Effect of pre-pregnancy BMI (Obesity) on pregnancy related complications with specific emphasis on Indian Studies: Systematic review based on PRISMA Guideline

Alka Pawalia[1], Satya Savant[2], Sivachidambaram Kulandaivelan[3,*], Vikram Singh Yadav[4]

[1]Research Scholar & Assistant Professor, [3]Assistant Professor, GJUST, Hisar, [4]Assistant Professor, College of Physiotherapy, Pt. BDS University of Health Sciences, Rohtak, [2]Senior Gynaecologist, Savant Nursing Home, Hisar

***Corresponding Author:**
Email: tryhard2024@yahoo.co.in

Abstract

Background: Obesity is a modifiable risk factor associated with many complications in human beings.
Objective: To find and report the articles dealing with BMI on maternal (prenatal and perinatal) and child (perinatal and postnatal) complications with specific emphasis on Indian studies.
Data source: Pubmed and Google Scholar were searched with key terms within the limit of studies between 2008 and 2015.
Study eligibility criteria: Studies with at least 4 complications were compared with BMI classification, both cross-sectional and case-control studies; both prospective and retrospective studies were included.
Participants and intervention: Pregnant women, who were classified according to BMI criteria, were compared with prenatal, perinatal and immediate postnatal complications in both mother and child.
Study appraisal and synthesis methods: Since Pubmed is the primary source of selection of articles there was no separate appraisal of included studies other than eligibility criteria. 37 articles which met the eligibility included for results review and discussion.
Results: Odd ratio (OR) of gestational diabetes (4.62), pregnancy induced hypertension (3.23), cesarean section (2.88), preeclampsia (2.69), microsomia (4.65), macrosomia (3.95), NICU admission (3.39), perinatal death (3.17) in obese/overweight Indian mother is either equal or higher than western counterparts.
Limitation: Present study neither did meta-analysis nor did any inferential statistics.
Conclusion and implications of key findings: Present study concretely supports that obesity was associated with many pre, peri and postnatal complications in both mother as well as child. So, primary and secondary prevention measure has to be taken to control the weight in reproduction age females

Keywords: Mother complication, Prenatal complication, Perinatal complication, Postnatal child complication

Access this article online	
Quick Response Code:	Website: www.innovativepublication.com
	DOI: 10.5958/2394-2754.2016.00054.0

Introduction

Rationale: India with a population of 1.29 billion people is the second most populous country in the world only after China. It represents almost 17.31% of the world's population, which means one out of six people on this planet live in India. With the population growth rate at 1.58%, India is predicted to have more than 1.53 billion people by the end of 2030 taking the top position. Also more than 50% of India's population is below the age of 25 and over 65% below the age of 35 making it a young nation. India is a rapidly progressing and developing nation and this has lead to rapid transition in the socioeconomic and hence in the epidemiological status too. Once being a poor and undernourished nation, it has now become a rapidly developing and economically stable nation eventually making it the third most obese nation in the world[1]. Interestingly Indians have been shown to be obese at a lesser BMI value as compared to the standard WHO cutoffs due to their greater predisposition to abdominal obesity typically called as "Asian Indian phenotype"[2].

A recent increase in the prevalence of overweight and obese women of reproductive age in India has been shown by many studies[3-5]. Pregnancy has been cited as one of the reasons for obesity in women. Excessive weight both before pregnancy and during pregnancy has been found to increase the various pregnancy related adverse outcomes or complications both for the mother and the child[6]. Since the problem of obesity in the reproductive years of a women has been shown to be affecting her and her child in the long run, also predisposing the future generations to risk of various obesity related co-morbidities it needs to be addressed at the earliest.

Objectives

Primary objective is pre-pregnancy BMI, particularly over-weight and obesity odds, on selected maternal and child complications in pregnant women. Comparing studies from India, other Asian countries,

western countries in terms of maternal and child complications odds (OR- odd ratio).

