SIGNS OF ABNORMAL MOTOR PERFORMANCE IN PRESCHOOL CHILDREN

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BACKGROUND: The determination of the level of motor development should be a common part of examinations performed by paediatricians, physiotherapists and also teachers. The importance has been increasing because of the prevalence of developmental coordination disorder.
OBJECTIVE: The aim of the study was to find the differences in performance of the selected motor tasks of gross motor function in preschoolers on both quantitative and qualitative parameters.
METHODS: In the study 261 children were included, boys and girls aged 4–6 years (the average age 5.4 years) attending regular kindergartens. We used motor tasks of standing on one leg and hopping. Significant differences in quantitative parameters were assessed by two-way ANOVA in Statistica (version 9) software. Relative frequency of characters in qualitative parameters was assessed by the test of the difference between two proportions.
RESULTS: Significant differences between the age groups appeared in the quantitative parameters comparing 4 and 5 year old children and 4 and 6 year old children. Regardless of gender there were no differences between 5 year and 6 year old children. Overall, the girls mastered the tasks of the test better than the boys in the quantitative parameters of evaluation. From the evaluation of the quality of motor performance the most frequently reached performance in the tasks of the test has been described (relative frequency of characters). Significantly different motor performance from most children of the sample was observed particularly in the associated movements of limbs or trunk and face, showing for a reduced ability of selective relaxation at higher demands of the movement task.
CONCLUSIONS: The different motor performance in observed parameters, showing for a reduced ability of selective relaxation, could be regarded as signs of abnormal motor performance in that age category.

Keywords: Developmental coordination disorder, gross motor function, selective relaxation.

INTRODUCTION

The pre-school period is characterized by large somatic changes, the body constitution of the child has been changed and the level of motor coordination has been rapidly evolving. The determination of the level of motor development should be a common part of examinations performed by paediatricians, physiotherapists and also teachers.

In case of discrete motor disorders, this has an effect on abnormal motor skills development, which also forms a negative attitude to physical activity in general. It has been shown that the disorder in the area of gross and fine motor abilities, or coordination, is negatively reflected in the activities of daily life (Activity of Daily Living, ADL) and in the school environment (Barnhart, Davenport, Epps, & Nordquist, 2003; Gwynne & Blick, 2004; Hadders-Algra & Carlberg, 2008; Smyth, 2006).

The detection of abnormal motor development allows us to include motion-controlled intervention with the use of central nervous system plasticity in children's age before starting primary school.

The evaluation of the postural level at the same time can be used for determining the predispositions to the increased physical stress of the children's motor system in sport and for the possible selection of young sporting talent.

The progression of learning motor skills in preschool age is individual and depends on the environment and heredity. Each movement skill develops from the initial through the elementary to mature stage of the performance, regardless of gender. However, there are individual differences between the skills. A child can cope with one skill in the initial phase and he/she achieves the degree of maturity in different skills at the same time to the full. The different degrees of maturity can be achieved even within one motor model (Gallahue & Ozmun, 1997).

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Postural strategy changes qualitatively depending on the level of development of control systems, the nature of the environment and the performance of a motor task throughout motor development (Latash, 2008). Children aged 4 to 6 years are learning to integrate incoming sensory information, customize the feedback for postural control and effectively manage muscle activity during motor tasks. They are learning to improve overall economy of motion (Shumway-Cook & Woollacott, 2001).

Postural strategies can be divided into two types:

1. "En block" strategy, according to Bernstein's theory working with the principle of reducing the number of degrees of freedom in the joints and thus reducing complexity to control movement.
2. "Segmental" strategy includes a greater number of degrees of freedom of movement in the segments which requires a higher level of control already.

The quality of the movement increases by changing the movement strategy depending on the circumstances and the experience (Latash, 2008). The ability to differentiation of the movement reflects the quality of the habitual motor program for the movement and motor skill and the overall level of control (Faladová & Nováková, 2009; Piek, 2006). The associated movements of limbs, trunk and face are the qualitative signs, showing for a reduced ability of selective relaxation (Kolář & Druga, 2013).

