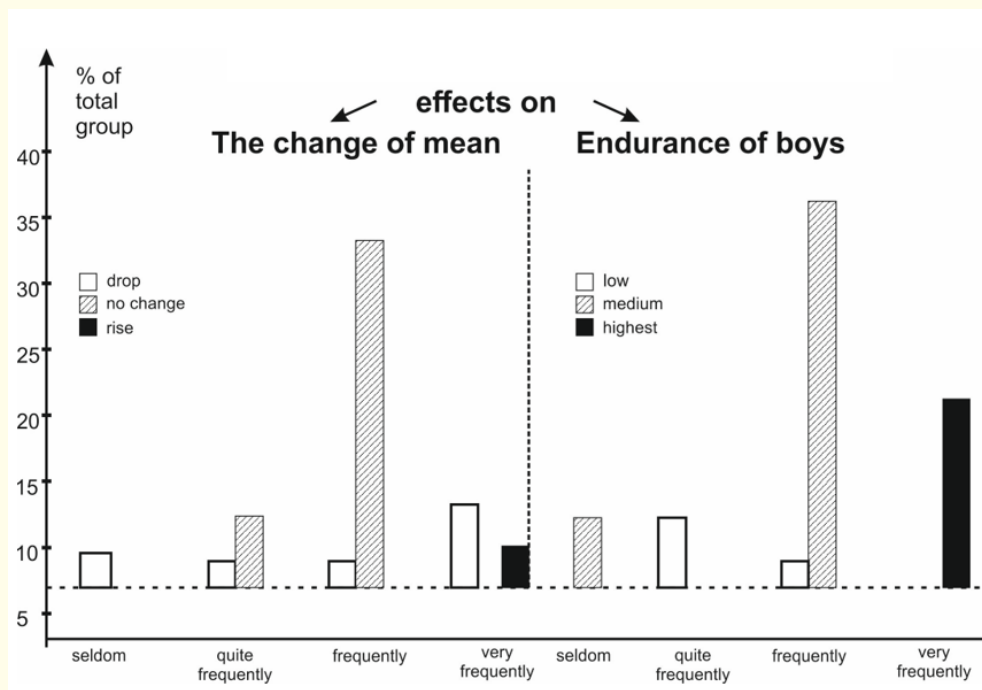


Figure 5

When $r = k = 3$ and $n = 90$, then $ss = 4$ and the number of fields in the distribution table $= r \times k = 9$. Thus, the number in one (each) table field $l_x = 90/9 = 10$.

χ^2 (for $T = 0.56$) = 56.45 [from the formula for T, i.e. from the relationship between T and χ^2], so for one field of the dashboard $56.45/9 = 6.27$

So, if $l_x = 10$ = frequency expected/obtained [see theory and recipes for calculation of χ^2] then frequency obtained/expected = 17.92 or 2.08.

$17.92 - 10 = 7.92$ and $7.92/10 \times 100\% = 79.2\%$.

Ergo: the number of e.g. subgroups of surveyed children whose average school grades increased significantly during the semester [on average by about 0.4 on a scale of grades from 2 to 5 increasing in accordance with the increase in "knowledge", i.e. cognitive values needed to obtain a higher or lower grade] increases in parallel by 35 - 80%. These are significant and spectacular changes. The same applies to changes in speed or endurance. For example, when we compare boys who ran 1000 m in 4 minutes with those who ran this distance in 3 minutes, we will orient the speed of the former is one-third higher and the energy consumed [as kinetic energy] is about 77% higher.

Unfortunately, we still do not know, like nobody in the world, what substance (s) affects such a measurable increase in strength, speed or school grades (not to mention the possible mechanism of this impact). And the increase in the latter must be a parallel increase in the "net" memory, both momentary, short-term and long-term, ability to associate and draw conclusions, the ability to observe, listen, speak, write and understand - because such abilities and skills are necessary for both obtaining good and very good school grades, but all the more so that during the semester these grades - and they are medium - improved [and it can be assumed that the cognitive abilities mentioned above are proportional to at least the square of the formal grade]. ↓ {"old fragment" but put into a "new place"}!!!