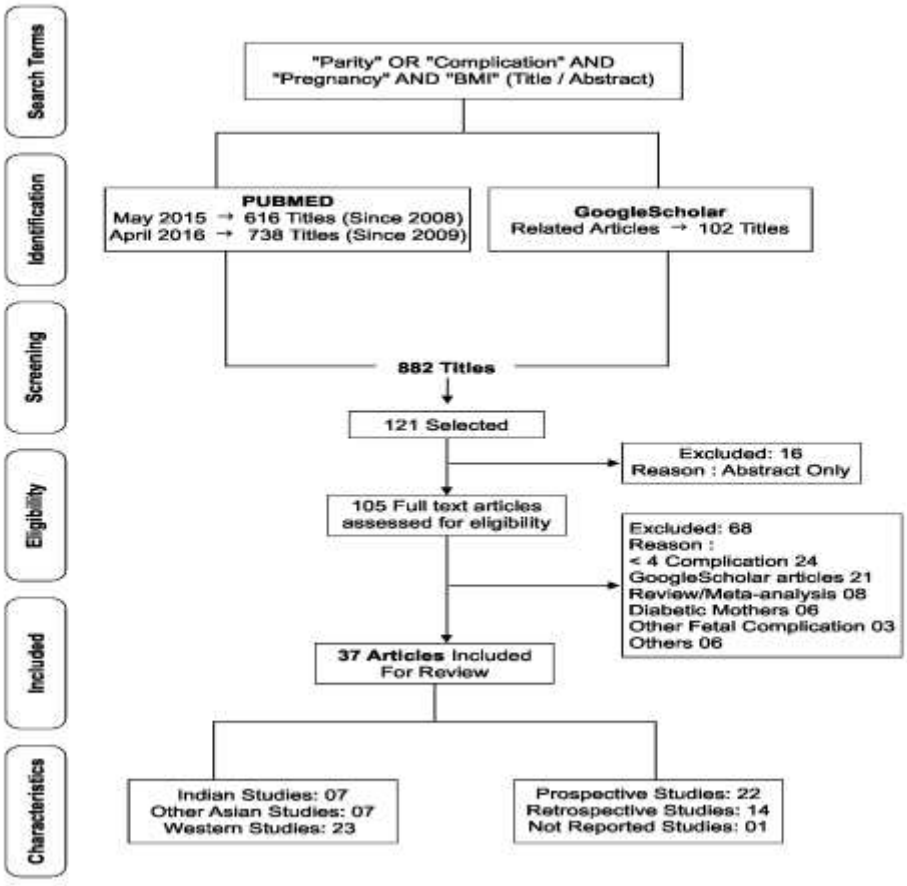
Methodology

Eligibility criteria: Study should be either prospective or retrospective cohort (longitudinal study). Study should be either cross sectional or case-control design. Article should be in full text; available in English language. Article should be published in 2008 or later. Study should be based on BMI classification in pregnant women on at least 4 pre-selected maternal and child complications.

Information sources: PUBMED (primary source), Google Scholar (secondary source only for Indian studies) search engines were used to collect relevant articles. Search was first done in May 2015 and final search was done on 30th April 2016. Articles were screened since 2008.

Search strategy: Search was primarily done in PUBMED using key terms in advanced search. Key terms used were "Parity" OR "Complication" AND "Pregnancy" AND "BMI" [all in title/abstract only]. Initial search in 2015 yielded 616 titles since 2008. Same search strategy yielded 737 titles since 2009 later in 2016. During initial search in 2015, we used same search methodology in 'Google Scholar' and used related articles from first eligible article. This yielded 102 articles. Thus we totally screened 882 titles for this review. We included Indian studies from 'Google Scholar' and all studies from 'PUBMED'. Overall search methodology is being presented schematically in Fig. 1.

Figure 1: Selection Process Of Eligible Studies Based On PRISMA Guidelines



Study selection: 882 titles were screened independently by two authors, AP and SK. They selected 121 articles that were related to the objective of the review in which we could not get full text for 16 titles. Thus 105 full text articles were selected for the eligibility. Three authors, AP, SK and VSY, independently reviewed the 105 articles based on eligibility criteria and selected 37 articles for final review. They were divided into Indian[7-13], other Asian[14-20] and Western including Africa[22-43] studies.

Data collection process: Odd ratio (OR) of individual complication is derived from formula, proportion in overweight/obese BMI divided by proportion in normal BMI pregnant population, with 95% confidence interval (95% CI). Unadjusted OR is preferred, if 'n' is not available, adjusted OR used. OR is calculated for individual BMI categories as well as combined overweight and obesity categories. If OR only available in different BMI categories, combined OR was calculated by giving weightage to 'n' in each group.

Data items: 16 prenatal, perinatal and postnatal complications- 8 maternal and 8 fetal- were selected for this review. They were pregnancy induced hypertension (PIH), gestational diabetes (GDM), eclampsia or pre-eclampsia, premature rupture of membrane (PROM), cesarean section (CS), induction of labor (IOL), instrument used in delivery (ID), haemorrhage, pre-term birth (PTB), small for gestational age (SGA), large for gestational age (LAG), microsomia including low birth weight, macrosomia, low Apgar score, admission in neonatal intensive care unit (NICU), fetal death including still birth.

Summary measure: Mean±standard deviation (SD) of OR along with median and range, minimal and maximal value, for each complication was calculated and presented in results.

Risk bias across studies: Different studies used different BMI level as reference and definition for obesity also differed between Asian and Western studies. In many case-control studies, BMI level for cases were very high (BMI 30 $Kg.m^{-2}$ or above).

Results

Study selection: Total 882 titles were screened and 37 full text articles[7-43] were selected based on eligibility criteria. Process of selection of articles is schematically given in Fig. 1.

