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ASSESSMENT OF INDICATORS OF RANGE OF MOTION AND STRENGTH OF INDIVIDUAL MUSCLE GROUPS IN CHILDREN WITH CONSEQUENCES OF HIP DYSPLASIA

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Purpose: to determine the features of functional disorders of the hip joints, formed as a result of dysplasia in preschool children.

Material and methods: 131 children of preschool age (average age 5,6 ± 0,5 years) participated in the research, which was conducted during 2014-2019. Participants were divided into two main groups: the main group (MG, n = 68) – children with a history of developmental hip dysplasia (DDH) (identified by the analysis of medical records) and a comparison group (CG, n = 63) – children without hip joint disorders. To evaluate the results, we used the method of strain dynamometry (manual muscle tester with a mechanical force sensor "EXPANDER") and the method of goniometry.

Results: the research results of electrotensodynamic measurements of lower extremities muscles in children of MG indicate a significant decrease in the strength of the muscles-abductors of the thigh (m. gluteus medius, m. gluteus minimus, m. tensor fasciae latae) of the injured limb relatively intact (intact – 85,8 ± 6,8 and affected 54,5 ± 4,9 ((± S), ($p \leq 0,05$)) and hypertonicity of the thigh-adductor muscles (m. gracilis, m. adductor longus, m. adductor brevis) from the affected limb

relative to the intact limb (intact – 68,2 ± 4,4, affected – 95,8 ± 4,1, (± S), ($p \leq 0,05$). The research of the indicators of tensodynamometry of children with DDH revealed a strong direct correlation between the state of the muscular system and the development of the adduction contracture of the hip joint (correlation coefficient between the strength indicators of the muscles-abductors of the thigh and the amplitude of abduction ($r = 0,7$ (strong straight ligament, $p < 0,05$)).

Conclusions: tensodynamometric examination of the muscles revealed a decrease in the tone of the abductor muscles of the thigh, biceps femoris, m. semitendinosus, m. semimembranosus, m. quadriceps femoris, m. sartorius. The result of the functional activity of the muscles is the formation of a torsion-valgus deformity of the hip joint, which requires a step-by-step individual implementation of rehabilitation and corrective interventions.

Keywords: dysplasia of the hip joints, preschool age.

Introduction

Congenital hip dysplasia (CHD) is a genetically determined complex of pathological anatomical and functional abnormalities, including underdevelopment of the acetabulum, proximal thigh, lack of ligaments, which may be accompanied by impaired joint relations [1]. The "insidiousness" of dysplasia is that without clinical and instrumental screening of newborns, it can be undetected by parents and contribute to the vascular disorders in the femoral head (Perthes' disease) of preschool children resulting in necrosis of the femoral head, pain, lameness and disability [1 - 3].

Epifanov V.O. and coauthors note that the deformation of the lower limb is a consequence of diseases at an early age, birth defects or dysplastic changes in the skeletal system as a result of significant static loads [4]. Statistical data of the Ministry of Health of Ukraine show that 17-20% of preschool children have the consequences of hip dysplasia in the form of lower limbs valgus and varus deformity [2, 5]. Other clinical signs that occur as a result of HJD include limited movement in

the HJ, contracture of the thigh and leg muscles, shortening of the limb, and, as a consequence, a violation of the normal walking stereotype [2, 5, 6].

Zinchenko V. V. pays attention to the fact that shortening of the lower limb, which is determined visually, can be observed not only with obvious unilateral dislocation, but also with dysplasia, even bilateral one with different location of the thighs in height [3].

Despite the importance of the topic and summarizing the literature, we have uncertain points in the development of pathology and treatment of disorders. As a result, a number of unresolved issues arise: for example, it is quite deeply researched what functional disorders occur in newborns with HJD, but it is unknown what disorders are characteristic of children, whose pathology was not detected in time or the period for treatment from the moment of diagnosis was missed; what are the functional disorders that in preschool children with HJD have, and can these disorders be influenced to improve the functional state of the musculoskeletal system and such patients quality of life?

The purpose of the reseach is to determine the features of functional disorders of the hip joints, which were formed as a result of dysplasia of preschool children.

Material and Methods of the research

The research was conducted on the basis of Sumy special preschool educational institution (kindergarten) №20 "Smile" and Sumy preschool educational institution (kindergarten) №39 "Tower" during 2014-2019. The study included 131 preschool children (average age 5,6 ± 0,5 years). Two groups were formed to conduct research: the main (MG, n = 68) - children with unilateral HJD in the anamnesis (identified by the results analysis of medical records) and the comparison group (CG, n = 63) - children without disorders of the hip joints. The studies were conducted in accordance with the ethical standards that are written in the Helsinki Declaration of the World Medical Association "Recommendations for Physicians in Human Biomedical Research" (as amended in 2013). Written informed parental consent was also obtained from all persons involved in the study. The tensodinamometry method

(manual muscle tester based on the mechanical force sensor “EXPANDER”) and goniometry method were used to evaluate the results.

