

ANALYSIS OF TYPE AND FREQUENCY DYNAMICS OF REHABILITATION ASSISTIVE DEVICES IN CHILDREN WITH CEREBRAL PALSY

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Background. Currently, cerebral palsy is the most common neuromuscular disease in the pediatric population. Spastic forms of cerebral palsy are characterized by secondary musculoskeletal complications. They are corrected by the use of assistive devices and, especially, orthoses, along with surgical treatment, botulinum toxin, and others.

Aim. The aim of this study was to assess the type and frequency dynamics of rehabilitation assistive devices in children with spastic forms of cerebral palsy, depending on the level of the gross motor function of the patient.

Materials and methods. A prospective analysis was conducted by questioning 214 parents of children with spastic forms of cerebral palsy who were treated for the period from 2017 to 2019. The patients were divided into five groups according to the gross motor function classification (GMFCS). The statistical processing was performed using the application package Statistica 10 and Microsoft Excel.

Results. Statistically significant differences in variances ($p < 0.05$) were obtained between the number of rehabilitation assistive devices used in the anamnesis in the year before the questionnaire (period I) and assistive devices used in the last six months before the questionnaire (period II). Repeatedly, patients used orthopedic shoes the most often, and the trunk-hip-knee-ankle-foot orthoses the most rarely. We found five main causes groups of assistive device use failure for children with cerebral palsy.

Conclusion. Statistically significant differences in variances were obtained between the frequency of rehabilitation assistive devices used in the anamnesis and during the last six months before the questionnaire was obtained. It has been confirmed that patients used orthopedic shoes most regularly; of all functional orthoses, hip adductor orthosis was used most often repeatedly, whereas the trunk-hip-knee-foot orthoses were the least common. Factors such as a negative attitude of the child towards the orthosis, uncomfortable in life, the presence of construction errors of the product, the absence of appropriate appointments in the individual rehabilitation and habilitation programs for the patient, have led to the most frequent rejection of the reuse of the technical device for rehabilitation. At the same time, positive or negative dynamics on the condition of the patient affected the regularity of the use of a technical device for rehabilitation in only one in six patients.

Keywords: cerebral palsy; orthoses; spasticity; gross motor function; rehabilitation; contractures; rehabilitation; gross motor function classification system; assistive devices.

АНАЛИЗ ДИНАМИКИ ТИПОВ ТЕХНИЧЕСКИХ СРЕДСТВ РЕАБИЛИТАЦИИ И ЧАСТОТЫ ИХ ИСПОЛЬЗОВАНИЯ У ПАЦИЕНТОВ С ДЕТСКИМ ЦЕРЕБРАЛЬНЫМ ПАРАЛИЧОМ

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Обоснование. На сегодняшний день детский церебральный паралич является самым распространенным нейроортопедическим заболеванием в педиатрической популяции. Одна из особенностей спастических форм детского церебрального паралича состоит в формировании вторичных ортопедических осложнений, для коррекции которых наряду с другими методами (хирургическими, ботулинотерапией и т. д.) используют технические средства реабилитации, и прежде всего ортезы.

Цель — оценить динамику количества типов технических средств реабилитации и частоту их использования у пациентов со спастическими формами детского церебрального паралича в зависимости от уровня глобальных моторных функций пациента.

Материалы и методы. Произведен проспективный анализ путем анкетирования 214 родителей детей со спастическими формами детского церебрального паралича, получавших лечение в клинике за период с 2017 по 2019 г. Пациенты ранжированы на пять групп согласно классификации глобальных моторных функций GMFCS. Статистическая значимость зафиксирована на уровне вероятности ошибки $p < 0,05$. Статистическая обработка данных выполнена с помощью пакета прикладных программ Statistica 10 и Excel.

Результаты. Исследование показало наличие статистически значимых различий между количеством технических средств реабилитации, использованных за год до анкетирования (период I), и технических средств реабилитации, использованных в течение последних 6 мес. перед анкетированием (период II). Оказалось, что наиболее часто пациенты повторно выбирают ортопедическую обувь, а наиболее редко — аппараты на нижние конечности и туловище по типу «тройник». Основные причины отказа пациентов от технических средств реабилитации можно разделить на шесть групп.

