ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

Review on Childhood Obesity: Discussing Effects of Gestational Age at Birth and Spotting Association of Postterm Birth with Childhood Obesity

Manish Prasad Gupta
Department of Pediatrics, Shanghai First Maternity and Infant Hospital, Tongji University School of Medicine
2699 Gaoke Road, Shanghai, China

Abstract:- Overweight and obesity in children and adolescents and its negative effects on health, including increased risks of long-term diseases like type II DM, CVD, dyslipidemia, , stroke, hypertension, respiratory issues, gallbladder disease, sleep apnea, osteoarthritis, along with certain malignancies, which are already identified during the perinatal and prenatal period is one of the most important worldwide health concerns of the twenty-first century. To overcome the current epidemic of overweight and obesity, obstructing their risk factors is important in an effort to prevent the development of obesity and overweight. Multiple epidemiological research studies have shown a connection between BMI acquired later in life and birth weight; however, the results are constrained by the absence of information on gestational age. Majority of studies reported relation of childhood obesity with the preterm born children in study of relation with the gestational age. Although more likely to become obese in later adulthood, preterm and low birth weight born child are small and/or lean at birth, whereas post-term usually not and above all, children born postterm showed signs of a rapid weight gain that led to obesity decades early. Thus, the purpose of this review study is to determine the impact of the gestational age at delivery and to provide an overview of the evidence supporting the link between childhood obesity and post-term birth.. Thorough systemic review conducted on online database Pubmed, Google Scholar and found only few studies on association with the post-term born children. Limited evidence necessitated the studying of additional adult post-term cohorts to accurately determine future risks to health and to investigate these potential metabolic alterations, as well as if the alterations in adiposity continue or get worse throughout adulthood, and how these correlations vary in adult born post-term in terms of pattern and amplitude.

Keywords:- *Gestational Age at Birth (Postterm, Early Term, Full Term, Preterm); Childhood Obesity; Adiposity; Overweight.*

I. INTRODUCTION

Obesity in children has emerged as a major worldwide public health challenges[1] and within the course of the last 20 years, its prevalence has sharply increased in many developed nations [2]. The rising prevalence of juvenile obesity and its connection to obesity in adulthood has turned into a worldwide health concern, with a prolonged obese condition raising the risks of consequences related to obesity [3, 4] such as increased incidence of adult obesity related risk of chronic diseases like cancer, cardiovascular disease and type II diabetes, which may precede premature mortality[5-8]. Due to high prevalence and risk of childhood obesity, it must be controlled with immediate and effective interventions with more studies and research required which must focus on providing insights into the underlying modifiable factors of obesity in children.

The term Childhood obesity is the accumulation of extra body fat and the proliferation of excess adipocytes [1]. Body mass index (BMI), which is determined from the individual’s height and weight measurements (BMI = weight/height (kg/m2)), is the recognised clinical reference for assessing overweight and obesity for children aged 2 years and up [9-13]. Generally, BMI provides a decent estimate of adiposity in the healthy paediatric population [14]. However, a significant percentage of children with decreased muscle mass from inactivity may have their adiposity undervalued due to overestimating of fatness in little children or those with relatively high muscle mass [15]. As such, BMI ought to be considered a proxy for obesity [16] and the weight for length is the recognised indicator of obesity and overweight in children under the age of two. With respect to age and sex, BMI varies substantially during early and late stage of life. Consequently, in contrast to adults, BMI cut-off points used to categorise childhood and adult obesity should be sex–age-specific [17]. In order to evaluate abdominal adiposity, waist-to-hip ratio and waist circumference could be the measurement of choice, however, skinfold thickness is useful in determining adiposity [9, 18-21].

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

➢ *The Following are BMI-based Classifications of Overweight and Obesity for Child and Adolescents Ages 2 to 20 Years [12]:*

- Overweight: BMI more or equal to 85th to less than 95th percentile for sex and age
- Obesity: BMI more or equal to 95th percentile for sex and age
- Severe obesity: BMI more or equal to 120% of the 95th percentile, or BMI more or equal to 35 kg/m2 (whichever is lower) [22, 23]. This correlates to about the BMI z score at or above 2.3 above the mean, or the 99th percentile [24, 25].

Obesity in children is the result of a complicated interaction of several inheritable, ecological and socioeconomical variables, including the family, community, and school [16]. While earlier epidemiologic research focused at risk hazards for childhood and adulthood, current longitudinal research has brought attention to the vital significance of earlier experiences of life, encompassing those that occur prior to birth [26] or prenatal and perinatal variables. Various organ system's functional maturation, cellular differentiation and replication, and the rapid growth of the body occur throughout the time from conception to birth [27]. According to study of the literature, relationship among birth weight and birth length with childhood obesity has been documented in a number of research, the majority of which found a positive correlation of birth weight with childhood obesity [28]. However, limited studies have been reported focusing gestational age at birth as the predictors of childhood obesity. The majority of those investigations have demonstrated the correlation of low gestational age or children born preterm and term [29-31] with the childhood obesity with only few study reported association with post-term born children [26, 32-36]

Obesity and overweight and majority of their associated morbidity are preventable. Therefore prevention must be given top attention. Also because of the fact that obesity is notoriously challenging to manage, hence prevention alone is most important step to overcome that epidemic. Inspired by the concept that early life and perinatal environments can have a significant impact on long-term health, a new preventative paradigm has surfaced in the last few years [28]. A broad understanding of the effect of perinatal factors especially gestational age at birth on childhood obesity will aid in directing efforts at intervention and creating successful population-based initiatives and regulations to overcome the epidemic and morbidity related to childhood obesity. For this reason, the goal of this review study is to discuss effects of gestational age at birth and to analyse the association of postterm born children with the childhood obesity. In order to locate journal for this study's review, a search was conducted using keywords as childhood, children, child, overweight, obesity, BMI, body mass index, adiposity, gestational weeks, gestational age at birth, post maturity and postterm on internet databases PubMed and Google Scholar.