The nutritional products/foods or rather their components X, Y, Z-or their metabolites) can affect the studied signs of the mental and physical capacity as substrates, inhibitors or activators (allosteric effectors including) for enzymes or carrier proteins, pro- and antioxidants, [co-]agonists and antagonists of the receptors for hormones and growth factors but also-as it should be considered-transcription factors influencing expression of certain genes (switching them on and off and affecting their "time-table"). Therefore, they could be the nutriepigenetic effectors.

So what [i.e. which potential "type of mechanism" may be responsible for: A/ decrease in the necessary physical or mental capacities B/ no effect on them and finally C/ increase/improvement of these abilities (due to the increase in the frequency of a given food/meal/custom e.g. eating late dinner/supper)?

Relatively the easiest is to try to explain the case A. There can be two non-contradictory [both can take place at about the same time] explanations:

1. One possibility is simply a shortage of ingredients [because it is difficult to imagine that it was one ingredient] necessary for "current work" at short or medium run or when, for example, solving mathematical tasks or remembering dates. Then increasing the frequency of eating e.g. fruit, fish or meat causes an increase in the tissue (muscle, brain) concentration of the substance present in the meal/type of food, e. g. Zn (+2) ions or vitamin C; in general, however, this could apply to many substances [actually hard to exclude any] not so much present in the diet sensu stricto but resulting from digestion and even subsequent metabolism of foods [single fatty acids, glucose, ATP - formed from adenosine formed from nucleotides and nucleic acids in the diet, single amino acids, especially exogenous].
2. The second possibility is that the food ingredient or rather the product of its digestion or metabolite of the latter is simply a "metabolic poison" e.g. inhibitor of some essential enzyme or hormone receptor antagonist. But then increasing the frequency of food component V will "worsen the situation - leading to a decrease in" current fitness [unlike explanation 1].

Any lack of influence [B] can be explained either by: 1] balancing of negative and positive influences, e.g. the effect of inhibitor and activator; antagonist and agonist; repressor and derepressor; or assuming that simply adding further Z kind of food does not improve [does not remove the deficit, because there is no deficit "at the entrance"], because the examined people have a sufficient level of e.g. Fe (+2) or Cu (+2) or iodine or polyunsaturated fatty acids etc., so supplementation [or increasing the frequency of eating foods that are "source" of the substances mentioned above] nothing changes. And this possibility was confirmed by a number of researchers who showed that it has/can take place for a number of vitamins and macro- and microelements [2-4].

The most difficult is to explain the “type of mechanism” for the increase/improvement of these skills [C] There are two situations here: α] increase in low skills to “average levels” [e. g. increase in the number of students with an average state of assessments - with a decrease in the number of those with low condition] and β] increase from a value in the medium range to a value in the high range. Insofar as situation α] can be easily explained simply by the already mentioned “removal of apparent deficit” situation β] is very difficult to explain. It is known that calcium ions are necessary for muscle contraction, but it is hard to imagine that even in people who drink milk every other day, drinking extra milk [supplying calcium ions to the body, isn't it] will improve muscle function by supplying more calcium to myosin heads. The calcium concentration necessary for activation of myosin ATPase is either “locally” too low [lower than a certain limit] and contraction does not occur or higher - no matter how much - from the limit value - and contraction occurs. Just to have a higher endurance/power (here I will use an analogy to the work of the car - referring to the famous “Behavioral Genetics” of Plomin and colleagues [39])” is not enough to add “fuel [glucose, fatty acids] or grease “ [vitamins, macroelements], but “different engine structure” or “wealth of solutions in car construction” is necessary.

So simply higher content of “red” muscle fibers [rich in hemoglobin, myoglobin and mitochondria] must be achieved. Similarly, to improve inference ability, increased synaptogenesis and the formation of new networks of neuronal connections are necessary. This type of change is simply increased biosynthesis of new proteins, i.e. increased expression of specific genes. Because such an effect is influenced by [and we and nobody else know what] components of certain foods [i.e. rather, their digestion products or their metabolites] means that we are dealing with nutriepigenetic effects.

