

**MINISTRY OF HEALTH OF UKRAINE
NATIONAL O.O. BOHOMOLETS MEDICAL UNIVERSITY
DEPARTMENT OF PEDIATRICS №2**

**METHODICAL GUIDE
to a Practical Class
FOR STUDENTS**

Educational discipline – Propaedeutic of Pediatrics, including nursing practice,
basic medical skills in the pediatric department

Field of Study - "Healthcare"

Level of training - II (Master's) educational qualification level

Specialty 222 "Medicine"

Department of Pediatrics No. 2

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Lesson topic: Anatomical and physiological characteristics of the nervous system
in children. Neuropsychological development of children at different ages.
Methods and frequency of assessment.

Competencies developed through the study of the topic:

General

Ability to engage in abstract thinking, analysis, and synthesis.

Ability to learn and acquire up-to-date knowledge.

Ability to apply knowledge in practical situations.

Knowledge and understanding of the subject area of pediatric propaedeutics and the professional role of a physician caring for children of various ages.

Ability to make well-founded decisions.

Ability to work in a team.

Ability to engage in interpersonal interaction.

Ability to use information and communication technologies.

Ability to search for, process, and analyze information from various sources.

Commitment and persistence regarding assigned tasks and assumed responsibilities.

Specialized (professional) competencies

To determine the anatomical and physiological characteristics of the nervous system in children of various ages and their clinical significance across different stages of child development.

To determine the characteristics of a child's neuropsychic development at different ages.

To identify the key criteria for assessing neuropsychic development and the essential skills a child should acquire at specific ages.

Ability to gather information regarding a child's neuropsychic development and the state of their nervous system, and to analyze the obtained data.

Ability to assess the neuropsychic development of children of various ages.

Subject-specific learning outcomes

Assess the state of the nervous system in children of various ages

Assess a child's psychomotor development

Monitor a child's neuropsychic development

The aim of studying the topic: To develop professional competencies for achieving program learning outcomes regarding the age-related characteristics of nervous system development and formation in children, and to develop skills for assessing the neuropsychic development of children of various ages.

Equipment - textbook, personal computer with appropriate software, charts for assessing the psychomotor development of children of various ages, methodological guidelines, a set of individual structured tasks.

Lesson plan and organizational structure

Name of the stage	Description of the stage	Learning levels	Time
Preparatory stage	Organizational measures	*	10
The main stage	Test control about the lesson, checking and announcing the results.	**	20
	- theoretical survey; - clarification of the most important points regarding the characteristics of nervous system, main milestones of the development; - students' work on acquiring skills for assessing the neuro-psychological development of children of various ages; - acquisition by students of skills in providing recommendations to parents regarding child development following the assessment of neuropsychic development.	*, **, ***	55
	Solving situational problems related to the lesson topic	**, ***	20
The final stage	Analysis and assessment of student work results. Announcement of the topic of the next lesson, an indicative map for independent work with literature.	*	10
	Totally	2,5 academic hours	115

* Introductory, **reproducible, *** reconstructive, **** creative learning levels.

Anatomical and physiological features of the nervous system in children

On the 3rd week of gestation embryo has 3 primary germ layers – endoderm, mesoderm and ectoderm. On ectodermal surface the neural plate appears, the bending of which leads to the formation of neural tube and neural crest. From the neural tube central nervous system will form, from neural crest – peripheral nervous system. The cells of neuroectoderm then differentiate into specialized cells – neurons, oligodendrocytes, ependymal cells and others. On the 5th week of gestation 3 primary brain vesicles (forebrain, midbrain, and hindbrain) are present. The formation of dorsal and ventral horns of spinal cord, peripheral motor and sensory nerves occurs. Thus, by the end of 8th week of gestation the gross structure of the nervous system formed. During the fetal period migration of neurons to form cortical layers, formation of synaptic connection by axons and dendrites, myelination, growth of neuron and glia take place.

The child is born with relatively large, but morphologically and functionally immature brain. Further development occurs under the external and internal environment up to 16 years.

The brain of a child has an abundant blood supply; however, the outflow of blood is slower in comparison with adults. Thus, in case of diseases there is an accumulation of toxic substances and metabolites occur, which leads to toxic forms of infectious diseases.

At birth, the spinal cord is more developed than the brain. After birth, the rate of increase in the mass and size of the spinal cord is slower. The length of the spinal cord increases more slowly than the size of the spinal canal. The lower segment of the newborn is located at the level of III the lumbar vertebrae, and by 4-5 years of age between the I and II lumbar vertebrae. These peculiarities should be considered when performing a lumbar puncture.