The materials of the study are formalized according to generally accepted principles and summarized in data matrix using an Excel 13.0 Microsoft Office software. Statistical analysis was performed in the software packages STATISTICA for Windows and IBM SPSS Statistics 22.

Results of the research

Underdevelopment of anatomical structures, weakness of the joint and ligament apparatus, which remain until the beginning of the child's walk, even with timely treatment in 5-20% of cases of HJD do not contribute to stable retention of the femoral head in the acetabulum and in 60% of cases instability is combined with joint damage, as well as ischemic disorders due to the use of ineffective (inadequate) orthopedic and restorative treatment [5, 6]. Among the negative consequences of hip dysplasia, special attention is paid to limiting the amplitude of movements in the hip joint, as in the future it causes walking disturbances and contributes to the progression of atrophy of the muscles of the lower limb.

To detect functional disorders of children with dysplasia, a reseach using goniometry was conducted. The amplitude of passive movements in the hip joint was measured in children, because the volume of passive movements in the state of joint hip dysplasia gives the most complete idea of the state of joint mobility. The results of the analysis of goniometry of the hip joints of children from MG and CG are presented in table 1.

According to the results of research it was found out that the indicators of the volume of movements during extension of the affected limb in the hip joint of children of the MG did not correspond to the norm: at normal volume of movement (equal to 0-10°) there was flexion contracture of children from MG (affected limb (-9,5± 4,3°($\bar{x}$ ±S)) compared to a healthy limb (3,3 ± 3,9 ($\bar{x}$ ±S)), which is 12,8° less than on the intact side ($p < 0,05$). Indicators of CG were normal (9,1 ± 4,1 and 8,5 ± 4,1 ($\bar{x}$ ±S) and were statistically different from the results of MG ($p < 0,05$).

Table 1

The results of goniometry of the hip joints of children from MG and CG at the stage of the ascertaining experiment

Movement	Normative meanings, degree	Main group (n = 68)		Comparison group (n = 63)		Comparison of indicators of affected and intact limbs (unilateral) MG and GP t-cr. Student
		intact limb	affected limb	dex limb	sin limb	
Bending	130-140	130,3± 3,4	128,2± 4,2	131,1± 3,5	128,08± 6,8	**p > 0,05**
		p > 0,05		**p > 0,05**		
Extension	0-10	3,3± 3,9	-9,5± 4,3*	9,1± 4,1	8,5± 4,1	**p ≤0,05**
		p ≤0,05		**p > 0,05**		
Withdrawal	40-45	40,1± 5,5	28,7± 3,5*	43,8± 4,45	42,4± 5,3	**p ≤0,05**
		p ≤0,05		**p > 0,05**		
Internal rotation	30-40	40,8± 4,1	43,2± 3,9	40,2± 3,1	39,2± 3,5	**p > 0,05**
		p > 0,05		**p > 0,05**		
External rotation	40-50	39,2± 5,3	25,7± 3,7*	36,3± 5,2	32,1± 6,05	**p ≤0,05**
		p ≤0,05		**p > 0,05**		

Note:
** - the significance of differences between groups at (p <0,05);*
MG - main group (children with a history of unilateral hip dysplasia)
CG - comparison group (healthy children)

According to the results of research it was found out that the indicators of the volume of movements during extension of the affected limb in the hip joint of children from MG did not correspond to the norm: at normal volume of movement (equal to 0-10°) of children from MG was flexion contracture (affected limb) 4,3° ($\bar{x}$ ±S)) compared to a healthy limb (3,3 ± 3,9°($\bar{x}$ ±S)), which is 12,8° less than on the intact side) (p <0,05). Indicators of CG were normal (9,1 ± 4,1 and 8,5 ± 4,1°($\bar{x}$ ±S) and were statistically different from the results of MG) (p <0,05). Obtained results confirm the presence of flexion contracture in the HJ of children

with HJD, which can be caused by asymmetry in the development of muscle strength of the lower limbs, namely hypotonia of the extensor muscles of the thigh (biceps femoris, m. semitendinosus, m. semimembranosus), which leads to the formation of walking of such children with half-bent legs.

Bending rates among children from CG and MG corresponded to the norm (in CG (131,1 ± 3,5 and 128,08 ± 6,8 ($\bar{x}$ ±S)) and in MG (intact – 130,3 ± 3,4 and damaged - 128,2±4,2 ($\bar{x}$ ±S)). Statistically significant differences between CG and MG were not detected (p> 0,05).