II. EPIDEMIOLOGY OF CHILDHOOD OBESITY

In recent decades, there has been an increase in the prevalence of obesity and overweight among children and adolescents worldwide. [37]. The prevalence varies by age and gender and is highest in western and industrialised nations, but is relatively low in certain developing nations. [17]. As per WHO , the prevalence of obesity and overweight was higher in Americas and eastern Mediterranean areas (30–40%) than in the European region (20–30%), African regions, south-east Asian, western Pacific (10–20% in the latter three) [17]. According to the research, between 1980 to 2013, there is 47.1% increase in prevalence of overweight and obesity combined seen worldwide [38]. In 2013, the overall percentage of boys and girls with overweight or obese were approximately 12.9 and 13.4% respectively in developing nations, while 23.8 and 22.6% respectively were observed in developed nations [38]. An increase in childhood obesity was also observed in China [39, 40]. In China, an estimated 30.4 million people (or 5.1 and 9.9% of adolescents and school-age children, respectively) were overweight or obese in 2010. [41]. The percentage of overweight and obesity among Eastern and western Asia countries was 24.5% and 11.9% respectively [42]. In 2008, 170 million children under the age of 18 were assessed to be overweight or obese, and by 2030, it is predicted that 30% of all children will be affected [43, 44]. Trends in BMI for children and adolescence have accelerated in some parts of Asia and are no longer connected with those of adults, while they have plateaued in many developed nations, despite still being at high levels [45]. Asian countries had the greatest prevalence rate of adolescent obesity, according to a comparison study conducted across emerging nations. [46].

Furthermore, there is variation of prevalence of childhood obesity within nations across Asia: over 65% in the Maldives to 3.5% in rural Bangladesh [47], 30% in Saudi Arabia and Iran and approximately 12.5% in children of China [48]. According to a systematic review and meta-analysis research of Asian countries, the pooled prevalence (overall, girls and boys) of obesity in children aged 5 to 11 years was 5.8%, 4.8% and 7.0% respectively and 8.6%, 6.2% and 10.1% respectively for obesity in adolescents age 12–19 years. Additionally, the percentage of overweight children (overall, girls and boys) were 11.2%, 10.9% and 11.7% respectively; and for adolescents overweight, the percentage were 14.6%, 13.7% and 15.9% respectively [49].

III. AETIOLOGY AND RISK FACTOR OF CHILDHOOD OBESITY

Over the past few decades, there has been a global rise in the prevalence of paediatric obesity. A deeper comprehension of the underlying causes of paediatric obesity is necessary to stop the trend through improved preventive and intervention techniques. [50]. Obesity is the result of complex interactions of multiple factors and the emergence of obesity is strongly influenced by both heredity and the environment. [50]. Pregnant mothers' lifestyle, early nutrition for their child, and their upbringing environment

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

are all thought to be important factors in preventing childhood obesity. [51]. Environment, behaviour, genetics and biology which favour an unfavourable balance between an individual's energy intake and expenditure are among the factors that contribute to childhood obesity. [52]. However, there are also other relevant factors including intrauterine factors, physically active, dietary habits, duration of sleep and socio-economic condition [50]. Studies finding relation with maternal and paternal BMI study reported that childhood obesity is related to father's BMI [53, 54]. The key role in the development of syndrome of metabolism, type II DM and obesity in the offspring is played by the intrauterine environment where the fetus grows [55, 56]. Figure 1 presents the conceptual framework of major risk factor correlated with childhood obesity.