Motor tasks, which have been used in the study, are based on fundamental movement patterns of early childhood. They are a part of the series of tests of motor ability in which, in particular, the aspects of static and dynamic balance, coordination of movement and orientation in space are monitored. The following text summarizes the basic forms of motor skills of standing on one leg and hopping.

According to Gallahue and Ozmun (1997), standing on one leg represents the most frequent motion task to evaluate the static balance. With slight modifications, this task is presented in most of the tests of gross motor abilities in children. According to Touwen (1979), a three year old child can stand on one leg for 5–6 seconds, at the age of five 10–12 seconds and a six year old child is able to stand for about 13–16 seconds. From 7 to 8 years children are able to stand on one leg for 20 seconds. Hadders-Algra and Carlberg (2008) report, that children aged 5 to 7 years are already able to stand for 20 seconds.

A number of studies were carried out in the tasks of standing on both and on one leg with the use of dynamic posturography and methods of surface electromyography in children. It shows that on postural stability is the most involved in somatosensory information and less visual information and through a strategy of open loops (the open-loop strategy) in children younger than 4–5 years (Slabounov & Newell, 1994 in Hadders-Algra & Carlberg, 2008).

Optimal performance (coordination) by Gallahue and Ozmun (1997) includes stable standing, where slight displacement of gravity with the compensation movement of the trunk and/or upper limb are tolerated, absent significant symmetric or asymmetric associated movements of head (tongue, lips in particular), trunk, upper or lower limbs (significant compensatory manoeuvres to maintain balance). It also includes understanding the instructions without difficulty and the ability to concentrate all the time. The performance on each leg is relatively balanced.

Wickstrom (1983) describes hopping as one of the complex comprehensive forms of the jump requiring a coordinated ability, rhythmic and more elaborately controlled movement. It is often preceded by repeated vertical jumps on both legs. Gabard (1996 in Holm, Tveter, Fredriksen, & Vøllestad, 2009) argues that jumping on one leg is considered the most complex form of basic jumping and is a part of many advanced motor skills in games, dance, and other sports activities. For children over 5 years of age it is also the best test for the detection of muscle strength of musculus triceps surae. According to Holm et al. (2009), jumping on one leg can show higher variability in lower limbs, which enables it to be the test with a higher discriminatory value in comparison with walking.

Children from 3 years of age jump more than five times, but mostly on the preferred leg only. Four year old children are able to hop 5–8 times, at five years of age 9–10 times and six year old children hop 13–16 times consecutively. On average, 25% of six year old children are able to hop more than 20 times on at least one lower limb. In seven to eight years, according to Touwen (1979), most children are able to hop twenty times on each lower limb. By Hadders-Algra and Carlberg (2008) children aged 5 to 7 years should be capable of jumping on one leg more than 20 times. Wickstrom (1983) presents that approximately 30% of five year old children are not able to hop more than 5 times consecutively. According to Touwen (1979), jumps are more demanding on a spot than in space. At the same time they note that the majority of children under the age of six are not able to handle this task. Primary abnormal performance of the task includes jumps without a visible take-off phase of the foot, the increased movements of upper limbs, trunk or non-standing leg, the inability to perform 5 consecutive jumps, non-rhythmical jumps etc. (Gallahue & Ozmun, 1997).

It is evident, that there are many studies dealing with the evaluation of gross motor skills in preschool age, but they are focused on a quantitative assessment mainly. The aim of our study was to find the differences in performance of the selected motor tasks of

gross motor function in preschoolers on both quantitative and qualitative parameters. We put emphasis on the evaluation of the quality of motor performance.

