The usefulness of assessing single-leg jumps in children aged 7–13 years in a postural-motor control test

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Abstract

Background: The quality of motor patterns during single-leg jumping can be a valuable adjunct to the diag-nosis of body stabilisation in school-age children.

Aims: The purpose of this study was to qualitatively and quantitatively analyse single-leg jumps in children aged 7–13 years.

Materials and methods: A total of 148 children (72 girls and 76 boys) aged 7 to 13 years participated in the study. The inclusion criterion was the lack of contraindications to jumping. The test station consisted of a circle with a diameter of 75 cm and two cameras placed on the side and in front of the sub-ject. The test consisted of eight jumping trials, with 30-second breaks between them. We evaluated the time the subjects needed to perform 15 jumps on one leg and the number of jumps on one leg within a given time unit (i.e. 30 seconds). The jumps were analysed qualita-tively and quantitatively.

Results: The predominant activity type of the supporting limb in most examined children was the in-termediate position. Internal rotation was observed in most children aged 7 years and external rotation in one-third of the children aged 13 years. The anterior type of positioning of the un-loaded lower limb occurred least frequently, and the posterior type occurred most frequently. The mixed type was noted in most 9-year-old children. Upper limb synkinesis was the most common compensatory behaviour (synkinesis) in the study group. The best average time was achieved by

Key words

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the 13-year-olds, while the 11-year-olds achieved the worst time. Statistically significant differences in the time required to perform 15 single-leg jumps occurred between the groups of 10- and 11-year-olds (p = 0.002) and between the 11- and 12-year-olds (p = 0.0002) to the disadvantage of the 11-year-old children. The differences in results were statistically significant between the 9-year--olds and all older age groups (p < 0.05). Statistical-ly significant differences (p = 0.01) were noted only for jumps with right-side rotations.

Conclusions: Single-leg jumping is a skill performed by younger school-age children variably and does not show a linear progression. The single--leg jumping assessment can be used as an adjunct to test-ing body stabilisation in children.

Introduction

The assessment of various forms of jumping is not standard in the neurodevelopmental as-sessment of the child. However, physiotherapy practice indicates that some children of differ-ent ages with developmental coordination disorder (DCD) [1] and children with postural de-fects have difficulties with various forms of jumping, especially single-leg jumping.

The quality of motor patterns during single-leg jumping may be a valuable adjunct to the diagnosis of body stability in school-age children. The availability of publications on this subject is limited [2, 3]. Assessment of single-leg jumping occurs in two motor skills tests by Johnson and Brace [4].

In the study by Matyja et al. [5], the developmental stages of jumping ability in chil-dren from 2 to 6 years of age are presented. In later developmental periods, the long jump is assessed in motor performance tests as a power check [6].

Aims

The aim of the study was the qualitative and quantitative analysis of single-leg jumping in children aged 7–13 years. The subject of the study was to determine variants of the activity of the supporting and unloaded lower limb and compensatory synkinesis, the number of jumps in selected time intervals for the right and left lower limbs, and qualitative and quantitative changes in particular age groups.

Material and methods

The study involved 148 children aged 7 to 13 years, including 72 girls and 76 boys. The dis-tribution of the study group is shown in **Table 1**. The study was performed at Primary School No. 42 in Sosnowiec (Upper Silesia, Poland) with the consent of the school board and par-ents. Inclusion criterion: no contraindications for performing jumping exercises. Exclusion criteria: diseases of the lower-limb joints, scoliosis, and previous traumatic episodes of the lower limbs (fractures and sprains within one year before the study).

Table 1. Characteristics of the study group.

Age	Number (n)	Percent (%)
7	27	18.24
8	27	18.24

9	15	10.14
10	14	9.46
11	28	18.92
12	24	16.22
13	13	8.78
Total	148	100

The test station consisted of a circle with a diameter of 75 cm and two cameras placed on the side and in front of the participant to capture the entire body (**Fig. 1**).

