Newborn and child growth and development – a systematic review

Crescimento e desenvolvimento do recém-nascido e da criança – uma revisão sistemática

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ABSTRACT
Throughout human history, the morphological aspects of the child have been viewed in different ways by different cultures, and many researchers did not believe in their uniqueness and saw them as "mini adults”. As a consequence, there was a neglect of the morphological peculiarities of the child. All this contributed to the fact that the number of studies on morphofunctional growth and development was scarce, so that professionals such as physiotherapists, speech therapists, pediatricians, nurses, among other professionals had insufficient material for consultation. In this sense, an analysis of the
factors responsible for the growth and development of the newborn and the child was developed. For this, a systematic review was developed from the survey of morphological and functional data of the newborn and the child.

**Keywords:** anthropometry, growth, child, development, newborn.

**RESUMO**
Ao longo da história da humanidade os aspectos morfológicos da criança foram vistos de diferentes maneiras por culturas diversas, sendo que muitos pesquisadores não acreditavam em sua singularidade e a viam como “mini adulto”. Como consequência, ocorreu negligência sob as particularidades morfológicas da criança. Tudo isso contribuiu para que o número de estudos sobre o crescimento e desenvolvimento morfofuncional fosse escasso, fazendo com que os profissionais como fisioterapeutas, fonoaudiólogos, médicos pediatras, enfermeiros, entre outros profissionais tivessem material insuficiente para consulta. Nesse sentido, foi desenvolvida uma análise dos fatores responsáveis pelo crescimento e desenvolvimento do recém-nascido e da criança. Para tanto, foi elaborada uma revisão sistemática a partir do levantamento de dados morfológicos e funcionais que abordam os fatores de crescimento e desenvolvimento do recém-nascido e da criança.

Palavras-chave: antropometria, crescimento, criança, desenvolvimento, recém-nascido.

**1 INTRODUCTION**

The term growth can be defined by the process of cell multiplication and differentiation, resulting in an increase in the dimensions of the body as a whole, or in specific parts, considering time since birth, age and height (GUEDES, 2011).

In general, it is considered as an increase in body size, which ceases with the end of the increase in height. Thus, to assess child growth, it is necessary to measure and monitor the anthropometric measurements of the child, such as weight, height, head and chest circumference, relating them to each other (CHAVES, 2013).

As for development, despite being associated with growth, it has been erroneously used as a synonym, and is characterized by the specialization of cells and evolutionary changes in organs and systems, resulting in greater efficiency of the body when performing its functions. Therefore, one can associate "growth" with quantitative changes and "development" with qualitative changes (GUEDES, 2011).

In addition, growth can occur due to hypertrophy and hyperplasia of cells, associated or not with the acquisition of abilities (MARCONDES, 1978). These mechanisms of cell modifications can be influenced by genetic factors and by external factors (ZEFERINO, 2003). It can also be defined by the increase in the amount of
metabolically active protoplasm, associated or not to the increase in cell size (OSOL, 1990).

Historically, growth evaluation took into consideration three indexes: weight for age, weight for height, and height for age. However, the World Health Organization (WHO) established that it should be considered mainly weight for height and height for age and that calculations should be made on statistical bases, such as percentage and standard deviation (ZEFERINO, 2003).

Moreover, the main mechanism for measuring growth became the Body Mass Index (BMI), whose formula is weight in kilograms divided by height in meters and squared. As age is a relevant factor for the interpretation of the result, it is necessary that in children a different reference value be adopted (ZEFERINO, 2003). In addition, the speed of growth is justified by the acquisition of mass, resulting in cumulative anthropometric indices, pre- and postnatal (FONSECA, 2017).

Thus, child growth is one of the best indicators of child health and stunting is currently the most representative anthropometric characteristic of the epidemiological picture of malnutrition in Brazil.

Thus, given the importance of addressing how growth and development is the main indicator of health conditions, this study aimed to contribute to the understanding of the relevant factors responsible for the periods of growth and development of the newborn and the child.