During the assessment of the volume of movements during the removal of the affected limb in the hip joint of children, a significant limitation of the volume of movements in the affected limb was found. Thus, the indicators of the available volume of movement during the removal of the affected limb in the HJ were among children of MG – 28,7 ± 3,5° ($\bar{x}$ ±S) and intact – 40,1 ± 5,5° ($\bar{x}$ ±S). Accordingly, the amplitude of withdrawal was less than normal and corresponded to 71,7% of normal range of motion in the affected joint, while the recorded values between intact and affected limbs differed significantly (p ≤0,05). Comparing the indicators (limb of the same name) between MG and CG statistically significant differences were traced (28,7 ± 3,5 in OG and 42,4 ± 5,3 in GP, ($\bar{x}$ ±S)), (p ≤0,05), which is a confirmation that movements in the hip joint of children with HJD are also limited due to the drive contracture, which may depend on the degree of displacement of the femoral head and the shortening of the drive muscles of the thigh of such children.

A similar trend was observed while estimating the amplitude of external rotation movements in the HJ of children with HJD of the main group. Thus, the results of goniometry of the hip joint showed that the available external rotation of the affected limb in the MG was 25,7 ± 3,7° ($\bar{x}$ ±S) and intact – 39,2 ± 5,3° ($\bar{x}$ ±S), (p ≤0,05). Accordingly, in the affected joint, the amplitude of external rotation was less than normal and corresponded to 64,3% of normal range of motion. The registered parameters between intact and affected limbs differed significantly (p ≤0,05). Restriction of external rotation is explained by muscle contracture, in

particular hypertension m. adductor magnus, which performs the reduction and internal rotation of the thigh. Restriction of external rotation can also be caused by the presence of pain during the performance of external rotation, which is confirmed by a number of specific tests, such as variations of the Kalchschmidt test [10].

Comparison of the results of the amplitude of internal rotation of children from MG revealed a slight increase in the amplitude on the affected side (40,8 ± 4,1 and 43,2 ± 3,9 ($\bar{x}$ ±S), (p> 0,05). But registered indicators of children from MG, so as from CG corresponded to the norm and did not differ significantly from each other (p> 0,05). Our results confirm the data from literature sources: in most cases, this excessive antetoria is accompanied by a violation of the centering of the femoral head relative to the acetabulum and is manifested by the peculiarity of the child's walking - walking with internal rotation of the leg [7-9].

Research of Mirzoeva A.M., Dombrovskaya L.V. on determining the bioelectrical activity of the muscles surrounding the hip joint shows that children (under fifteen years of age) with congenital hip dislocation have the lowest muscle electrogenesis. The percentage of the ratio of bioelectrical activity of the muscles of the diseased leg in relation to the healthy one is on average 40%, which certainly has a negative effect on the formation of stable ratios in dysplastic joints as a whole [3, 10].

The results of the study of electrotensodynamometry of the muscles of the lower limbs of children from MG indicate a significant decrease in the strength of the abductor muscles of the thigh (m. gluteus medius, m. gluteus minimus, m. tensor fasciae latae) of the injured limb relative to the intact one (p <0,05) in the hip joint (intact – 85,8 ± 6,8 and affected 54,5 ± 4,9 ($\bar{x}$ ±S), (p ≤0,05)) and hypertonicity of the adductor muscles of the thigh (m. gracilis, m adductor longus, m. adductor brevis) from the affected limb relative to the intact limb (intact – 68,2 ± 4,4, affected – 95,8 ± 4,1, ($\bar{x}$ ±S), (p ≤0,05).

Comparing the results of tensodynamometry of children from MG and CG, it was found out that the indicators of the comparison group corresponded to the

average values of the intact limb of children from MG and did not differ significantly statistically (p> 0,05). Thus, the strength of the abductor muscles of the thigh in CG corresponded to the meanings (89,2 ± 3,8 and 87,8 ± 5,5, ($\bar{x}$ ±S), (p> 0,05) and had no statistically significant differences from indicators of intact limb of children from MG (85,8 ± 6,8, ($\bar{x}$ ±S)). Evaluating the strength of the adductor muscles of the thigh among children from MG and CG it was found that the indicators on the side of the lesion were higher. This fact is connected with pathological drive contracture of children with HJD (table 2).