The study consisted of 8 jumping trials, with 30-second breaks between them. All tri-als were recorded with two video cameras. It was assessed how long the subject needed to perform 15 single-leg jumps and how many single-leg jumps he/she performed within a given time unit (i.e. within 30 seconds).

- Trials 1 and 2: 15 single-leg jumps in place on the left limb and 15 jumps in place on the right limb;
- Trials 3 and 4: single-leg jumps for 30 seconds on the left limb and single-leg jumps for 30 seconds on the right limb;
- Trials 5 and 6: single-leg jumps for 30 seconds on the left limb with right-side rotation around the body axis and single-leg jumps for 30 seconds on the right lower limb with right-side rotation around the body axis;
- Trials 7 and 8: single-leg jumps for 30 seconds on the left limb with left rotation around the body axis and single-leg jumps for 30 seconds on the right lower limb with left-side rotation around the body axis.

Jumping performance was analysed qualitatively and quantitatively. The qualitative analysis included variants of the positioning of the supporting lower limb, variants of the posi-tioning of the unloaded lower limb, and variants of compensation of the unloaded lower limb and upper limbs. The arithmetic mean was used to compile the results. Student's t-test was used for statistical analysis.

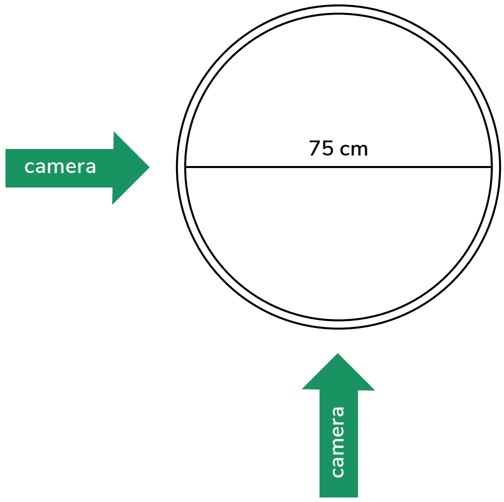


Figure 1. A schematic illustration of the study station.

Results

Considering the qualitative aspect of the jumping task, different variants of the supporting (jumping) lower limb and unloaded (free) limb were distinguished. Compensatory synkinesis of the upper limbs and/or lower limbs were also noted. Three types of activity were distin-guished for both the supporting and relieved lower limbs: type A – intermediate position, type B – internal rotation, and type C – external rotation (**Fig. 2**).

The activities of the unloaded lower limb were defined as: type a – anterior position, type b – posterior position, and type c – combined (anterior and posterior position) (**Fig. 3**).

Figure 2. Types of supporting lower limb activities (type A – intermediate position, type B – internal rotation, and type C – external rotation).

Figure 3. Types of unloaded lower limb activities (type a – anterior position and type b – posterior position).

During the performance of single-leg jumps, some children showed synkinesis of the shoulders, upper and lower limbs, or combined movements of the unloaded lower limb and upper limbs: type 1 – synkinesis of the shoulder girdle and/or upper limbs, type 2 – synkinesis of the unloaded lower limb, type 3 – synkinesis of the unloaded lower limb and upper limbs (combined type), and type 4 – no synkinesis (**Fig. 4**).