Заключение. Выявлено статистически значимое снижение частоты применения технических средств реабилитации в анамнезе и в течение последних 6 мес. перед анкетированием. Наиболее регулярно пациенты пользуются ортопедической обувью. Из всех функциональных ортезов наиболее часто повторно применялись аппараты на тазобедренные суставы, тогда как реже всего — аппараты на нижние конечности и туловище по типу «тройник». Наиболее часто к отказу от повторного использования технического средства реабилитации приводили такие факторы, как негативное отношение ребенка к изделию, бытовые трудности, наличие конструктивных погрешностей изделия, отсутствие соответствующих назначений в индивидуальной программе реабилитации и абилитации пациента. В то же время положительная либо отрицательная динамика в состоянии больного влияла на регулярность применения технических средств реабилитации лишь у каждого шестого пациента.

Ключевые слова: детский церебральный паралич; ортезы; спастичность; уровень двигательной активности; контрактуры; реабилитация; GMFCS; технические средства реабилитации.

Infantile cerebral palsy (ICP) is the most common neuro-orthopedic disease in the pediatric population [1]. It occurs with a frequency of 2.6 to 3.6 cases per 1000 live births [1–3]. According to the most frequent clinical manifestations, this disease has several forms, the most common of which are spastic [3, 4]. One characteristic of the spastic forms is the early emergence of secondary orthopedic complications. The use of rehabilitation assistive devices (RAD), such as an orthosis, is an integral element of comprehensive medical rehabilitation. The use of an RAD aims to both eliminate deformities [5] and expand the physical capabilities of the patient [6]. Parents and practitioners-clinicians choose the necessary RADs, especially orthoses, based on the variety of RAD types and clinical manifestations of the disease. In several cases, to correct “all” pathological positions and deformities, parents acquire an excessive amount of RADs based on medical recommendations or the opinions of other people. From our point of view, the use of numerous products is impractical for the child and parents, as their application of the principle of “a little bit of everything” not only does

not have a positive effect but can ultimately lead to the formation of a persistent negative attitude toward RADs in a child. As a consequence, the child may reject RADs, including the necessary ones. This study is aimed at studying the presented problem based on the analysis of questionnaires completed by parents.

This work aimed to evaluate the changes in the number of types of RADs and the frequency of their use by patients with spastic forms of ICP, depending on the level of gross motor functions.

Materials and methods

Using the questionnaire method, a retrospective analysis of 214 parents of pediatric patients with spastic ICP, aged 2 to 17 years inclusive, who were admitted for the first time for treatment to the clinic of the Federal Scientific Center of Rehabilitation of the Disabled named after G.A. Albrecht of the Ministry of Labour and Social Protection of the Russian Federation for the period from 2017 to 2019, was performed. The patients were ranked in five groups according to the classification of

Frequency analysis of rehabilitation equipment used in periods I and II in the treatment of patients with cerebral palsy by the GMFCS classification

