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Physical, emotional and social aspects of vulnerability in adolescence

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Abstract
Adolescence is characterized as a transitional period between childhood and adulthood that involves developmental changes in the physical, psychological, social and neurobiological domains. During this phase of life, there are several physical and emotional events regulated by neurohormones which are fundamental for human development, responsible for changes in thoughts, attitudes, and body size and composition which culminate in complete maturity for a laborious and reproductive life. In addition, the necessary insertion in the social environment has great influence on living with family and peer groups, which will help to shape the individual.
This article presents some physical, emotional and social characteristics involved in the adolescent's growth and development process, seeking to highlight the aspects directly related to the vulnerability of human beings in their second decade of life.

Keywords: Adolescence, adolescent vulnerability, risk behavior, adolescent development

Introduction
From the middle of the 19th century adolescence started to be recognized as a fundamental period of human existence for the consolidation of the adult individual. Adolescents represent 16% of the world's population and need to be studied and understood to better receive the comprehensive care that takes into account the socio-cultural insertion, respecting their autonomy as a human being who has rights and responsibilities [1].
Adolescence is characterized as a transitional period between childhood and adulthood that involves developmental changes in the physical, psychological, social and neurobiological domains. Due to these transformations that occur at all systems, adolescents have some important characteristics such as great ability to recognize social and emotional information, high exploration and activity, novelty and sensation seeking, meeting new people, and confronting challenges [2, 3].
During adolescence, there are several physical events regulated by neurohormones - denominated puberty - which are fundamental for human development, responsible for changes in body size and composition, which culminate in complete maturity for a laborious and reproductive life [4, 5].
All events that occur during puberty (physical growth and, mainly, development of secondary sexual characters) can contribute to the adolescent being considered a vulnerable individual.

Vulnerability
As a growing and developing individual, adolescents are intrinsically vulnerable and need to be recognized as such. Part of the vulnerability in this phase of life may be due to biological changes that occur in the central nervous system (CNS) which contribute to a natural increase in tendencies toward sensation seeking and others motivational or emotional changes during pubertal maturation, when young people are exposed to some of the highest safeguarding risks [6, 7].
Vulnerability can be understood as a complex concept that involves the state of dependence, caused by a certain weakness, and the subsequent susceptibility of someone to suffer some loss or damage. It comprises a set of biological, social, cultural and epidemiological factors that limit an individual's ability or freedom to protect themselves from the risks that may be involved in their daily actions [8].

The period of adolescence is the time of developmental and plastic formation of new traits of mature personality. An important characteristic of adolescent behavior is the greater propensity to take risks, characterized by the search for rewards, instead of avoiding punishment.

Adolescents are vulnerable as they expand their lives in domains beyond the control of their families. As they are not yet fully developed the ability to make decisions exposes them to risks and vulnerability to physical and psychological damage that can have a negative impact on their lives [9]. The severity of these risks depends on the challenges they face and the ability to manage them [10].

What can contribute to the adolescent's vulnerability?

Central nervous system development

The neurological development of adolescent, with some structural, neurochemical and molecular changes, is basically directed towards the acquisition of executive skills, the search for immediate rewards and emotional regulation to overcome the transformational events that occur during this period of life [11, 12].

As adolescent development occurs in a heterogeneous manner, with regions developing at different speeds, the functional connections between brain regions are constantly changing during this period. Brain maturation process follow the caudal-to-rostral direction [13] and typical adolescent behaviors, such as sensation seeking and risk-taking, are believed to be linked to continuous changes in brain development during adolescence [14].

The adolescent's brain has great plasticity. Neural plasticity can be defined as an adaptive change in the structure and functions of the nervous system as a function of interactions with the internal or external environment [15]. However, this plasticity can represent a great vulnerability [3] due to structural and functional maturation characterized by a decrease in cortical grey matter volume, progressive increase in white matter volume and density [16], pruning, overproduction of axons, refinement of synaptic connectivity, myelination and maturation of long-range axonal pathways [2], organization of the cytoskeletal with proteins that act on the polarity of axons and growth of dendrites [17].

During the development of the adolescent's central nervous system (CNS), both the limbic system and the prefrontal cortex assume fundamental roles that allow to understand the actions and attitudes characteristic of this phase of life. The limbic system comprises amygdala, hippocampus, nucleus accumbens, thalamus, cingulate spin and is recognized as the neural reward system or pleasure center.

On the other hand, the prefrontal cortex (PFC), which is responsible for making decisions, working memory, perception and attention, is the last structure of the CNS to mature [17]. A development incompatibility between these two regions is responsible for the adolescents' particularly typical attitudes. PFC has an important role in the regulation of emotions, attention, memory and cognition [18].

