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KORNÉLIA JENČOVÁ, SILVIA DURANKOVÁ, ALEXANDER CSANÁDY,
JARMILA BERNASOVSKÁ, INGRID RUŽBARSKÁ

# ANTROPOMETRY OF YOUNGER SCHOOL AGE CHILDREN FROM SLOVAKIA

*ABSTRACT: The aim of the study was the anthropometry of 7–10 years old children at the primary school in Slovakia. In the study, eleven measured anthropometric parameters (V1–V11) were evaluated on a group of 162 probands (77 girls and 85 boys). The differences between the sexes were compared and body size effect between sexes were evaluated. In most of the measured parameters, the girls achieved higher average values.*

*KEY WORDS: Variability – Sex differences – Two-way ANOVA – Anthropometric parameters*

## INTRODUCTION

Anthropometry is defined as the measurement science of human body for purposes of understanding human physical variation. This science involves the systematic measurement of the physical properties of the human body, i.e., the body size and shape. (Del Prado-Lu 2007, Frederics *et al.* 2000, Bogin, Varela-Silva 2010, Veldhuis *et al.* 2013, Contreras *et al.* 2014, Hassapidou *et al.* 2015, Cichá *et al.* 2017). Evaluation of the body growth based on the age is an important and reliable method in the monitoring of health in an individual child. Height and weight measurements are also the most frequently used indices to evaluate the nutritional state of the community. Koštálová *et al.* (2005) showed that each age group has its anatomical, psychological and functional peculiarities. A childhood is a very dynamic period of life in which the differences between children of different ages are more pronounced than among adults of different ages. The usefulness of anthropometry is also conditioned by the fact that it is considered to be the most readily available, inexpensive and non-invasive method that reflects the nutritional status of the individual (De Onis *et al.* 1996). Changes in body composition that occur during aging vary across sexes, populations, and also ethnic groups, while affecting anthropometric parameters (Bogin *et al.* 2010). Therefore, reference tables are necessary for a paediatric monitoring of child's growth and development (Kato *et al.* 2014, Bong *et al.* 2015, Cheng

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*et al.* 2019). The data obtained on the basis of anthropometric measurements were used to monitor and evaluate the healthy development and performance of children in the Czech Republic (Cichá *et al.* 2017). In other studies, considerable attention was paid to metric differences in individual proportions and body parts (Farkas *et al.* 1984, 2005, Contreras *et al.* 2014, Gába, Přidalová 2015, Capatan *et al.* 2014, Jervas 2015). Das and Roy (2010) noted that anthropometric characteristics serve to better understand the growth process by describing changes in body size and morphology according to age. The authors also assumed that these changes did not reach their peak to the same extent as other changes. These changes may be visible between anthropometric characteristics, between populations, or between sexes. Body proportionality is characterized as a result of different growth of individual body segments (Gustafsson, Lindenfors 2004, Nevill *et al.* 2009, Burton 2010). Interpersonal changes in the proportions and shape of the human body are caused by differences in genetic predisposition, lifestyle such as hygiene, diet, health case and the environment (Das, Roy 2010, Bogin *et al.* 2010, Alderman *et al.* 2003).

This study was undertaken because new reports on the anthropometric body size of children from Slovakia (Central Europe) are still insufficient. Accordingly, the main purposes of our research were to i) contribute to the knowledge of quantitative characteristics of the size of body variables, ii) test the presence of sexual dimorphism in body size, and iii) compare our results with those of other researchers from other populations.

TABLE 1: Descriptive statistics children in school age of seven and eight years old. The statistics given are number (N); mean (M); standard deviation (SD); interval of margins (min, max); (95% CI) lower and upper 95% of the confidence interval of mean and coefficient of variance (V). Abbreviations of the anthropometric variables are explained in the Material and methods section.