Criteria	Period	GMFCS level of gross motor functions						Difference between rehabilitation assistive devices used in periods I and II, %	Pearson χ^2 test, level of <i>p</i>
		GMFCS 1	GMFCS 2	GMFCS 3	GMFCS 4	GMFCS 5	TOTAL		
Orthopedic shoes	I	100.0%	100.0%	100.0%	95.2%	100.0%	211 (98.6%)	12.8	0.000
	II	82.1%	100.0%	88.5%	79.0%	81.5%	184 (86.0%)		
Antirotation cuff	I	10.7%	8.3%	8.2%	0.0%	0.0%	11 (5.1%)	36.4	0.000
	II	7.1%	5.6%	4.9%	0.0%	0.0%	7 (3.3%)		
Splint for the lower limb	I	71.4%	80.6%	91.8%	82.3%	85.2%	179 (83.6%)	25.3	0.000
	II	57.1%	50.0%	73.8%	59.7%	63.0%	133 (62.5%)		
Device for the lower limb and trunk	I	0.0%	8.3%	26.2%	29.0%	25.9%	44 (20.6%)	72.7	0.000
	II	0.00%	0.00%	8.20%	9.7%	3.7%	12 (5.6%)		
Device for the hip joints	I	0.0%	13.9%	31.2%	38.7%	33.3%	57 (26.6%)	33.3	0.000
	II	0.0%	5.6%	18.0%	35.5%	11.1%	38 (17.7%)		
Device for the lower limb	I	7.1%	8.3%	23.0%	16.1%	7.4%	31 (14.5%)	61.2	0.000
	II	3.6%	0.0%	9.8%	6.6%	3.7%	12 (5.6%)		
Device for the ankle joint	I	3.6%	16.7%	13.1%	14.5%	14.8%	28 (13.1%)	60.7	0.000
	II	3.6%	2.8%	4.9%	6.5%	7.4%	11 (5.1%)		
Standing frame	I	0.0%	25.0%	55.0%	71.0%	63.0%	103 (48.4%)	45.9	0.000
	II	0.0%	0.0%	21.3%	48.4%	48.2%	56 (26.7%)		

gross motor functions (Gross Motor Function Classification System; GMFCS). To assess the dynamics of variants and the frequency of RAD application, we conventionally determined two time periods (I and II). The survey was a single-step questionnaire. Period I started from the time of the first orthosis and ended a year before the questionnaire, while period II included the last six months before the survey. The choice of the 6-month-interval between the periods was because this time was sufficient to overcome administrative obstacles in preparation for the planned re-orthosis, and, in most cases, adapt the child and parents to the use of the RADs prescribed previously.

We also analyzed the age of first use of the primary orthosis and changes of the overall motor development of the child and his physical abilities (from the point of view of the parents) over a minimum of the past five years, except for the first year of the child's life.

Statistical analysis by quantitative indicators was conducted based on the non-parametric Kruskal–Wallis test. The quantitative indicators were described using the mean value and standard deviation in the form $M \pm S$. On all graphs for quantitative variables, the arithmetic mean was indicated by a dot, the median was indicated by a horizontal segment, the interquartile range was represented by a rectangle, and the minimum and maximum values were indicated by vertical segments. The statistical significance of various values for binary and nominal indicators was determined using the

Pearson chi-squared test. Statistical significance was recorded with the error probability level of $p < 0.05$. Statistical data processing was performed using the software package Statistica 10 and Excel.

Results

All patients were distributed into five groups by the classification of disorders of the level of the GMFCS [7]. According to this distribution, 28 patients (13.1%) had the recorded GMFCS level of 1, 36 patients (16.8%) had GMFCS 2, 61 patients (28.5%) had GMFCS 3, 62 patients (29.0%) had GMFCS 4, and 27 patients (12.6%) had GMFCS 5. Thus, the maximum number of patients had recorded levels of GMFCS 3 and 4, whereas patients with GMFCS levels 1 and 5 were the least numerous. The distribution by gender was homogeneous. The average age of the patients under study was 8.2 ± 3.7 years, the proportion of pediatric patients over the age of four years was 93%, and that over six years old was 69%.

The study of the options for the RADs applied showed that in ICP patients, the RADs were used in complex treatment, which affected the support and movement of the child. These included orthopedic shoes, antirotation cuff, splint for the lower limb, splint for the upper limb, device for the ankle joints, device for the entire lower limb, device for the hip joints, device for the lower limb and trunk (tees), body jackets, and supports for standing (standing frames). We did not include in the analysis the