The reduction in reward sensitivity leads adolescents to seek higher levels of novelty and external stimulation [2], while the self-regulatory executive functions are still maturing. For this reason, adolescents are less capable of regulating and controlling their behavior, presenting poor judgement and lack of impulse control even though they are driven to seek increasing levels of novelty and external stimulation [2, 3]. The consequence of these neuronal transformations in adolescent's CNS is the vulnerability to pathologic insults like stress, drugs of abuse and dietary deficiencies [12].

Myelin provides efficiency and speed in the conduction of the neuronal signal, allowing rapid communication between different brain regions. Situations that cause changes in neural connectivity, for example, due to structural changes in the connection of the white matter pathways, can lead to later psychiatric disorders [19].

Changes in the body

The process of physical changes that occurs in adolescence includes the growth of height and weight, development of systems (mainly cardiorespiratory and reproductive), growth of the skeleton and muscles with increased strength and resistance and changes in body composition which comprises fat, fat mass, and fat-free mass distribution which occurs differently between the sexes.

During adolescence the maxim rate of linear growth is known as peak height velocity. The progression of linear growth starts in extremities, followed by growth of the torso, and upper extremities [20] and it's a period of organization of new bones, elongation of the extremities, and responsiveness of ligaments and tendons to sex steroids action. Skeleton growth occurs due to the mineralization of the short bone nuclei and the long bone epiphyses, replacing the growth plate which is a very fragile region of the bone [21].

There is a window of skeletal vulnerability which coincides with the pubertal growth spurt. Puberty is a biological event of adolescence and represents a period of dynamic physical growth and development that can last from 3 to 5 years. Pubertal maturation is a sequence of stages related to androgenic or estrogenic stimulation that begins with a reactivation of the hypothalamic-pituitary-gonadal axis and influences the entire organism [22].

The pubertal years are critical period for bone mass acquisition which is the amount of bone acquired when accumulation ceases after growth is complete. The greatest gains in bone mass occur approximately 6 months after the adolescent's growth spurt.

Transient decreases in bone strength and bone mineral density during linear growth provide the appearance of fractures [23]. Optimizing bone strength accrual during growth is important for fracture prevention. Adolescence is considered the best time to strengthen bone because periosteal surfaces are rapidly growing. Physical activity during the rapid growing years of adolescence adds bone mass to periosteal surfaces that enhance bone strength.

The development of muscle mass accompanies the velocity of linear growth and the peak increase in muscle strength follows a peak in muscle mass about one year [20]. However, it is still observed a musculoskeletal flexibility due to incomplete development of ligaments, joint capsules, and tendons. Given the rapid growth in height and weight, and the temporary fragility of some structures (growth cartilage, apophysis and joint surface) the adolescent is more susceptible to fractures [20].

For females, there is an additional risk when using contraceptives. Some data suggest that long-term receipt of an oral monophasic contraceptive formulation may result in suboptimal peak bone mineralization because these preparations may suppress the hypothalamic-pituitary-ovarian axis, thereby decreasing endogenous estradiol production [24, 25].

Nutrition

Nutritional needs during adolescence should be sufficient to maintain basal metabolism, promote growth and maturation, support suitable level of physical activity, and attend social demands in general.

During the period of greatest growth speed adolescents have their energy requirement increased from 2300 kcal/day to about 3400 Kcal/day (male) and 2800 Kcal/day (female). This total energy must be obtained through a balanced diet that contains 15% protein, 50% carbohydrate and 35% fat. Among the main micronutrients that need to be part of the adolescents' diet calcium, iron, zinc and vitamin D stand out, fundamental elements for growth and structural differentiation [26, 27].

Over 99% of the body's calcium is found in skeletal stores and, to reach the peak of bone mass, an adequate intake of calcium and vitamin D is necessary. While zinc is essential for growth, sexual maturation, immune function, and wound healing, iron is essential for the formation of hemoglobin and anemia prevention. Iron deficiency anemia, dyslipidemia, obesity, lower bone mass, folate deficiency, obesity, and intestinal constipation are some of the health problems related to an inappropriate diet [27-29]. Iron deficiency, even in the absence of anemia, can lead to reduced work capacity, increased fatigue and learning difficulties [30]. The high consumption of soft drinks can increase the incidence of fractures, reducing participation in extracurricular activities and active sports [31].

Eating habits are influenced by factors such as family, group of friends, financial availability, globalization and media [32]. However, adolescents exhibit various behaviors related to food that can interfere with an adequate intake of nutrients, notably: not having breakfast, modifying the composition of meals, replacing meals with quick snacks, long intervals between meals, preference for high calorie foods and sugar beverages, reduction of some food groups such as milk and dairy products, search for alternative diets (vegetarianism, veganism, etc.), and consumption of nutritional supplements [33-35]. Adolescence is recognized as a critical time point for establishing lifelong health behaviors. Many adolescents consume poor diets, failing to meet the minimum recommendations for fruits, vegetables, whole grains, and dairy products while exceeding the maximum recommended intakes of sodium, saturated fat and added sugars. The utilization of dietetic calcium can be compromised due to the large consumption of soft drinks with high phosphate content (inhibits the action of dihydroxyvitamin D) and snacks with excess sodium (risk factor for urinary sodium loss), interfering in bone mineral density [36, 37].

