Papers on Anthropology XXXII/1, 2023, pp. 18–28

HEAD SIZE AND ACADEMIC PERFORMANCE

Leiu Heapost

Tallinn, Estonia

ABSTRACT

The aim of the paper was to study the potential correlation between school students' head size and academic performance. As the material, the head length and breadth measurement data of 5034 7–18-year-old ethnic Estonian school students measured by Prof. J. Aul in 1966–1969 were used. To get an overview of head size and the development of its growth, head module A was used. The correlation between head size and school students' academic performance was studied using the data of 4840 school students aged 8–18 years (2406 boys and 2434 girls). Academic performance was assessed based on school students' grades in a three-point system: I – low, II – medium, III – good academic performance. As a result, head module A was found to increase relatively evenly and relatively modestly in Tallinn school students during their school years (7% in boys and 4.5% in girls), while boys' heads were larger than girls'. Relative head module A decreased in school students with age in both boys and girls. Until the age of 14 years, relative value of head module A is greater in boys than in girls; from the age of 16 years, however, the relative value of head module A becomes greater in girls than boys. A significant correlation between academic performance and head size was found in both boys and girls. The greatest differences in head size were between students with low and good academic performance. Head module A of the latter was essentially greater. In puberty, a few years later in boys than in girls, the mentioned correlation was weaker.

Keywords: *schoolchildren; head size; growth dynamics; academic performance; Estonians*

https://doi.org/10.12697/poa.2023.32.1.02

INTRODUCTION

The current issue of *Papers on Anthropology* is dedicated to the 90th birth anniversary of Professor Helje Kaarma, the journal's creator and its former chief editor, head of the Centre for Physical Anthropology at the University of Tartu. Last year (2022), 30 years passed from the publication of the first issue of the journal. That year included several remarkable dates concerning the great figures in Estonian anthropology: in 2022, Prof. Helje Kaarma departed this life [15]; 125 years passed from the birth of Juhan Aul, the founder of Estonian anthropology [18], 100 years from the birth of paleoanthropologist and somatologist Karin Mark, Juhan Aul's first student in anthropology [10]. All of them made great contributions to Estonian national culture and science in the area of physical anthropology.

As Prof. Juhan Aul's student and his colleague, I participated in anthropological expeditions organised under Prof. J. Aul's supervision by the Department of Zoology at Tartu State University (now the University of Tartu) to research school students all over Estonia from 1960 onwards.

While recalling my teachers and colleagues, I felt the need to look back at developmental anthropological research of school students in the second half of the previous century. In his studies, Prof. J. Aul relied on the view that the physical development of populations changes according to their social development and changes in environmental factors, and these changes should be monitored. He paid particular attention to studying the physical development of growing Estonian youth, to age-related anthropology and educational anthropology, based on the viewpoint of Maria Montessori, an Italian early 20th century researcher, that young people's physical and mental development and work capacity are inextricably related to their morphophysiological structure. This, however, requires knowledge of the development level and essence of young people's anthropometric characteristics – knowledge of developmental anthropology. In his lectures and discussions, J. Aul often emphasised that we should study how people (school students) who have developed under different social conditions and have different mental abilities diverge and consider the practical need to apply this knowledge in schoolwork. He understood the physical development of the youth in the most general meaning – the growth and development of individual body parts, the morphological formation of the young person's body [2].

In the middle of the last century, we did not have much data about the dimensions of school students' head as one of the body parts, as from the viewpoint of assessment of humans' physical development and bodily capabilities, they were not considered of great significance. J. Aul has expressed the necessity of studying head measurements as follows: "In terms of their ontogenetic development, however, they still belong to the field of physical development, and due to their regional variability and relatively high genetic stability, they play an important role in the racial analysis of humanity. Likewise, one cannot not deny the development level of the dimensions of the head in the formation of mental abilities" [2:83].