| | | Boys | | | | Girls | | | | Effect size | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Trait | age | N | M±SD | 95% CI | V | N | M±SD | 95% CI | V | d | Power |
| V1 | 7 | 19 | 124.70±6.44 | 121.60–127.80 | 5.16 | 13 | 124.20±7.42 | 119.70–128.70 | 5.98 | 0.07 | very small |
| V2 | 7 | 19 | 98.80±7.24 | 95.31–102.30 | 7.33 | 13 | 99.38±6.48 | 95.46–103.30 | 6.52 | 0.08 | very small |
| V3 | 7 | 19 | 46.56±3.63 | 44.81–48.31 | 7.80 | 13 | 47.41±3.19 | 45.48–49.33 | 6.72 | 0.25 | small |
| V4 | 7 | 19 | 68.69±4.18 | 66.68–70.70 | 6.08 | 13 | 68.54±5.86 | 64.98–72.09 | 8.59 | 0.03 | very small |
| V5 | 7 | 19 | 28.76±1.69 | 27.95–29.58 | 5.89 | 13 | 29.08±4.57 | 26.33–31.84 | 15.70 | 0.10 | very small |
| V6 | 7 | 19 | 19.74±1.76 | 18.89–20.59 | 8.92 | 13 | 18.50±1.69 | 17.48–19.52 | 9.13 | 0.72 | medium |
| V7 | 7 | 19 | 52.95±3.18 | 51.42–54.48 | 6.00 | 13 | 52.45±3.42 | 50.38–54.51 | 6.52 | 0.15 | very small |
| V8 | 7 | 19 | 64.66±3.29 | 63.07–66.24 | 5.09 | 13 | 62.95±4.37 | 60.31–65.60 | 6.95 | 0.45 | small |
| V9 | 7 | 19 | 25.82±4.14 | 23.82–27.81 | 16.04 | 13 | 25.54±2.88 | 23.80–27.28 | 11.26 | 0.08 | very small |
| V10 | 7 | 19 | 2.89±0.30 | 2.74–3.03 | 10.29 | 13 | 2.61±0.16 | 2.52–2.70 | 5.95 | 1.07 | large |
| V11 | 7 | 19 | 4.40±0.56 | 4.13–4.67 | 12.63 | 13 | 4.03±0.28 | 3.87–4.20 | 6.82 | 0.19 | very small |
| | | | | | | | | | | | |
| V1 | 8 | 25 | 127.50±7.83 | 124.30–130.70 | 6.14 | 27 | 131.30±5.66 | 129.10–133.60 | 4.31 | 0.56 | medium |
| V2 | 8 | 25 | 103.40±7.48 | 100,30–106.50 | 7.24 | 27 | 106.70±6.41 | 104.20–109.30 | 6.00 | 0.48 | small |
| V3 | 8 | 25 | 48.07±3.47 | 46.64–49.50 | 7.22 | 27 | 50.77±3.77 | 49.28–52.26 | 7.42 | 0.74 | medium |
| V4 | 8 | 25 | 72.48±7.58 | 69.35–75.61 | 10.45 | 27 | 75.09±6.48 | 72.53–77.65 | 8.62 | 0.37 | small |
| V5 | 8 | 25 | 30.39±2.81 | 29.23–31.55 | 9.25 | 27 | 30.48±2.95 | 29.32–31.65 | 9.67 | 0.03 | very small |
| V6 | 8 | 25 | 22.98±10.93 | 18.47–27.49 | 47.54 | 27 | 20.79±4.14 | 19.15–22.43 | 19.93 | 0.27 | small |
| V7 | 8 | 25 | 55.36±4.65 | 53.44–57.28 | 8.39 | 27 | 56.11±4.42 | 54.37–57.86 | 7.88 | 0.17 | very small |
| V8 | 8 | 25 | 64.97±3.97 | 63.33–66.61 | 6.11 | 27 | 68.80±8.46 | 65.45–72.14 | 12.30 | 0.57 | medium |
| V9 | 8 | 25 | 27.08±5.03 | 25.00–29.16 | 18.58 | 27 | 29.33±6.00 | 26.96–31.71 | 10.95 | 0.40 | small |
| V10 | 8 | 25 | 2.88±0.26 | 2.77–2.98 | 9.05 | 27 | 2.86±0.31 | 2.73–2.98 | 10.83 | 0.10 | very small |
| V11 | 8 | 25 | 4.19±0.35 | 4.04–4.32 | 8.27 | 27 | 4.29±0.35 | 4.15–4.43 | 8.24 | 0.31 | small |

## MATERIAL AND METHODS

The anthropometric research was conducted from June 2020 to September 2020 at a primary school in eastern Slovakia (Spišské Podhradie town). In the evaluation, only the children with the signed informed consent from their parents were included. It should be noted that the sample size was also influenced by positive responses to the informed consent of the parents or legal guardians of the children. Moreover, all children had the same social-economic status i.e., they came from families with same life standard.