The diet needs to offer adequate concentrations of omega-3 and omega-6 polyunsaturated fatty acids for normal brain development [12]. Consumption of high fat and sugar foods is associated with poorer performance on hippocampal-dependent memory tasks compromising academic and executive performance in adolescent populations, contributing to social disadvantage when they transition to adulthood [38, 39].

Foods with high caloric value and palatability are capable of influencing the neurodevelopment of frontostriatal and frontotemporal neurocircuits. Palatable foods are known to stimulate brain circuits in a similar way to drugs of abuse, releasing dopamine in the mesocorticolimbic system [40].

Eating patterns such as take away food and chips, fatty dairy products or an unhealthy diet, are associated with poorer mental health outcomes and an increased risk of mental disorders [41-43]. Therefore, adolescents are susceptible to the development of selective eating disorder and food avoidance emotional disorder.

Body image and weight have an influence on eating behavior, inducing dietary restrictions that interfere with nutritional status. Adolescents are aggressively targeted by food marketing messages (primarily for unhealthy foods) and susceptible to this messaging due to developmental vulnerabilities and peer-group influence [44]. Restaurant, food, nutritional supplements, and beverage advertising targeted to adolescents almost exclusively promotes energy-dense nutrient-poor products, especially fast food, sugary drinks, candy, and snacks [45, 46].

Sleep

Sleep is a basic need and fundamental for health and quality of life and sleep deprivation during adolescence is a major problem in modern society [47]. The adolescent is a being biologically programmed to sleep and wake up later, and most of the morning his brain is not awake.

At the beginning of puberty, the adolescent undergoes biological changes in the homeostatic and circadian systems that alter the body's internal clock, altering the release of melatonin at night, which makes sleep difficult [18]. Therefore, there is an asynchrony between the internal pacemaker and the external time [48, 49].

Adolescents need 8 to 10 hours of sleep per night and, for various reasons, (delayed sleep timing, conflict with school start times, electronic media devices use at night or present in the bedroom, shifts in the circadian rhythm, lack of bedtime monitoring, stress at home/school and preference for later bedtime and wake times) this is not followed [18, 50].

The duration of night sleep plays an important role in the health of adolescents, with a significant impact on their physical and psychological well-being. Sleeping for the recommended number of hours on a regular basis is associated with better physical and mental health outcomes, including improved cognitive performance, attention, behavior, emotional regulation and quality of life [18, 51].

Lack of sleep is associated with behavioral and neurocognitive problems, mainly learning disorders and attention deficit, lower academic performance, poor concentration, increased daytime tiredness, mood fluctuations, and reduced opportunities for socialization and search for professional activities [52].

Emotional development

Adolescents are even less able to regulate and control their behavior particularly in emotional and social contexts. During the maturation process of the brain, the adolescent can make decisions guided by the amygdala, a structure responsible for emotions and emotional behaviors, leading to a greater search for rewards because the immature prefrontal cortex still lacks the self-regulatory capacity necessary to properly assess and control impulsivity and risk-taking behavior [53, 54].

The modifications that occur in the adolescent's body are accompanied by emotional, affective and cognitive changes, and the emotional development is particularized for each adolescent in their social context, leading them to a new way of thinking. During this period the definitive emotional structures of the adult personality will be built. From the emotional point of view, the transition from childhood to

adolescence presupposes the loss of the child's body, the child's identity and the childhood parents [55].

The loss of children's identity leads to distance and less interest in parents/relatives and the search for support in peer groups where everyone identifies with each other, aiming for identity and independence. They begin to show signs of rebellion and difficulties in accepting advice from adults. The changes that occur with the body require the adolescent to adapt and accept this new aesthetic conformation. Physical changes in the body, previously graceful and childlike, become perceived and little understood, arousing interest and stimulating, initially as a solitary exploration and, subsequently, with feelings through sexual experimentation, seeking out contact with other people, a situation that triggers eroticism and the search for a partner [55].

Sexual initiation has occurred earlier among adolescents increasing the risk of unplanned pregnancies and sexually transmitted diseases. The thought that "it can't happen to me", the of ten ambiguous messages from the media or colleagues, low self-esteem, families with less parental supervision, low income families, and poor academic achievement has contributed to this reality [56-59].