The last anthropological expedition under J. Aul's supervision to study Estonian school students was arranged in Tallinn in 1966–1969. Tallinn is a relatively large city, and the population is socio-economically more diversified than elsewhere, which enabled him to broaden the research programme.

The materials collected in Tallinn differ from others, as for the first time in Estonia, in addition to body measurements, the students' academic performance was recorded along with some socio-economic factors like mean income per capita in the family, housing conditions, parents' occupation, number of children in the family, etc. [5].

To avoid differences in measurement technique, most measurements were performed by J. Aul in person. At separate research trips to the schools of Tallinn, I collected data on school students' academic performance (grades).

J. Aul kindly trusted me with analysis of the materials collected in Tallinn, and based on them, I wrote a Candidate's thesis (later PhD) under Prof. Aul's supervision [8]. Unfortunately, I could not use all the data in the thesis at that time. I have partly used these data in an article on Tallinn school students' work capacity (in relation to their socio-economic conditions) [5] and in presentations "On the connections between school students' physical development and academic achievement" [3] and "On the impact of some environmental and genetic factors on school students' physical development". The data collected in Tallinn have also successfully been used later by other researchers [e.g., 16, 17].

I have also provided an overview of Tallinn school students' head dimensions earlier [6, 7, 9]. The growth of head dimensions is somewhat different from the growth of all other body dimensions or organs because the growth of the cranial part of the head is closely related to the development of the brain. It is also generally known that the head part of the human body grows earlier than the lower part.

For example, the weight of a newborn's brain accounts for 25% of that a grown-up brain, body weight 5%; at the age of 10 years, it accounts for 95%, body weight only 50% [4].

Indirect information on head size is provided by head module A which is the sum of head length and breadth. Head module A gives even a somewhat better idea of head size than head circumference because head length and breadth can be measured more precisely than head circumference. Head module A and head circumference show an extremely high correlation. In adult Estonian men, the corresponding correlation coefficient is 0.95. Head module A also provides a better overview of the progress of head growth than head length and breadth separately. Neither can we deny the high correlation between head module A and brain size [2:86].

Skull volume correlates strongly with brain size (head circumference vs. brain volume: $r = 0.72–0.86$) [11]. Brain and head size, in turn, correlate phenotypically with intelligence ($r = 0.19–0.63$) [13]. So, we cannot ignore the development level of head measurements in the formation of mental abilities either. After all, the brain is the organ of mental functions. Moreover, it is at the service of the whole body.

Estonians are well known to be among the tallest nations. Estonians' heads are also comparatively large. Estonian men's head module A is 349.58 mm (20.32% of height – 173 cm) [1]. Among Finno-Ugric and neighbouring peoples, Swedes and Estonians have the largest heads (Estonians 350.9 mm, relative head module 20.3%). The dependence of the head module on body height is rather high ($r = 0.80$, $y = 0.78$) [12: 86]. Estonians' relative head module even surpasses that of Swedes. Considering body height, only Estonians and north-eastern Finns are the people with a big or very big head module.

Estonian women also have large heads (head module A is 339 mm). Because of big body height, their relative head module is among the average, but among peoples with the same height, the heads of Estonian women are among the largest [14:49].

Tallinn school students, like Estonians in general, are known as one of the tallest populations [8, 12 et al]. Therefore, the head size of Tallinn school students and its potential correlation with academic performance attracts interest.

MATERIAL AND METHODS

The anthropometric data of the present study were collected under Prof. J. Aul's supervision from 13 schools of general education in Tallinn in 1966–1969 during the anthropological expedition of the Department of Zoology at Tartu State University (now the University of Tartu). In this paper, head length and

head breadth measurement data of 5034 7–18-year-old Tallinn schoolchildren of Estonian ethnicity are used. For the analysis of the correlation between academic performance and head size, the measurement data of head length and head breadth of 4840 school students (2406 boys and 2434 girls) were used; these had been measured by Prof. Juhan Aul in person.
As the head size measure, head module A which is the sum of head length and breadth is used here.