Study characteristics: Among 37 selected articles, 7 articles were from India[7-13], 7 articles were from other Asian countries[14-20] and 23 articles were from Western countries including Africa[21-43]. 22 studies were prospective studies[7,8,10-13,16,20,21,24-26,28,30-33,36-38,42,43] and 14 studies were retrospective studies[14,15,17-19,22,23,27,29,34,35,39-41]. 10 studies were case-control studies[8,9,11,13,24,26,29,30,34,38]. Total of 807235 pregnant women (mean 21817, median 1418) participated in all 37 included studies. Indian studies were with least number of participants (total 2892, mean 413, median 250), followed by other Asian studies (total 43958, mean 6280, median 1418) and Western studies included maximum participants (total 760385, mean 33060, median 2810).

Risk bias within studies: Among 7 Indian studies, 2 case-control studies[11,13] used different BMI level as control- <30 $Kg.m^{-2}$[11] and 20-22 $Kg.m^{-2}$[13]. One study[19] from other Asian countries used BMI 18.5 to <23 $Kg.m^{-2}$ as control. Among 23 Western studies, 8 studies used extreme BMI values in their control and or comparative groups. Crane et al.[26] compared normal BMI with >50 $Kg.m^{-2}$ whereas Knight et al.[38] compared BMI <50 $Kg.m^{-2}$ with BMI >50 $Kg.m^{-2}$. Vinayagam and Chandraharan[34] and Galen et al.[35] compared normal BMI with BMI >40 and >35 $Kg.m^{-2}$ respectively. Marshall et al.[39] classified pregnant women BMI into 3 categories- 30-39.9 $Kg.m^{-2}$, 40-49.9 $Kg.m^{-2}$ and >50 $Kg.m^{-2}$. They calculated OR for these three groups. 3 studies[27,41,43] included extreme BMI value of >40 Kg.m-2 in their BMI classifications.

Results of individual studies: Among 7 Indian studies (Table 1), all articles reported CS risk (OR ranged 2.25[9] to 3.45[11], median 2.98[8]) in obese mothers. 3 complications are reported by 6 studies each- GDM, OR ranged 2.95[10] to 17.75[12]; pre-eclampsia/eclampsis, OR ranged 1.51[11] to 16.32[10]; and haemorrhage, OR ranged 1.21[11,12] to 5.99[7], in obese mothers. 5 studies reported IOL risk, OR ranged 1.17[13] to 4.74[10] and median 2.24[8], in obese mothers. 4 studies reported PIH, OR ranged 1.33[12] to 8.31[10] and ID risk, OR ranged 0.71[8] to 54.0[9] in obese mothers. PROM is reported in only 2 articles, OR 1.38[13] and 1.77[10], in obese mothers. 6 studies reported PTB, OR ranged 1.05[8] to 4.80[11]. 3 fetal complications are reported by 4 studies each- microsomia/low birth weight, OR ranged 1.87[8] to 17.6[9]; macrosomia, OR ranged 1.98[10] to 5.68[9] and perinatal death/still birth, OR ranged 1.27[13] to 7.28[10]. 3 studies each reported following 2 fetal complications- low Apgar, OR ranged 1.35[8] to 4.2[11] and NICU admission, OR ranged 2.05[12] to 5.74[10]. LGA is reported by 2 articles, OR 4.79[12] and 13.8[11]. SGA is reported by one, OR 0.94 [12]. In all 8 maternal complications reported in Indian studies, OR is always greater than 1.0 except one[8] complication (ID). Among 16 pregnancy related complications reported by Indian studies, only one complication- SGA- OR is less than 1.0 meaning increased pre-pregnancy BMI adversely affected these complications.

Table 1: Effect of BMI on pregnancy related complications in Indian studies (n=2892 pregnant women in N=07 studies)