Thinking, which was previously concrete, becomes abstract, hypothetical-deductive, allowing reasoning about propositions that are not necessarily true, building hypotheses based on assumptions, but still with insecurity when it needs to make decisions and choices. Adolescents create their world with their own social value. As they do not understand what is happening they begin to idealize and fantasize situations to satisfy desires, ignoring and/or opposing the world of adults. They need to try new things, explore and look for new values, and get peer acceptance. They suffer great external influences from the culture of their peers who must satisfy their needs, goals and life model. The critical view of family and society leads them to be omnipotent, as self-assertion, which makes them think they are invulnerable and immune against everything. Egocentrism, demanding attitudes, contestation and religious fanaticism or atheism are also identified at this stage of life. The adolescent finds it difficult to distinguish his thoughts from other people's thoughts, he feels observed and controlled, which characterizes the so-called “imaginary audience” [3].

Other important characteristics of this age group are impulsiveness, exaggerated feelings of invulnerability, curiosity, the need to explore the world, escape unpleasant sensations and improve performance, which increases the risk for inappropriate behavior, predisposition to accidents and exposure to unsafe sex and psychoactive substances [10, 53]. Also, adolescents can be considered hostages to the media that influence self-esteem and self-discovery, while putting young minds at risk of cyber-bullying and exposure to inappropriate content [1].

Body Image

Adolescents are always looking to place their bodies in the historical, social and cultural context in which they live. The social, physical, cultural and psychological changes that characterize adolescence interact with the formation of body image (BI). BI is the mental representation of the body and the way it is perceived involving senses and feelings, being a fundamental aspect for the development of the identity and self-esteem. Adolescence represents a critical period for the healthy body image development due to the transitions that occur during this phase of life [60, 61].

The body undergoes rapid and profound changes and needs to be recognized, understood and adapted to the new social conditions in force imposed by the media or by the peer group. Not always understood, the body tends to be tested to its limits, being used as a way to discharge unpleasant emotional experiences. The experience of having your body changing rapidly, out of your control, generates disturbing feelings such as impotence, fragility and passivity in the face of misunderstood facts, which can cause anxiety, fear and shame that reverberate in the socialization process [15, 62].

Mass media acts a creator of social stereotypes, and are powerful transmitter of societal values and standards, especially those regarding fashion, food, weight and ideal beautiful, and often these patterns are reinforce via family and peer influence [63]. The wide dissemination in the media of standards of beauty, healthy eating and physical activities contributes to the promotion of ideal images for adolescents. This influence of the ideal body pattern can be perceived negatively and lead to the emergence of harmful attitudes such as special diets, excessive training, use of anabolic steroids and plastic surgery. Distortion of body self-perception with negative impact of viewing idealized advertising images on the immediate experience of body image satisfaction can be exacerbated and lead to serious nutritional disorders like anorexia nervosa and bulimia nervosa [63-65].

Social context

The social tasks of adolescent development include to acquiring identity, autonomy and a future orientation toward adult responsibilities.

The current social context has generated adolescents increasingly exposed to risky behaviors, discrimination, bullying, unintentional injuries, and violence. The association between low socioeconomic conditions, with restricts access to goods and services (health care, medicines, school), nutritious foods, leisure activities and opportunities for exercise or social participation and adverse health events has been observed for a long time and in different contexts [66].

In many regions of the world problematic social and racial relationships, poverty, low educational level, and few job possibilities are concerns which might contribute to participation in risky behavior (unsafe sexual activity, risky driving, alcohol or drug intoxication, etc) [9, 67]. Also, adolescents who reside in low-income urban neighborhoods, with systemic discrimination and economic deprivation, are exposed to a range of severe and chronic stressors beyond those that are typical for the general population [68, 69]. Exposure to violence (both as a victim and as a witness) and to other stressors associated with urban poverty contribute to heightened rates of psychological problems among low-income urban youth [69].

Drug abuse

At all times new chemicals are placed on the market, arousing the curiosity and interest of adolescents who are looking for different sensations. Substance use typically begins in adolescence. Illicit drug use can be part of a rite of passage from childhood to the new phase of life, as an attempt to demonstrate rebellion against family or social

authority, or even to agree with peer pressure that requires drug experimentation.

The predominance of the striatal reward function over the cognitive control system of the prefrontal cortex characterizes adolescence as a sensitive period in the development of problematic use of illicit substances [70].

Some causes for the early onset of psychoactive substances are related to the evocation of childhood experiences of stress, such as neglect, neuropsychological impairment, family and peer development and accelerated sexual maturation [54].

The anatomical and functional immaturity of the central nervous system predisposes to behaviors that put adolescents in contact with illicit drugs that, in turn, cause important and definitive cognitive, emotional and functional changes, and long-lasting behavioral and neurobiological consequences [71, 72].

The developing brain is particularly vulnerable to the harmful effects of illicit drugs including tobacco, alcohol, nicotine products, cannabinoids, and other psychostimulants drugs [73, 74]. These substances can compromise the development of the prefrontal cortex and modify reward systems, affecting socio-emotional processing and cognition. Other consequences include anxiety, impaired working memory and increased risk of drug abuse in adulthood [75, 76].