Additionally, I collected the data on school students' academic performance (grades) from class registers and in consultation with the teachers later after the expeditions. For each student, I calculated their average academic performance score, which I later added to the corresponding student's individual anthropological observation sheet. (Usually, the grades began from three on a five-point scale, as giving a lower grade showed the teacher's "incompetence" then, not the student's mental abilities.)

To evaluate academic performance, I used a three-point system: I – low, II – average and III – good academic performance. I encoded the whole material collected from Tallinn, and then it was processed at the Computing Centre of Tartu State University with the computer Ural-4.

The purpose of the study was to provide an overview of the head size (head module A) of 8–18-year-old ethnic Estonian school students in Tallinn and its relationship with academic performance.

RESULTS AND DISCUSSION

The data in Table 1 show that head module A increases in boys at a relatively even rate until 14 years of age; then the growth accelerates somewhat. This continues until the age of 18 years without slowing down. Girls' head module A also increases slowly in the first four school years; from the age of 11 to 14 years, growth is considerably quicker; then growth decelerates at a subsiding rate and seems to have ended by the age of 18 years.

During the entire school age, head module A is bigger in boys than in girls. The sexual difference in head module A is the smallest at the age of 13 and 14 years when the sexual dimorphism index (SDI) is 98. In most general terms, the age-related formation of head module A resembles that of the students with the lowest academic performance (see Table 1, Figure 1). Some of the "jumps" in the graph may be caused by the scantiness of the material, but the correlation between the head size and academic performance is still obvious.

Table 1. Changes in absolute (mm) and relative (%) head module A according to age.

Age	Boys		Girls		Age	Boys		Girls	
	abs.	rel.	abs.	rel.		abs.	rel.	abs.	rel.
7	330.7	26.4	323.7	25.8	13	341.2	22.1	334.3	21.4
8	332.4	25.5	324.3	25.3	14	343.8	21.3	336.9	21.0
9	334.5	24.8	326.6	24.4	15	347.3	20.6	336.7	20.7
10	336.8	24.0	329.3	23.7	16	348.6	20.2	338.2	20.7
11	337.8	23.4	330.0	22.8	17	350.8	19.9	339.3	20.7
12	340.7	22.7	332.5	22.0	18	354.7	20.0	338.4	20.6

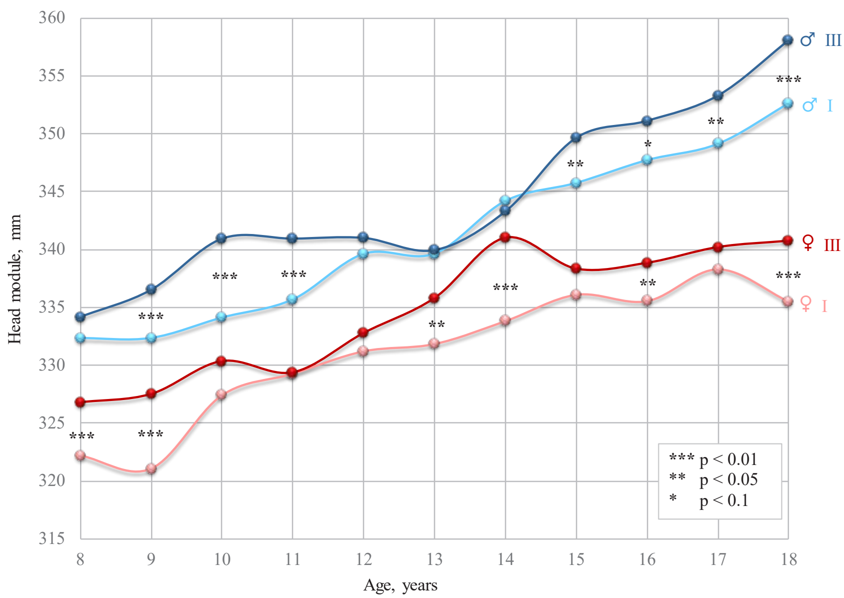

Figure 1. Academic achievement and head module A. Comparison of groups I and III.