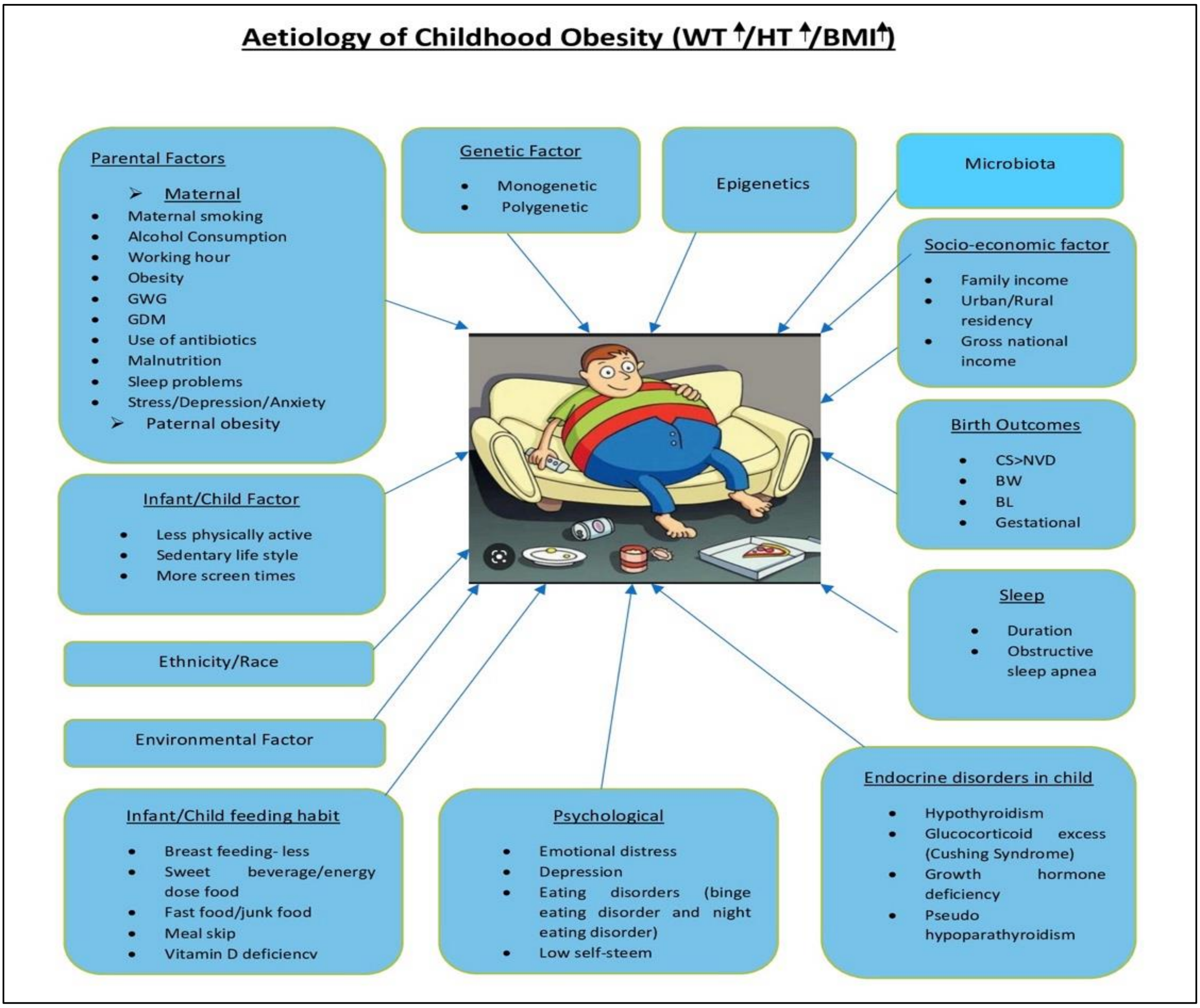

Fig 1 Major Risk Factors Associated with Childhood Obesity

IV. ASSOCIATION OF CHILDHOOD OBESITY WITH PRENATAL, PERINATAL AND POSTNATAL FACTORS

This is the crucial period of foetus and infant when programming of body composition occurs. Infant obesity develops as a result of both prenatal and early postnatal influences, such as intrauterine gain of weight or breastfeeding [57]. Prenatal and postnatal variables that cause excess adiposity in children also affect parental obesity and genetic variations of obesity-related genes in children and parents. [58, 59]. Various research and studies has been conducted till date correlating prenatal and postnatal variables linking emergence of newborn adiposity and obesity in children such as study of preterm and LBW [60-62], diabetes during pregnancy [63], gestational weight gain [64] and formula feeding to the infants [65]. Not only LBW or preterm born children develop adiposity but also term born children of large for gestational age (LGA) [66-68]and small for gestational age (SGA) [69] were affected by the increased adiposity. The overall determinants influencing the infant adiposity and childhood obesity is summarized in Table1.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

Table 1 Determinants of Childhood Obesity

Prenatal factors	Perinatal factors	Postnatal factors
Pre-pregnancy maternal BMI Gestational weight gain Paternal obesity Gestational Diabetes Mellitus Maternal malnutrition Alcohol consumption during pregnancy Diet during pregnancy- high free sugar intake, less consumption of polyunsaturated fat	Birth weight Birth length SGA/LGA Gestational age at birth	Breast feeding Formula feeding Rapid infant growth Macronutrient intake during infancy- high protein intake, sugar sweated beverages Sleep duration screen time

V. EFFECTS OF GESTATIONAL AGE AT BIRTH ON CHILDHOOD OBESITY

Apart from the various epidemiological studies focusing on the adult and childhood risk factors, a number of recent research has mostly examined early life experiences, as well as prenatal events, such as foetal life. [70]. According to numerous studies in the literature, newborn adiposity is a stronger predictor of appropriate intrauterine growth and, as such, may be a better precursor of obesity in later life. [51, 56, 71-73]. A review of the literature revealed that most research observed a positive correlation among newborn weight at birth and childhood obesity [28], with number of studies examining the correlation of childhood obesity with birth weight and length. However, those studies have to deal with important limitation of incomplete data regarding gestational age.

Gestation is the critical period for human development. Neonatal body composition is influenced by gestation and perinatal factors [74]. During study of infant within 4 days of life, it has been concluded that %BF (percentage body fat) increased significantly with gestational age [75] and also reported in another study that greater adult weight and BMI were correlated with longer gestational [32]. Gestational age at birth was significantly correlated with child's BMI in the first decade of life [76]. Various definition of gestation used in the clinical practice in the past and categorized them into prematurity (<37gestational weeks), term (37-42 gestational weeks) and post term (>42 gestational weeks). Within this 5-week gestational age range of term gestation, there is variance in the increased perinatal and neonatal morbidity especially respiratory disease in newborn which is related to morbidity encountered by both preterm and postterm born children. For this justification, it was believed that additional classifications would be assumed into early term (37 0/7 - 38 6/7 gestational weeks), full term (39 0/7 - 40 6/7 gestational weeks), and late term (41 0/7 - 41 6/7 gestational weeks) [78]. This 5-week span is also considered crucial as the foetal maturation pathway seems to be ongoing [79] which is subsequently linked to the children's short- and long-term morbidity [80, 81].

After a study of the literature, majority of the studies for various endocrine and metabolic disorders in children and adolescence such as hypothyroidism [82, 83], insulin insensitivity [84-86], overweight and obesity [87, 88] have listed preterm (<37 weeks of gestation) as a risk variable. As preterm children follow their childhood development into school age, their growth differs from that of children born fullterm [89-95]. The entering phase of growth of preterm born infant adapts to extra uterine environment that could indicate an environment mismatch outside of utero, resulting in changes to body composition [56, 96-100]. There is a correlation between gestational age at birth and preterm births reported in previous research on altered adiposity, obesity, cardio-metabolic risk factors, such as insulin resistance, hypertension and impaired glucose control, as well as delivery methods [88, 101-107]. Additionally, the study found that within the first two years of life, extremely preterm (23–27 weeks of gestation) and very preterm (28–31 weeks of gestation) newborns usually experience postnatal growth failure followed by catch-up weight and length growth [108]. Study on association of childhood obesity with entire category of gestational age at birth have reported that extremely rapid weight gain is observed in early term and late preterm born children in the initial 4 month of life which is the significant indicator for obesity tracking up to the age of 7 years [31]. Similar predisposition of early term association was also observed in other study [109-111]. There aren't many studies available on the connection between childhood obesity and post-term births, with four studies displaying evidence of positive association with the childhood overweight and obesity [26, 32, 33, 36], while remaining two studies shows no effect on children's BMI or adiposity displaying negative association [34, 35].