METHODS

Sample

The sample was made up of 261 children, boys and girls aged 4–6 years, the average age was 5.4 years. None of the children was known to have a more serious motor disorder. The parents signed an informed consent with the testing and completed a short questionnaire. At the time of measurement all the children attended kindergartens without any specialization in the regions of Moravia in the Czech Republic. The research was approved by the Ethics Committee of the Faculty of Physical Culture of Palacký University in Olomouc.

Tests

In our study every child has been tested by four motion tasks: standing and hopping on one leg, jump and about face and a tandem walking on the line. We will present the results of tasks standing on one leg and hopping.

Standing on one leg

Standing on one lower limb tests static balance. With small modifications (reliability was tested in the pilot study, Šlachtová, 2010) is this task included in the majority of tests for the evaluation of static balance in children, for example in MABC Movement Assessment Battery for Children (Henderson & Sugden, 1992), BOT-2-Oseretsky Test Bruininks of Motor Proficiency, 2nd ed. (Deitz, Kartin, & Kopp, 2007).

Performance: the child is encouraged to stand on one leg with their eyes opened for 20 seconds. Each leg is tested.

Starting position: non-standing leg is lifted up to 90° flexion in the knee and hip joint (in the sagittal plane), with upper limbs freely along the body.

Quantitative evaluation: the time of standing in seconds (maximum 20 seconds).

Qualitative evaluation (rated qualitative parameters): S1 – facial expressions, S2 – deviations of the trunk, S3 – internal rotation of the hip of non-standing leg, S4 – associated movement of the upper limbs, S5 – associated movement of the hands, S6 – attention.

The interpretation of motor manifestations in the area of head, trunk and limbs were assessed using characters 0, 1, 2 (0 – parameter is not present; 1 – parameter is evident, but not throughout the whole performance of the task; 2 – this parameter is evident almost throughout the whole performance of the task).

Hopping

This task was derived from test Charlop-Atwell Scale of Motor Coordination (Charlop & Atwell, 1980).

Performance: the child is encouraged to hop 10 times consecutively on one leg remaining in a circle with the diameter of 60 centimetres. Each leg is tested.

Starting position: the child is standing on one leg in a circle, the other leg is slightly lifted up.

Aids: friction tape about 2.5 cm wide on the perimeter of the circle.

Quantitative evaluation: the number of errors out of 10 hops. A mistake is considered as jump outside the circle, interruption during 10 jumps, ground touch of non-standing leg.

Qualitative evaluation (rated qualitative parameters): P1 – facial expressions, P2 – take-off phase of the foot, P3 – softness of the landing, P4 – associated movement of the upper limbs, P5 – associated movement of the hands, P6 – rhythmicity, P7 – coordination.

The interpretation of motor manifestations in the area of head, trunk and limbs were assessed using characters 0, 1, 2 (0 – parameter is not present; 1 – parameter is evident, but not throughout the whole performance of the task; 2 – this parameter is evident almost throughout the whole performance of the task).

The parameters of the take-off phase (P2) and the softness of the landing (P3) were assessed according to the maturity phase: 0 – initial phase, no or minimum take-off/hard landing, 1 – the elementary phase, take-off without adequate rolling/softer landing, 2 – mature phase, the take-off with adequate rolling/soft, quiet landing.

The assessment of the parameter of coordination was based on the definition of motor coordination when partial movements or movement phases are placed in a harmonious complex. Well coordinated movements are smooth with the appropriate range of movement, dynamics and rhythm (Hirtz, 2002 in Měkota & Novosad, 2005).

The tasks were evaluated by one beginner and one experienced (with 11 years of practice) college-educated physiotherapists.

Data processing

Age and gender differences in observed quantitative variables were assessed by two-way ANOVA and post-hoc LSD Fisher test.

For qualitative variables relative frequency of each character (0, 1, 2) and each qualitative parameter was determined. The differences in relative frequency of various characters were assessed by the test of the difference between two proportions.