Table 2

Indicators of thigh muscle strength (according to electrotensodynamometry data) of children from MG (n = 68) and CG (n = 63) at the stage of the ascertained experiment

Indicators	Limb	MG affected / intact	CG dex/ sin	Comparison of indicators between MG and CG t-cr. Student
		x ± S	x ± S	
The strength of the thigh muscles during abduction, (N) (thigh abductor muscles)	Affected	54,5±4,9*	89,2±3,8	**p ≤0,05**
	Intact	85,8±6,8	87,8±5,5	**p > 0,05**
t-cr. Student		**p ≤0,05**	**p > 0,05**	
The strength of the thigh muscles during reduction (N) (thigh adductor muscles)	affected	95,8±4,1*	70,5±4,8	**p ≤0,05**
	intact	68,2±4,4	72,4±3,6	**p > 0,05**
t-cr. Student		**p ≤0,05**	**p > 0,05**	
The strength of the thigh muscles during flexion in the hip joint (N)	affected	75,9±4,1*	120,6±6,2	**p ≤0,05**
	intact	91,2±4,2	124,3±5,1	**p ≤0,05**
t-cr. Student		**p ≤0,05**	**p > 0,05**	
The strength of the thigh muscles during extension in the knee joint, (N)	affected	65,4±6,2*	99,3±4,7	**p ≤0,05**
	intact	80,2±4,2	101,4±5,1	**p ≤0,05**
t-cr. Student		**p ≤0,05**	**p > 0,05**	

*Note: * - differences are valid at p <0,05*

Our tensodynamometric reseach among patients with hip dysplasia revealed a strong direct correlation between the condition of the muscular system and the development of drive contracture of the hip joint. Thus, there is a pronounced drive contracture in the hip joint of children with HJD, which is associated with hypotonia of the thigh abductor muscles (m. gracilis, m. adductor longus, m. adductor brevis) from the affected limb (correlation coefficient between indicators strength of the abductor muscles of the thigh and the amplitude of the withdrawal r = 0,7 (strong connection, p <0,05).

According to the results of the assessment of the strength of the flexor muscles of the thigh (m. quadriceps femoris, m. sartorius) it was found out that the indicators of CG (120,6 ± 6,2 and 124,3 ± 5,1 ($\bar{x}$ ±S)) exceeded the results among children from MG (intact – 91,2 ± 4,2, affected 75,9 ± 4,1 ($\bar{x}$ ±S)), (p ≤0,05). The same trend was found out while assessing the strength of the extensor muscles of the thigh (m. biceps femoris, m. semitendinosus, m. semimembranosus) of children from MG and CG. Low muscle strength in the MG (affected 65,4 ± 6,2 and intact 80,2 ± 4,2 ($\bar{x}$ ±S), (p ≤0,05)) may be caused by violation of the normal functioning of the hip joint, which causes the development of asymmetry of muscle tone, resulting in violation of the walking pattern and, consequently, less activity of children with HJD, which may affect physical development of such children.

Thus, our reseach proves that there is an asymmetry in the development of muscle strength of the lower extremities (tone of adductor muscles exceeds the tone of thigh abductor muscles, there is an asymmetry of muscle tone of flexors and extensors of the thigh when compared with the intact limb) and pronounced rotational-drive and flexion contracture of the affected hip joint of the limb among preschool children with HJD. Also, the muscle tone of the extensor muscles of the thighs among children with HJD is still lower than among healthy children, which may be due to low activity of children with HJD.

Our future research work will be aimed at study of the level of physical development of children with HJD and their comparison among healthy children.

Conclusions / Discussion

In the scientific and methodological literature it is often noted that the severity of treatment of children with hip dysplasia is caused not only by the high degree of pathological changes in the cartilaginous structure but also by the fact that the soft tissue component of the hip joints is affected and it leads to the contractures of the muscles of the thigh and lower leg, shortening of the limb, and, as a consequence, - a violation of the normal stereotype of walking.

Extended and supplemented information includes the facts that children of preschool age with HJD have an asymmetry in the development of muscle strength of the lower limbs. The obtained results of electrotensodynamometry indicate a significant decrease in the strength of the thigh abductor muscles (m. gluteus medius, m. gluteus minimus, m. tensor fasciae latae) of the injured limb relative to the intact ($p < 0,05$) in the hip joint (intact - 85,8 ± 6,8 and affected 54,5 ± 4,9 ($\bar{x}$ ±S), ($p \leq 0,05$)) and muscle adductors of the thigh hypertonia (m. gracilis, m. adductor longus, m. adductor brevis) from the affected limb relative to the intact limb (intact – 68,2 ± 4,4, affected – 95,8 ± 4,1, ($\bar{x}$ ±S), ($p \leq 0,05$).

Thus, the result of the established imbalance of functional activity of muscles is the formation of torsional-valgus deformity of the hip joint, which requires a gradual individual rehabilitation and correction interventions.

Prospects for further research in this area are the development and implementation of a targeted program of rehabilitation interventions, taking into account identified disorders of the musculoskeletal system among children with hip dysplasia in SMART-format.

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