VI. ASSOCIATION OF POSTTERM BIRTH AND CHILDHOOD OBESITY

Even though post-term birth has no known long-term consequences, in addition to preterm birth and low birth weight, it has been linked to higher perinatal morbidity and death [112, 113]. Due to a poor foetal environment caused by insufficient nourishment or physiological stress, a prolonged gestation may result in long-term postnatal abnormalities in body composition and detrimental metabolic consequences. [26, 32]. It has been proven that the observed metabolic and body composition abnormalities such as high blood pressure, increased fat mass and lower insulin sensitivity in post term children are comparable to small for gestational age (SGA) and preterm born children [26, 33] which was also supported by other studies reporting similar type of abnormalities in adults and children who were born SGA or premature [86, 114-116].

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

After searching for the association of post-term birth with childhood obesity, only few studies (six) on post-term born children has been found with smaller body of evidence with mixed results regarding their association with childhood obesity evaluating different outcomes in the study. While analysing anthropometry or BMI of children, one study reported that Post-term born children were heavier and had greater BMI than term born children and the marked differences were reported particularly among women born ≥43 weeks of gestation [32]. This finding was supported by other study, reported that post-term boys weighed 11.8 kg more than term subjects and that the overall prevalence of overweight and obesity was 47% in post-term boys and 13% in term boys (P <0.01) as well as higher weight velocity among them at the age of 16 years.[26]. The only differences among both study was that earlier shows association in women but later had association with post-term born boys. Beltrand et al reported boys, but not girls, showed faster gains in weight in early years of life, increasing the risk of obesity in adolescence and also reported identical growth pattern and BMI in girls born term and postterm [26]. Likewise, on assessment of body composition and insulin sensitivity in postterm born child, revealed lower insulin sensitivity as well as lower FFM and more body fat, including increased central adiposity, truncal fat, and a greater proportion of androgynous to gynaecological fat at the age of 4 to 11 years in postterm children than control term children and also concluded that postterm children were found to be displaying other early marker of metabolic syndrome [33]. On examining the association between gestational age and BMI at different ages, smaller declines in average BMI compared to term infants(37-41 weeks of gestation) were observed among children born very early(<33 weeks of gestation) and early(33-36 weeks of gestation), while late-born children(42+ weeks of gestation) maintained a higher trajectory between 3 and 5 years of age. However, the differences observed in very early and early-born children at 9 months had diminished and were similar to term-born children by the age of 5 years [36]. In contrast, two studies on post term born showed evidence of either no effect on BMI or negative association with childhood overweight/obesity and adiposity. From a recent large-scale study focusing on preschool children which was conducted in China, found that post-term pregnancies not only associated with increased risk of thinness but also a lower risk of overweight/obesity, and overall lower growth parameters [35]. Similarly, research on post-term adolescence's exercise ability and cardiac function found no appreciable variations in BMI and body composition between post-term and term control children and postterm adolescence was linked to decreased exercise capacity, possibly as a result of modifications to the peripheral vascular system, but no variations in core cardiac function were noted [34]. The various study on post-term born children and its association with childhood obesity is illustrated in Table 2.

Table 2 Summary of Studies Showing Association of Postterm Born Children with Childhood Owo

Authors (year)	No. of Participants	Observation	Final outcome	Evidence of association
Derraik et al. 2016 [32]	Post-term (n = 27 153) Term (37–41 weeks of gestation; n=184245)	Weight, height, BMI	Women born postterm had a BMI 0.2 kg/m2 higher and were 0.5 kg heavier than women born at term, considerably born very post-term (≥43 weeks).	Positive
Beltrand et al. 2012 [26]	525 children (including 17 boys and 20 girls born post-term)	Values of height and weight velocity, weight, height, and BMI	In post-term boys, weight velocity was higher (but not height) at ages 1.5-7 and again at 11.5-16 years of age.	Positive
Ayyavoo et al. 2013 [33]	36 born post-term (18 boys) and 41 (27 boys) born at term (38–40 weeks' gestation).	Body composition from whole-body DEXA scan.	Compared to term controls, post-term children showed higher central adiposity with more truncal fat and a greater android to gynoid fat ratio, in addition to having more body fat and less fat free mass.	Positive
Jabakhanji SB et al 2018 [36]	Very early (<33 weeks), early (33-36 weeks), on time (37-41 weeks], and late birth (42 + weeks); n= 10377	Height, weight and BMI at age 9 months, 3 and 5 years	Child born late had a higher BMI. Up to the ages of 3 and 5 years, late children continued on their higher trajectory.	Positive
Murali et al. 2018 [34]	48 adolescents (56%males) 25 born post term, 23 born at term (37-41 weeks' gestation)	Whole body DEXA scan,	There were no variation in BMI, %body fat and fat-free mass.	No effect
Tang J et al. 2022 [35]	Post term children (>42 weeks' gestation); n=2369 post-term	Weight, height, BMI and BMI-for-age z score, weight-for-age	Children born at postterm had significantly lower BMI-for-age z score, weight-for-age z score, and	Negative

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

		z score, and height-for-age z score	height-for-age z score than those born at term at preschool age, and these differences were stable when stratified by child sex.	