The numeric value of head module A increases in Tallinn 7–18-year-old boys by 24 mm (7%), in girls by 14.7 mm (4.5%). Relative head module A decreases with age in both boys and girls. Until the age of 14 years, the relative value of head module A is greater in boys than in girls; from the age of 15 years, however, its relative value becomes greater in girls than boys.

At the age of 18 years, boys' head module A is 354.7 mm, girls' – 338.4 mm (relative head module 20.0% and 20.6% respectively) (Table 1). Adult Estonian men's relative head module A is also smaller (20.3%) than women's (20.9%).

The head module A of Estonian women is 339 mm [14], of Estonian men – 350.9 mm (rel. 20.3%) [12]. In the 1930s, Estonian men's average head module A was 349.58 mm [1]. Thus, according to different authors, one of Estonians' characteristics is comparatively large head.

Age-related changes in head module A in three groups formed on the basis of school students' grades are presented in Figures 1–3. The figures show that the absolute values of boy's head module A are greater than girls'; the smallest difference appears at the age of 13–14 years like in head module A SDI. When the formation of head module A is compared in groups I and III (students with the lowest and the best academic performance), the correlation between head size and academic performance can be seen clearly. (Statistical probability is shown in the figures.) Head module A was revealed to be the greatest in group III. Table 2 shows that, in younger age groups, the head (head module A) is bigger in children with good academic performance (in boys by 4 mm on average, in girls by 5 mm). Thereafter, during two or three years, the difference in head size decreases in both boys and girls, but in older school age, the correlation between head size and academic performance increases again (mean difference more than 4 mm in both sexes) (Table 2). Weakening of the correlation between head size and academic performance appears in Tallinn girls a few years earlier (at the age of 10–12 years) than in boys (at the age of 12–14 years) (Table 2).

Table 2. Mean differences in head size (mm) based on students' grades (I–III).

Age (years)	Boys			Age	Girls		
	III–I	III–II	II–I		III–I	III–II	II–I
8 ... 11	3.7	2.4	1.0	8 ... 9	5.4	1.8	3.7
12 ... 14	0.5	0.0	1.4	10 ... 12	1.9	0.5	1.4
15 ... 18	4.2	3.1	0.7	13 ... 18	4.2	1.3	2.9

As Figure 2 shows, there is obvious correlation between head size and academic performance in boys of groups III and II (good and medium academic performance), except in middle-school age when the correlation is weaker (Table 2). In girls, stronger correlation appears only at the age of 14–15 years (Figure 2).

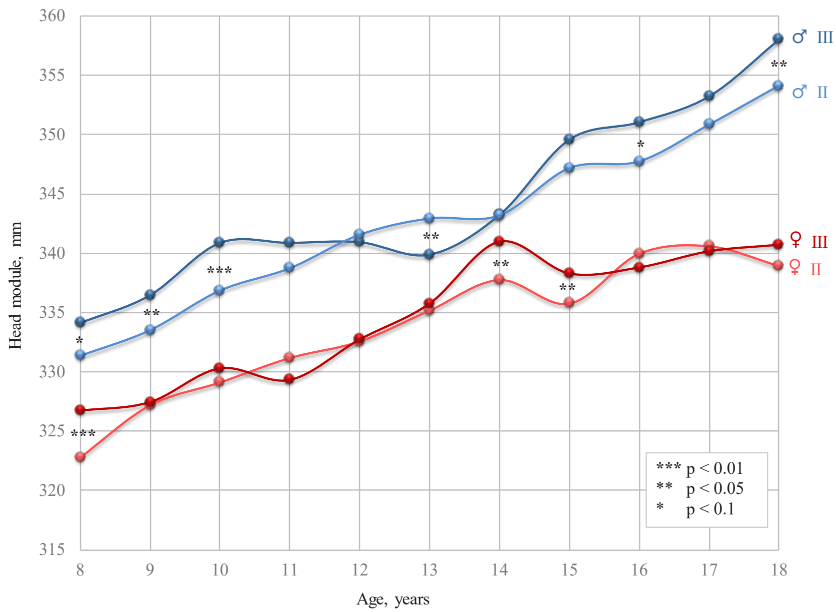

Figure 2. Academic achievement and head module A. Comparison of groups II and III.

