PROFESSIONAL ARTICLES

Functional Abilities of Children with Cerebral Palsy

Introduction. Cerebral palsy is one of the leading causes of neurological impairment in childhood. The dominant clinical sign is the impairment of gross motor functions; however, associated conditions may limit the child with cerebral palsy in daily activities as well. The aim of this study was to determine the functional status of children with cerebral palsy, its relationship with the types of cerebral palsy, and concomitant conditions. Material and Methods. The sample included 206 children with cerebral palsy. The data were obtained from medical records with clinical characteristics of cerebral palsy, and associated conditions. The clinical types of cerebral palsy were determined using the Surveillance of Cerebral Palsy in Europe registry and topographical categories. Gross motor function abilities were evaluated using the Gross Motor Function Classification System and manual abilities by the Manual Ability System Classification. Results. According to the Gross Motor Function Classification System, about two thirds of children with cerebral palsy (64.0%) had levels I, II or III of gross motor function impairment. A statistically significant difference was noted with respect to the distribution of various clinical types of cerebral palsy in relation to functional classification based on Gross Motor Function Classification System (p < 0.001), as well as in the functional classification in terms of intellectual impairment (p <0.001); children with severe forms of intellectual impairment were classified at a higher level of functional limitation. Epilepsy was more prevalent in children with higher level of functional limitation (p = 0.009). Conclusion. Two thirds of children with cerebral palsy could walk independently or with walking aids. Children with quadriplegia and dyskinetic type of cerebral palsy had the most limited functional abilities. Associated conditions were more prevalent in children with higher functional limitations.

Key words: Athletic Performance; Genotype; Gene Expression; Polymorphism, Single Nucleotide; Exercise; Programs; Peptidyl-Dipeptidase A; Actinin; Muscle, Skeletal

Sažetak


Ključne reči: sportsko postignuće; genotip; ekspresija gena; polimorfnizam jednog nukleotida; vežbanje; programi; angiotenzin konvertujući enzim; aktinin; skeletni mišići
Introduction

Cerebral palsy (CP) is one of the leading causes of neurological impairment in childhood [1, 2]. Worldwide studies on the prevalence of CP indicate that it is much higher in developing countries, and its incidence varies from 1.5 to 3.0 per 1,000 live births [2]. The clinical picture of CP is dominated by the functional impairment of motor skills pertaining to the degree of motor function limitation in all body regions, including speech and oral motor performance. The capacity for independent movement, walking in particular, is often used as a rough measure for assessing the severity of motor deficit [3]. According to Palisano et al., classification of gross motor function is based on the Gross Motor Function Classification System (GMFCS) as follows: level I and II indicate ability to walk unaided, level III pertains to walking with hand-held support or assistance, while individuals classified at level IV and V are unable to walk [3–5]. The definition of the degree of motor function is based on functional limitations, with particular emphasis on the sitting function (upper body control) and walking, use of assistive technologies, including walking aids (walker, crutches, walking stick) and wheelchair, as well as reduced motion quality [6]. Thus, GMFCS provides guidelines for healthcare professionals, allowing them monitoring and treatment of health issues associated with CP [7].

Upper extremity functional abilities of children diagnosed with CP may be assessed using the Manual Ability Classification System (MACS) which is a systematic classification method which evaluates how children with CP use their hands to handle objects in daily activities. The MACS focuses on self-initiated manual dexterity, with specific focus on the object use in “personal space” (those in close proximity to one’s body, rather than objects out of reach) [8]. Empirical evidence shows that child’s motivation and cognitive ability impact his ability to handle objects manually, and therefore affect the MACS level [9].

Children diagnosed with CP often have associated conditions, such as epilepsy, impaired vision or hearing, compromised attention and communication, as well as behavioral and cognitive disorders [10]. It is necessary to identify the presence or absence of these disorders, as their presence is known to inhibit everyday activities [11, 12]. It is believed that the cognitive status, severity of motor impairment, and subtype of CP are positively correlated. Children with spastic diplegia and quadriplegia are less successful at tasks that require motor activity, compared to verbal tasks [13].

Given that the signs and symptoms of CP are primarily based on the functional impairments of motor skills, i.e. the greatest limitation of patient’s abilities in everyday activities, our aim was to determine the functional status of children with CP and to investigate its relationship with the type of CP and concomitant diseases.