Adolescents' exposure to tobacco/nicotine and alcohol (often associated with energy drinks to increase the excitatory effect), generally considered legal and socially accepted, can lead to subsequent abuse of other substances, triggering a cascade process, difficult to control and with serious consequences [73, 77, 78].

Social media

More and more adolescents have discovered new social environments conducive to building friendships, relationships and minimizing feelings of loneliness on social media, so that digital apps and platforms can be considered an integrant part of their social life [45, 79].

However, studies demonstrate the negative impacts of social media on adolescents' physical and mental health, associating their use with a sedentary lifestyle, poor social interaction, impaired school performance, low self-esteem, anxiety, depression, dissatisfaction with body image and with real life [80-84].

Social media grows very quickly. One of the most recent events that have caused changes in adolescents' relationships and behavior is the so-called "sexting", that is, the dissemination of erotic and sensual content through digital devices. Studies have shown that this practice is associated with unfavorable events such as cyberbullying, grooming, and sextortion [85-87].

The need for self-assertion and the attempt to gain confidence is often expressed in the appreciation of the number of likes that their posts receive with their social status, leading the teenager to create profiles that do not correspond to the reality to be accepted by colleagues [80, 88].

The use of new technologies that allow anonymity combined with the need to follow the rules of your peer group and show adherence to the group has been associated with increased risks of depressive behaviors, anxiety, abuse of illegal substances, paranoia and suicide attempts [79, 80].

Conclusions

The development of adolescents goes through imbalances and instabilities necessary for the modulation of their biological and emotional aspects. In this phase of life, the risk taken and involvement in problematic situations are common due to lack of understanding, underestimation or ignorance in relation to reality [6, 7, 89].

Technological progress combined with new family patterns and current social and cultural demands have not been accompanied by advances that can help adolescents to face these situations. Adults (family members, teachers, health care providers, etc.) can help to reduce the vulnerability of adolescents by supporting them during this phase of transition into adulthood and, when necessary, modifying the world in which they live through education programs and intervention, with the objective of moderating risk behaviors in adolescence [9].

Adolescents are resistant to receiving prior guidance. However, it is important to develop studies that can increase knowledge about their vulnerability and assist professionals in implementing public programs and policies aimed at protecting and providing adequate support to this population.

References

1. Sharma E, Seshadri SP. Adolescence: contemporary issues in the clinic and beyond. Asian J Psichiatry 2020; 47:101-103.
2. Crews F, He J, Hodge C. Adolescent cortical development: a critical period of vulnerability for addiction. Pharmacol Biochem Behav. 2007; 86:189-199.
3. Leshem R. Brain development, impulsivity, risky decision making, and cognitive control: integrating cognitive and socioemotional process during adolescence - an introduction to the special issue. Develop Neuropsychol. 2016; 41:1-5.
4. Vijayakumar N, Op de Macks Z, Shirtcliff EA, Pfeifer JH. Puberty and the human brain: insights into adolescent development. Neurosci Biobehav Rev. 2018; 92:417-436.
5. Cheng HL, Harris SR, Sritharan M, Behan MJ, Medlow SD, Steinbeck KS. The tempo of puberty and its relationship to adolescent health and well-being: A systematic review. Acta Paediatr, 2019. doi: 10.1111/apa.15092. [Epub ahead of print].
6. Dahl RE. Adolescent brain development: a period of vulnerabilities and opportunities. Ann N Y Acad Sci 2004; 1:1-22.
7. Littler N. Adolescent safeguarding: a review of the literature. Nurs Child Young People. 2019; 31:30-35.
8. Adger WN. Vulnerability. Global Environ Change. 2006; 16:268-281.
9. Nightingale EO, Fischhoff B. Adolescent risk and vulnerability: overview. J Adolesc Health. 2002; 31S:3-9.
10. Fischhoff B. Adolescent vulnerability and psychological interventions. Int Encyclop Soc Behav Scien 2001; 1:116-119.
11. Spear LP. Adolescent neurodevelopment. J Adolesc Health 2013; 52:S7-S13.
12. O'Connor RM, Cryan JF. Adolescent brain vulnerability and psychopathology through the generations: role of diet and dopamine. Biol Psychiatry