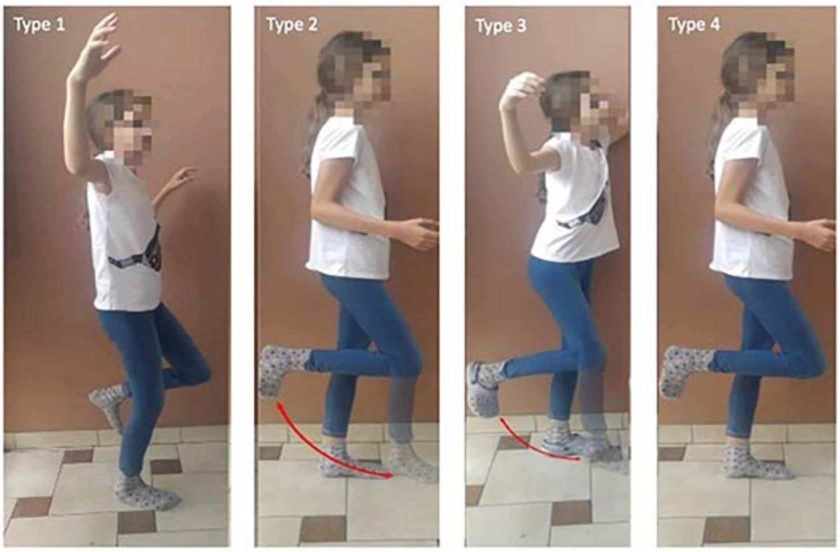


Figure 3. Examples of compensatory activities: the arrows indicate the direction of movement of the unloaded lower limb (type 1 – synkinesis of the shoulder girdle and/or upper limbs, type 2 – synkinesis of the unloaded lower limb, type 3 – synkinesis of the unloaded lower limb and upper limbs – combined type, and type 4 – no synkinesis).

The graphs below show the distribution of the activity types of the supporting lower limb (**Fig. 5**) and unloaded lower limb (**Fig. 6**).

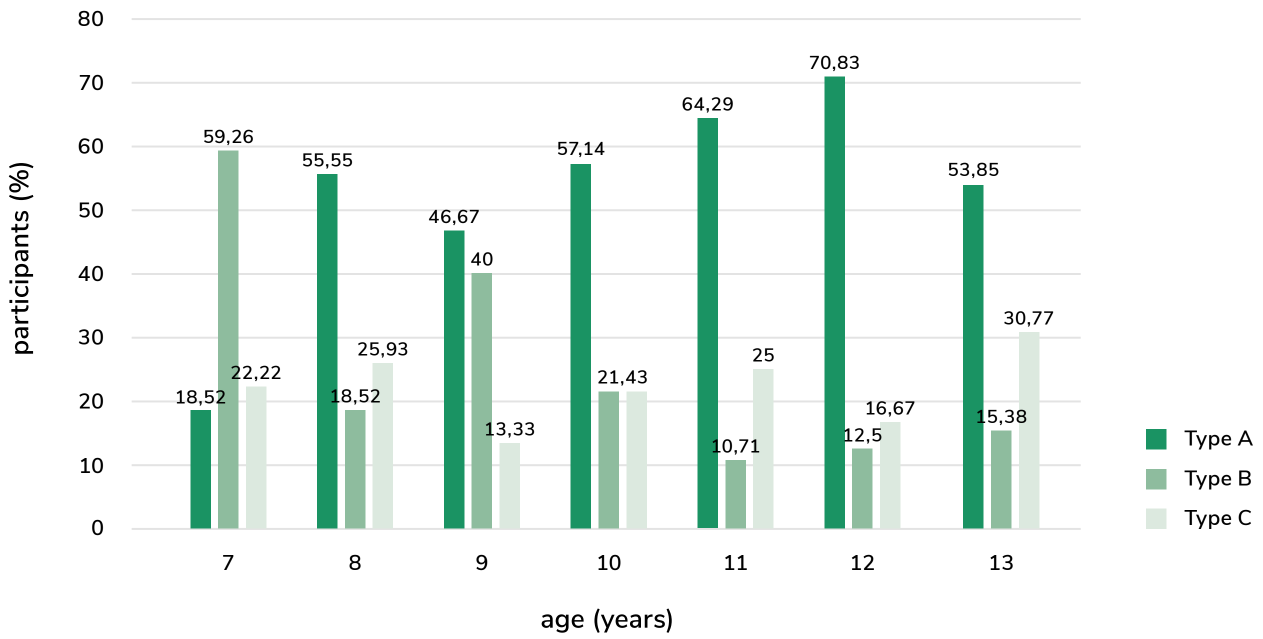


Figure 5. Percentage distribution of activity types of the supporting lower limb.