Author	BMI Classification	Risk factors assessed results (or, 95% CI) [Combined or for synthesis]
Dasgupta et al., 2014, India	<25 (99) >25 (100) 25-34.9 (81) ≥ 35 (19)	GDM 5.0 (1.56-15.75); 8.5 (2.63-35.44) [5.57 (1.82-17.04)] PIH 2.36 (1.14-4.88); 6.22 (2.12-17.87) [2.88 (1.45-5.74)] Eclampsia/preeclampsia 5.07 (1.84-13.95); 16.25 (3.43-76.07) [4.12 (1.58-10.71)] Macrosomia 2.48 (0.22-27.89); 11.5 (0.99-134.4) [4.08 (0.45-37.20)] CS 2.99 (1.37-6.50); 12.86 (3.84-43.13) [3.26 (1.59-6.67) PTB 1.5 (0.66-3.49); 1.4 (0.34-5.37) [1.48 (0.67-3.30)] IOL 1.3 (0.69-2.4); 3.94 (0.93-18.6) [1.40 (0.78-2.52)] Instrumental delivery 2.83 (1.98-6.78); 4.56 (0.94-22.06) [2.09 (0.92-4.75)] Haemmorahge 3.2 (0.6-16.9); 22.4 (4.08-122.8) [5.99 (1.29-27.79)]
Kumari et al., 2014, India	20-24.9 (200) 25-29.9 (168) ≥30 (32)	Preeclampsia 2.13 (1.25-3.65); 3.35 (1.45-7.73) [2.31 (1.38-3.86)] GDM 3.14 (1.70-5.82); 7.36 (3.11-17.45) [3.68 (2.04-6.65)] Haemorrhage 2.17 (1.23-3.83); 3.01 (1.24-7.29) [2.30 (1.33-3.96)] IOL 2.35 (1.52-3.64); 1.71 (0.78-3.73) [2.24 (1.47-3.41)] Instrumental delivery 0.75 (0.38-1.49); 0.51 (0.11-2.29) [0.71 (0.37-1.38)] CS 2.58 (1.69-3.94); 7.25 (2.98-17.63) [2.98 (1.98-4.49)] Microsomia 1.77 (0.97-3.25); 2.38 (0.92-6.18) [1.87 (1.05-3.34)] Macrosomia 3.36 (1.51-7.49); 8.30 (2.99-23.03) [4.04 (1.88-8.71) Low Apgar 1.38 (0.68-2.79); 1.19 (0.35-4.34) [1.35 (0.68-2.67)] NICU admission 1.82 (0.97-3.41); 6.52 (2.78-15.24) [2.38 (1.33-4.28)] PTB 0.99 (0.53-1.87); 1.36 (0.48-3.86) [1.05 (0.58-1.90)]
Gaur et al., 2013, India	< 18.5 (93) **18.5-24.9 (136)** ≥25 (21)	Preeclampsia [11.37 (4.11-31.44)] CS [2.25 (0.87-5.80)] Instrumental delivery [5.10 (6.08-479.2)] Microsomia [17.6 (5.77-53.60)] Macrosomia [5.68 (1.89-17.01)]
Meenakshi et al., 2012, India	20-24.9 (45) 25-29.9 (87) >30 (83)	GDM [2.95 (0.84-10.40)]* PIH 9.17 (1.17-71.83); 7.44 (0.93-59.19) [8.31 (1.10-62.90)] Preeclampsia 9.17 (1.17-71.83); 26.23 (3.44-200.0) [16.32 (2.19-121.92)] PROM 2.14 (0.66-6.86); 1.40 (0.41-4.76) [1.77 (0.58-5.37)] IOL 4.45 (1.25-15.86); 5.05 (1.42-17.96) [4.74 (1.40-16.08)] CS 2.59 (1.14-5.89); 3.59 (1.57-8.17) [3.04 (1.41-6.53)] Haemorrhage [2.44 (0.40-14.91)]* Low Apgar 1.29 (0.60-2.77); 1.70 (0.79-3.65) [1.48 (0.73-2.98)] NICU admission 5.38 (1.93-14.99); 6.13 (2.20-17.10) [5.74 (2.16-15.26)] Fetal death 4.12 (0.89-19.02); 7.44 (0.93-59.19) [7.28 (1.69-31.32)] PTB 2.88 (1.01-8.17); 3.07 (1.08-8.73) [2.97 (1.10-7.98)] Microsomia 1.82 (0.47-6.97); 2.60 (0.70-9.66) [2.19 (0.63-7.65)] Macrosomia [1.98 (0.58-6.70)]* * indicates OR is normal plus overweight (132) with obese (83)
Sujatha et al., 2012, India	<30 (100) > 30 (100)	Pre eclampsia [1.52 (1.04-6.11)] GDM [4.8 (1.01-3.02)] PTB [4.8 (1.01-3.02)] IOL [3.14 (1.60-5.80)] CS [3.45 (1.65-7.15)] LGA [13.8 (3.1-60.57)]

		Fetal death [2.04 (0.36-11.4)] Low Apgar [4.20 (0.88-20.5)] Haemorrhage [1.21 (0.35-4.11)]
Verma and Shrimali, 2012, India	≤ 19.9 (116) 20-24.9 (406) 25-29.9 (165) 30 -34.9 (84) > 35 (13)	Hemorrhage 1.38 (0.46-4.18); 1.08 (0.23-5.07); NA [1.21 (0.45-3.29)] PIH 1.10 (0.59-2.05); 1.39 (0.66-2.92); 4.57 (1.34-15.57) [1.33 (0.80-2.22)] GDM 4.97 (0.44-55.18); 31.15 (3.70-262.37); 121.50 (11.60-NA) [17.75 (2.28-138.31)] PTB 1.15 (0.46-2.89); 1.65 (0.58-4.67); 2.17 (0.26-17.81) [1.36 (0.64-2.91)] SGA 0.96 (0.43-2.12); 1.05 (0.39-2.86); 1.39 (0.17-11.14) [0.94 (0.47-1.86)] LGA 3.55 (1.40-9.00); 5.97 (2.23-15.97); 14.93 (3.44-64.77) [4.79 (2.11-10.87)] NICU admission 1.74 (0.84-3.61); 2.14 (0.91-5.08); 6.11 (1.55-24.05) [2.05 (1.10-3.83)] Fetal death 1.65 (0.27-9.96); 3.28 (0.54-19.92); NA [2.08 (0.46-9.38)] CS 1.58 (1.00-2.50); 3.31 (1.97-5.56); 12.73 (3.80-42.63) [2.31 (1.58-3.38)] Instrumental delivery 1.49 (0.35-6.29); 1.96 (0.37-10.26); NA [1.56 (0.45-5.44)]
Mandal et al., 2011, India	≥ 30.0 (422) 20-22 (422)	GDM [6.12 (3.51-10.65)] PIH [5.76 (2.90-11.56)] Preeclampsia [2.80 (1.49-5.26)] PTB [1.44 (0.93-2.23)] Haemorrhage [1.39 (0.72-2.70)] CS [2.87 (2.17-3.80)] Instrumental Delivery [2.56 (1.52-4.29)] Fetal death [1.27 (0.86-1.89)] Macrosomia [9.90 (2.29-42.78)] IOL [1.17 (0.89-1.55)] PROM [1.38 (0.86-2.23)]