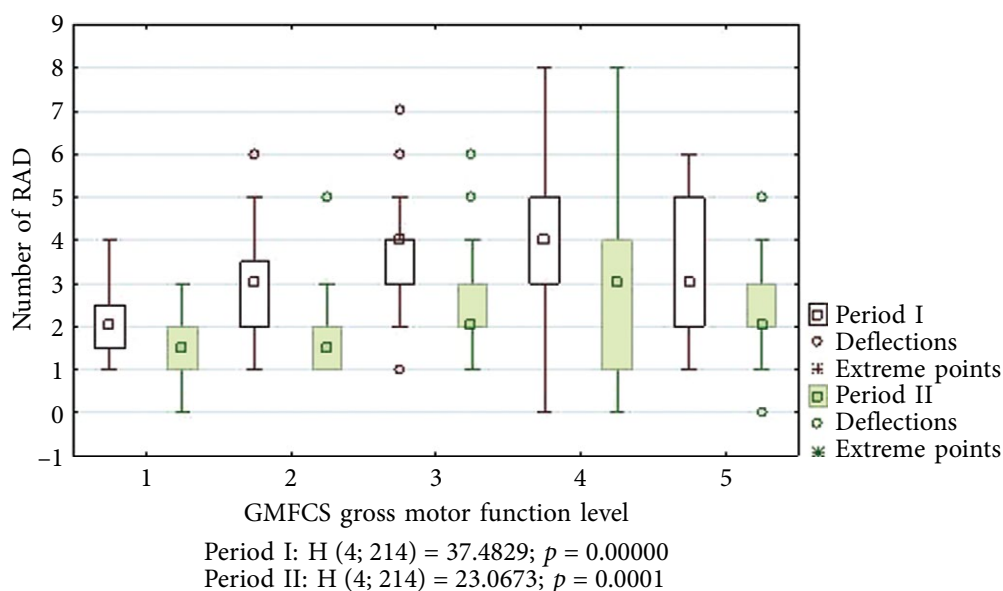


Fig. 1. Number of rehabilitation assistive devices (RAD) used in periods I and II, depending on the level of gross motor functions GMFCS: H — Kruskal–Wallis test

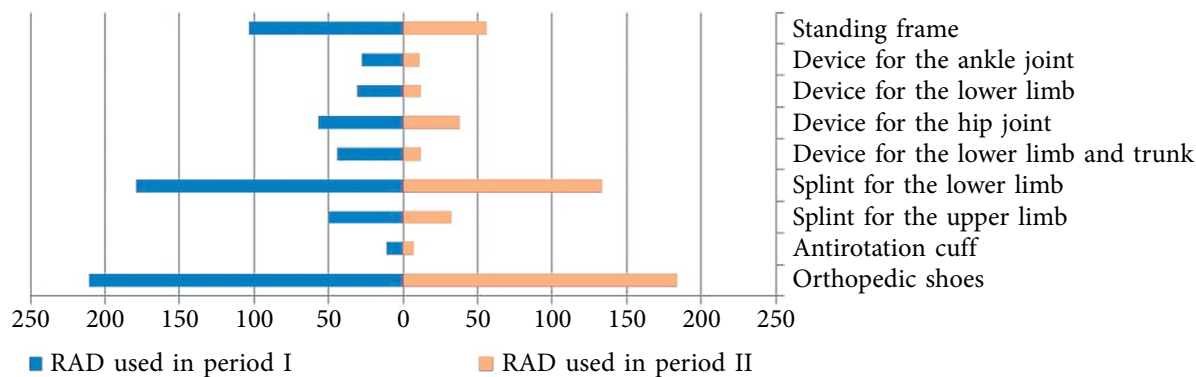


Fig. 2. Results of the analysis of the number of rehabilitation assistive devices (RAD) used by patients in periods I and II

orthoses for the upper limbs and trunk (splints, body jackets) (see Table 1).

Using the Kruskal–Wallis test, a statistically significant difference ($p = 0.000$) was revealed between the total number of RADs used in periods I and II in one patient.

Figure 1 demonstrates the presence of a statistically significant decrease between the average number of RADs used in one patient in periods I and II. In this regard, a further quantitative and qualitative analysis of the studied RADs was performed for the indicated periods. The statistical significance was tested using the Pearson chi-squared test that revealed the presence of differences in all types of RADs (Table 1). The results of the above analysis are presented in Fig. 2.