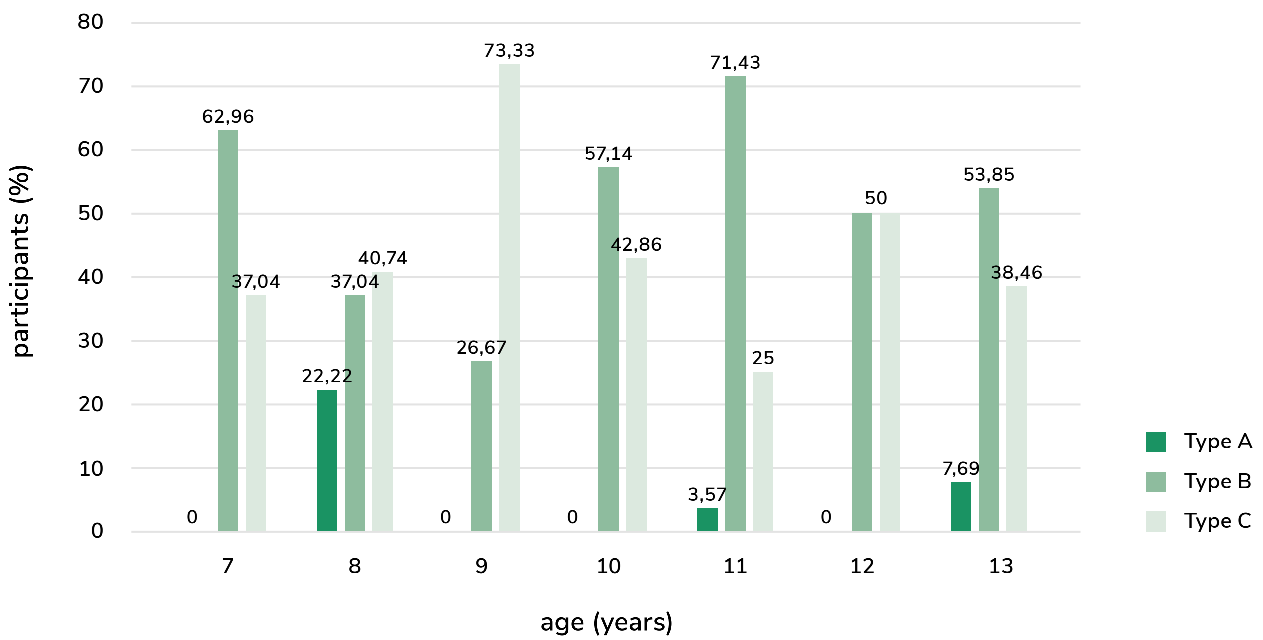
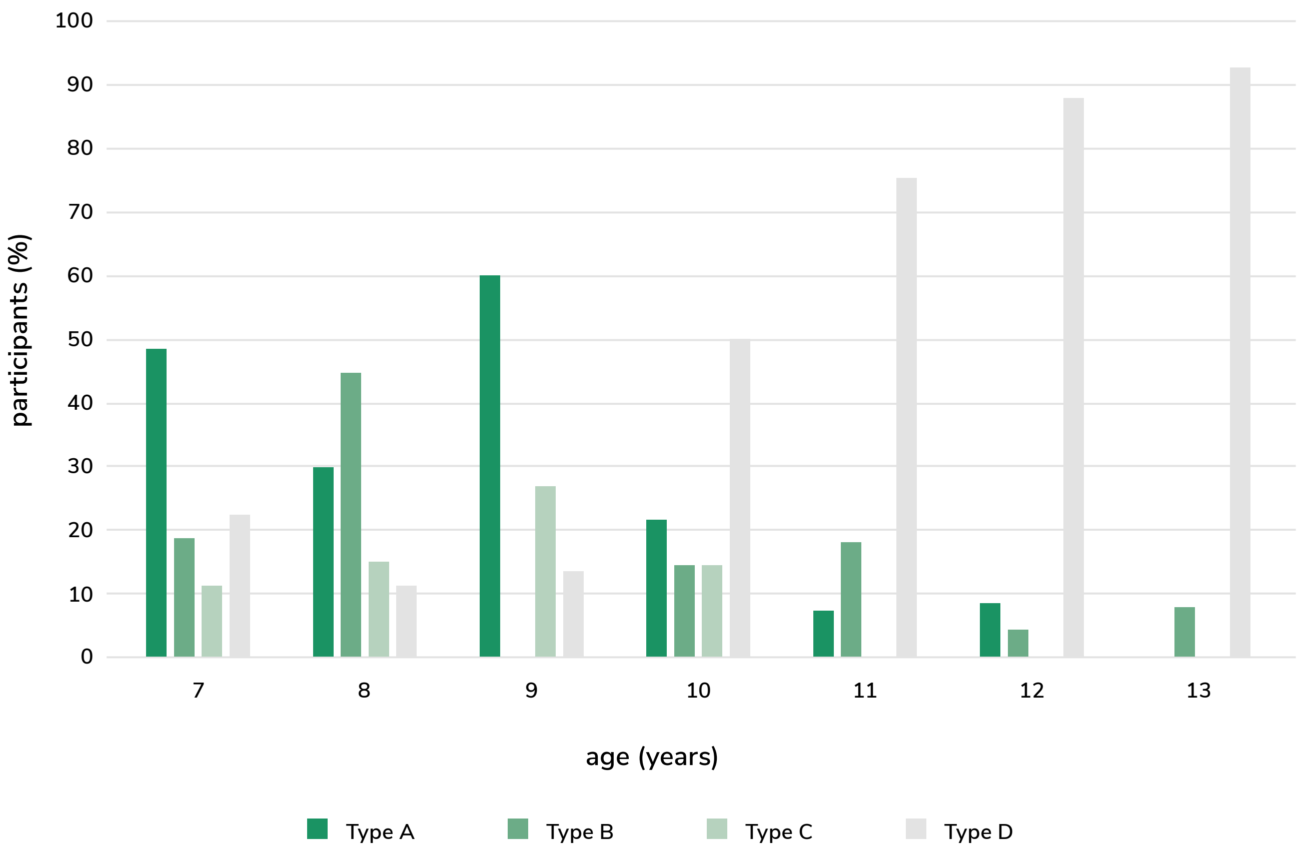