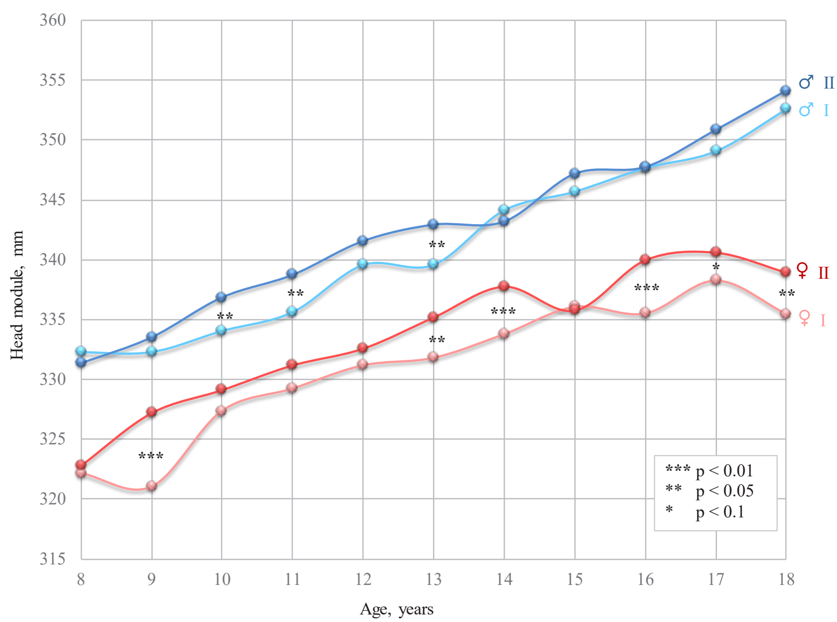

Figure 3. Academic achievement and head module A. Comparison of groups II and I.

Figure 3 shows that, in younger boys of groups I and II (low and medium academic performance), there are differences in head size, but after 14 years of age, there are no significant differences. The absence of differences in head size in groups of older boys with lower academic performance can also be related to their carelessness about studies or grades. The head of 8–9-year-old girls of group II (medium academic performance) is on average 3.7 mm larger than of the girls of group I (low academic performance). From the age of 13 years, the corresponding mean difference is 2.9 mm (Table 2).

In conclusion, it can be said that:

1. Head module A is a good anthropometric variable that clearly expresses the differences between populations.
2. Head module A increases comparatively evenly during school age. The age of puberty exerts influence on the formation of the head but not essentially compared to body measurements.
3. In all age groups, head module A is greater in boys than in girls of the same age.
4. During school age, noticeable changes happen in head size and its proportions. As head length grows more intensively and for a longer time than head breadth [6], relative head module A decreases with age. Until the age of 14 years, the relative value of head module A is greater in boys than in girls; from the age of 15 years, however, the relative value of head module A becomes greater in girls than in boys. The head length-breadth index also undergoes a similar age-related change. Until the age of 14 years, the girls of Tallinn are more dolichocephalic than boys. From the age of 15 years, boys become more dolichocephalic than girls [6].
5. A significant correlation between academic performance and head size was found in both boys and girls. The differences in head size were the greatest between the students with low (group I) and good academic performance (group III). Head module A of the latter was essentially greater. In puberty, in boys a few years later (at the age of 12–14 years) than in girls (at the age of 10–12 years), the mentioned correlation was weaker.
6. It can be supposed that the big head, typical of Estonians, both Tallinn school students and adults, is one of the special characteristics of this population along with big body height, light pigmentation, and several other characteristics. The continuity of morphological characteristics in the population of

Estonians can be traced back to at least the 11th–12th century or even earlier times. Head size may be one in the complex of characteristics specific to this population. The latter hypothesis should be checked on bioarchaeological material.