It was revealed that patients used orthopedic shoes and splints for the lower limb of various designs most stably. The frequency of their use in period II was 87% and 75%, respectively, of the same indicator in period I. In the structure of functional orthoses, the frequency of using devices for hip joints in period II was the highest among all similar orthoses (67%). The number of patients who continued to use devices for the entire lower limb and ankle joint was comparable (39% each). Only 12 of 44 patients repeatedly used one of the most complex orthoses (the “tee” type device for the lower limbs and the trunk), which amounted to 27%. The antirotation cuff was chosen by patients and their parents most rarely of all the RAD studied. In period I, only 11 pediatric patients used it, whereas only seven (64%) of them continued to use this product in period II. An analysis of the use of additional means of support, walkers, canes, and supports for standing (standing frames), showed that 60% of disabled pediatric patients reuse walkers

and canes. In contrast, only 50% of patients use standing frames.

A more detailed analysis was performed to detect tendencies to use RADs based on the level of gross motor functions. It was revealed that pediatric patients chose orthopedic shoes most often of all the evaluated RADs. The best indicator was recorded in pediatric patients with GMFCS levels 2–3 (89% or more). A high frequency of repeated application of splints to the lower limb was found in patients with GMFCS levels 1 and 3 (80%). Hip joint devices were preferred by patients in the GMFCS 2–5 groups, with the largest number of patients who reused the orthosis being noted in the GMFCS 4 group (92%), and the smallest was in the GMFCS 5 group (33%). Based on the analysis of the distribution of functional orthoses on the ankle joints, they were used in complex rehabilitation by patients with all levels of motor activity. The maximum frequency of use was recorded in GMFCS 3–4 groups. Patients reused the device for their lower extremities and trunk much less frequently. Only a third of patients had GMFCS 3–4, and, in rare cases, patients had GMFCS 5. None of the pediatric patients in the GMFCS 2 group used the “tee” repeatedly. Only patients who were capable of independent support and mobility selected an antirotation cuff. The frequency of reuse in groups GMFCS 1–2 and GMFCS 3 was almost identical, 67% and 60%, respectively.

The highest frequency of reuse of standing frames (supports for standing) was registered in patients with a GMFCS level 5 of motor activity (77%).

Considering the data on the statistically significant ($p < 0.05$) difference between the RADs applied in periods I and II, the reasons for the refusal of RADs by pediatric patients and parents

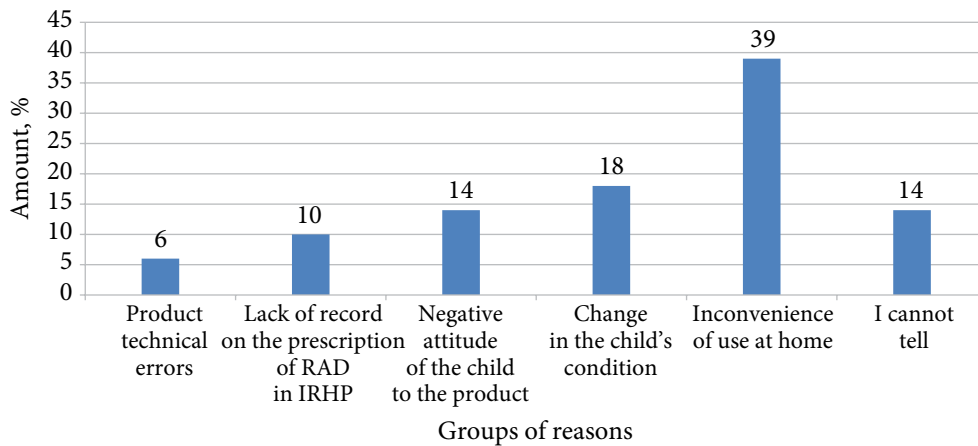


Fig. 3. Distribution by groups of reasons for patients refusing to use rehabilitation assistive devices (RAD): IRHP — an individual rehabilitation and habilitation program

were analyzed. This task was implemented by including the question on the reasons for refusal in the questionnaire. All reasons were divided into six groups (Fig. 3):

- 1) technical errors of the product (6.0%);
- 2) the absence of a record on the prescription of RAD in the individual rehabilitation and habilitation program (9.6%);
- 3) the negative attitude of the pediatric patient to the product (14.1%);
- 4) changes in the child's condition, such as improvement or deterioration (17.6%);
- 5) inconvenience or impossibility to use at home (38.7%); and
- 6) I cannot tell (14.0%).