BMI: Body mass index; CS: Cesarean section; GDM: Gestational diabetes mellitus; IOL: Induction of labor; LGA: Large for gestational age; NA: Value not available; NICU: Neonatal intensive care unit; NS: Not significant; PIH: Pregnancy induced hypertension; PROM: Premature rupture of membrane; PTB: Pre term birth; SGA: Small for gestational age

Among 7 other Asian studies (Table 2), 6 articles each reported PIH, OR ranged 1.95[20] to 6.95[14], and PTB risk, OR ranged 0.86[19] to 2.36[18] in obese mothers. 5 studies reported GDM in obese mothers, OR ranged 2.05[17] to 3.63[16]. 3 complications are reported by 4 studies each- CS, OR ranged 1.66[18] to 2.00[17]; microsomia, OR ranged 1.02[14] to 1.41[18] and macrosomia, OR ranged 1.43[18] to 6.67[20]. 2 complications are reported by 3 studies each- pre-eclampsia/eclampsia, OR ranged 1.68[14] to 2.96[16] and SGA, OR ranged 0.71[17] to 2.82[14]. 3 complications are reported by 2 studies each- IOL, OR 1.47[18] and 3.70[20]; LGA, OR 2.02[17] and 2.24[19]; PROM, OR 1.04[19] and 1.67[14]. One study is reported the following 4 complications- haemorrhage (1.79[14]), low Apgar (1.97[19]), NICU admission (1.28[19]) and perinatal death (3.26[20]). Among 15 pregnancy related complications reported, except 2 (PTB and SGA), all other complications minimum OR value is greater than 1.0. Three studies reported OR value lesser than 1.0 in two different fetal complications, PTB[19] and SGA[17,19]. This indicates that increasing BMI values in pre-pregnancy mother adversely affects the pregnancy related complications.

Table 2: Effect of BMI on pregnancy related complications in other Asian studies (n=43958 pregnant women in N=07 studies)