Nevertheless, our data consisted of 162 probands (77 girls and 85 boys), i.e., children of younger school age between 7 and 10. We evaluated eleven anthropometric parameters of younger school age. Eleven body traits were measured, based on the recommendations of several authors (Kopecký *et al.* 2013, 2019). Their abbreviations and definitions are as follows: the body height (V1), the shoulder height (V2), the height of the tip of the forefinger (V3), the height of the front of the lumbar spine (V4), the biacromial shoulder width (V5), the bispinal breadth (V6), the length of upper limb (V7), the chest circumference (V8), the body weight (V9), the nose width (V10), the mouth width (V11).

The obtained dataset (untransformed data) was evaluated using the following statistical parameters: mean (M), standard deviation (SD), 95% confidence interval (95% CI) and coefficient of variation (V). The Hotelling's $T^2$-test was performed to test the sexual dimorphism. We evaluated the effect size (Cohen's d)

TABLE 2: Descriptive statistics children in school age of nine and ten years old. The statistics given are number (N); mean (M); standard deviation (SD); interval of margins (min, max); (95% CI) lower and upper 95% of the confidence interval of mean and coefficient of variance (V). Abbreviations of the anthropometric variables are explained in the Material and methods section.

| | | Boys | | | | Girls | | | | Effect size | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Trait | age | N | M±SD | 95% CI | V | N | M±SD | 95% CI | V | d | Power |
| V1 | 9 | 23 | 134.90±4.42 | 133.00–136.80 | 3.27 | 19 | 140.60±8.36 | 136.60–144.70 | 5.95 | 0.89 | large |
| V2 | 9 | 23 | 109.20±5.89 | 106.60–111.70 | 5.40 | 19 | 114.40±7.96 | 110.50–118.20 | 6.96 | 0.75 | medium |
| V3 | 9 | 23 | 51.12±2.69 | 49.95–52.28 | 5.26 | 19 | 53.92±4.08 | 51.96–55.89 | 7.56 | 0.83 | large |
| V4 | 9 | 23 | 76.56±5.26 | 74.29–78.83 | 6.87 | 19 | 79.04±8.85 | 74.77–83.30 | 11.19 | 0.35 | small |
| V5 | 9 | 23 | 31.87±2.92 | 30.61–33.13 | 9.15 | 19 | 31.65±2.32 | 30.54–321.77 | 7.31 | 0.08 | very small |
| V6 | 9 | 23 | 25.45±11.46 | 20.50–30.41 | 45.01 | 19 | 23.32±3.60 | 21.59–25.05 | 15.42 | 0.24 | small |
| V7 | 9 | 23 | 57.74±4.41 | 55.83–59.64 | 7.63 | 19 | 59.67±6.01 | 56.78–62.57 | 10.07 | 0.24 | small |
| V8 | 9 | 23 | 68.55±5.76 | 66.06–71.04 | 8.40 | 19 | 72.05±6.60 | 68.87–75.23 | 9.16 | 0.57 | medium |
| V9 | 9 | 23 | 33.13±6.81 | 30.19–36.08 | 20.56 | 19 | 35.58±7.40 | 32.01–39.15 | 20.80 | 0.35 | small |
| V10 | 9 | 23 | 3.04±0.33 | 2.91–3.18 | 10.66 | 19 | 2.82±0.31 | 2.68–2.97 | 10.93 | 0.67 | medium |
| V11 | 9 | 23 | 4.58±0.65 | 4.30–4.86 | 14.25 | 19 | 4.42±0.42 | 4.04–4.45 | 9.95 | 0.61 | medium |
| | | | | | | | | | | | |
| V1 | 10 | 18 | 139.90±5.98 | 136.90–142.90 | 4.28 | 18 | 142.80±6.95 | 139.30–146.20 | 4.87 | 0.45 | medium |
| V2 | 10 | 18 | 114.70±9.94 | 109.80–119.70 | 8.66 | 18 | 116.40±7.11 | 112.80–119.90 | 6.11 | 0.20 | small |
| V3 | 10 | 18 | 52.76±2.75 | 51.39–54.13 | 5.21 | 18 | 54.54±3.69 | 52.71–56.37 | 6.76 | 0.55 | medium |
| V4 | 10 | 18 | 75.55±7.09 | 72.03–79.07 | 9.36 | 18 | 83.12±5.85 | 80.21–86.02 | 7.03 | 1.17 | large |
| V5 | 10 | 18 | 33.11±4.20 | 31.02–35.20 | 12.68 | 18 | 33.58±3.15 | 32.01–35.14 | 9.38 | 0.13 | very small |
| V6 | 10 | 18 | 20.12±4.62 | 17.82–22.41 | 22.94 | 18 | 23.93± 4.34 | 21.77–26.09 | 18.15 | 0.85 | large |
| V7 | 10 | 18 | 61.53±10.40 | 56.35–66.70 | 16.91 | 18 | 60.79±6.52 | 57.55–64.03 | 10.72 | 0.09 | very small |
| V8 | 10 | 18 | 70.59±4.17 | 68.52–72.67 | 5.90 | 18 | 76.17±8.04 | 72.17–80.16 | 10.55 | 0.87 | large |
| V9 | 10 | 18 | 34.36±6.86 | 30.95–37.77 | 19.95 | 18 | 38.90±9.09 | 34.38–43.42 | 23.35 | 0.56 | medium |
| V10 | 10 | 18 | 2.99±0.37 | 2.81–3.17 | 12.35 | 18 | 3.16±0.54 | 2.89–3.42 | 16.95 | 0.37 | small |
| V11 | 10 | 18 | 4.58±0.51 | 4.33–4.84 | 11.06 | 18 | 4.51±0.55 | 4.22–4.79 | 12.29 | 0.13 | very small |