2 MATERIAL AND METHODOLOGY

A systematic review was developed by means of data collection in the literature as well as in the main databases such as: PubMed, SciELO, LILACS and CAPES journals.

The search strategy used was the cross-referencing between the keywords related to the investigated theme that appear in the Health Sciences Descriptors "DeCS/MeSH" in Portuguese, English and Spanish: Antropometria; Anthropometry; Growth and Development; Crecimiento y Desarrollo; Criança; Child; Niño; Newborn; Infant, Newborn; Newborn.

We intentionally used at least three keywords at a time in each of the databases consulted.
Inclusion criteria were technical books and scientific articles containing morphological descriptions and morphometric data in the context of the newborn and child.

As exclusion criteria, editorials were disregarded for not undergoing a rigorous evaluation process as occurs in scientific articles and technical notes published without references.

3 RESULTS AND DISCUSSION
3.1 NEWBORN GROWTH

During the growth of the newborn, anatomical changes naturally occur. Growth monitoring (mass gain) is an important data for monitoring the health of the newborn, and is done from fetal life until the end of childhood. There are factors that interfere with this acquisition of mass, such as gestational weeks and nutrition. The growth of the full-term newborn is different from that of the premature or underweight newborn, and how it is nourished is definitely the most important factor. Despite this, it is currently believed that weight gain in the first month is approximately 1 kilogram, and it is important to emphasize that at this stage nutrition comes entirely from breast milk, which enables the hydration and nutrition of the newborn (LEONE et.al 2017, American Academy of Pediatrics, 2009).

The acquisition of weight, from the beginning of life, stands out as an important tool for assessing the health and living conditions of the child. Conventionally, body mass is assessed by two factors, weight gain (mass) and body length of the neonate. Parallel to the gain in body mass is the gain in brain mass due to the continued development of the nervous system after birth. Thus, the head circumference is used clinically to evaluate the growth of the neonate and also diagnose changes such as macro and microcephaly (LEONE et.al 2017, ANCHIETA, 2004, Xavier, 1995).

This normal growth is accompanied by a graph called the "Growth Curve", in which the expected increase in the variables mentioned through the weeks after birth is presented. To this end, there are several models of curves, however, none to date is considered ideal and definitive, because this process is determined by variable factors (LEONE et.al 2017, ZEFERINO, 2003; Ministry of Health, 2002).
3.2 CHILD GROWTH

In childhood, the overall development of the body and the renewal of tissues occurs. It involves increased body mass characterizing a process of morphological remodeling and functional maturation, defining the physiological characteristics of the child, differentiating it from the adult. The processes of growth and child development involve different phenomena in their physiological conception, parallel in their course, but associated in their meaning (MONTEIRO, 2016; CRUZ et al, 2018).

There are factors that determine infant growth such as: weight gain, anthropometric indices according to the age and sex of the child, adequate initial sensory capacities (touch, taste, smell, sight, hearing, and primitive reflexes), general and refined motor skills according to the age pattern. Moreover, growth is directly linked to the integration body/environment, which do not necessarily occur at the same speed or sensitivity. Growth is an important indicator of quality of life and child health because of its relationship with socioeconomic, environmental and cultural aspects of the population, i.e., children subjected to adequate health conditions, food and care tend to grow and develop their full potential (MOREIRA, 2011; MONTEIRO, 2016; GAÍVA et al, 2018).

Growth can be characterized in 4 phases: a) phase 1- corresponds to the period of intrauterine growth (conception until birth); b) phase 2- called early childhood (occurs from birth to two years of age); c) phase 3- corresponds to the second childhood (intermediate phase); d) phase 4- called adolescence (final phase of growth) (MOREIRA, 2011).