Author	BMI Classification	Risk factors assessed **results** (or, 95% CI)
Liu et al., 2015, China	Underweight (254) Normal (2152) Overweight/Obese (567)	CS [1.74 (1.44-2.10)] Haemorrhage [1.79 (1.28-2.52)] PTB [1.95 (1.44-2.64)] PROM [1.67 (1.06-2.62)] GDM [2.06 (1.68-2.52)] PIH [6.94 (3.91-12.30)] Preeclampsia [1.68 (1.05-2.68)] SGA [2.82 (1.29-6.17)] Macrosomia [1.02 (0.76-1.36)]
Sun et al., 2014, China	<18.5 (108) 18.5 – 24 (769) 24 – 28 (363) ≥ 28 (178)	PIH 2.72 (1.41-5.21); 5.92 (3.05-11.49) [3.72 (2.10-6.61)] PTB 1.49 (1.00-2.20); 1.79 (1.11-2.88) [1.58 (1.12-2.24)] Microsomia 1.26 (0.72-2.22); 1.15 (0.54-2.44) [1.32 (0.74-2.04)] Macrosomia 1.64 (1.14-2.36); 2.92 (1.93-4.39) [2.03 (1.48-2.78)]
Ebrahimi-Mameghani et al., 2013, Iran	<25 (603) 25-29.9 (262) >29.9 (83)	PIH 1.98 (0.95-4.13); 13.66 (6.98-26.75) [4.90] Preeclampsia 1.68 (0.78-3.62); 6.78 (3.18-14.26) [2.96] GDM 1.91 (0.63-5.74); 8.78 (3.18-24.17) [3.63] PTB 1.25 (0.47-3.20); 3.72 (1.40-9.86) [1.87]
Li et al., 2013, China	<18.5 (3809) 18.5 – 24 (21942) 24 – 28 (6185) ≥ 28 (2037)	GDM 1.91 (1.70-2.14); 2.46 (2.09-2.90) [2.05] PIH 2.03 (1.70-2.43); 5.07 (4.17-6.16) [2.79] CS 1.62 (1.52-1.73); 2.49 (2.20-2.81) [2.00 (1.88-2.12)] PTB 1.15 (0.98-1.35); 1.70 (1.36-2.11) [1.31 (1.14-1.51)] LGA 1.73 (1.59-1.88); 2.80 (2.49-3.15) [2.02 (1.87-2.17)] SGA 0.75 (0.67-0.83); 0.61 (0.50-0.74) [0.71 (0.65-0.79)] Macrosomia 1.76 (1.62-1.93); 2.86 (2.53-3.23) [1.96 (1.81-2.11)] Microsomia 0.92 (0.72-1.16); 0.96 (0.68-1.35) [1.19 (1.00-1.41)]
Yazdani et al., 2012, Iran	≤ 19.9 (128) 20-24.9 (412) 25-29.9 (356) 30 -34.9 (98) > 35 (6)	Pre-eclampsia 1.97 (1.09-3.55); 2.88 (1.35-6.16); 10.34 (1.78-60.4) [2.24 (1.29-3.90)] IOL 1.3 (0.94-1.80); 2.11 (1.33-3.36); 3.20 (0.63-16.13) [1.47 (1.09-1.99)] CS 1.40 (1.02-2.17); 2.04 (1.20-3.48); 11.97 (2.14-66.80) [1.66 (1.17-2.37)] PTB 2.10 (0.91-4.82); 2.92 (1.01-8.40); 8.95 (0.94-84.6) [2.36 (1.08-5.15)] Microsomia 1.44 (0.85-2.43); 1.38 (0.63-3.04); NA [1.41 (0.86-2.32)] Macrosomia 0.90 (0.40-2.02); 0.82 (0.36-1.87); 5.68 (0.62-51.90) [1.43 (0.72-2.83)]
Choi et al., 2011, Korea	<18.5 (417) 18.5 < 23 (1556) 23 and < 25 (236) >25 (204)	GDM 1.58 (0.80-3.15); 4.46 (2.63-7.59) [2.90] PIH 2.26 (1.11-4.58); 2.53 (1.26-5.07) [2.38] PTB 1.10 (0.57-2.10); 0.58 (0.26-1.28) [0.86] PROM 0.95 (0.47-1.94); 1.15 (0.57-2.32) [1.04] SGA 0.69 (0.42-1.13); 1.08 (0.69-1.69) [0.87] LGA 1.79 (0.92-3.48); 2.77 (1.49-5.16) [2.24] Low Apgar 1.96 (1.20-3.18); 1.98 (1.19-3.29) [1.97] NICU admission 1.42 (0.78-2.61); 1.11 (0.57-2.16) [1.28] CS 1.62 (1.23-2.14); 2.49 (1.85-3.34) [1.98 (1.60-2.45)]
Meher-un-nisa et al., 2009, Saudi Arabia	< 18.5 (20) 18.5-24.9 (310) 25-29.9 (331)	PIH 1.59 (0.85-2.97); 2.20 (1.20-4.03); 3.13 (1.15-8.50) [1.95 (1.12-3.37)]

	30-39.9 (300) >40 (39)	GDM 1.62 (0.73-3.60); 2.25 (1.04-4.87); 4.41 (1.42-13.60) [2.06 (1.02-4.15)] CS 3.41 (1.87-6.23); 3.74 (2.04-6.85); 5.90 (2.38-14.62) [3.70 (2.11-6.46)] Macrosomia 4.85 (1.39-16.94); 7.70 (2.27-26.10); 15.04 (3.44-65.70) [6.67 (2.05-21.71)] Perinatal mortality 2.82 (0.29-27.3); 3.12 (0.32-30.17); 8.13 (0.49-132.6) [3.26 (0.40-26.63)]

BMI: Body mass index; CS: Cesarean section; GDM: Gestational diabetes mellitus; IOL: Induction of labor; LGA: Large for gestational age; NA: Value not available; NICU: Neonatal intensive care unit; NS: Not significant; PIH: Pregnancy induced hypertension; PROM: Premature rupture of membrane; PTB: Pre term birth; SGA: Small for gestational age

Among 23 Western (including African) studies (Table 3), 20 studies reported CS, OR ranged 1.31[23] to 4.62[26], in obese mothers. 16 studies reported macrosomia, OR ranged 1.28[23] to 4.55 [26], in children of obese mothers. 5 complications are reported by 12 studies each- preeclampsia/eclampsia, OR ranged 1.16[23] to 5.18[24]; haemorrhage, OR ranged 1.03[37] to 5.93[34]; PTB, OR ranged 0.68[24] to 6.31[34]; low Apgar, OR ranged 0.57[24] to 3.09[34]; and perinatal death, OR ranged 0.94[31] to 3.39[26]. 2 maternal complications are reported by 11 studies each- GDM, OR ranged 3.11[36] to 17.13[26], median 3.92[27] and PIH, OR ranged 1.49[31] to 6.33[38], median 3.09[42]. 2 complications are reported by 9 studies each- IOL, OR ranged 0.81[26] to 1.91[38], median 1.54[35] and NICU admission, OR ranged 0.77[23] to 3.53[38], median 1.49[30]. 8 studies reported microsomia, OR ranged 0.73[28] to 1.12[39], in children of obese mothers. 6 studies reported SGA, OR ranged 0.46[24] to 1.07[30], in children of obese children. 3 complications are reported by 5 studies each- ID, OR ranged 0.60[32] to 1.76[24], median 0.76[27]; PROM, OR ranged 0.60[26] to 2.36[29], median 1.17[28]; and LGA, OR ranged 1.09[30] to 1.90[42], median 1.42[43]. Among 16 pregnancy related complications, 9 complications have at least one study OR less than 1.0 and 3 complications- ID, Microsomia, SGA- have median OR less than 1.0.