for differences between both sexes (Nakagawa, Cuthill 2007, Sawilowsky 2009). We also used two-way ANOVA with age and sex as factors to test their interaction and evaluate the variability. All descriptive analyses were evaluated using the statistical analysis system GraphPad Prism version 5.01 (GraphPad Software, Inc., San Diego, California, USA), and the two-way ANOVA were done using the Statistical Software OriginPro 8.6 (Microral Software Inc., Northampton, USA). Effect size was estimated using free MS Excel 2003 effect size calculator (https://www.cem.org/ attachments/EBE/ EffectSizeCalculator.xls).

## RESULTS

The descriptive statistics for each considered measurement are reported with samples divided by sex and age in *Table 1* and *Table 2*. Our results showed that the overlap of values in measurements for both sexes was evident (*Figure 1*), though it can be concluded that, in most characters, girls overtook boys in the growth. Similarly, the Hotelling's $T^2$-test ($T^2 = 40.62$, $p = 0.005$) showed presence of sexual dimorphism in general. The two-way ANOVA confirmed the influence of age on overall variability (*Table 3*). Effect size analyses for somatic traits between sexes confirmed small or medium statistical power except for several traits in older children (*Tables 1, 2*).

## DISCUSSION

Anthropometric studies performed in different age groups and both sexes provide important insights into the health status and development of the population (Topcu *et al.* 2017). Our results confirmed differences in sexes, where boys had lesser values of measured traits than girls. Average values of body height and body weight of the monitored group of 7–10 years-old children point to growth and intersex differences of physical growth and development (Bernasovský, Bernasovská 1999). We showed a different growth rate, the achievement growth rate in body height and body weight as well as gradual decrease growth rate. In eastern Slovakia, similar findings were reported as in the other countries (Tanner *et al.*, 1966, Banik *et al.* 1970, Eveleth, Tanner 1976, Hamill *et al.* 1979, Corlet 1984, Al-Hazza 1990, De Lorenzo *et al.* 1995, Whittaker *et al.* 2005, Hafezi *et al.* 2010, Neyzi *et al,* 2015, Karakas *et al.* 2005, Sharma *et al.* 2018). The

TABLE 3: Results of two-way ANOVA of the fourteen anthropometric measures (V1–V11) and their F-values for three effects (age, sex, and age x sex). The statistics given are degree of freedom (df), sum of square (ssq) and p-values (p). Significant variables are shown with the significant levels: $^{*}p<0.05$, $^{**}p<0.01$ and $^{***}p<0.001$, p – statistic significant. Abbreviations of the anthropometric variables are explained in the Material and methods section.