As can be seen from Fig. 3, over half (68.4%) of the reasons for parents to refuse RADs were subjective and associated with organizational problems when prescribing the products or adapting to them, the negative attitude of the child, and technical errors of the product. In only 17% of cases, the causes of

failure were because of an objective change in the patient's condition.

According to Fig. 4, it is evident that the same causes of failure are characteristic for patients of groups GMFCS 1–2. However, their role is different for patients with different severities of the lesions. Thus, if the main reason in the GMFCS 1 group is the lack of a record on the prescription of RAD in an individual rehabilitation and habilitation program, then for disabled pediatric patients with a level of GMFCS 2, the reason for the inconvenience of using RAD at home was prevailing. In the GMFCS 3 and 4 groups, the number of options for the refusal reasons increased, whereas, in the GMFCS 3 group, the primary cause of the refusal was an improvement in the child's condition. However, in the GMFCS 4 group, a significant proportion of the refusals were because of the inconvenience of using RADs at home, and the negative attitude of the child to the orthosis. Patients with the most severe degree of motor impairment (GMFCS 5)

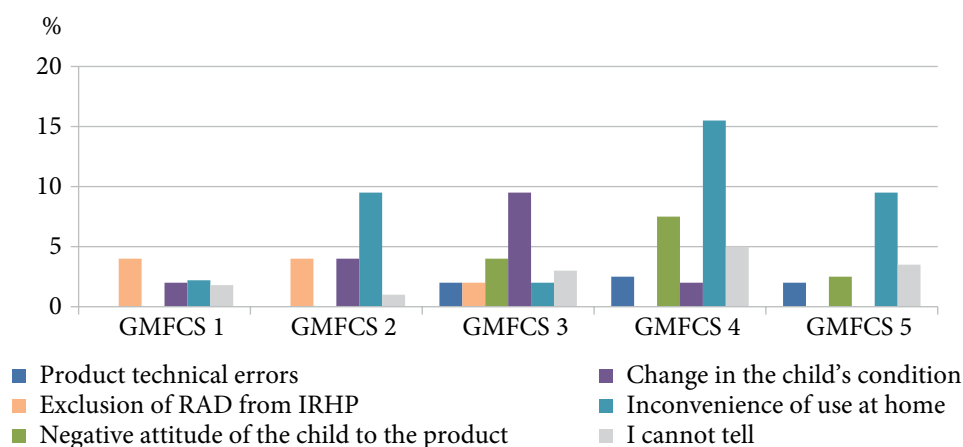


Fig. 4. Distribution of the groups of reasons for refusing to use rehabilitation assistive devices (RAD) depending on the level of the patient's gross motor functions: IRHP — an individual rehabilitation and habilitation program

did not comply with recommendations for the use of RADs, mainly for domestic reasons. In addition to the above reasons noted by the respondents, based on a detailed assessment of all the information obtained by questioning, several other reasons can be identified. First, in the medical community, there is a lack of consistency in recommendations regarding the age of primary orthosis, depending on the disease severity. Therefore, parents are not well informed in this field. Indirectly, this is confirmed by the data presented in Fig. 5, as the interquartile range of the age of the primary orthosis, increases as motor impairment worsens, beginning with GMFCS 3 patients and reaching a maximum in the group of GMFCS 5 patients.

Second, the psychological aspect of caring for severely disabled pediatric patients is an essential factor in the efficiency of rehabilitation in general, and orthosis in particular. On average, 90% of parents of patients with GMFCS levels 1–4 noted positive changes in the motor development of the child. In contrast, almost 45% of the parents of pediatric patients with GMFCS level 5 did not notice an improvement, which cannot but affect their motivation.

Discussion

The world literature presents publications on the study of the effectiveness of certain types of RADs in groups of patients or individual patients [8–10]. At the same time, we did not reveal any data on the analysis of the attitude of patients and their parents to the orthoses used, as well as the analysis of the reasons for refusing them. This feedback is an essential component of effective rehabilitation, including orthosis, since, for a positive result of treating a patient with the pathology under study, the assistive device should be used not temporarily, but regularly. Accordingly, the study of such feedback from patients and their families is a necessary element in assessing the role of orthoses in the rehabilitation of patients with ICP.