RESULTS

Quantitative evaluation

No significant influence was found for gender in all age categories for standing on one leg. Significant differences between age groups appeared in quantitative parameters comparing 4 and 5 year old children ($p < .001$) and 4 and 6 year old children ($p < .001$), both for boys and girls (Figure 1, 2).

The tendency to reduce the number of errors is evident in the task of hopping on the right leg with increasing age. The girls generally achieved better results. Significant differences have been demonstrated in the age category and gender. There have been found significant differences between boys and girls at the age of 4 and 5 in detail. The girls at the age of 4 reached significantly worse results than the 5 year old girls ($p = .002$), respectively 6 years old girls ($p = .003$), but at the same time, these values were close to the results of the 5 ($p = .233$), resp. 6 years old boys ($p = .094$). The boys at the age of 4 have statistically significantly worse results in comparison to 5 ($p < .001$), respectively 6 year old boys ($p < .001$). Statistically significant differences between boys at the age of 5 and 6 years ($p = .534$) were not found. Similar results have been found for the left leg in both tasks.

Qualitative evaluation

Statistical analysis in the qualitative parameters has been focused on the size of the values in the character, which was the smallest relative frequency of children in each parameter and which was statistically significant in the difference between the two ratio tests.

Significant differences in relative frequency were observed in parameters deviation in the trunk (left leg) and associated movements of upper limbs in character 0 (no present) and in parameter attention (character 0) in the standing on one leg task in 4 year old children (Figure 3).

The differences were observed in parameters take-off phase (the right leg), softness of the landing (both legs) and associated movements of hands (the right leg) in character 2 in the hopping task.

Significant differences in relative frequency were found in character parameters facial expressions and internal rotation of non-standing leg received character 2 (throughout the whole performance of the task) in the standing on one leg task in a group of five-year old children (Figure 3).

DISCUSSION

The average time of standing on one leg was 13.8 (the right leg), or 13.6 (the left leg) seconds in each of the age categories in the ratio of boys to girls in seconds: 7–8:9 (4 years), 12–13:15 (5 years), 16:20 (6 years). If we compare our results with literature above in the section introduction, then the boys corresponded with standards, the girls achieved better values.

The tendency to reduce the number of errors has shown with the increasing age in the hopping task. The girls reached better results. Overall, the children showed an average 2 errors in the ratio of boys to girls in the category 4 years: 5–6:3 errors, at 5 years 2:1 and 1:1 for 6 year old children.

Significant differences between the age groups appeared in the quantitative parameters comparing 4 and 5 year old children and 4 and 6 year old children in both tasks. Regardless of gender there were no differences between 5 year and 6 year old children. Overall, the girls mastered the tasks of the test better than the boys in the quantitative parameters of evaluation. In the scientific literature the frequency of developmental coordination disorder (DCD) 2–3 times more common in boys is quoted (Geuze, 2005), Barnhart (2003) lists the more common occurrence for the boys in the proportion 2:1.