| Trait | Factor | df | ssq | F | p |
|---|---|---|---|---|---|
| V1 | sex | 1 | 432.31 | 9.68 | 0.00221** |
| | age | 3 | 6185.54 | 46.16 | 0.00*** |
| | sex x age | 4 | 6709.21 | 37.55 | 0.00*** |
| V2 | sex | 1 | 337.93 | 6.31 | 0.01305* |
| | age | 3 | 5474.66 | 34.05 | 0.00*** |
| | sex x age | 4 | 5912.36 | 27.58 | 0.00*** |
| V3 | sex | 1 | 187.94 | 15.88 | 1.02907E-4*** |
| | age | 3 | 943.09 | 26.57 | 5.93969E-14*** |
| | sex x age | 4 | 1159.00 | 24.49 | 8.88178E-16*** |
| V4 | sex | 1 | 399.10 | 9.7 | 0.00304** |
| | age | 3 | 2267.36 | 17.17 | 1.08459E-9*** |
| | sex x age | 4 | 2746.96 | 15.60 | 9.13124E-11*** |
| V5 | sex | 1 | 0.79 | 0.08 | 0.77163ns |
| | age | 3 | 376.99 | 13.40 | 7.80775E-8*** |
| | sex x age | 4 | 379.64 | 10.13 | 2.56822E-7*** |
| V6 | sex | 1 | 16.74 | 0.35 | 0.55315ns |
| | age | 3 | 509.14 | 3.58 | 0.01527* |
| | sex x age | 4 | 521.71 | 27426.00 | 0.03004* |
| V7 | sex | 1 | 9.39 | 0.29 | 0.58899ns |
| | age | 3 | 1380.83 | 14.36 | 2.5652E-8*** |
| | sex x age | 4 | 1400.38 | 10.93 | 7.6678E-8*** |
| V8 | sex | 1 | 377.87 | 10.21 | 0.00169** |
| | age | 3 | 1693.21 | 15.24 | 9.41084E-9*** |
| | sex x age | 4 | 2126.87 | 14.36 | 5.17931E-10*** |
| V9 | sex | 1 | 217.69 | 5.46 | 0.02069* |
| | age | 3 | 2834.99 | 23.71 | 1.03351E-12*** |
| | sex x age | 4 | 3086.22 | 19.36 | 5.76095E-13*** |
| V10 | sex | 1 | 0.25 | 2.14 | 0.14584ns |
| | age | 3 | 1.76 | 5.4 | 0.00233** |
| | sex x age | 4 | 1.96 | 4.21 | 0.00291** |
| V11 | sex | 1 | 0.81 | 3.48 | 0.06387ns |
| | age | 3 | 2.54 | 3.67 | 0.01371* |
| | sex x age | 4 | 3.35 | 3.62 | 0.00746** |

anthropometric data of children from Saudi Arabia for body weight were found to be similar to those of France, Japan, Egypt (Eveleth, Tanner 1976) and Botswana (Corlet 1984). However, boys from West Germany were considerably heavier than the Saudi boys with the exception of boys at the age of 14 (Eveleth, Tanner 1976). When the Saudi boys' data for body weight were plotted and compared with some standards from the U.S.A. (Hamill *et al.* 1979) and the U.K. (Tanner *et al.* 1966), it was evident that the boys from the USA are markedly heavier than the Saudis at all ages reported. Authors found that pubertal acceleration in girls started 2 years earlier than in boys.

The Italian boys had a lower average weight than our boys at the age of 7 and 9, at the age of 8 and 10 they reached approximately the same value of the average weight and at the age of 10 they reached a higher average weight than the Slovak boys. At the age of 7 and 9 years, Italian boys had a lower average value of body height and in other age categories they reached approximately the same values as our research sample. For girls, the average values of body height and body weight in Slovakia were higher (De Lorenzo *et al.* 1995).

In a study by Neyzi *et al.* 2015, Turkish girls were compared with girls from Norway, Belgium and the WHO organization. Our 9-years-old girls achieved a higher average value of body weight and a higher average value of body height. 9-years-old boys had higher average body weight and higher average body height than 9-years-old boys from Turkey, Norway, Belgium and the WHO.

The highest differences were observed in average body weight and average body height between Slovak and Saudi boys from the study by Al-Hazza (1990). Data for body height of the Saudi boys were also compared. Saudi boys have lower height values than those of the French, German, or Italian boys. On the other hand, Saudi boys showed similar values to those of Japan and Egypt.

In the study by Whittaker *et al.* (2005), white and Asian races were compared at the age of 9 years. Compared to the average values of the chest circumference measured in children from this study, average values of our girls were higher by 7 cm and those of boys by 2 cm.