2014; 75:4-6.
13. Erhardt J, Zagorac I. Neuroenhancement and vulnerability in adolescence. Eur J Bioeth. 2019; 10:149-170.
14. Hammerslag LR, Gulley JM. Sex differences in behavior and neural development and their role in adolescent vulnerability to substance use. Behav Brain Res 2016; 298:15-26.
15. Cousijn J, Luijten M, Feldstein Ewing SW. Adolescent resilience to addiction: a social plasticity hypothesis. Lancet Child Adolesc Health. 2018; 2:69-78.
16. Lamblim M, Murawski C, Wittle S, Fornito A. Social coneectedness, mental health and the adolescent brain. Neurosc Biobehav Rev. 2017; 80:57-68.
17. Shaw GA, Dupree JL, Neigh GN. Adolescent maturation of the prefrontal cortex: role of stress and sex in shaping adult risk for compromisse. Genes Brain Behav 2019, e12626. doi: 10.1111/gbb.12626. [Epub ahead of print].
18. Galván A. The need for sleep in the adolescent brain. Trends Cognit Scienc. 2020; 24:79-83.
19. Vanes LD, Moutoussis M, Ziegler G, Goodyer IM, Fonagy P, Peter B *et al*. White matter tract myelin maturation and its association with general psychopathology in adolescence and early adulthood. Hum Brain Mapp. 2020; 41:827-839.
20. Brown KA, Patel DR, Darmawan D. Participation in sports to adolescent growth and development. Transl Pediatr. 2017; 6:150-159.
21. Gordon CM, Zemel BS, Wren TAL, Leonard MB, Bachrach LK, Rauch F *et al*. The Determinants of peak bone mass. J Pediatr. 2017; 180:261-269.
22. Dai J, Scherf KS. Puberty and functional brain development in humans: Convergence in findings? Dev Cogn Neurosci. 2019; 39:100690. doi: 10.1016/j.dcn.2019.100690. Epub 2019 Aug 8.
23. McKay D, Broderick C, Steinbeck K. The adolescent athlete: a developmental approach to injury risk. Ped Exerc Sci. 2016; 28:488-500.
24. Powell A. Choosing the right oral contraceptive pill for teens. Pediatr Clin North Am. 2017; 64:343-358.
25. Apter D. Contraception options: aspects unique to adolescent and young adult. Best Pract Res Clin Obstet Gynaecol. 2018; 48:115-127.
26. Das JK, Salam RA, Thornburg KL, Prentice AM, Campisi S, Lassi ZS *et al*. Nutrition in adolescents: physiology, metabolism and nutritional needs. Ann N Y Acad Sci. 2017; 1393:21-28.
27. Christian P, Smith ER. Adolescent undernutrition: global burden, physiology, and nutritional risks. Ann Nutr Metab. 2018; 72:316-328.
28. Khan A, Chawla RK, Guo M, Wang C. Risk factors associated with anaemia among adolescent girls: a cross sectional study in District Peshawar, Pakistan. J Pak Med Assoc. 2019; 69:1591-1595.
29. Yackobovitch-Gavan M, Shvalb NF, Bhutta ZA. Malnutrition and catch-up growth during childhood and puberty. World Rev Nutr Diet 2018; 117:129-150.
30. Cairo RCA, Silva LR, Bustani NC, Marques CDF. Iron deficiency anemia in adolescents: a literature review. Nutr Hosp. 2014; 29:1240-1249.
31. Assumpção D, Dias MRMG, Barros MBA, Fisberg RM, Barros Filho AA. Calcium intake by adolescents: a population-based health survey. J Pediatr (Rio J). 2016; 92:251-259.
32. McNaughton SA. Understanding the eating behaviors of adolescents: application of dietary patterns methodology to behavioral nutrition research. J Am Diet Assoc 2011; 111:22622-9.
33. Banna J, O'Driscoll J, Boushey CJ, Auld G, Olson B, Cluskey M *et al*. Parent and household influences on calcium intake among early adolescents. BMC Public Health. 2018; 18:1390-1403.
34. Rodrigues PRM, Luiz RR, Monteiro LS, Ferreira MG, Gonçalves-Silva RMV, Pereira RA. Adolescents' unhealthy eating habits are associated with meal skipping. Nutrition. 2017; 42:114-121.
35. Reichelt AC, Rank MM. The impact of junk foods on the adolescent brain. Birth Defects Res 2017; 109:1649-1658.
36. Beal T, Morris SS, Tumilowicz A. Global patterns of adolescent fruit, vegetable, carbonated soft drink, and fast-food consumption: a meta-analysis of global school-based student health surveys. Food Nutr Bull 2019; 40:444-459.
37. Gracia-Marco L. Calcium, vitamin D, and health. Nutrients. 2020; 12(2). pii: E416. doi: 10.3390/nu12020416.
38. Labouesse MA, Lassalle O, Richetto J, Iafrati J, Weber-Stadlbauer U, Notter T *et al*. Hypervulnerability of the adolescent prefrontal cortex to nutritional stress via reelin deficiency. Mol Psych. 2017; 22:961-971.
39. Dush JL. Adolescent food insecurity: a review of contextual and behavioral factors. Public Health Nurs. 2020; 1:1-12.
40. Corkins MR, Daniels SR, de Ferranti SD, Golden NH, Kim JH, Magge SN *et al*. Nutrition in children and adolescents. Med Clin North Am. 2016; 100:1217-1235.
41. Jack FN, Kremer PJ, Berk M, de Silva-Sanigorski AM, Moodie M, Leslie ER *et al*. A prospective study of diet quality and mental health in adolescents. PLoS ONE 2011; 6:e24805.
42. Heidari Z, Feizi A, Roohafza H, Rabiei K, Sarrafzadegan N. Are dietary patterns differently associated with differentiated levels of mental health problems? Results from a large cross-sectional study among Iranian manufacturing employees. Heidari Z, *et al*. BMJ Open 2019; 9:e020083. doi:10.1136/bmjopen-2017-020083.
43. Jacob L, Stubbs B, Firth J, Smith L, Haro JM, Koyanagi A. Fast food consumption and suicide attemps among adolescents aged 12-15 years from 32 countries. J Affect Disord. 2020; 266:63-70.
44. Truman E, Elliott C. Identifying food marketing to teenagers: A scoping review. Int J Behav Nutr Phys Act 2019; 67:1-10.
45. Fleming-Milici F, Harris JL. Adolescent's engagement with unhealthy food and beverage brands on social media. Appetite. 2020; 146:104501. doi: 10.1016/j.appet.2019.104501. Epub 2019 Oct 25.
46. Evans CEL. Next steps for interventions targeting adolescent dietary behaviour. Nutrients. 2020; 12:1-4.
47. Jamieson D, Broadhouse KM, Lagopoulos J, Hermens DF. Investigating the links between adolescent sleep deprivation, fronto-limbic connectivity and the onset of mental disorders: a review of the literature. Sleep Med 2020; 66:61-67.