Material and Methods

This qualitative, clinical-epidemiological, classical study was conducted at the Clinic of Children’s Rehabilitation and Rehabilitation, of the Institute of Child and Youth Healthcare of Vojvodina in Novi Sad. The study was approved by the Ethics Committee of the Institute and the Faculty of Medicine, University of Novi Sad. The analysis included all patients diagnosed with CP from 1990–2009, resulting in a sample of 206 children. Part of this comprehensive study is presented in this paper. Initially, medical histories of all patients were reviewed in order to ascertain their gestational age at birth, as well as their CP clinical characteristics and associated conditions. Clinical CP types were determined according to the Surveillance of Cerebral Palsy in Europe (SCPE) and topographically [14]. Based on clinical presentations, five-level GMFCS was performed, whereby level I indicated the highest functional ability, and level V the most severely limited motor function. For each of the five levels, the description of gross motor function included four age groups: under the age of 2, between the age of 2 and 4, between the age of 4 and 6, and between the age of 6 and 12 years [6]. Based on the clinical picture and the occupational therapists’ reports, the quality of the upper extremity function was assessed using the MACS and it was classified into five levels, where level I indicated easy and successful use of objects, while level V implied that the patient was unable to manually manipulate objects [8]. Data on associated conditions (mental defects, epilepsy, visual impairments) were gathered from the patients’ medical records provided by neurologists, neuro-pediatricians, psychologists, speech therapists and ophthalmologists.

The collected data were saved in a database specifically designed for the purpose of this study. The subsequent data analysis consisted of descriptive and inferential statistics. Attributional characteristics were presented through frequencies and percentages. Comparison of the observed and expected frequencies was performed via $\chi^2$ test, whereas analysis of correlation between two characteristics was done using the Spearman correlation coefficient test. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) Statistics 17.0 computer software.

Results

According to the GMFCS, nearly two thirds of children with CP (64.0%) exhibited a motor function impairment at levels I, II or III, whereas levels IV and V were found in 17.5% and 18.6% children, respectively (Table 1).

In the examined sample, a statistically significant difference was found in the distribution of clinical types of CP, according to the GMFCS functional ability ($\chi^2$ test, $p < 0.05$).
In children diagnosed with spastic unilateral CP, GMFCS levels I and II were the most prevalent (92.5%), whereas quadriplegic patients were mostly classified at levels IV and V (95.6%). The same findings were found in children with dyskinetic (64.7%) and ataxic (66.7%) type of CP.

On the other hand, in 54.7% of the examined children, motor function was classified at GMFCS levels I or II, while 34.4% of the sample had level III, as shown in Table 2.

According to MACS classification, the majority (88.9%) of children with spastic unilateral CP were classified at level II (41.7%) or level III (47.2%). Nearly all diplegic children (92.1%) exhibited manual ability at level I (48.9%) or level II (42.2%), while 77.1% of quadriplegic patients demonstrated MACS level IV (38.7%) or level V (48.4%). Manual dexterity in children with dyskinetic CP varied from levels II – V, whereby the majority were classified at level III (33.3%) or IV (33.3%), as shown in Table 3.

Analyses revealed statistically significant differences ($\chi^2 = 93.984, p < 0.001$) between the mental deficit and the GMFCS functional classification. As displayed in Graph 1, severe cognitive impairment was absent in children at level I, while it was found in 59.1% and about 33% of children classified at GMFCS levels IV and V, respectively. Similarly, epilepsy was statistically significantly more associated with the GMFCS level ($\chi^2 =13.531, p = 0.009$). More specifically, the percentage of CP patients with concomitant epilepsy increased with the GMFCS level, from 25.5% at GMFCS level I to 58.3% at level V. On the other hand, no significant differences were found between visual impairment and the GMFCS classification.

**Discussion**

In the present study, the gross motor skill distribution represented by the GMFCS classification levels (64% of the sample at levels I – III, and the remaining 36% at IV or V) was in agreement with the report of Himmelmann, whereby 69% of the assessed children exhibited levels I to III, and the remaining 31% of the studied sample were classified at levels IV or V [14]. Similar findings were yielded by a study conducted in Australia [16]. On the other hand, in Sweden...
and Island, the researchers classified 5 – 10% fewer children at the highest GMFCS levels [17, 18]. This discrepancy may be due to the greater number of quadriplegic children in our sample. The differences in the prevalence of gross motor impairments at different GMFCS levels can also be explained by the difficulties in precisely assessing children under the age of two, compared to more mature patients. Gorter and colleagues examined the predictive value of GMFCS administered to children under the age of 2, and reporting that in 42% of cases the initially established level was revised as the children aged, typically to the higher level indicative of greater functional impairment [19]. Yet, Palisano et al. claimed that GMFCS classification was stable over time [3, 6]. Bax and colleagues believed that the disparities in these findings stem from the use of an overly wide age span, suggesting that it should be defined more precisely when using this classification system [20].