The peripheral parts of the analyzers (sense organs) are structurally formed, but they do not function enough, due to the immaturity of the cortical centers.

Physiological reflexes of newborns:

Sucking reflex: observed from birth to 10-12 months;

Rooting (search) reflex: when touching the corner of the mouth, the child turns his head towards the stimulus (observed up to 3-4 months);

Snout reflex: when touching lips with a finger, child pulls his lips in the form of a proboscis (up to 2-3 months);

Babkin's reflex: when pressing with the thumb on the palm of the child, he opens his mouth and tilts his head to his chest (up to 2-3 months);

Protective reflex: When lying prone, the child turns their head to the side and flexes their limbs (observed up to 1-2 months). The inability to turn the head in this position may indicate muscle hypotonia.

Placing and Stepping reflexes: When the baby's feet touch a hard surface, the infant appears to bear weight on them. If the baby is tilted forward in this position, they will make stepping movements (observed up to 1–2 months of age).

Galant and Perez reflex: Stroking the back along and beside the spine while the infant is held in ventral suspension causes the trunk to flex. Persistence of these reflexes beyond six months is pathological.

Moro reflex: A two-phase protective reflex consisting of the sequential extension (abduction) and flexion (adduction) of the arms in response to sudden sounds, jolts, or a loss of support (observed up to 3-4 months). It's absent in cerebral depression. Unilateral response suggests brachial plexus palsy (Erb's or Klumpke's palsy) or fracture of clavicle.

Grasping reflex: when applying fingers to the palm or soles, the child grabs them (up to 3 months)

Crawling reflex: in the prone position, movements resembling crawling appear falling (observed up to 3-4 months).

Babinski reflex: toes fan when the foot is stroked

Asymmetric tonic neck (ATN) reflex (Fencer's Pose): turning the head to one side increases extensor tone on that side and flexor tone on the contralateral side. If response is excessive and obligatory suggest neurological abnormality (up to 2-4 months)

Neuropsychological development

During the period of childhood, the child acquires specific skills (developmental milestones), that occurred in a predictable sequence and reflect the interaction of the child's neurological system with the environment. Monitoring a child's development over time is necessary for promotion of healthy development and identification of children who may have developmental problems.

Developmental milestones can be grouped in domains:

- statics
- gross motor,
- fine motor (including self-care),
- communication (speech, language and nonverbal),
- cognitive,
- social-emotional

Newborn period

Soon after birth, neonates are alert and ready to interact. Few behavior states of newborn baby have been described: quite sleep, active sleep, drowsy, alert, fussy and crying. Depending on state, muscle tone, spontaneous movement and response to stimuli could be different. Senses of baby attuned to the caregiver's face, voice and touch, baby uses already behavioral cues (crying, gazing). Responsive care enables a calm, alert processing state for engagement and interaction and, with repetition, creates memory and close emotional relationship with caregivers.

For newborn babies flexed posture is typical, almost all physiological reflexes of newborns are positive (Moro, support reflex, hand grasp reflex, sucking reflex).

The first year of life

The first year of life provides the platform for development. There is a peak of the neural plasticity – the ability of the brain to be shaped by experience. Total brain volume doubles in the 1st yr of life. At the age of one month, the volume is approximately 36% of an adult's volume, and at the age of one year, it is 72%. The infant acquires new skills in all developmental domains.

Age 1-2 months

Infants have innate need to make sense of the world. Different stimuli, even during caretaking activities, support the development of cognition. With time, infants attend less to repeated stimuli, their attention will increase to novel stimuli.

Emotional development in this age is characterized by the presence of crying. In most cases, crying/fussiness is temporary and normal behavior in this age. Crying normally peaks at about 6 wk of age, when healthy infants may cry up to 3 hr/day, then decreases to 1 hr or less by 3 mo. During this period, parents require special support, including learning to recognize the behavioral signals that precede crying and to interact calmly with the child in response to those signals. The pediatrician must pay attention to the presence of signs of postpartum depression in mothers.

Age 2-6 months

In this period, the development of primary emotions occurred – anger, fear, disgust, surprise, joy, and interest. Motor and sensory maturation is observed in this age. Physiological reflexes of newborn disappear, and it means that there is no more limitation for voluntary movement, infants can examine objects and manipulate them with both hands. At this age, the ability to roll over develops because of increasing control of truncal flexion. Holding head also opens a new visual range. Infants no longer focus exclusively on mother; they explore world and their own bodies. They learn how muscle movement generates tactile and visual sensation, the sense of self is developed.