48. Ryan W, Brant PL, Erika EH, Peter LF, Franzen MM, Yanhua HT *et al*. Impact of sleep and circadian rhythms on addiction vulnerability in adolescents. Biol Psych 2018; 83:987-996.
49. Bowers JM, Moyer MA. Adolescent sleep and technology-use rules: results from the California Health Interview Survey. Sleep Health. 2020; 6:19-22.
50. Quante M, Khandpur N, Kontos EZ, Bakker JP, Redline S. Let's talk about sleep": a qualitative examination of levers for promoting healthy sleep among sleep-deprived vulnerable adolescents. Sleep Med. 2019; 60:81-88.
51. Orben A, Przybylski AK. Teenage sleep and technology engagement across the week. Peer J 2020; 8:e8427. doi: 10.7717/peerj.8427.
52. Matos MG, Marques A, Peralta M, Gaspar T, Simões C, Pinto HR *et al*. Sleep in adolescence: sex matters? Sleep Sci. 2019; 12:138-146.
53. Kuzma EK, Peters RM. Adolescent vulnerability, sexual health, and de NP's role in health advocacy. J Am Assoc Nur Pract. 2016; 28:353-361.
54. Chwedorowicz R, Skarżyński H, Pucek W, Studziński T. Neurophysiological maturation in adolescence - vulnerability and counteracting addiction to alcohol. Ann Agric Environ Med. 2017; 24:19-25.
55. Aberastury A, Knobel M. La adolescencia normal. Buenos Aires, Paidós, 1971
56. Lara LAS, Abdo CHN. Age at time of initial sexual intercourse and health of adolescent girls. J Pediatr Adolesc Gynecol. 2016; 29:417-423.
57. Furlanetto MF, Ghedin DM, Gonçalves TR, Marin AH. Individual and contextual factors associated with sexual initiation among adolescents. Psicol Reflex Crit. 2019; 32:25-33
58. Nogueira-Avelar E, Silva R, Raat H, Reitz E, Plat M, Deković M *et al*. Longitudinal associations between sexual communication with friends and sexual behaviors through perceived sexual peer norms. J Sex Res. 2019; 21:1-10.
59. Lindberg LD, Maddow-Zimet I, Marcell AV. Prevalence of sexual initiation before age 13 years among male adolescents and young adults in the United States. JAMA Pediatr. 2019; 173:553-561.
60. Jasik CB. Body image and health. Prim Care Clin Office Pract. 2014; 41:519-537.
61. Jiménez-Flores P, Jiménez-Cruz A, Bacardi-Gascón M. Body-image dissatisfaction in children and adolescents: a systematic review. Nutr Hosp. 2017; 34:479-489.
62. Voelker DK, Reel JJ, Greenleaf C. Weight status and body image perceptions in adolescents: current perspectives. Adolesc Health Med Ther. 2015; 6:149-158.
63. Burnette CB, Kwitowski MA, Mazzeo SE. "I don't need people to tell me I'm pretty on social media:" A qualitative study of social media and body image in early adolescent girls. Body Image. 2017; 23:114-125.
64. Durkin SJ, Paxton SJ. Predictors of vulnerability to reduced body image satisfaction and psychological wellbeing in response to exposure to idealized female media images in adolescent girls. J Psychosom Res. 2002; 53:995-1005.
65. Vaquero-Cristóbal R, Alacid F, Muyor JM, López-Miñarro PÁ. Body image: literature review. Nutr Hosp 2013; 28:27-35.
66. Desmond C, Seeley J, Groenewald C, Ngwenya N, Rich K, Barnett T. Interpreting social determinants: Emergent properties and adolescent risk behaviour. PLOS ONE | https://doi.org/10.1371/journal.pone.0226241 December 26, 2019.
67. Jenkins LM, Chiang JJ, Vause K, Hoffer L, Alpert K, Parrish TB *et al*. Subcortical structural variations associated with low socioeconomic status in adolescents. Hum Brain Mapp. 2020; 41:162-171.