The results of our study showed that patients most often choose orthopedic shoes (99%), while the vast majority of patients (87%) continued to use them again. From our point of view, such constant wearing of orthopedic shoes is because of the high frequency of pathological locations and deformities at the level of the foot and ankle

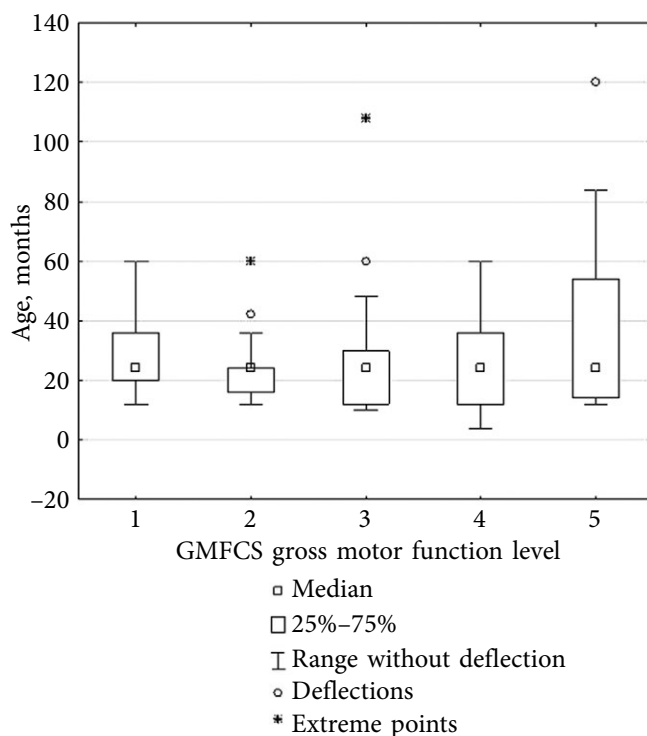


Fig. 5. Age at the beginning of the use of rehabilitation assistive devices in pediatric patients with spastic forms of cerebral palsy

joint, and the necessity to fix them regardless of the child's condition. For example, orthopedic shoes provide at least minimal support when the child is in the standing frame or in the sitting position. It is noteworthy that there is a mismatch between the high frequency of wearing orthopedic shoes in the studied group of patients and the low coverage of this aspect in the literature. In this case, the majority of publications, mainly Russian works of the second half of the 20th century, are concerned with the study of the design aspects of the shoes [11, 12].

More than 83% of all pediatric patients in period I used splints of various designs on their lower extremities, which is consistent with the data of several international researchers reporting the widespread use of such orthoses in ICP patients [13–16]. We have not seen studies on the dynamics of the reuse of splints and the attitude of patients toward them. According to our results, on average, a quarter of all patients over time refused to use them. In contrast, more often (28.6%) this occurred in pediatric patients of the GMFCS 1 group, and most rarely (8.2%) were noted in pediatric patients of the GMFCS 3 group.

Hip joint devices were used in period I by 57 patients (27%), 67% of which reused this orthosis. This was the highest indicator among all

devices for the lower extremities. In our opinion, the distribution of these devices in patients with different levels of gross motor functions is of significant interest. The indicated functional orthosis was used in period I by every third patient in GMFCS 3–5 groups, with the highest reuse rate (51%) in pediatric patients with GMFCS level 4. According to parents, this is primarily because of visually assessed changes in the lower extremities, in particular, elimination of the legs “crossing,” greater stability in the upright position, and better stability the sitting position. Thus, Semenova, in her monograph, reported the need to correct the lower limb adductors in the hip joints in the second half of the 20th century [17]. At the same time, we found a significantly lower frequency (27%) of reuse of an orthosis, such as a device for the lower extremities and the trunk (“tee”), which was originally intended for patients with severe statodynamic disorders. In our opinion, the above tendency indicated indirectly that parents and most specialists were in favor of choosing less massive, more functional products, which were more convenient in everyday life. Thus, devices for the lower limbs and trunk were used by patients with GMFCS levels 2–5. Patients of groups GMFCS 2 and 5 almost completely refused to reuse these orthoses (0% and 3.7%, respectively), whereas in groups GMFCS 3 and 4, only every third child repeatedly received a “tee.” According to the questionnaire, these devices were reused with a very low frequency, mainly because of the inconvenience for domestic use and the negative attitude of the child toward the product.