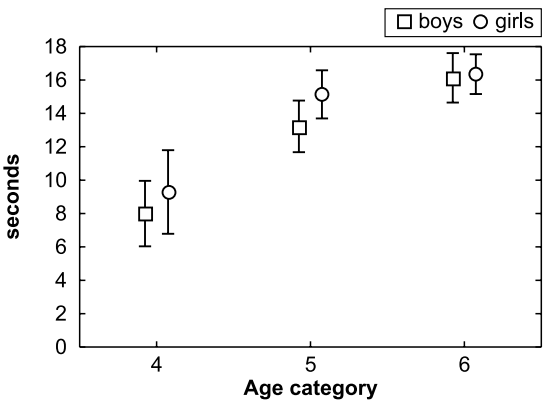

Figure 1. The influence of age and sex: standing on the right leg

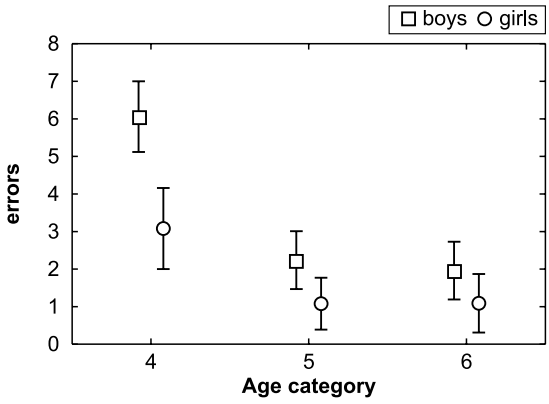

Figure 2. The influence of age and sex: hopping on the right leg

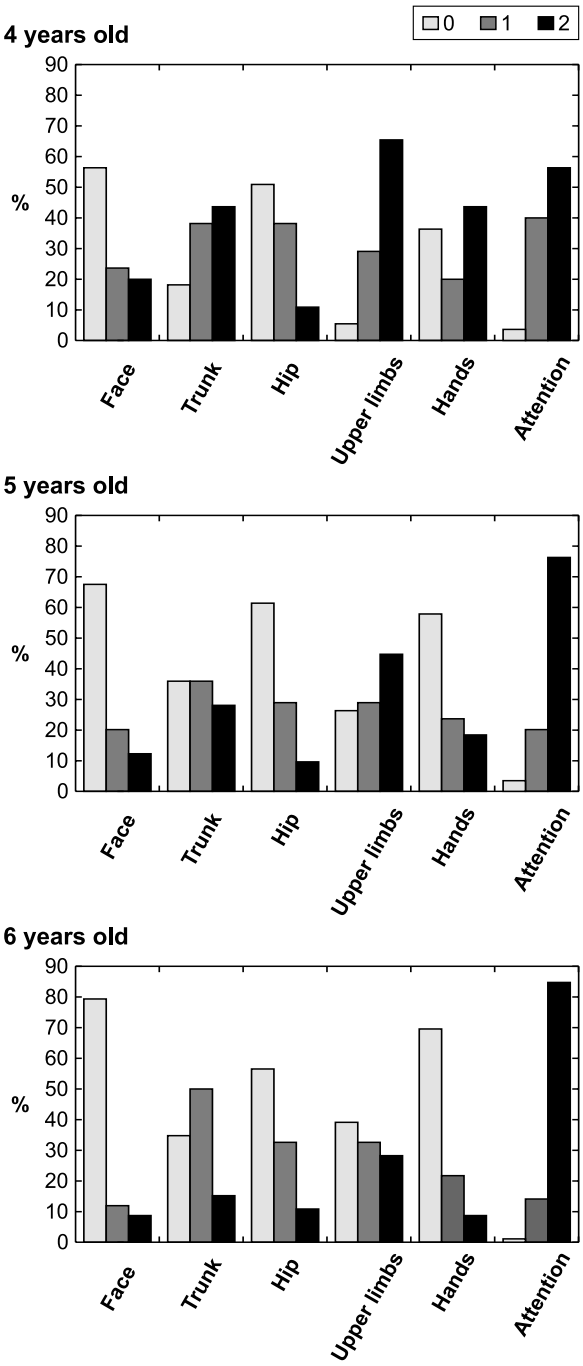

Figure 3. Qualitative evaluation of the task standing on the right leg in 4, 5 and 6 year old children. 0 = parameter is not present, 1 = parameter is evident, but not throughout the whole performance of the task, 2 = parameter is evident almost throughout the whole performance of the task

