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Review article

Paediatric obesity and cardiovascular risk factors – A life course approach

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ABSTRACT

Childhood obesity is increasingly prevalent worldwide, and Portugal presents one of the highest prevalence of obesity and overweight among the European countries. Since childhood obesity is a risk factor for obesity in adulthood, the high prevalence of overweight and obesity in paediatric age currently experienced is expected to lead to even higher prevalence of obesity in adulthood in future decades.

It is well known that the prenatal period and infancy are critical or sensitive periods for obesity development, but a growing body of evidence also suggests a relevant role of childhood and adolescence. The exposure to some factors during these periods or specific time frames within these periods may confer additional risk for obesity development.

Paediatric obesity is associated with cardiovascular risk factors both in the short or medium-term, but also in the long term, conferring additional risk for future adult health. However, it is not clear whether the relation between paediatric obesity and adult health is independent of adult adiposity. There is a moderate to high tracking of obesity from paediatric age into adulthood, which may partially explain the association with adult outcomes. Therefore, there has been increasing interest on life course frameworks to study the effect of the dynamics of adiposity across paediatric age on adult outcomes, namely on the cardiovascular disease risk. The use of this approach to study determinants and consequences of obesity raises methodological challenges to summarize the exposure to adiposity/obesity across the life span, being the identification of growth trajectories and the quantification of the duration of obesity among the most used methods. However, further investigation is still needed to explore the best methods to summarize exposure to adiposity and its variation across time.

Paediatric obesity

Prevalence and trends

High prevalence of obesity is a major public health concern and obesity is acknowledged as a global pandemic.[1] The Global Burden of Disease (GBD) Study 2013 reported an increase in worldwide prevalence of overweight and obesity between 1980 and 2013.[2] The GBD Study 2013 used data from surveys, reports, and published studies with physical measurements or self-reported height and weight, and presents detailed estimates of overweight and obesity by region and country, for both children and adults.[2] Data from this report estimated 2.1 billion overweight and obese individuals worldwide in 2013, reflecting the rise of 27.5% in the prevalence of overweight and obesity in adults and of 47.1% in children in the period from 1980 and 2013.[2] The rate of increase was higher from 1992 to 2002, and slowed down in the past decade, particularly in developed countries, but prevalence is still increasing in most countries.[2]

Considering the age strata, the analysis of trends in obesity prevalence over successive birth cohorts showed that the most rapid weight gains have occurred in the age group of 20–40 years, in both developed and developing countries, and that peak prevalence of obesity was moving to younger ages in developed countries.[2] Prevalence of obesity in paediatric age has markedly increased since 1980, in particular in developed countries: from 1980 to 2013 it increased from 16.9% to 23.8% in boys, and from 16.2% to 22.6% in girls.[2] In Portugal, information on national data on paediatric obesity collected by routine is scarce and surveillance initiatives on childhood obesity have been implemented just in recent years.[3] Estimates from the GBD Study 2013 using secondary

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data sources reported for Portugal 28.7% of overweight and obesity in children and adolescents (<20 years) for boys and 27.1% for girls, which is above the average estimate for the Western Europe: 24.2% and 22.0%, respectively.[2] The WHO European Childhood Obesity Surveillance Initiative (COSI) was established in 16 countries to measure trends in overweight and obesity in children aged 6.0–9.0 years.[4] Data collected in this context showed that Portugal was one of the European countries presenting the highest prevalence of obesity and overweight.[4] In 2007/2008 prevalence of overweight (>1 *z*-score, according to WHO growth reference) was 40.5% in 7-year-old boys and 35.5% in girls; the respective estimates in 2009/2010 were 31.5% and 36.2%.[4] A previous cross-sectional national study developed in 2002/2003 had reported 20.3% of overweight (excluding obesity) and 11.3% of obese children aged 7–9.5 years, but using the IOTF criteria.[5]

For Portuguese adolescents, repeated national data on obesity is available from the Health Behaviour in School-aged Children (HBSC), a WHO cross-national survey conducted every four years in 44 countries and regions across Europe and North America.[6] The self-reported data showed that among Portuguese adolescents from the 6th, 8th and 10th grades there was 18.2% of overweight and obesity combined in 2014, according to the IOTF reference, and prevalence was higher in boys.[7] The comparison with previous HBSC surveys showed stable estimates of overweight and obesity since 2002.[7,8]