Figure 6. Percentage distribution of activity types of the unloaded lower limb.

In most of the children studied, the dominant type of activity of the supporting lower limb was the intermediate position. Internal rotation was observed in most of the children aged 7 years, and external rotation in one-third of the children aged 13 years. Based on the results obtained, it was noted that the anterior type of the unloaded lower limb occurred the least frequently and the posterior type the most frequently. The combined type was found in the majority of the 9-year--old children. The graph shows the frequency of occurrence of par-ticular types of synkinesis (**Fig. 7**).



Upper limb synkinesis was the most common compensatory mechanism in the study group. Most of the children aged 10 to 13 years did not display synkinesis anymore. Tables 2 and 3 present the quantitative parameters of the single-leg jumping tasks.

The time taken to perform each trial was recorded for the quantitative analysis. Trials 1 and 2 were measured in seconds (the amount of time needed to perform 15 single-leg jumps). The best average time was obtained by the 13-year-old children, while the worst time was obtained by the 11-year-olds. Statistically significant differences ($p < 0.05$) were found be-tween the groups of 10- and 11-year-olds ($p = 0.002$) and 11- and 12-year-olds ($p = 0.0002$), to the disadvantage of the 11-year-old children. The differences in results are statistically sig-nificant ($p < 0.05$) between the 9-year-olds and all older age groups.

Trials from 3 to 8 represent the average number of single-leg jumps performed in 30 seconds. The best average result from all trials was achieved by the group of 9-year-olds and the worst by the 11-year-olds. From the age of 7 to 9, the average number of jumps for all trials increased, then slightly decreased for the age of 10. It is worth noting that the results worsened significantly in the 11-year-old children. The highest number of trials in which a statistically significant difference was noticed occurred between the groups of 11- and 12-year-olds. This observation applies to all trials in **Tables 2 and 3**.

Table 2. The arithmetic means of the time taken to perform 15 single-leg jumps for particular age groups.