Age 6-12 months

Increased mobility in this age, understanding and communication skills, improved manipulative activity expand infants' exploration range. A major milestone in 9 month is understanding of object permanence (constancy), that objects continue to exist, even when not seen. Object permanence makes attachment possible. Anxiety arises in the presence of strangers. In this period development of language is prominent. Between 8 and 10 mo of age, babbling has new complexity, with multisyllabic sounds ("ba-da-ma"), later first words will be pronounced.

Second year

Most children start to walk without support at around 12-15 mo of age. That allows separation and independence, but child continues to need his parents. The relative independence of the first half-year often changes by increased clinginess around 18 mo. In this age, toddler begin simple play, directed to self and then to a doll or toy. Important learning for toddlers is imitation of parents or other children. Because of limitations in expressive communication and inability to control emotions almost all children will experience tantrums. Receptive language in toddlers precedes expressive language. Until 18 month of age children use polysyllabic jargonizing and mostly nonverbal communication. At 18-month child knows 10-15 words, at 24 months – 50-100. He starts to combine them and make simple sentences.

The preschool years

The critical milestones in this age are language development and expanding social sphere. Vocabulary increases to 2000 words in this period. Children start to use past and then future tenses, the number of words in a typical sentence equals the child's age (2 by age 2 yr, 3 by age 3 yr, and so on). For preschooler socialization

and playing with peers is crucial. Children practice adult roles and learn what behaviors are acceptable.

Middle childhood

This period is characterized by increased separation from parents. Child will spend a lot of time in school and acquire such skills as reading, writing, calculating. That requires language, cognitive (memory, attention) and perceptual (visual analyses, proprioception) processes.

Methods and frequency of assessment.

The concept of developmental trajectories recognizes that complex skills build on simpler ones. This highlights the importance of developmental surveillance. Early detection and correction of delays can prevent secondary mental health problems.

The development examination should include steps:

1. Elicit parents' concerns
2. Identify/update family and child medical history, biological and psychosocial risk factors
3. Measure children's skills
 - a. Screen milestones in all domains,
 - b. Asses the presence of red-flags
 - c. Autism specific screening at 18 and 24 month
4. Observe/measure parent-child interactions
5. Conduct a careful physical exam
6. Interpret results, explain findings, decide on any needed referrals [2]

Development examination should be providing during every well visit. In Ukraine according to the protocol of the Ministry of Health of Ukraine (N 149) the frequency of visits:

- first year of life – every month;
- second year of life – every 3 months;
- third year of life – every 6 months;
- after 3 years of life – every year.

Main milestones for neuropsychological development assessment:

Age, mo	Statics	Motor activity	Speech-language	Cognitive	Social-emotional
1	Begins to hold his head for several minutes	Physiological muscle hypertonus	The appearance of cooing with single sounds at the end	Watches person, looks at toy for several seconds,	Reacts with dissatisfaction to loud sound

	when on tummy	decreases, athetosis-like movements of the limbs disappear by the end of the month. Expressed primary reflexes: proboscis, sucking, grasping, Moro, etc.	of the month, pronounces sounds between “a” and “e”	react to loud sounds	and light stimuli
2	Holds head up when on tummy, holds head for several minutes in vertical position. Moves both arms and both legs.	Turns his head in different direction.	Frequent short cooing. Reacts to loud sounds	Looks at moving object for several seconds	Looks at face of parent/ doctor; Smiles when parents talk to or smile at him.
3	Holds head without support	Mostly primary reflexes disappear. Reaches toward and misses objects	Frequent long cooing, says “aah, ngah”	Active reaction on sounds and bright objects	Sustained social contact; Social smile
4	Pushes up onto elbows/forearms when on tummy	Reaches object. Turns from back to side.	Makes sounds like “oooo” and “aahh” (cooing), Sound “m” and “b” appear. Makes sounds back when you talk to him	Looks at his hands and toys in hands with interest Start to recognize his mother for the first time	Laugh when someone try to make her laugh; Looks at parent, moves, or makes sounds to get or keep your attention
5	Stands with support by the armpits, rests on the tips of the fingers	Brings hands to mouth Starts to roll back to front Reaches and grasps an object.	Rhythmic sounds	Recognizes familiar people Shows interest in other infants	Responds to different intonation, Laughs loudly
6	Prone: Weight borne on hands with extended arms, chest and upper part of the abdomen therefore being off the couch Sits (supported) for a few minutes	Rolls front to back and usually back to front Palmar grasp at 6 month Transfers objects between hands	Looks toward person talking to him Takes turns making sounds with you Makes squealing noises	Looks for dropped object Prefers familiar people	Emotions are differentiated. Different behavior with familiar people and strangers. Lifts his arms up to be picked up.