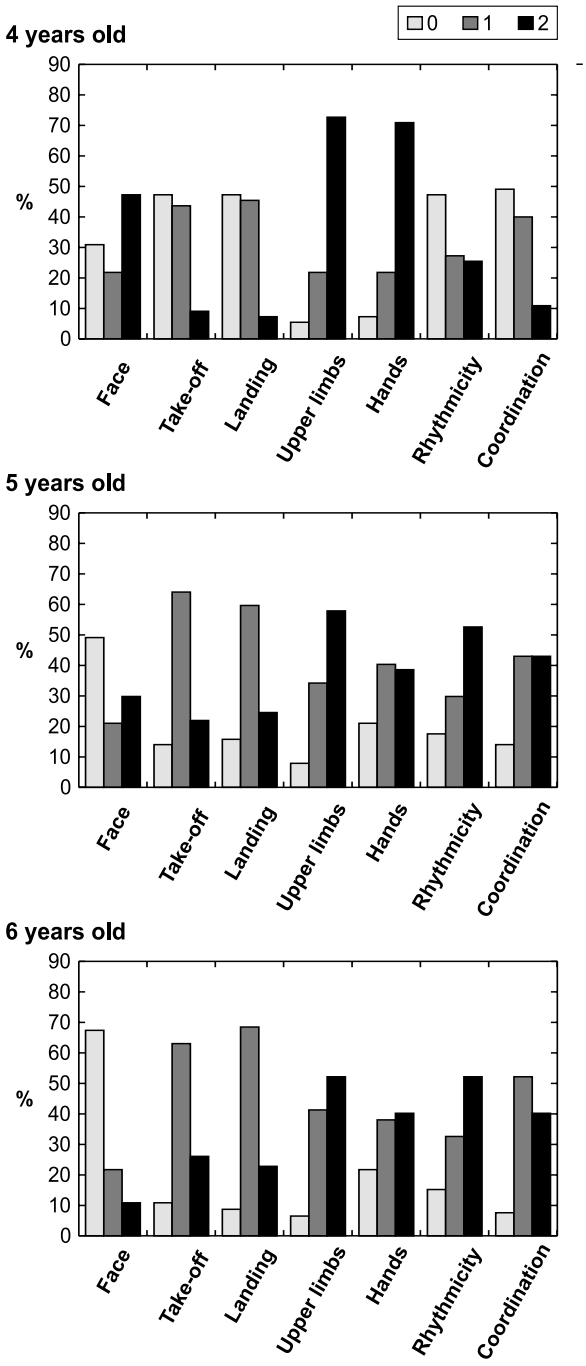

Figure 4. Qualitative evaluation of the task hopping on the right leg in 4, 5 and 6 year old children. 0 = parameter is not present, 1 = parameter is evident, but not throughout the whole performance of the task, 2 = parameter is evident almost throughout the whole performance of the task

The differences between the sexes are changing in the course of motor development, the little differences between boys and girls, were described at an early period of development of preschool age in the older literature. During the development and growth the differences will only accentuate and stop only in adulthood (Wickstrom, 1983). There is a general consensus that in the early period of development boys focus more on throwing, jumping and running, while girls tend to be more skilful in hopping, skipping and fine motor skills.

This corresponds with the activities, which are more gender-specific. Newer data in the literature, however, are not completely uniform. For example, a study by Hardy, King, Farrell, Macniven, and Howlett (2010) describes different results in the acquisition of ballistic skill in favour of boys, while girls outperform boys in locomotor skills such as running, galloping, jumping and high jumping. According to Haywood and Getchell (2009), in general, the differences in the performing of motor tasks between girls and boys are mostly dependent on the type of movement task.

From the evaluation of the quality of motor performance the most frequently reached performance in the tasks of the test has been described. On the contrary, a significantly different motor performance from most children of the sample was observed particularly in the associated movements of limbs or trunk and face, showing a reduced ability of selective relaxation at higher demands of the movement task. The majority of observed parameters appeared below the 10% threshold of the relative frequency.

If we summarize all monitored parameters, for which there are significantly different motor performance, then in each age category appeared as follows: for four years in the task of standing on one leg without deviation in the trunk (the left leg) and without associated movements of upper limbs. It suggests that this finding is associated with the development of postural strategies, when younger children apply the "en block" strategy, which, according to the Bernstein theory, works with the principle of a reduction in the number of degrees of freedom in the joints (Latash, 2008). Less skilful children have chosen this movement's strategy.