Our findings point to statistically significant differences in the distribution of CP types in relation to the GMFCS classification. The majority of children exhibiting a hemiplegic form of CP were classified at levels I or II, with only three children at level III and one at level IV. These results are in line with those reported by Beckung et al., who classified all hemiplegic patients at levels I – IV, with greater prevalence of cases at lower levels [21]. Himmelmann and colleagues examined the predictive value of GMFCS levels IV or V found in 2/3 of the examined cases, which is in agreement with the results yielded by a Swedish study [22]. Beckung and colleagues, on the other hand, found that the dyskinetic CP was the most prevalent at level III [21]. Ataxic CP is very rare and according to the available evidence it is distributed across the first three GMFCS levels. In our sample, children with ataxic CP were classified at levels I, II and IV, with the greatest number found at level IV, in line with the results reported by other authors [16, 21]. Significant variations in the functional abilities of ataxic children could be attributed to the predominance of symptoms indicative of hypotonic or ataxic CP, due to which some researchers separated children predominantly displaying hypotonia from the group exhibiting ataxia [16, 26].

The MACS allows manual dexterity to be classified in the evaluation of the upper extremity function in everyday life. According to the prevailing consensus, manual functional abilities are much more restricted in children with unilateral spastic CP, in relation to their gross motor functions, whereas diplegic CP tends to primarily impair gross motor functions [27]. Our findings indicated that more than 75% of children with unilateral spastic CP exhibited manual dexterity at levels II or III. Children diagnosed with hemiplegic CP have a tendency to neglect the affected upper extremity, which compromises their ability to partake in bimanual activities, resulting in classification at MACS level II [8]. Our results showed that children with diplegia typically exhibit manual functions at levels I or II, while those with quadriplegia are classified at level IV or V, and the dyskinetic CP mostly corresponds to levels III, IV or V. According to Carnahan et al., quadriplegic and dyskinetic CP forms usually correspond to MACS levels IV or V. In children with these types of CP, upper extremity function can be improved through occupational therapy, provided that they do not suffer any cognitive impairment [27]. It is widely established that the upper extremity function depends on both cognitive status and patient’s self-directed motor control [28].

According to our findings, higher GMFCS levels, indicative of greater functional impairment, are associated with greater prevalence and severity of concomi-

### Table 3. Distribution of MACS levels by CP types

<table>
<thead>
<tr>
<th>MACS/Sistem klasifikacije manuelnih sposobnosti</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>Total/Ukupno</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spastic unilateral/Spastični unilateralni</td>
<td>N (%)</td>
<td>3 (8.3)</td>
<td>15 (41.7)</td>
<td>17 (47.2)</td>
<td>1 (2.8)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>SB* diplegia/SA* diplegija</td>
<td>N (%)</td>
<td>22 (48.9)</td>
<td>19 (42.2)</td>
<td>3 (6.7)</td>
<td>1 (2.2)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>SB* quadriplegia/SA*kvadrupliška</td>
<td>N (%)</td>
<td>0 (0.0)</td>
<td>1 (3.2)</td>
<td>3 (9.7)</td>
<td>12 (38.7)</td>
<td>15 (48.4)</td>
</tr>
<tr>
<td>Dyskinetic/Diskinetični</td>
<td>N (%)</td>
<td>0 (0.0)</td>
<td>1 (11.1)</td>
<td>3 (33.3)</td>
<td>3 (33.3)</td>
<td>2 (22.2)</td>
</tr>
<tr>
<td>Ataxic/Ataksični</td>
<td>N (%)</td>
<td>0 (0.0)</td>
<td>2 (66.7)</td>
<td>0 (0.0)</td>
<td>1 (33.3)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total/Ukupno</td>
<td>N (%)</td>
<td>25 (20.2)</td>
<td>38 (30.6)</td>
<td>26 (21)</td>
<td>18 (14.5)</td>
<td>17 (13.7)</td>
</tr>
</tbody>
</table>

*SB – spastic bilateral/spastični bilateralni
tant conditions, such as mental deficit, visual impairment and epilepsy. Consequently, GMFCS classification level can be viewed as a reliable indicator of the overall extent of disability in children with CP. In their work, Himmelmann and colleagues correlated the higher GMFCS levels with the greater number of associated impairments, while in children born at term, GMFCS classification reflected the severity of adverse perinatal or neonatal events, such as intracranial bleeding or cerebral infarction and hypoxic-ischemic encephalopathy [22].

Conclusion

In the examined sample, two thirds of the children with cerebral palsy were capable of walking, either independently or with assistance (corresponding to Gross Motor Function Classification System - levels I – III), while the remaining third of the examined children were immobile (and were thus classified at Gross Motor Function Classification System – levels IV or V). In terms of functional classification, about 50% and 90% of children with bilateral and unilateral spastic cerebral palsy, respectively, were classified at levels I or II, pointing to the highest functional ability. Functional ability was most compromised in quadriplegic and dyskinetic cases of cerebral palsy, and those children were classified at levels IV or V. According to the Gross Motor Function Classification System classification, more severe functional impairments were related to higher prevalence and greater extent of associated conditions, such as mental deficit, visual impairment and epilepsy.

References