7	Sits briefly, with support of pelvis. May support most of weight; bounces actively	Reaches out for and grasps large object; transfers objects from hand to hand; grasp uses radial palm	Forms polysyllabic vowel sounds	Reaches to grab a toy he wants	Joins the game, repeating actions of adults. Getting tired, demands attention of mother
8	Crawls, extending its arms forward. Lies down, sits, gets up by himself.	Grabs a cube with each hand and holds them for a short time	Makes different sounds like “mamamama” and “babababa”	Shows with his hands “goodbye”. Nodding of the head shows agreement, objection	Adequate emotional reactions in response to communication. Observes the actions of other children.
9	Sits without support. When supported by the hands, stands	Intentionally drops an item Can play independently with toes. Scissors grasp	Repetitive consonant sounds (“mama,” “dada”)	Adequately responds with actions to simple questions and request “give me a doll”, “sit here” Knows his name Respond to music with dance movements	Easily comes into contact on emotional, playful, verbal levels. Repeats the actions of other children.
10	Sits up alone and indefinitely without support, with back straight Pulls to standing position; “cruises” or walks holding on to furniture. Creeps or crawls.	Grasps objects with thumb and forefinger; pokes at things with forefinger; picks up pellet with assisted pincer movement.	The first words that child understands appear, several words in the vocabulary.	Looks for objects when dropped out of sight (like his spoon or toy) Repeats the movements of adults “talks on the phone”, cooking	Is shy, clingy, or fearful around strangers ; Shows several facial expressions, like happy, sad, angry, and surprised; Plays with other children
11	Crawls on hands and knees with cross coordination. Stands without support. Takes steps forward, supported by both hands.	Pincer grasp appear	The number of monosyllabic words is replaced by two-syllable words. Uses the words of the simplified version.	Fulfills simple demands and requests. Knows the concepts: “you can”, “you cannot”, understands prohibitions.	Child has first friends, with whom he plays. Selective attitude toward the children.
12	Pulls up to stand Walks, holding onto furniture	Can play with toys for an hour or more	Calls a parent “mama” or “dada” or another special name. Vocabulary - 8-12 words	Fulfills more complex requirements and requests, understands them	Plays simple ball game; makes postural adjustment to dressing

					releases object to other person on request or gesture uncovers hidden toy; attempts to retrieve dropped object; releases object grasped by another person
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Main milestones for neuropsychological development assessment (second year of life):

Age	15 months	18 month	21 months	24 months
Receptive language	Responds to approval or prohibition. Try to find on request object that was just played with	Select items according to the certain characteristics	Understands adults' questions about events, depicted on picture	Listening to the stories of adults (without picture), understanding events, can image the people
Expressive language	Says words with 2 vowels	Names objects and actions at the moment of interest	During the game, indicates his actions with words and two-words sentences	When communicating with adults, uses 3-word sentences, using nouns and pronouns
Sensory development	Oriented in two contrasting sizes, shapes of objects: "big" and "small". Correlates, compares the properties of objects	Orients itself in 3-4 contrasting shapes of objects (sphere, cube, bricks)	Differentiates 3-4 forms of objects, focuses on the quantitative characteristics "a lot", "little"	Select 3-4 contrasting colors according to the sample. Combines objects by shape, size, color
Game	Reproduces previously learned actions with objects in game: feeds a doll	Displays actions in the game, that often observes. Drives a car by a rope, builds a house out of cubes	Depicts simple plot constructions – overlaps like "gate", "huts" etc	Plays a series of consecutive actions in the game
Movements	Walks for a long time, does not sit down, changes body position, bends, turns	Step over a stick that is lying on the floor (without support)	Step over a stick 5 cm high	Step over a stick 10 cm high
Skills	Eats solid food with spoon	Eats liquid food with spoon	Partially removes clothes with the help of adults (shoes, hat)	Partially puts on clothes (hat, shoes)
Emotions, social behavior	Empathy appears. Uses the word "no" when disagreeing	Uses "yes". Begins to distinguish between things belonging to	Helps in simple work (according to instructions).	An acute reaction on absence of mother. Starts to

		different family members: “grandmother’s glasses”, “mother’s bag”. Looks at his image in the mirror, identifies it with himself.	Imitates the actions of adults with household objects	describe his actions: “I am sitting”, “my doll”
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Main milestones for neuropsychological development assessment (third year of life):