Under normal conditions, each cell, tissue, and organ grows at their own degrees, patterns, and speeds. There are 4 fundamental types of growth of body structures: 1. general somatic growth (external dimensions, such as muscle and bone tissue, blood volume, organs of the respiratory, circulatory and digestive systems); 2. neural growth: (corresponds to the evolution of the central nervous system and increase in head circumference); 3. lymphoid growth (development of the thymus, lymph nodes, tonsils, spleen and bone marrow); 4. genital growth (maturation of the testicles, ovaries, epididymis, seminal vesicles, prostate, uterus and appendages) (MOREIRA, 2011; CRUZ et al, 2018).
3.3 HUMAN DEVELOPMENT

Human development occurs from conception to death, however, it is most evident during childhood, when the baby learns to communicate, sit, crawl, stand, walk, and hold objects among other skills and functions that are clear signs of the child's evolution (PAPALIA et al, 2013).

Regarding development, it can be understood as gradual change and expansion; progress from simpler to more advanced stages of complexity; emergence and expansion of the individual's capabilities through growth, maturity, and learning (CHAVES et al, 2013). Maturation of motor skills and feeding abilities occur at the same time as the development of the Central Nervous System (CNS) associated with the learning experience (TELLES & MACEDO, 2008). In the first year of life, there is a close relationship between the evolution of the CNS and functions that appear or disappear, reflex functions evolve to complex and voluntary ones; some activities present at birth are "inhibited" in the first year, re-emerging as voluntary and complex activities, automated at a higher level in the Nervous System (TELLES & MACEDO, 2008).

Human development depends on many factors, mainly on that of adaptation, as the major goal is to cope with the constantly changing internal and external conditions of existence. There are two types of developmental change, the quantitative which is linked to the change in weight, height or vocabulary of the child, and the qualitative which is when the individual performs movements or functions that they did not do before, such as walking and talking (PAPALIA et al, 2013).

Growth, in general, is considered as an increase in body size, which ceases with the termination of the increase in height. Thus, to evaluate child growth it is necessary to perform the measurement and monitoring of anthropometric measures of the child, such as: weight, height, cephalic and chest circumference, relating them to each other (CHAVES et al, 2013).

One of the reasons why human development is so complex is that various aspects such as physical, cognitive and psychosocial are interconnected and evolving. Several morphofunctional changes that occur in childhood seem to be related to a maturation of the body and brain, thus, a segment of acquired skills may be interconnected with the physical and cognitive part, such as language acquisition and bipedal gait (PAPALIA et al, 2013).
Motor development evolves in an organized manner, with each stage being a consequence of the preceding one and necessary for the subsequent stage. In the first two years, progressive patterns of global and fine motor and oral motor development are prerequisites for self-feeding skills, favoring the nutritional status and growth of infants (TELLES & MACEDO, 2008).

3.4 PRENATAL DEVELOPMENT

Prenatal development begins at the moment of fertilization. Furthermore, the zygote presents itself after the processes of fertilization and syngamy are successful, becoming an embryo after successive cleavages, which by the end of the second week should be completely implanted in the endometrium (LANGMAN, 2016). During the third week of development there is the formation, through gastrulation, of the 3 germinative embryonic leaflets, endoderm, mesoderm and ectoderm, responsible for the formation of their tissues and organs (BORMEY, 2015). From this moment there is the formation of the primitive heart and the rudimentary vascular system, in addition to the sprouting of the limbs. At the end of the first month the embryo that measures 4 to 5 millimeters undergoes two folds, one longitudinal and one lateral that convert the trilaminar embryonic disk into a cylinder (MOORE, 2016).

The already formed placenta and amniotic cavity are responsible for nourishing the embryo while there is no umbilical cord. The heart, already functioning beats at a rapid rate of on average 150 beats per minute and the first central nervous system synapses in the spinal cord begin to form between the seventh and eighth week (CUNNINGHAM, 2016). At 22 to 24 millimeters in length, it already becomes possible to distinguish, through its growth, the limbs, face and ears that are already on the side of the embryo’s head. The formation of the respiratory system begins with the growth of the intra-segmental bronchial tree that will last until the sixteenth week of development. By the end of the embryonic period, the beginnings of the main organ systems are already established (NAZARI, 2011; MOORE, 2016).