VII. CONCLUSION

The prevention of childhood obesity is the topic of discussion nowadays because of its increasing incidence worldwide as well as long-term obesity related health consequences in later life. Also preventing and managing postterm pregnancy should be in consideration because of greater perinatal mortality and morbidity. This review study has found mixed result with comparatively more study stated that postterm birth is more prone to increase the risk of metabolic syndrome, overweight, obesity and insulin resistance in both male and female in adult life together with reduced capacity of exercise in postterm born adolescents. Further, the post-term born children showed evidence of exhibiting additional early metabolic syndrome indicators, such as increased body fat and central adiposity. Therefore, we speculate determining these associated variables may aid in identifying high-risk women who are pregnant and creating individualised therapies to lower the likelihood of postterm delivery. We discovered limited evidence of association of childhood obesity with post-term born children, which made it necessary to research more post-term cohorts in adulthood in order to accurately determine the long-term health hazards linked to longer gestation or postmaturity. Future research is required to investigate these potential metabolic alterations as well as whether the alterations in adiposity continue or intensify into adulthood, and the trend and strength of these relationships vary in adult post-term births.

REFERENCES

[1]. Wang Y, Lobstein T. Worldwide trends in childhood overweight and obesity. Int J Pediatr Obes 2006; 1 (1): 11-25.

[2]. Biro FM, Wien M. Childhood obesity and adult morbidities. Am J Clin Nutr 2010; 91 (5): 1499s-1505s.

[3]. Whitaker RC, Wright JA, Pepe MS, et al. Predicting obesity in young adulthood from childhood and parental obesity. N Engl J Med 1997; 337 (13): 869-873.

[4]. Guo SS, Chumlea WC. Tracking of body mass index in children in relation to overweight in adulthood. Am J Clin Nutr 1999; 70 (1): 145s-148s.

[5]. Whitlock G, Lewington S, Sherliker P, et al. Body-mass index and cause-specific mortality in 900 000 adults: collaborative analyses of 57 prospective studies. Lancet 2009; 373 (9669): 1083-1096.

[6]. Ashwell M, Gunn P, Gibson S. Waist-to-height ratio is a better screening tool than waist circumference and BMI for adult cardiometabolic risk factors: systematic review and meta-analysis. Obes Rev 2012; 13 (3): 275-286.

[7]. Shields M, Tremblay MS, Connor Gorber S, et al. Abdominal obesity and cardiovascular disease risk factors within body mass index categories. Health Rep 2012; 23 (2): 7-15.

[8]. Vucenik I, Stains JP. Obesity and cancer risk: evidence, mechanisms, and recommendations. Ann N Y Acad Sci 2012; 1271 (1): 37-43.

[9]. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser 1995; 854 1-452.

[10]. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. World Health Organ Tech Rep Ser 2000; 894 i-xii, 1-253.

[11]. Cole TJ, Bellizzi MC, Flegal KM, et al. Establishing a standard definition for child overweight and obesity worldwide: international survey. Bmj 2000; 320 (7244): 1240-1243.

[12]. Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, et al. CDC growth charts: United States. Adv Data 2000; (314): 1-27.

[13]. Wang Y. Epidemiology of childhood obesity--methodological aspects and guidelines: what is new? Int J Obes Relat Metab Disord 2004; 28 Suppl 3 S21-28.

[14]. Freedman DS, Sherry B. The validity of BMI as an indicator of body fatness and risk among children. Pediatrics 2009; 124 Suppl 1 S23-34.

[15]. Javed A, Jumean M, Murad MH, et al. Diagnostic performance of body mass index to identify obesity as defined by body adiposity in children and adolescents: a systematic review and meta-analysis. Pediatr Obes 2015; 10 (3): 234-244.

[16]. Kumar S, Kelly AS. Review of Childhood Obesity: From Epidemiology, Etiology, and Comorbidities to Clinical Assessment and Treatment. Mayo Clin Proc 2017; 92 (2): 251-265.

[17]. Wang Y, Lim H. The global childhood obesity epidemic and the association between socio-economic status and childhood obesity. Int Rev Psychiatry 2012; 24 (3): 176-188.

[18]. Moreno LA, Rodríguez G, Guillén J, et al. Anthropometric measurements in both sides of the body in the assessment of nutritional status in prepubertal children. Eur J Clin Nutr 2002; 56 (12): 1208-1215.

[19]. Fernández JR, Redden DT, Pietrobelli A, et al. Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. J Pediatr 2004; 145 (4): 439-444.

[20]. Lee S, Bacha F, Gungor N, et al. Waist circumference is an independent predictor of insulin resistance in black and white youths. J Pediatr 2006; 148 (2): 188-194.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

[21]. Helba M, Binkovitz LA. Pediatric body composition analysis with dual-energy X-ray absorptiometry. Pediatr Radiol 2009; 39 (7): 647-656.

[22]. Kelly AS, Barlow SE, Rao G, et al. Severe obesity in children and adolescents: identification, associated health risks, and treatment approaches: a scientific statement from the American Heart Association. Circulation 2013; 128 (15): 1689-1712.

[23]. Skinner AC, Skelton JA. Prevalence and trends in obesity and severe obesity among children in the United States, 1999-2012. JAMA Pediatr 2014; 168 (6): 561-566.

[24]. Flegal KM, Wei R, Ogden CL, et al. Characterizing extreme values of body mass index-for-age by using the 2000 Centers for Disease Control and Prevention growth charts. Am J Clin Nutr 2009; 90 (5): 1314-1320.

[25]. Gulati AK, Kaplan DW, Daniels SR. Clinical tracking of severely obese children: a new growth chart. Pediatrics 2012; 130 (6): 1136-1140.

[26]. Beltrand J, Soboleva TK, Shorten PR, et al. Post-term birth is associated with greater risk of obesity in adolescent males. J Pediatr 2012; 160 (5): 769-773.

[27]. Simmons R. Perinatal programming of obesity. Semin Perinatol 2008; 32 (5): 371-374.

[28]. Oken E, Gillman MW. Fetal origins of obesity. Obes Res 2003; 11 (4): 496-506.

[29]. Ong KK, Ahmed ML, Emmett PM, et al. Association between postnatal catch-up growth and obesity in childhood: prospective cohort study. Bmj 2000; 320 (7240): 967-971.

[30]. Eriksson JG, Forsén T, Tuomilehto J, et al. Effects of size at birth and childhood growth on the insulin resistance syndrome in elderly individuals. Diabetologia 2002; 45 (3): 342-348.