Please note that:

1. Even if we used some standardized quantitative test of food intake, we would not be able to prove what substances [components of specific foods, or rather their digestion products or their metabolites] have an impact and whether it is an epigenetic effect.
2. Similarly, even a detailed quantitative analysis of how much protein, fat and their components, vitamins, micro- or macroelements would not help.
3. Similarly would not help to carry out more sophisticated modern statistical analyzes – e.g. factor analysis [or even a fairly simple analysis of Spearman's rank correlation]
4. Quoted by us the researchers were also unable - and usually they were not even tempted - to explain why actually increasing the frequency of eating breakfast affects - as if - to improve cognitive abilities [10-13,19-21].
5. Actually, in most cases, we do not know exactly why - and under what specific substances - there is such and no other impact, e. g. “adverse health effects” of sweetened carbonated drinks “, although very many people take it for granted
6. Even in the work in which the nutriepigenetic effect on gene expression has been confirmed/demonstrated, there is generally talk of an increase in gene expression [22,23], but there are no works that would indicate a “targeted effect” that is, an increase in the expression of specific genes [i.e. for specific proteins] by specific food substances - or their metabolites.

Certainly, only the combination of the above-mentioned points “actions” 1-3 with the analysis of the full transcriptome and metabolome analyzes as well as very sophisticated morphological assays/maps of functioning of brain would explain the mechanisms of the observed effects of the diet. Assuming that possibility of passage of potential activators/regulators [come from food] through blood-brain barrier would be confirmed.

For which genes could the postulated nutriepigenetic effect take place? And how is it possible that very often this influence is visible - at least qualitatively, but sometimes even quantitatively - both for cognitive skills [brain] but also for endurance [muscles] and even speed-in the same people?

Considering the need to use large amounts of ATP for both nervous and physical work, one might think that it could be a gene for mitochondrial DNA-dependent RNA polymerase [and this gene is part of nuclear DNA], without which expression severe mitochondriogenesis could not be undergone.

But it would be reasonable to accept a gene candidate for some so-called chaperones, necessary for transporting newly formed proteins over even large distances, i.e. for example axonal transport to axonal endings, so to newly formed synapses in the growing networks of neuron connections, as well as to newly emerging neuromuscular junctions. And in turn it turned out a long time ago that

after training in hypoxia, which is known to increase endurance (e.g. long-distance runners) in their muscles (biopsies), the concentration of some messenger RNA increased [40], including citrate synthase (Krebs cycle) and cytochrome oxidase (respiratory chain), as well as for phosphofructokinase and for the glucose transporter i.e. proteins necessary after all for anaerobic glycolysis [speed!] and for glucose burning [endurance and brain work].

Memorization (prerequisite for good grades at school) cannot occur without expression (transcription) of genes in the brain. It was demonstrated by Kaczmarek [34] and many other authors [35-38]. The same concerns (in principle) every physical activity in every movement, especially taking into account that the influence of a nutrient X, Y, Z, present in food [or its metabolite], is observed over several days/weeks and during this time all the protein components-required for a given capacity-are repeatedly destroyed by free radicals and proteolytic enzymes and will have to be formed de novo by means of expression of certain genes.

Conclusion

Our study indicates the existence the effects of elements of everyday diet, foods and nutritional habits on the cognitive abilities, as manifested by changes (positive more than negative) of the average grade during semester in adolescents; however, these effects are particularly evident in younger children (11 - 12 years-old); during the peak of puberty they quite often decrease and disappear; occasionally new "effectors" emerge. Observed statistically significant dependencies are quite often found in case there are no effects of sex, age and BMI on given aspect of nutrition [and in any case there was no effect i.e. significant dependence of sex, age and BMI directly on cognitive and other studied children abilities].

The average school grades received in both age groups depends significantly on the frequency of having breakfast and eating fast-food. In the younger group (A) there are also many other dependences (from drinking milk, eating fish, vegetables, fruits).

What is especially important, the beneficial and detrimental effects of nutrition on the cognitive abilities and physical capacity occur parallelly (kalos kagathos); another words the same elements of everyday diet/nutrition [or rather the frequency of their consuming/ applying] increase [only few of them look to entail the decrease]both the number [and%] of children whose average school grades increased during the semester and the endurance [aerobic]estimated with the results of run on 600m (girls)or 1000 m (boys)but also their speed [rather anaerobic effort] estimated with the results of sprints(60m girls and 100m boys).

The observed effects might come from nutriepigenetic mechanisms. However, the proving of this idea seems to be extremely difficult.

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