Moreover, from the third month of gestation on, the fetal period begins, extending until birth, being marked by growth and maturation of organs and tissues (LANGMAN, 2016). In this period, there is the development of subcortical brain structures and ossification centers, with differentiation of fingers and toes, in addition to the
development of skin and some appendages such as nails (NAZARI, 2011; CUNNINGHAM, 2016).

The external genitalia of the fetus, now with 6 to 7 millimeters, begins to be formed and the kidneys already begin to produce urine, which can reach 14 milliliters daily (REY, 2001). By the end of the third month all internal organs should be formed, making the fetus able to perform some voluntary movements (MONTANARI, 2013; LANGMAN, 2016). Around the fourteenth week it is already possible to identify the fetus’ sexogenital by means of imaging exams (REY, 2001).

In the nervous system, the maturation of the mesencephalon occurs. The fetus that already measures about 14 centimeters is able to swallow, transport and absorb some molecules such as glucose (KOLDOVSKY, 1965; MILLER, 1982).

In the respiratory system, from the last week of the fourth month of development, each lung bronchiole will give rise to several respiratory bronchioles (NAZARI, 2011; CUNNINGHAM, 2016).

By reaching the middle of gestation, the fetus weighs an average of 600 grams, moving more. Its skin becomes more colored and covered by the lanugo, fine and velvety hair, in addition to the emergence of hair (MOORE, 2016). It is in the period of the sixth month that the phase of mass acquisition intensifies, consisting of an accumulation of fat, however, proportionally its head is still much larger than the rest of the body. Concomitant occurs the myelination of ventral roots of some nerves, however, the final process of myelination occurs after birth (MONTANARI, 2013; CUNNINGHAM, 2016).

From the eighth month of gestation, with 40 centimeters, if delivery occurs, the preterm infant already has a 90% chance of survival without sequelae, this is due to the almost complete maturation of the respiratory system (MONTANARI, 2013; CUNNINGHAM, 2016). In addition, their skin is covered by caseous vernix, a protective fatty substance formed by their sebaceous glands (MOORE, 2016).

At 9 months of gestation, the fetus reaches a head-neck length of approximately 50 centimeters, with complete maturation of the auditory system. The alveolar phase begins, the last stage of maturation of the respiratory system before birth, with the production of surfactant by the type II pneumocytes (LANGMAN, 2016; CUNNINGHAM, 2016). From that moment on, the fetus changes position to favor delivery, which by the ninth month, now at term, is ready for birth, with almost all organs already matured and functional (NAZARI, 2011; MONTANARI, 2013).
3.5 POSTNATAL DEVELOPMENT

The evolution of the organic systems in the human being persists after the period of embryonic development, so that they gradually mature and adapt as functional needs arise. In the first moments after birth, there is a need for insufflation of the lungs to perform gas exchange. The exchange of fluid from the lungs, for air, causes a rapid drop in pulmonary vascular resistance. Concomitantly, the umbilical cord is occluded after birth, increasing systemic vascular resistance. These two events decrease the inflow of blood into the ductus venosus, causing its anatomical closure. On the other hand, the increased oxygen pressure and the fall of prostaglandin E2 (produced by the placenta), causes severe vasoconstriction of the ductus arteriosus in the first 12 hours postpartum, and it closes completely, approximately, after 60 hours in more than 90% of infants (PUTHIYACHIRAKKAL, 2013; NOORI, 2012; WEEB, 2008).

Meanwhile in the left atrium, the greater pulmonary perfusion and consequent elevation of venous return, causes a tendency to flow from left to right, through the foramen ovale. With the shock of the flows coming from opposite directions, the primary and secondary septum are pressed as a valve resulting in the occlusion of the foramen ovale (FAZIO et al, 2010).