[31]. Wang G, Johnson S, Gong Y, et al. Weight Gain in Infancy and Overweight or Obesity in Childhood across the Gestational Spectrum: a Prospective Birth Cohort Study. Sci Rep 2016; 6 29867.

[32]. Derraik JG, Lundgren M, Cutfield WS, et al. Body Mass Index, Overweight, and Obesity in Swedish Women Born Post-term. Paediatr Perinat Epidemiol 2016; 30 (4): 320-324.

[33]. Ayyavoo A, Derraik JG, Hofman PL, et al. Pre-pubertal children born post-term have reduced insulin sensitivity and other markers of the metabolic syndrome. PLoS ONE 2013; 8 (7): e67966.

[34]. Murali M, Hofman PL, Derraik JGB, et al. Exercise capacity and cardiac function in adolescents born post-term. Scientific Reports 2018; 8 (1): 12963.

[35]. Tang J, Gou W, Fu Y, et al. Association between postterm pregnancy and adverse growth outcomes in preschool-age children. Am J Clin Nutr 2022; 116 (2): 482-490.

[36]. Jabakhanji SB, Boland F, Ward M, et al. Body Mass Index Changes in Early Childhood. J Pediatr 2018; 202 106-114.

[37]. Rivera J, de Cossío TG, Pedraza LS, et al. Childhood and adolescent overweight and obesity in Latin America: a systematic review. Lancet Diabetes Endocrinol 2014; 2 (4): 321-332.

[38]. Ng M, Fleming T, Robinson M, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. Lancet 2014; 384 (9945): 766-781.

[39]. Ji CY. The prevalence of childhood overweight/obesity and the epidemic changes in 1985-2000 for Chinese school-age children and adolescents. Obes Rev 2008; 9 Suppl 1 78-81.

[40]. Ji CY, Cheng TO. Epidemic increase in overweight and obesity in Chinese children from 1985 to 2005. Int J Cardiol 2009; 132 (1): 1-10.

[41]. Ji CY, Chen TJ. Empirical changes in the prevalence of overweight and obesity among Chinese students from 1985 to 2010 and corresponding preventive strategies. Biomed Environ Sci 2013; 26 (1): 1-12.

[42]. Olaya B, Moneta MV, Pez O, et al. Country-level and individual correlates of overweight and obesity among primary school children: a cross-sectional study in seven European countries. BMC Public Health 2015; 15 475.

[43]. Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. Lancet 2011; 378 (9793): 804-814.

[44]. Mistry SK, Puthussery S. Risk factors of overweight and obesity in childhood and adolescence in South Asian countries: a systematic review of the evidence. Public Health 2015; 129 (3): 200-209.

[45]. Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128·9 million children, adolescents, and adults. Lancet 2017; 390 (10113): 2627-2642.

[46]. Caleyachetty R, Echouffo-Tcheugui JB, Tait CA, et al. Prevalence of behavioural risk factors for cardiovascular disease in adolescents in low-income and middle-income countries: an individual participant data meta-analysis. Lancet Diabetes Endocrinol 2015; 3 (7): 535-544.

[47]. Jayawardena R, Byrne NM, Soares MJ, et al. Prevalence, trends and associated socio-economic factors of obesity in South Asia. Obes Facts 2013; 6 (5): 405-414.

[48]. Lobstein T, Jackson-Leach R, Moodie ML, et al. Child and adolescent obesity: part of a bigger picture. Lancet 2015; 385 (9986): 2510-2520.

[49]. Mazidi M, Banach M, Kengne AP. Prevalence of childhood and adolescent overweight and obesity in Asian countries: a systematic review and meta-analysis. Arch Med Sci 2018; 14 (6): 1185-1203.

[50]. Ang Y, Wee BS, Poh B, et al. Multifactorial Influences of Childhood Obesity. Current Obesity Reports 2012; 2

[51]. Larqué E, Labayen I, Flodmark CE, et al. From conception to infancy - early risk factors for childhood obesity. Nat Rev Endocrinol 2019; 15 (8): 456-478.

[52]. Budd GM, Hayman LL. Childhood obesity: determinants, prevention, and treatment. J Cardiovasc Nurs 2006; 21 (6): 437-441.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