According to the study by Banik *et al.* (1970) both sexes in all age categories achieve much lower average values of chest circumference than children from our measured group.

The shoulder width in our study increased gradually. In 10-year-old boys, an average value of 33.11 cm was observed. The results were different when compared to the study by Hafezi *et al.* (2010). They followed younger school-aged children in Iran. The authors confirmed a mean value of 31.07 cm shoulder width for 10-year-old boys, which is much lower than the value in our study population. The girls in the study had a mean value of 31.63 cm at the age of 10. In our study sample, girls had a shoulder width of 33.58 cm. In both cases, our probands achieved higher values than the children in Iran.

In 8-year-old children in our sample, the length of the upper limb was 55.36 cm in boys and 56.11 cm in

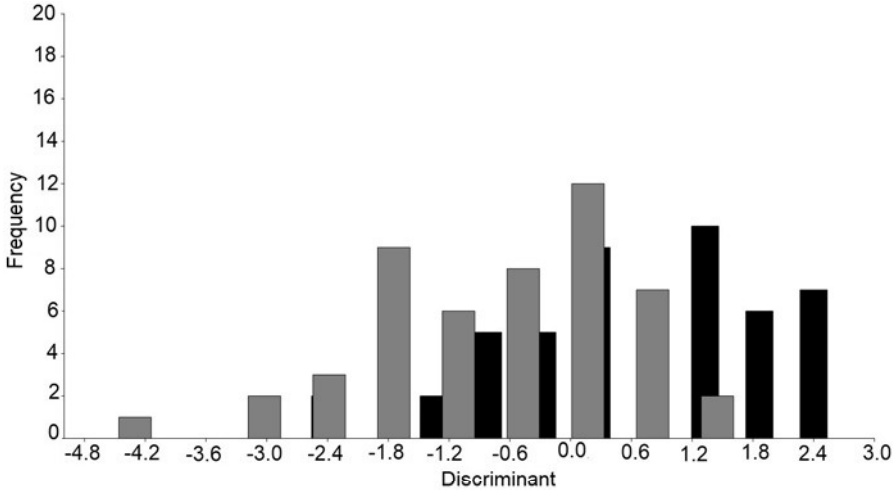


FIGURE 1: Frequency histogram of the scores for the Hotelling T2-test between both gender of school age chlidren of Slovak population from Central Europe (Slovakia).

girls. Compared to the study by Sharma *et al.* (2018), our 8-year-old children had higher values than younger school-aged children in Asia, where the mean value in 8-year-old children was 54.00 cm. In the group of 9-year-old children, the children from Asia had a mean value of 57.50 cm in the upper limb length. Our children of the same age had a mean value of 57.74 cm in boys a 59.67 cm in girls in the upper limb length values.

In all age categories, we observed higher mean values compared to the Asian and Turkish child population. Ten-year-old Turkish boys and girls had a mean upper limb length of 59.83 cm and 59.31 cm, respectively. These values were lower than in our group of 10-year-old boys and girls under the observation (Karakas *et al.* 2005).

In our study population, we confirmed the large individual variability of younger school-aged children. Despite the smaller sample sizes, this research provided a lot of interesting and important information regarding the Slovak population of children of younger school age.

## CONCLUSION

The aim of study was the anthropometric analysis of younger school children from eastern Slovakia. Fourteen anthropometric parameters were measured in total. The measurements in sexes overlapped, but analyses confirmed significant differences between them. Our results also confirmed differences in the dimensions for most somatic characteristics in the populations compared to our population. Nevertheless, to confirm the above statements, more materials from all regions of Slovakia will need to be evaluated in future.

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Kornélia Jenčová
Silvia Duranková*
Alexander Csanády
Jarmila Bernasovská
E-mail: kornelia.jencova3d@gmail.com
E-mail: silvia.durankova@unipo.sk
E-mail: alexander.csanady@unipo.sk
E-mail: jarmila.bernasovska@unipo.sk

Department of Biology
Faculty of Humanities and Natural Sciences
University of Prešov,
17. novembra, 081 16
Prešov, Slovakia

Ingrid Ružbarská
Faculty of Education,
University of Prešov, 17. novembra, 081 16
Prešov, Slovakia
E-mail: ingrid.ruzbarska@unipo.sk

*Corresponding author.