68. Resnick MD. Protective factors, resiliency and healthy youth development. Adolesc Med. 2000; 11:157-164.
69. Reife I, Duffy S, Grant KE. The impact of social support on adolescent coping in the context of urban poverty. Cult Div Ethnic Min Psychol, 2019, 22. doi: 10.1037/cdp0000296. [Epub ahead of print].
70. Guerria C, Pascua M. Impact of neuroimmune activation induced by alcohol or drug abuse on adolescent brain development. Int J Dev Neurosc 2019; 77:89-98.
71. Gould TJ. Addiction and cognition. Addict Sci Clin Pract 2010; 5:4-14.
72. Mooney-Leber SM, Gould TJ. The long-term cognitive consequences of adolescent exposure to recreational drugs of abuse. Learn Mem. 2018; 25:481-491.
73. Ren M, Lotfipour S. Nicotine gateway effects on adolescent substance use. West J Emerg Med 2019; 20:696-709.
74. Jadhav KS, Boutrel B. Prefrontal cortex development and emergence of self-regulatory competence: the two cardinal features of adolescence disrupted in context of alcohol abuse. Eur J Neurosci. 2019; 50:2274-2281.
75. Salmanzadeh H, Ahmadi-Soleimani SM, Pachenari N, Azadi M, Halliwell RF, Rubino T *et al*. Adolescent drug exposure: a review of evidence for the development of persistent changes in brain function. Brain Res Bull. 2020; 156:105-117.
76. Tervo-Clemmens B, Quach A, Calabro FJ, Foran W, Luna B. Meta-analysis and review of functional neuroimaging differences underlying adolescent vulnerability to substance use. Neuro Image. 2020; 209:1-12.
77. McCool BA, McGinnis MM. Adolescent vulnerability to alcohol use disorder: neurophysiological mechanisms from preclinical studies. Handb Exp Pharmacol 2019. doi: 10.1007/164_2019_296. [Epub ahead of print].
78. Squeglia LM, Jacobus J, Tapert SF. The influence of Ssbstance use on adolescent brain development. Clin EEG Nuerosc. 2009; 40:1-8.
79. Crone EA, Konijn EA. Media use and brain development during adolescence. Nat Comm 2018; 9:588-593.
80. Shah J, Prithwijit D, Nallammai M, Milanaik R. New age technology and social media: adolescent psychosocial implications and the need for protective measures. Current Opin Pediatr. 2019; 31:148-156.
81. Kelly Y, Zilanawala A, Booker C, Sacker A. Social media use and adolescent mental health: findings from the UK millennium cohort study. E Clin Med 2019; 6:59-68.
82. Rajamohan S, Bennett E, Tedone D. The hazards and benefits of social media use in adolescents. Nursing 2019; 49:52-56.
83. Odgers CL, Jensen MR. Annual Research Review:

Adolescent mental health in the digital age: facts, fears, and future directions. J Child Psychol Psychiatry, 2020. doi: 10.1111/jcpp.13190. [Epub ahead of print].
84. O'Reilly M. Social media and adolescent mental health: the good, the bad and the ugly. J Ment Health 2020 Jan 28:1-7. doi: 10.1080/09638237.2020.1714007. [Epub ahead of print].
85. Strasburger VC, Zimmerman HZ, Temple JR, Madigan S. Teenagers, sexting, and the law. Pediatrics 2019; 143:e20183183.
86. Shafer A. Advancing research on adolescent sexting. J Adolesc Health. 2019; 65:711-712.
87. Soriano-Ayala E, Cala VC, Dalouh R. Adolescent profiles according to their beliefs and affinity to sexting. a cluster study. Int J Environ Res Public Health 2020; 17:1087; doi:10.3390/ijerph17031087.
88. Vannucci A, Simpson EG, Gagnon S, Ohannessian CM. Social media use and risky behaviors in adolescents: A meta-analysis. J Adolesc. 2020; 79:258-274.
89. Quadrel MJ, Fischhoff B, Davis W. Adolescent (in) vulnerability. Am Psychol. 1993; 48:102-116.