ACKNOWLEDGMENTS

I thank Reet Maldre for the figures.

REFERENCES

1. Aul J. (1964) Antropologija estoncev = Anthropologia Estonica. TRÜ Toimetised 158.
2. Aul J. (1982) Eesti kooliõpilaste antropoloogia. Tallinn: Valgus.
3. Eesti Looduseuurijate Seltsi Aastaraamat. 66. köide (1978). Tallinn, 154.
4. Harrison G. A., Weiner J. S., Tanner J. M., Barnicot N. A. (1968). Human biology. Moscow: Mir (in Russian).
5. Heapost L. (1974). Tallinna kooliõpilaste tööjõudluse näitajatest. In: Antropoloogia-alaseid töid II. TRÜ Toimetised, 330. Tartu, 50–66.
6. Heapost L. (1977). Pea mõõtmete kasvudünaamikast. In: Eesti Looduseuurijate Seltsi aastaraamat. 65. köide: Antropoloogia probleeme Eestis. Tallinn: Valgus, 120–135.
7. Heapost L. (1977). Tallinna kooliõpilaste näo mõõtmed. In: Antropoloogia-alaseid töid III: Eestlaste antropoloogiliste andmete analüüs. TRÜ Toimetised, 438. Tartu, 114–132.
8. Heapost L. (1984). Tallinna kooliõpilaste ealine antropoloogia (1966–1969). Tallinn: Valgus.
9. Heapost L. (1994). Growth changes in dimensions of the head and face in Estonian schoolchildren. In: International conference: Somatotypes of Children II. Tartu, Estonia, June, 15–18. Tartu, 13–14.
10. Heapost L. (2022). Karin Mark 100. Eesti Loodus, 4, 72–74.
11. Ivanovic D. M., Leiva B. P., Castro C. G., Olivares M. G., Jansana J. M. M., Castro V. G., Almagià A. A. F., Toro T. D., Urrutia M. S. C., Miller P. T., et al. (2004). Brain development parameters and intelligence in Chilean high school graduates. Intelligence, 32 (5), 461–479. https://doi.org/10.1016/j.intell.2004.07.001
12. Mark K., Heapost L. (2014). Soome-ugri rahvaste füüsiline antropoloogia. Tallinn: Eesti Teaduste Akadeemia Kirjastus.
13. Rushton J. P., Ankney C. D. (2009). Whole brain size and general mental ability: a review. Int J Neurosci, 119 (5), 692–732. https://doi.org/10.1080/00207450802325843

14. Silla R., Teoste M. (1989) Eesti noorsoo tervis. Tallinn: Valgus.
15. Tiit E.-M. (2022). *In memoriam*: Helje Kaarma. Eesti Loodus, 3, 77.
16. Valge M., Meitern R., Hõrak P. (2019). Morphometric traits predict educational attainment independently of socioeconomic background. BMC Public Health, 19 (1), ARTN 1696. https://doi.org/10.1186/s12889-019-8072-7
17. Valge M., Meitern R., Hõrak P. (2021). Anthropometrics of Estonian children in relation to family disruption: Thrifty phenotype and Trivers-Willard effects. Evolution Medicine and Public Health, 9 (1), 276–286. https://doi.org/10.1093/emph/eoab022
18. Veldre G. (2022). Juhan Aul – 125 years from the birth of the founder of Estonian anthropology. Papers on Anthropology, 31 (2), 7–17. https://doi.org/10.12697/poa.2022.31.2.01

Address for correspondence:
Leiu Heapost
E-mail: leiuheapost@gmail.com