Table 3: Effect of BMI on pregnancy related complications in Indian studies (n=760385 pregnant women in N=23 studies)

Author	BMI Classification	Risk factors assessed results (or, 95% CI)
Linden et al., 2016, Ghana	<18.5 (49) 18.5-24.9 (469) 25-29.9 (313) >30.0 (169)	CS 1.50 (0.90-2.52); 2.26 (1.29-3.96) [1.76 (1.12-2.77)] Heamorrhage 2.03 (0.85-4.89); 1.88 (0.66-5.37) [1.76 (0.96-3.24)] PIH 1.83 (0.93-3.62); 4.24 (2.17-8.28) [2.63 (1.46-4.76)] Fetal death 1.50 (0.37-6.06); 0.69 (0.08-6.24) [1.22 (0.33-4.57)] Microsomia 0.79 (0.42-1.51); 0.99 (0.47-2.09) [0.86 (0.49-1.50)] Macrosomia 2.60 (1.25-5.40); 2.14 (0.89-5.18) [2.44 (1.23-4.88)] Low Apgar 1.43 (0.91-2.22); 1.16 (0.66-2.05) [1.33 (0.89-2.00)]
Stuber et al., 2015, Wurzburg	<25 (1957) 25-30 (548) >30 (305)	GDM 3.33 (2.47-4.49); 4.71 (3.36-6.60) [3.80 (2.93-4.93)] PIH 4.89 (2.16-11.06); 7.88 (3.41-18.26) [5.98 (2.91-12.28)] Pre-eclampsia 1.62 (0.89-2.95); 4.03 (2.32-7.00) [2.46 (1.54-3.92)] Macrosomia 1.49 (0.62-3.62); 2.73 (1.12-6.64) [1.93 (0.95-3.94)] CS 1.43 (1.15-1.77); 1.99 (1.54-2.59) [1.62 (1.35-1.94)]
Fouelifack et al., 2015, Cameroon	<18.5 (17) 18.5-24.9 (228) 25-29.9 (152) 30.0 or > (65)	CS 1.28 (0.84-1.96); 1.37 (0.78-2.41) [1.31 (0.89-1.92)] Haemorrhage 1.29 (0.68-2.42); 0.86 (0.34-2.21) [1.16 (0.64-2.09)] Pre-eclampsia 1.29 (0.68-2.42); 0.86 (0.34-2.21) [1.16 (0.64-2.09)] NICU admission 0.70 (0.37-1.31); 0.95 (0.43-2.10) [0.77 (0.44-1.34)] Low Apgar 1.00 (0.49-2.03); 1.19 (0.48-2.94) [1.06 (0.56-1.99)]

