SUMMARY

Introduction

The age of 7-9 years is a key period for children in the formation of an internal movement pattern and complete control of the upright body position. During locomotion and standing, a change from trunk strategy to head stabilization strategy is observed. In children, the development of balance consists mainly in formulating a set of different postural strategies, and then learning to choose the most desirable one for maintaining balance or performing a motor task. It is only at the age of 12 that they achieve the efficiency of using visual and vestibular stimuli in postural control.

Human's maintenance of postural balance depends on his biomechanical and neurophysiological conditions. Somatic features are inextricably linked with the former. It was found that due to the greater inertia of the body, children with higher BMI values cope worse with the strategy of the hip joint and obtain less favorable results in tests on an unstable surface, while on a stable surface the differences in COP displacement values in children with normal weight and obese children are smaller. .

The functional asymmetry of the lower limbs in their supporting function has been the subject of research by many authors, but the obtained results seem to be contradictory. Lower limb preference may depend partially on the context of the task. In the support function on a stable surface, according to most authors, it is manifested by a slightly greater load on the non-dominant limb and a higher frequency of corrective movements of the dominant one. On unstable, the differences between them are greater due to the precision of the movement task.

In the literature on the subject, you can find few works on the development of the process of maintaining balance in children at an early school age, including postural stability on different types of ground and taking the somatic structure of the subjects into account. In this respect, population studies, covering the age range of 7-10 years contained in the work, were conducted over 40 years ago by Watanabe (1979). Similar studies were followed by Riach and Hayes (1987) and Usui et al. (1995). In Poland, such tests on stable ground conditions were carried out by Sobera (2010).

Aim of study

The aim of the study was to characterize the process of maintaining the balance of the body of healthy children aged 7-10 in the conditions of a stable (force platform) and unstable ground

(seesaw) in the two-legged position, in terms of the somatic structure and functional asymmetry of the lower limbs.

The following research hypotheses were formulated: (1) A manifestation of the improvement of stability in the standing position will be a decrease in body sway in subsequent age ranges. With the maturation of the nervous system and the related improvement of the sensory integration of the balance system, the relationship with the age of individual balance measures will be stronger and stronger. (2) The level of stability of the subjects will increase as their weight-height relationship decreases. (3) In children aged 7 to 10 years, the asymmetry of the support function of the lower limbs is towards the non-dominant lower limb, however, when maintaining balance in conditions of a stable ground, both lower limbs assume the supporting function, therefore functional asymmetry will not occur in this case. With conscious control of the tilting of the balance platform, the lower limbs alternately repossess the stabilizing function and in this case asymmetry will occur, preferring the non-dominant limb.

Material and methods

The research covered all children aged 7 to 10, students of public primary schools in Zakopane, which constituted a total of 1230 people (579 girls and 651 boys). They were carried out in 2018 and 2019. Postural stability in the conditions of a fixed and moving ground was determined taking the weight and height factor (BMI), body proportions (Manouvrier index) and functional asymmetry of the lower limbs into account.

The measurement of the balance in the conditions on a stable ground was carried out on a CQ Electronic stabilographic two-plate platform with dimensions: length 280 (640), width 350, height 50 mm and weight about 10 kg. The subject's task was to stand freely on both feet, with the feet parallel to the width of the hips. Each foot rested on a separate stabilograph plate. During the test, the subject kept a still position with his eyes directed at the fixation point. The actual measurement lasted 30 s.

To determine the level of balance on an unstable ground, the Libra balance platform from the Italian company EasyTech was used, with dimensions: length 430 mm; width 420mm; height 65 mm and weight 2.5 kg. The examination was carried out only in the frontal plane. The subject's task was to operate the platform in such a way, through the appropriate pressure with the feet, that the line (sinusoid) drawn by it on the computer screen reflected the model center line as best as possible. It was preceded by a warm-up (30 s). The actual measurement lasted one minute.

Results

In the conditions of a stable ground, almost all parameters recorded on the double-plate platform indicated a significant improvement in the level of postural stability with the age of the examined children. The strongest negative relationships between age and stability results were found for path length (SP: r=-0.39, p <0.001), COP displacement velocity (MV: r=-0.30, p<0.001) and their range (r=- 0.22, p<0.001). In dynamic conditions, these relationships turned out to be even stronger than in the case of free standing on a stable surface. The strength of the relationship between the individual parameters of the balance platform (IS, PC and PW) and the age of the subjects was r=-0.48, p<0.001. In all cases, the relationship between the calendar age of the subjects and their results, both in static and dynamic conditions, was linear, indicating a constant, proportional improvement in stability.

In static conditions, the analysis of the conditions of the level of stability in relation to the somatic structure of the subjects showed a large diversification of the selected groups of BMI and Manouvier indices in relation to the results of individual stabilograph parameters. In almost all cases, the results indicated an improvement in the level of stability with an increase in the value of the analyzed anthropological indicators. The COP area (50%) and its distance and speed (42%) turned out to be the most sensitive to changes in BMI. To a lesser extent frequency (25%) and range (19%). In the groups of the Manouvier index, the largest changes were recorded in relation to area (27%), path length and COP speed (18%). In dynamic conditions these relations were different. Length relationships were more important for stability than weight-height relationships. In the groups of the Manouvier index, the greatest differentiation was found in relation to the precision of balancing (PW=44%), smaller to the stability index (IS=28%) and total area (PC=24%). The relative differences between individual BMI ranges were much smaller and amounted to 13 for the stability index (IS), and only 11% for the total area (PC).

The analysis of the functional asymmetry of the lower limbs in their support function showed a difference in its direction depending on the dominance. In static conditions, right-footed people achieved more favorable results of individual measures of stability of the two-plate platform for the left limb. A significant degree of asymmetry was demonstrated in the anteroposterior swings, while in the lateral swings it was small. For left-footed people, however, more favorable values of stability determinants on the dominant limb were found. As in right-footed people, this concerned primarily anteroposterior sway.

In dynamic conditions, the same direction of functional asymmetry of right- and left-footed people was obtained as on the two-plate platform. Right-footed people obtained better results of the total area (PC) and output area (PW) for the left side of the record of the balance test, and vice versa for the side of the dominant limb. In relative terms, the differences were small but statistically significant. The test was carried out only in the frontal plane.

Conclusions

1. The examined children were characterized by a constant, significant improvement in the measures of postural stability in the following age ranges from 7 to 10 years, proportional to their physical development. In relative terms, it was similar in both equilibrium conditions, but a stronger relationship between the age of the respondents and their level of stability was found in dynamic conditions.
2. In static conditions, the relations of stability measures with anthropological indicators, as well as two-factor regression models, indicate a greater impact on the balance of the subjects' body mass than the length of their lower limbs. They turned out to be ambiguous in dynamic conditions, where a greater impact on the stability of length proportions than BMI was found, but this could not be confirmed in two-factor regression models.
3. Both in static and dynamic conditions, the functional asymmetry of the lower limbs differed in their support function depending on the direction of dominance. Right-footed people obtained more favorable results of individual stability measures for the non-dominant limb, while left-footed people had the opposite, on the dominant - i.e. left - limb.
4. Determination of conditions and analysis of changes in the process of developing postural balance in healthy children may be the starting point for determining the developmental norms of stability in conditions of stable and unstable ground at the age of 7-10 years. The entire population of Zakopane children covered by the research can be a reference database for similar studies.