Age	30 months	36 months
Expressive language (grammar)	Uses complex sentences with 3 and more words	Uses complex subordinate sentences
Expressive language (questions)	The questions “where” appear	The questions “why” and “when” appear
Sensory development	Creates a complex geometric structure according to the sample. Select various objects of 4 main colors according to the sample	Correctly uses geometrical figures according to their purpose. Names 4 main colors
Game	The game has a “plot” character. The child reflects the relationship and sequence of actions from surrounding life.	There are elements of a role-playing game. Introduce a toy into game instead himself. Uses pencils, can depict simple objects and names them.
Movements	Step over a stick 15 cm high	Step over a stick 20 cm high
Skills	Eats carefully, puts on clothes by himself	Can buttons some buttons. Uses napkins
Emotions, social behavior	Knows the parts of the body. Can inform about condition.	Understands and uses pronouns “I”, “my”, “you”, “yours”. Knows about gender

The doctors tactics based on result of the assessment (according to the protocol of the Ministry of Health of Ukraine (N 149)) :

Results	Tactics
Indicators of psychomotor development correspond to the age of the child	Further observation. Care counseling
A one-month delay in the acquisition of certain skills during the first year of life.	Developmental care counseling. Re-examination after 1 month. If the detected delay persists at re-examination after 1 month is necessary consultation of a pediatric neurologist

A 3-month delay in the acquisition of certain skills during the second year of life.	Developmental care counseling. Re-examination. Terms are determined individually. If the detected delay persists at re-examination consultation of neurologist is necessary
A six-month delay in the acquisition of certain skills during the third year of life.	Developmental care counseling. Re-examination. Terms are determined individually. If the detected delay persists at re-examination consultation of a neurologist is necessary

Red Flags in Developmental Screening

The presence of any of the following signs indicates serious developmental disorders:

- Loss of developmental skills at any age;
- Confirmed visual impairment, parental concern regarding gaze fixation or tracking of objects (consultation with a pediatric ophthalmologist required)
- Hearing loss at any age (consultation with a pediatric otolaryngologist is required).
- Persistently low muscle tone or floppiness;
- No speech by 18 mo, especially if the child does not try to communicate by other means such as gestures (simultaneous referral for urgent hearing test);
- Asymmetry of movements or other features suggestive of cerebral palsy, such as increased muscle tone;
- Persistent toe walking;
- Complex disabilities;
- Head circumference above the 99.6th centile or below 0.4th centile. Also, if circumference has crossed 2 SD (up or down) on the appropriate chart or is disproportional to parental head circumference
- child can NOT:
 - sit unsupported by 12 mo;
 - walk by 18 mo (boys) or 2 yr (girls) (check creatine kinase urgently);
 - walk other than on tiptoes
 - run by 2.5 yr
 - hold object placed in hand by 5 mo (corrected for gestation)
 - reaches for objects by 6 mo (corrected for gestation)

- points at objects to share interest with others by 2 yr

For Autism specific screening M-CHAT is recommended to use. M-CHAT includes 23 questions for parents about the child. For example:

Does your child respond when you call his or her name?

or

Does your child point with one finger to ask for something or to get help?

Assessing the answers allows revealing risk of Autism spectrum disorder.

All information is available on official site: [M-CHAT™ - Autism Screening \(mchatscreen.com\)](https://mchatscreen.com)

Recommended literature

1. Nelson Textbook of Pediatrics, 2-Volume set, 22-nd edition. By Robert M. Kliegman, Bonita M.D. Stanton, Joseph St. Geme and Nina F Schor. – Philadelphia, PA : Elsevier Inc., 2024 - 4472 p. ISBN-10 : 032352950X ISBN-13 : 978-0323529501
2. Jennifer M. Zubler, Lisa D. Wiggins, Michelle M. Macias, Toni M. Whitaker, Judith S. Shaw, Jane K. Squires, Julie A. Pajek, Rebecca B. Wolf, Karnesha S. Slaughter, Amber S. Broughton, Krysta L. Gerndt, Bethany J. Mlodoach, Paul H. Lipkin; Evidence-Informed Milestones for Developmental Surveillance Tools. Pediatrics March 2022; 149 (3): e2021052138. 10.1542/peds.2021-052138
3. Katilov O.V., Dmitriev D.V., Dmitrieva K.Yu., Makarov S.Yu. Clinical examination of a child. 3rd edition. Vinnytsia: Nova Kniga, 2023. 520 p.
4. Developmental Milestones – OSCE Guide
<https://geekymedics.com/developmental-milestones/>
5. Dosman CF, Andrews D, Goulden KJ. Evidence-based milestone ages as a framework for developmental surveillance. doi: 10.1093/pch/17.10.561. PMID: 24294064; PMCID: PMC3549694
6. M-CHAT™ - Autism Screening (mchatscreen.com)

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