Objectively measured data on weight and height of adolescents is not collected at the national level in Portugal, on a regular basis. Only cross-sectional studies are available at national level in adolescents, and some cross-sectional or cohort studies at regional or local level. A national cross-sectional school-based study in 2008 including over 22,000 children and adolescents aged 10–18 years of age, found 17.4% of overweight and 5.2% of obesity, according to IOTF cut-offs.[9] A review on obesity in Portuguese children and adolescents published in 2011, which included studies since 2007 from specific regions or communities, reported estimates based on IOTF cut-offs ranging from 13.4% to 28.6% in males and from 8.8% to 25.6% in females for overweight for adolescents (10–19 years); estimates for obesity varied between 3.2% and 13.0% in males, and from 0.6% and 5.8% in females.[10] Longitudinal data is scarce, but in the EPITeen cohort, which recruited 13-year-old adolescents enrolled at schools of Porto in 2003/2004, the prevalence of obesity at the baseline was 11.3% in boys and 9.2% in girls and the prevalence of overweight 16.9% and 16.0% respectively for boys and girls, according to the CDC reference.[11] Data from the follow-up of participants showed a mean decrease in the body mass index (BMI) *z*-score between 13 and 17 years, resulting in a decrease in the prevalence of obesity to 7.8% in boys and 3.8% in girls.[12]

Although the lack of harmonized, objectively measured data, and collected on a regular basis on obesity in paediatric age in Portugal, available data suggest that Portugal presents one of the highest prevalence of paediatric obesity and overweight among the European countries.[2,4] Since childhood obesity is a risk factor for obesity in adulthood, the high prevalence of overweight and obesity in paediatric age currently experienced by our country, as well as in most countries, is expected to lead to an even higher prevalence of obesity in adulthood in future years and decades.[13,14]

Critical and sensitive periods for obesity development

A growing body of evidence shows that there are critical or sensitive periods across the life course for obesity development.[15–17] Critical periods refer to specific stages of the development during which exposure to specific environmental stimuli may confer permanent anatomical or functioning changes with consequences for long-term effects of specific outcomes.[16,18,19] These are specific time frames, during which exposures may confer increased risk of disease, but outside those time frames exposure to those factors do not confer additional risk of disease. A sensitive period refers to time frames of also rapid development, during which a greater effect of exposure to some factor is stronger in comparison to exposure outside that period, but that effect may be modified or reversed.[18,19]

Foetal life is an example of a critical period, since tissues and organs systems undergo profound development and exposure to specific factors may irreversibly "programme" physiological functioning, playing an important role in disease aetiology.[16,20,21] Adolescence, on the other hand, may be considered a sensitive period since a range of different developmental stages occur at variable time periods, and a specific critical period may not exist. However, in the literature the prenatal period, infancy, childhood and also adolescence are all usually identified as critical periods for obesity development.

Prenatal period and infancy

Regarding the prenatal period and infancy, observations that maternal nutrition could impact on offspring obesity were firstly described in the Dutch Hunger Winter Study in the 1970s.[22] This study showed that 19-year-old males who had been exposed to famine in the first two trimesters of gestation, due to severe food rationing imposed in the winter and spring 1944–1945 during the Second World War, had higher prevalence of obesity, in comparison to those exposed in the other trimesters.[22] Later epidemiological studies by Barker et al.[23–25] on the association between rates of infant mortality and adult deaths (ecological analysis) and on the association between birthweight and adult mortality from ischaemic heart disease conducted to the developmental origins theory, also known as the "Barker's hypothesis".[26] This theory suggests that undernutrition during gestation may lead to foetal programming that changes body's structure, function, and metabolism with implication in the aetiology of adult coronary heart disease.[26] This theory was later expanded to the Developmental Origins of Health and Disease (DOHaD)[27,28] incorporating the effect of broader environmental exposures (nutrition, environmental chemicals, drugs, infections, or stress), not only in pregnancy but also in preconception period and in infancy, due to developmental plasticity, on widespread consequences for later health including obesity. In line with this theory several studies have shown that factors such as maternal obesity, nutrition and stress, exposure to chemicals during pregnancy and rapid postnatal weight gain are associated with obesity.[29,30] Mechanisms might include epigenetic processes, such as DNA methylation, that alter gene expression and increase susceptibility for later disease, but also shared social influences across generations.[19,29,30] The inter-generational effects of disease susceptibility seems not to be restricted to one generation, since some studies have shown associations across at least three generations.[31]

Childhood

Adiposity rebound occurring at mid-childhood is also acknowledged as a critical period for obesity development.[15,16] Adiposity increases during the first year of life, and then a decline is observed until a minimum (nadir) reached at approximately 6 years of age; the increase in adiposity registered after that nadir was firstly described as adiposity rebound by Rolland-Cachera et al.[32] The timing of the adiposity rebound was shown to predict later adiposity levels; the earlier the age of adiposity rebound, the greater the degree of adiposity in adolescence and in young adulthood.[32,33] Several studies have replicated the findings on the association between early adiposity rebound and obesity later in life.[16,34] As shown by Taylor et al., the difference in BMI at 18–21 years can be around 3 BMI units higher for those with early adiposity rebound (<5 years), compared to those with late rebound (>7 years).[34]

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