When analyzing the world literature, only a limited number of works exist on the role of tee-type devices in the complex treatment of ICP patients, including a few Russian patents and publications. At the same time, we found several articles on the use of devices for hip joints (hip abductor brace/orthosis SWASH orthosis) in the rehabilitation of such patients. The main subject of study was the effect of orthoses on the condition of the hip joints, mainly in combination with surgical treatment and/or botulinum therapy [18–20]. Nevertheless, we did not find publications covering both the effect of orthoses on the hip joints and characteristics of support and movement, and on feedback from parents of patients regarding the ease of use in everyday life, the child’s reaction to the product, and the regularity of use.

Devices for the ankle joint and the entire lower limb were used in 13% and 15% of cases, respectively, which is the minimum indicator among all functional orthoses. At the same time, only 40% of patients reused them. The number of patients who continued to use ankle joint devices was the highest in groups with GMFCS levels 4 and 5. The data obtained confirmed again that the above thesis regarding the choice of parents for less massive orthoses even for severe patients. In our study, the indicators of the frequency of use of the device for ankle joints differed clearly from the data presented in the international literature. In most publications, the authors considered the efficiency of the orthoses for ankle joints of various designs (AFO, GRAFO, leaf-spring AFO, and others) as the most commonly used in the rehabilitation of patients with GMFCS levels 1–3 [8–10, 21–22].

Standing frames (support for standing) were preferred by almost half of pediatric patients studied starting from GMFCS level 3. These data are somewhat different from those presented in the international literature [23]. In particular, according to Gericke et al. [24], the use of standing frames is advisable in ICP patients with levels of GMFCS 4 and 5. As our study showed, 46% of patients who used standing frames in period I refused their further use. According to Bush et al. [25] and Lyons [26], possible reasons for this may be the association of the standing frame with the negative aspect of using it both for the child (pain and discomfort) and for parents (the complexity and time required to place the child in the support, the unwieldiness of this type of RAD). In addition, Lyons et al. [26] considered that the discomfort caused by standing frames in pediatric patients provokes greater increases in muscle spasticity and, results in the development or intensification of pain. The above-described drawbacks of the supports for standing are even more applicable to devices for the lower limbs and trunk, which, according to parents, are often used only as individual standing frames. Despite this, in our opinion, as well as in the opinion of several international authors [27–29], “stationary” supports for standing (standing frames) represent one of the components for postural management. Moreover, all the above disadvantages are subjective and can be leveled by the correct selection of the RAD and the organization of the adaptation mode to it.

Conclusion

A statistically significant decrease in the frequency of use of RAD was revealed one year before the survey and during the six months before it. Patients used orthopedic shoes most regularly. Devices for hip joints were used repeatedly and most often of all functional orthoses, whereas “tee” type devices for the lower limbs and trunk were used the least often. The most common reasons for refusing to use RAD repeatedly included the child’s negative attitude toward the product, domestic difficulties, the presence of design flaws in the product, and the lack of appropriate prescriptions for the individual rehabilitation and habilitation program for the patient. At the same time, the positive or negative dynamics in the patient’s condition affected the regularity of using RAD only in every sixth patient.

Additional information

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Author contributions

E.I. Jomardli created the concept and design of the study, formed the questionnaire, collected and processed the material, performed the literature analysis, wrote the basic text, performed staged and final editing of the article.

A.A. Koltsov created the concept and design of the study, formed the questionnaire, performed staged and final editing of the article.

All authors made a significant contribution to the study and preparation of the article, read and approved the final version before its publication.

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