The morphological development of the lungs is fully formed in the period before birth, but the alveoli are still immature. With birth, the entry of air and the beginning of lung activity, begins the alveolar maturation that will extend until the age of 8 years. With this, there is an enlargement of the bronchial tree in the region of the base of the lungs stimulated by the increase in the area and growth of the rib cage (RENDAS, 1979).

In addition, it is important to highlight that at the moment of birth, the skull and the brain are not completely formed. The skull bones are separated by membranous bands, where the cranial sutures will be formed; they also present large areas of separation in the angulations of the parietal bones, called fontanelles. These structures are found like this for two reasons: first, because of the heading, which will imply the passage of the baby's head through the narrow birth canal; the second factor is justified by the important growth of the brain, later on. Moreover, the brain continues in an intense process of growth and development due to synaptogenesis, myelination and increased dendritic branching in the postnatal period (PINEL, 2007; TAVANO, 2008).

However, postnatal development does not occur in one direction only. In addition to the growth and evolution of systems, there are also regressive changes, which include
the loss of neurons that are not being activated, in a process called programmed cell death (apoptosis). In some areas of the brain, this process can eliminate up to 80% of the neuronal population (HUTTENLOCHER, 1994).

As for the body composition of the neonate, newborns and children have different proportions, sizes, shapes, and volumes of regions, organs, and structures related to adaptive needs. The upper and lower limbs are proportionally equal in length until about two years of age, when they begin to differentiate. The lower limbs grow, reaching adulthood about 1/6 longer than the upper limbs. This fact is justified by the growth of striated skeletal muscles parallel to bone growth (SCHÜNKE et al., 2006; MOORE & DALLEY, 2007).

Important changes also occur in the topography of the urogenital system. In the fetal period, the already formed pelvic cavity is shallow and after birth, it gradually enlarges reorganizing the abdomino-pelvic organs. In the female newborn, the uterine body is short with a long cervix. In males, the newborn's prostate is large due to maternal hormonal influence. Over time, in the first months of life, the gland decreases in size and restarts growing again slowly and steadily until puberty (TAVANO, 2008).

3.6 HUMAN DEVELOPMENT BY INTRINSIC FACTORS

Human beings are born with a genetic potential for growth that may or may not be reached, depending on the living conditions to which they are exposed from conception to adulthood. Thus, the growth process is influenced by intrinsic (genetic) and extrinsic (environmental) factors (ROMANI et al, 2004).

About 80% of stature is determined by parental size. Regarding genetics, there is no single growth gene. There are hundreds of them that interact with each other and contribute, each one, with a larger or smaller portion to the final stature. In this sense, 423 genes have been identified that interfere with growth. These genes are spread across all the chromosomes. Some are related to the production and action of hormones; others, to cellular function and there is still a large portion of these genes, which are linked to health and development of growth cartilage (SOCIEDADE BRASILEIRA DE PEDIATRIA, 2016).

One of the hormones that stand out during the child development phase is the Growth Hormone (GH), a substance produced by the pituitary gland. Moreover, it acts in strengthening the supply of minerals that are used to promote bone development, also
assisting in the growth of teeth and muscle development (SOCIEDADE BRASILEIRA DE ENDOCRINOLOGIA E METABABOLOGIA, 2018).

GH acts in several ways in the child's body, besides acting by promoting cell growth, which results in increased growth speed, it interferes in the way the body metabolizes protein, fat and sugars. In addition, it acts to improve the functioning of the cardiovascular system and the mood of children (SOCIEDADE BRASILEIRA DE ENDOCRINOLOGIA E METABABOLOGIA, 2018).

Regarding linear growth, it can be said that the final height of the individual results from the interaction between his genetic load and environmental factors, which will allow a greater or lesser expression of his genetic potential (MONTEIRO, 2016).