Mature phase of take-off phase (the right leg), mature phase of softness of the landing (both legs) and very good coordination indicate, that these could be gifted children in this age category who can handle the task better than older children in the task hopping.

In 5, resp. 6 year old children there were observed two types of the movement strategy in significantly different motor performance from most children of the sample. The first was global hypotonia with the large range of movement in associated movements of the limbs and deviation of the trunk (without associated movements of hands mostly). The second type of the movement strategy was accompanied by slow reactions on changes with internal rotations in arms and hips and associated movements of hands and face, and also hard landing in the hopping task.

These observations could indicate a relation between the abnormal qualitative motor development, which might not have been recognized in ontogenesis until 1 year of age and which could be the sign of previous mild hypotonic or hypertonic (resp. hemiparetic) form of central coordination disorder, and the choice of different movement strategies in preschool children. When we found it then we recommend detailed assessment (neurological, psychological). It is clear that the decision about the child's intervention should not be based on one test. The test is only an instrument for the decision, and should not replace the clinical assessment (Smits-Engelsman, Fiers, Henderson, & Henderson, 2008). At the same time it is appropriate to complete the perinatal and postnatal history of the child and information from parents and teachers who are able to assess the child's behaviour in the activities of daily life in their natural environment.

CONCLUSION

Using motor tasks can be performed to evaluate gross motor function in preschool children in everyday practice. It requires a relatively small area and a minimum of tools and is possible within a few minutes. The different motor performance in observed parameters, could be regarded as signs of abnormal motor performance in that age category.

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ABNORMÁLNÍ MOTORICKÝ PROJEV U PŘEDŠKOLNÍCH DĚTÍ

(Souhrn anglického textu)

VÝCHODISKA: Vyhodnocení kvality provedení základních dynamických posturálních dovedností pediatrem, fyzioterapeutem a také učitelem považujeme za důležitou, často však opomíjenou součást primární prevence vzniku poruch hybného systému v pozdějším věku. Důležitost vyvstává s prevalencí vývojové koordinační poruchy v předškolním věku.

CÍL: Cílem práce bylo pomocí vybraných úkolů hrubé motoriky vyšetřit pohybové dovednosti předškolních dětí po stránce kvantitativních a kvalitativních ukazatelů.

METODY: Na souboru 261 dětí ve věku 4–6 let (průměrný věk 5,4 let) byly testovány pohybové úkoly stoje na jedné dolní končetině a poskoků na jedné dolní končetině. Významné rozdíly ve kvantitativních parametrech byly zhodnoceny dvoufaktorovou analýzou rozptylu (ANOVA v programu Statistica verze 9). Relativní četnost znaků v kvalitativních parametrech byla hodnocena testem rozdílů mezi dvěma poměry.

VÝSLEDKY: V kvantitativním hodnocení byly nalezeny významné rozdíly mezi čtyřletými a pětiletými dětmi a také mezi čtyřletými a šestiletými dětmi. Bez ohledu na pohlaví nebyly nalezeny rozdíly mezi dětmi pětiletými a šestiletými. Obecně děvčata dosáhla lepších výsledků v kvantitativních parametrech hodnocení. Z hodnocení kvality motorického provedení byl popsán nejčastější pohybový projev v jednotlivých věkových kategoriích. Významně odlišný motorický projev od většiny testovaných dětí v souboru byl sledován zejména v asociovaných pohybech končetin či trupu a obličeje svědčících pro sníženou schopnost selektivní relaxace při vyšších požadavcích motorického úkolu.

ZÁVĚRY: Odlišné motorické provedení ve sledovaných parametrech, které svědčí pro sníženou schopnost selektivní relaxace, může být považováno za příznaky abnormálního motorického provedení v dané věkové kategorii.

Klíčová slova: vývojová koordinační porucha, hrubá motorika, selektivní relaxace.