[53]. Patro B, Liber A, Zalewski B, et al. Maternal and paternal body mass index and offspring obesity: a systematic review. Ann Nutr Metab 2013; 63 (1-2): 32-41.
[54]. Lawlor DA, Smith GD, O'Callaghan M, et al. Epidemiologic evidence for the fetal overnutrition hypothesis: findings from the mater-university study of pregnancy and its outcomes. Am J Epidemiol 2007; 165 (4): 418-424.
[55]. Huang RC, Burke V, Newnham JP, et al. Perinatal and childhood origins of cardiovascular disease. Int J Obes (Lond) 2007; 31 (2): 236-244.
[56]. Gluckman PD, Hanson MA, Cooper C, et al. Effect of in utero and early-life conditions on adult health and disease. N Engl J Med 2008; 359 (1): 61-73.
[57]. Woo Baidal JA, Locks LM, Cheng ER, et al. Risk Factors for Childhood Obesity in the First 1,000 Days: A Systematic Review. Am J Prev Med 2016; 50 (6): 761-779.
[58]. Li A, Robiou-du-Pont S, Anand SS, et al. Parental and child genetic contributions to obesity traits in early life based on 83 loci validated in adults: the FAMILY study. Pediatr Obes 2018; 13 (3): 133-140.
[59]. Munthali RJ, Sahibdeen V, Kagura J, et al. Genetic risk score for adult body mass index associations with childhood and adolescent weight gain in an African population. Genes Nutr 2018; 13 24.
[60]. Yuan ZP, Yang M, Liang L, et al. Possible role of birth weight on general and central obesity in Chinese children and adolescents: a cross-sectional study. Ann Epidemiol 2015; 25 (10): 748-752.
[61]. Rogers I. The influence of birthweight and intrauterine environment on adiposity and fat distribution in later life. Int J Obes Relat Metab Disord 2003; 27 (7): 755-777.
[62]. Rockenbach G, Luft VC, Mueller NT, et al. Sex-specific associations of birth weight with measures of adiposity in mid-to-late adulthood: the Brazilian Longitudinal Study of Adult Health (ELSA-Brasil). Int J Obes (Lond) 2016; 40 (8): 1286-1291.
[63]. Logan KM, Gale C, Hyde MJ, et al. Diabetes in pregnancy and infant adiposity: systematic review and meta-analysis. Arch Dis Child Fetal Neonatal Ed 2017; 102 (1): F65-f72.
[64]. Starling AP, Brinton JT, Glueck DH, et al. Associations of maternal BMI and gestational weight gain with neonatal adiposity in the Healthy Start study. Am J Clin Nutr 2015; 101 (2): 302-309.
[65]. Weng SF, Redsell SA, Swift JA, et al. Systematic review and meta-analyses of risk factors for childhood overweight identifiable during infancy. Arch Dis Child 2012; 97 (12): 1019-1026.
[66]. Johnsson IW, Haglund B, Ahlsson F, et al. A high birth weight is associated with increased risk of type 2 diabetes and obesity. Pediatr Obes 2015; 10 (2): 77-83.
[67]. Yu ZB, Han SP, Zhu GZ, et al. Birth weight and subsequent risk of obesity: a systematic review and meta-analysis. Obes Rev 2011; 12 (7): 525-542.
[68]. Çetin C, Uçar A, Bas F, et al. Are metabolic syndrome antecedents in prepubertal children associated with being born idiopathic large for gestational age? Pediatr Diabetes 2013; 14 (8): 585-592.
[69]. Labayen I, Ruiz JR, Vicente-Rodríguez G, et al. Early life programming of abdominal adiposity in adolescents: The HELENA Study. Diabetes Care 2009; 32 (11): 2120-2122.
[70]. Godfrey KM, Gluckman PD, Hanson MA. Developmental origins of metabolic disease: life course and intergenerational perspectives. Trends Endocrinol Metab 2010; 21 (4): 199-205.
[71]. Cunha AJ, Leite Á J, Almeida IS. The pediatrician's role in the first thousand days of the child: the pursuit of healthy nutrition and development. J Pediatr (Rio J) 2015; 91 (6 Suppl 1): S44-51.
[72]. Catalano PM, Thomas A, Huston-Presley L, et al. Increased fetal adiposity: a very sensitive marker of abnormal in utero development. Am J Obstet Gynecol 2003; 189 (6): 1698-1704.
[73]. Goldstein RF, Abell SK, Ranasinha S, et al. Association of Gestational Weight Gain With Maternal and Infant Outcomes: A Systematic Review and Meta-analysis. Jama 2017; 317 (21): 2207-2225.
[74]. Nehab SRG, Villela LD, Abranches AD, et al. Influence of gestational and perinatal factors on body composition of full-term newborns. J Pediatr (Rio J) 2020; 96 (6): 771-777.
[75]. Hawkes CP, Hourihane JO, Kenny LC, et al. Gender- and gestational age-specific body fat percentage at birth. Pediatrics 2011; 128 (3): e645-651.
[76]. Geserick M, Vogel M, Gausche R, et al. Acceleration of BMI in Early Childhood and Risk of Sustained Obesity. N Engl J Med 2018; 379 (14): 1303-1312.
[77]. Committee Opinion No 579: Definition of Term Pregnancy. Obstetrics & Gynecology 2013; 122 (5): 1139-1140.
[78]. Spong CY. Defining "term" pregnancy: recommendations from the Defining "Term" Pregnancy Workgroup. Jama 2013; 309 (23): 2445-2446.
[79]. Tita AT, Landon MB, Spong CY, et al. Timing of elective repeat cesarean delivery at term and neonatal outcomes. N Engl J Med 2009; 360 (2): 111-120.
[80]. MacDorman MF, Kirmeyer SE, Wilson EC. Fetal and perinatal mortality, United States, 2006. Natl Vital Stat Rep 2012; 60 (8): 1-22.
[81]. Oshiro BT, Henry E, Wilson J, et al. Decreasing elective deliveries before 39 weeks of gestation in an integrated health care system. Obstet Gynecol 2009; 113 (4): 804-811.
[82]. Radetti G, Fanolla A, Pappalardo L, et al. Prematurity may be a risk factor for thyroid dysfunction in childhood. J Clin Endocrinol Metab 2007; 92 (1): 155-159.
[83]. R ÁR, Forman JL, Greisen G. Prematurity, smallness-for-gestational age and later hospital admissions: a nation-wide registry study. Early Hum Dev 2015; 91 (5): 299-306.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