3.7 HUMAN DEVELOPMENT BY EXTRINSIC FACTORS

Feeding corresponds to one of the main factors responsible for human development. The Ministry of Health advises that until 6 months of age the baby is fed exclusively through breastfeeding and after that complementary feeding should be introduced to meet the nutritional needs of the baby, because in addition to breastfeeding being determinant for the creation of a bond between mother and child, being something that also helps in the development increasing the chances of the child to be more peaceful and sociable during childhood, it has a large amount of nutrients and antibodies important for health due to its power to protect against diseases such as diabetes mellitus, malnutrition, allergies, obesity, caries, etc. (VENDRUSCULO, et al., 2012; COSTA, et al., 2013). The food transition, which begins after 6 months, is also extremely important both in the nutritional issue and in the discovery of new food experiences by the baby as sweet-salty, soft-hard, cold-hot, among others, being an important period for the formation of eating habits and if not performed correctly can make the child vulnerable to the development of school delay and chronic diseases in the future (VENDRUSCOLO, et al., 2012; BARBOSA, et al., 2007; SIMON et al., 2003).

Other extrinsic factors relevant to human development are found in the environmental, social and affective environment. Thus, the child when exposed to different stimuli begins to show molecular and cellular changes, mainly due to neuroplasticity. This process corresponds to the ability of the central nervous system to adapt in response to environmental influences, individual evolutionary character or traumatic injuries (SOUZA, et al., 2013). Experiences influence this process, modifying
sets of neurons from early postnatal life and this process continues throughout life (KOLB, et al., 2017), a wide variation of sensory and motor experiences can generate long-lasting plastic changes in the brain and these experiences can modify the brain in different ways at different ages (KOLB; GIBB, 2011).

The early years of life are essential for human development because of these brain plasticity events. There are many environmental factors that influence this process, such as the socioeconomic level, the culture in which the child is inserted, his family and educational connivance, and the stimuli offered to him (MORAIS, Et al., 2016; ARAUJO; ISRAEL, 2017).

The act of playing is essential for the child intellectual, physical, emotional and social development, because it is a stimulus that generates neuromotor responses and make the child discover the world (YAMAGUCHI; ISRAEL,2017; PFEIFER, Et al.,2009), allowing him to experience a wide variety of experiences and simulate their possible effect in real life (NIJHOF, et al., 2018). The family, the child's first contact, plays an important role in this process, offering affection, security, and necessary stimuli for its development. Thus, studies show that development is closely related to the mother's level of education, since mothers with higher levels of education are more concerned about exposing the child to greater stimulation (MORAIS, et al., 2016; KOBARG; VIEIRA., 2008; MOURA, Et al., 2004). In addition, a creative environment rich in stimuli is essential for neuromotor development (ARAUJO; ISRAEL, 2017) and the socioeconomic aspect may be related to this, the quality of the environment is linked with the monthly income of the family, so families with low income have low environmental quality for good child development (MORAIS, Et al., 2016; LAMY, Et al., 2011; DEFILIPO, et al., 2012; FREITAS, Et al., 2013; MARTINS, Et al., 2004).

Another environment that contributes to the child's development is the infant school, due to the quality of the structure and the amount of stimulation that is provided in this environment (YAMAGUCHI; ISRAEL, 2017; POLETTO; KOLLER, 2008). The neighborhood also plays a role in this process, as parents mediate their children's relationships outside the home, filtering the child's interaction with society which contributes to their cognitive development (MORAIS, Et al. 2016; YAMAGUCHI; ISRAEL, 2017).
4 FINAL CONSIDERATIONS

This study sought to emphasize the factors responsible for the growth and development of the newborn and the child for a better understanding of the various morphological changes that occur in this early stage of life. It is important to highlight that every human being is born with a genetic potential for growth that may or may not be reached, depending on the living conditions to which he/she is exposed from conception to adulthood.
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