Group Trial	7-year--olds	8-year--olds	9-year--olds	10-year--olds	11-year--olds	12-year--olds	13-year--olds
1	6.48	6.25	6.93	6.00	7.21	6.00	5.77
2	6.74	6.62	6.8	6.07	7.04	5.88	5.77

Table 3. The arithmetic means of the number of single-leg jumps within 30 seconds for particular age groups.

Group Trial	7-year--olds	8-year--olds	9-year--olds	10-year--olds	11-year--olds	12-year--olds	13-year--olds
3	73.00	73.03	72.73	65.57	63.64	65.46	66.08
4	70.33	73.29	71.60	65.21	63.14	65.42	66.15
5	58.48	58.14	63.00	56.43	51.79	59.00	55.62
6	59.40	63.03	64.06	58.00	53.75	57.29	58.46
7	62.33	65.00	69.53	57.93	54.93	58.25	60.62
8	57.66	67.22	66.93	55.71	55.64	59.83	55.92
$\bar{x}$ for 3-8 trials	63.53	66.62	67.98	59.81	57.15	60.88	60.33

It was also verified whether there were statistically significant differences between the right and left lower limbs in terms of duration of trials, number of jumps in a given time, and number of jumps with right and left rotations. A statistically significant difference ($p = 0.01$) was noted only for jumps with right-hand rotation.

Discussion

Around the age of 7–9, the so-called ‘hunger' for movement occurs. In this period, which coincides with many stimuli provided by new environments, the child shows excellent motor activity [6]. In the present study, as expected, it was noted that the number of single-legged jumps in the observed period increases with age for the 7–9-year-olds, slightly decreases at the age of 10 years, significantly decreases at the age of 11 years, and then increases at the ages of 12 and 13 years.

In girls between the ages of 10 and 12 and boys between 12 and 14, rapid growth oc-curs, which consequently changes body proportions. These transformations cause the centre of gravity to shift upwards, which impacts movement coordination [3, 7]. It is not excluded (when analysing the obtained results) that the age of 11 years is the most difficult for the mo-tor functioning of children. Moreover, statistically significant differences were noted between the children aged 12 and most of the other age groups.

The qualitative analysis of single-leg jumping indicates that between the ages of 7 and 13 years, there is a gradual change in the control of the supporting limb from internal rotation to the intermediate position, a gradual change in the control of the supporting lower limb from internal and external rotation to the intermediate position, and a significant decrease in the amount of synkinesis of the lower and upper limbs.

The results obtained from the quantitative analysis indicate that statistically significant differences in performing 15 single-leg jumps occurred between the groups of children aged 10 and 11 years and between the children aged 11 and 12 years, with the 11-year-olds per-forming the poorest.

Our quantitative results do not show a uniform trend with age: concerning the time needed to perform 15 single-leg jumps, no differences were noted between children from 7 to 10 years of age. There was a statistically significant increase in the time needed to perform 15 single-leg jumps in children aged 11 years and a significant decrease in the time needed to perform 15 single-leg jumps in children aged 12 years. It is difficult to explain this phenome-non because changes in body proportions and coordination—as mentioned above—occur be-tween the ages of 10 and 14 in both boys and girls. A statistically significant difference be-tween the number of single-leg jumps on the right and left leg occurred only in the trial with right-side rotation. A similar phenomenon is described in the article by Wytrębowicz [8], who draws attention to maintaining balance during jumps on the dominant lower limb in children aged from 3 to 5 years.

The results obtained for single-leg jumps indicate that this skill varies quantitatively and qualitatively with age, which might suggest that the ability to maintain dynamic balance increases with age. The fact that the quantitative deterioration of jumping is most significant at the age of 11 should be further investigated to determine the causes of this phenomenon. The present study is a preliminary report. Future studies should include an assessment of the reliability of the measurement method used.

Conclusions

Single-leg jumping is a skill performed by younger school-age children variably and does not show a linear progression. The single-leg jumping assessment can be used as an adjunct to test-ing body stabilisation in children

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