[84]. Rotteveel J, van Weissenbruch MM, Twisk JW, et al. Infant and childhood growth patterns, insulin sensitivity, and blood pressure in prematurely born young adults. Pediatrics 2008; 122 (2): 313-321.
[85]. Hofman PL, Regan F, Cutfield WS. Prematurity--another example of perinatal metabolic programming? Horm Res 2006; 66 (1): 33-39.
[86]. Hofman PL, Regan F, Jackson WE, et al. Premature birth and later insulin resistance. N Engl J Med 2004; 351 (21): 2179-2186.
[87]. Hui LL, Lam HS, Leung GM, et al. Late prematurity and adiposity in adolescents: Evidence from "Children of 1997" birth cohort. Obesity (Silver Spring) 2015; 23 (11): 2309-2314.
[88]. Ou-Yang MC, Sun Y, Liebowitz M, et al. Accelerated weight gain, prematurity, and the risk of childhood obesity: A meta-analysis and systematic review. PLoS One 2020; 15 (5): e0232238.
[89]. Roberts G, Cheong J, Opie G, et al. Growth of extremely preterm survivors from birth to 18 years of age compared with term controls. Pediatrics 2013; 131 (2): e439-445.
[90]. Roswall J, Karlsson AK, Allvin K, et al. Preschool children born moderately preterm have increased waist circumference at two years of age despite low body mass index. Acta Paediatr 2012; 101 (11): 1175-1181.
[91]. Bortolotto CC, Santos IS, Dos Santos Vaz J, et al. Prematurity and body composition at 6, 18, and 30 years of age: Pelotas (Brazil) 2004, 1993, and 1982 birth cohorts. BMC Public Health 2021; 21 (1): 321.
[92]. Mardones F, Villarroel L, Karzulovic L, et al. Association of perinatal factors and obesity in 6- to 8-year-old Chilean children. Int J Epidemiol 2008; 37 (4): 902-910.
[93]. Massion S, Wickham S, Pearce A, et al. Exploring the impact of early life factors on inequalities in risk of overweight in UK children: findings from the UK Millennium Cohort Study. Arch Dis Child 2016; 101 (8): 724-730.
[94]. Ni Y, Beckmann J, Gandhi R, et al. Growth to early adulthood following extremely preterm birth: the EPICure study. Arch Dis Child Fetal Neonatal Ed 2020; 105 (5): 496-503.
[95]. Bocca-Tjeertes IF, Kerstjens JM, Reijneveld SA, et al. Growth and predictors of growth restraint in moderately preterm children aged 0 to 4 years. Pediatrics 2011; 128 (5): e1187-1194.
[96]. Baird J, Jacob C, Barker M, et al. Developmental Origins of Health and Disease: A Lifecourse Approach to the Prevention of Non-Communicable Diseases. Healthcare (Basel) 2017; 5 (1):
[97]. Hanson MA, Gluckman PD. Early developmental conditioning of later health and disease: physiology or pathophysiology? Physiol Rev 2014; 94 (4): 1027-1076.
[98]. Kopec G, Shekhawat PS, Mhanna MJ. Prevalence of diabetes and obesity in association with prematurity and growth restriction. Diabetes Metab Syndr Obes 2017; 10 285-295.
[99]. Remacle C, Bieswal F, Reusens B. Programming of obesity and cardiovascular disease. Int J Obes Relat Metab Disord 2004; 28 Suppl 3 S46-53.
[100]. Rowe DL, Derraik JG, Robinson E, et al. Preterm birth and the endocrine regulation of growth in childhood and adolescence. Clin Endocrinol (Oxf) 2011; 75 (5): 661-665.
[101]. Johansson S, Iliadou A, Bergvall N, et al. Risk of high blood pressure among young men increases with the degree of immaturity at birth. Circulation 2005; 112 (22): 3430-3436.
[102]. Lawlor DA, Hübinette A, Tynelius P, et al. Associations of gestational age and intrauterine growth with systolic blood pressure in a family-based study of 386,485 men in 331,089 families. Circulation 2007; 115 (5): 562-568.
[103]. Sipola-Leppänen M, Vääräsmäki M, Tikanmäki M, et al. Cardiometabolic risk factors in young adults who were born preterm. Am J Epidemiol 2015; 181 (11): 861-873.
[104]. Fewtrell MS, Doherty C, Cole TJ, et al. Effects of size at birth, gestational age and early growth in preterm infants on glucose and insulin concentrations at 9-12 years. Diabetologia 2000; 43 (6): 714-717.
[105]. Perrin EM, O'Shea TM, Skinner AC, et al. Elevations of inflammatory proteins in neonatal blood are associated with obesity and overweight among 2-year-old children born extremely premature. Pediatr Res 2018; 83 (6): 1110-1119.
[106]. Ingol TT, Li R, Ronau R, et al. Underdiagnosis of obesity in pediatric clinical care settings among children born preterm: a retrospective cohort study. Int J Obes (Lond) 2021; 45 (8): 1717-1727.
[107]. Baldassarre ME, Di Mauro A, Caroli M, et al. Premature Birth is an Independent Risk Factor for Early Adiposity Rebound: Longitudinal Analysis of BMI Data from Birth to 7 Years. Nutrients 2020; 12 (12):
[108]. Euser AM, de Wit CC, Finken MJ, et al. Growth of preterm born children. Horm Res 2008; 70 (6): 319-328.
[109]. Alexander T, Conlon CA, Gamble G, et al. Body composition of New Zealand-born term babies differs by ethnicity, gestational age and sex. Early Hum Dev 2019; 140 104924.
[110]. Paz Levy D, Sheiner E, Wainstock T, et al. Evidence that children born at early term (37-38 6/7 weeks) are at increased risk for diabetes and obesity-related disorders. Am J Obstet Gynecol 2017; 217 (5): 588.e581-588.e511.
[111]. Hitze B, Bosy-Westphal A, Plachta-Danielzik S, et al. Long-term effects of rapid weight gain in children, adolescents and young adults with appropriate birth weight for gestational age: the Kiel Obesity Prevention Study. Acta Paediatr 2010; 99 (2): 256-262.
[112]. Olesen AW, Westergaard JG, Olsen J. Perinatal and maternal complications related to postterm delivery: a national register-based study, 1978-1993. Am J Obstet Gynecol 2003; 189 (1): 222-227.

ISSN No:-2456-2165 https://doi.org/10.38124/ijisrt/IJISRT24MAY162

[113]. Rosen MG, Dickinson JC. Management of post-term pregnancy. N Engl J Med 1992; 326 (24): 1628-1629.
[114]. Mathai S, Cutfield WS, Derraik JG, et al. Insulin sensitivity and β-cell function in adults born preterm and their children. Diabetes 2012; 61 (10): 2479-2483.
[115]. Mathai S, Derraik JG, Cutfield WS, et al. Increased adiposity in adults born preterm and their children. PLoS One 2013; 8 (11): e81840.
[116]. Derraik JG, Lundgren M, Cutfield WS, et al. Association Between Preterm Birth and Lower Adult Height in Women. Am J Epidemiol 2017; 185 (1): 48-53.