		Microsomia 1.12 (0.58-2.18); 0.91 (0.35-2.33) [1.06 (1.95)] Macrosomia 1.22 (0.55-2.68); 1.44 (0.54-3.89) [1.28 (0.63-2.62)] Fetal death 1.73 (0.65-4.59); 2.80 (0.93-8.37) [2.04 (0.85-4.92)]
Morgan et al, 2014, UK	**Normal** (244) Overweight and Obese (212)	IOL [1.61 (1.02-2.55)] Instrumental Delivery 1.76 (0.93-3.30)] CS [1.43 (0.88-2.33)] PTB [0.68 (0.24-1.91)] SGA [0.46 (0.09-2.37)] Macrosomia [2.00 (1.13-3.52)] Low APGAR [0.57 (0.10-3.15)]
Vinturache et al., 2014, Canada	Final groups: (1) normal (1313) (2) overweight (472) (3) obese (211)	PIH 3.1 (2.1-4.6); 5.7 (3.7-8.8) [3.76 (2.59-5.46)] Preeclampsia 3.5 (2.0-4.6); 5.3 (3.3-8.5) [3.81 (2.62-5.53)] PROM 0.69 (0.23-2.08); 0.39 (0.05-2.93) [0.60 (0.22-1.64)] Eclampsia 2.8 (0.5-13.8); 10.6 (2.5-44.6) [5.18 (1.37-19.57)] GDM 3.0 (1.8-5.0); 6.5 (3.7-11.2) [3.63 (2.26-5.81)] Haemorrhage 1.7 (1.2-2.5); 1.1 (0.6-2.0) [1.55 (1.10-2.20)]
Crane et al., 2013, Canada	Normal (5717) **≥50 (71)**	PIH [4.86 (2.68-8.83)] GDM [17.13 (9.33-31.45)] IOL [0.81 (0.46-1.42)] CS [4.62 (2.86-7.46)] Haemorrhage [2.13 (0.97-4.69)] PTB [1.21 (0.52-2.80)] Macrosomia [4.55 (2.80-7.39)] Microsomia [0.89 (0.28-2.86)] NICU admission [2.42 (1.29-4.53)] Low Apgar [1.83 (0.78-4.25)] Fetal death [3.39 (0.45-25.40)]
Denison et al., 2013, Scotland	**18.5 < 25 (61,232)** 25- < 30 (35,087) 30- < 40 (21,634) ≥ 40 (2,720)	PIH 1.56 (1.45-1.68); 2.33 (2.16-2.52); 3.15 (2.71-3.66) [1.91 (1.79-2.03)] Eclampsia 1.40 (0.78-2.51); 0.68 (0.28-1.66); 3.61 (1.25-10.37) [1.24 (0.73-2.10)] PROM 0.87 (0.75-1.00); 0.89 (0.75-1.06); 0.95 (0.62-1.44) GDM 2.73 (2.07-3.59); 6.96 (5.40-8.98); 22.63 (16.65-30.75) [3.92 (3.08-4.98)] IOL 1.24 (1.20-1.28); 1.51 (1.46-1.57); 1.77 (1.63-1.92) [1.36 (1.32-1.40)] Instrumental delivery 0.86 (0.83-0.89); 0.63 (0.60-0.67); 0.52 (0.45-0.60) [0.76 (0.73-0.79) CS 1.41 (1.37-1.46); 1.85 (1.79-1.92); 2.96 (2.74-3.20) [1.62 (1.58-1.67)] Low Apgar 0.95 (0.82-1.10); 0.97 (0.81-1.15); 1.14 (0.76-1.69) [0.96 (0.85-1.09)] Fetal death 1.07 (0.88-1.31); 1.42 (1.15-1.75); 1.85 (1.20-2.87) [1.24 (1.05-1.45)] NICU admission 1.05 (1.00-1.10); 1.24 (1.18-1.31); 1.62 (1.44-1.83) [1.14 (1.10-1.19)] PTB 0.96 (0.90-1.10); 1.13 (1.06-1.20); 2.31 (2.05-2.60) [1.03 (0.99-1.09)]
Gaillard et al., 2013, Netherlands	**20-24.9** 25-29.9 (1,334) ≥30 (611)	PIH 2.15 (1.55-2.97); 6.31 (4.30-9.26) [3.44] Preeclampsia 1.91 (1.21-3.00); 3.61 (2.04-6.39) [2.44] GDM 4.25 (2.32-7.76); 6.28 (3.01-13.06) [4.88] PROM 0.95 (0.65-1.37); 1.66 (1.08-2.55) [1.17] CS 1.52 (1.24-1.85); 1.91 (1.46-2.50 [1.64] Haemorrhage 1.34 (1.01-1.78); 1.44 (0.96-2.16) [1.37] PTB 1.04 (0.77-1.42); 1.53 (1.05-2.20) [1.19] Macrosomia 1.69 (1.35-2.12); 2.97 (2.16-4.08) [2.09]

		Microsomia 0.81 (0.64-1.03); 0.54 (0.38-0.78) [0.73] Low Apgar 1.56 (0.90-2.71); 2.05 (1.04-4.01) [1.71]
Iyoke et al., 2013, Nigeria	Healthy (324) Obese (324)	PROM [2.36 (1.12-5.04)] Pre-eclampsia/eclampsia [2.31 (1.72-4.48)] Haemorrhage [2.78 (1.02-7.93)] GDM [4.28 (1.62-11.74)] CS [4.30 (1.20-5.44)] Macrosomia [4.08 (1.06-8.41)] NICU admission [1.18 (1.00-3.29)]
Minsart et al., 2013, Belgium	18.5 - 29.9 (33818) >30.0 (4857)	CS [1.82 (1.70-1.95)] IOL [1.39 (1.31-1.48)] LGA [1.09 (0.99-1.19)] SGA [1.07 (0.96-1.20)] Macrosomia [1.80 (1.63-1.98)] NICU admission [1.49 (1.37-1.62)] Low Apgar [1.35 (1.21-1.50)] Fetal Death [1.17 (0.81-1.68)]
Mochhoury et al., 2013, Morocco	<18.5 **18.5–24.9 (871)** 25–29.9 (348) >30 (87)	PIH 1.07 (0.62-1.83); 3.36 (1.77-6.39) [1.49 (0.89-1.77)] Haemorrhage 1.09 (0.74-1.61); 1.93 (1.09-3.42) [1.25 (0.89-1.77)] CS 1.16 (0.79-1.71); 2.97 (1.76-5.00) [1.75 (1.26-2.43)] Microsomia 0.82 (0.41-1.65); 0.59 (0.14-2.53) [0.78 (0.41-1.50)] Macrosomia 1.29 (0.92-1.81); 4.25 (2.65-6.80) [1.74 (1.29-2.35)] Fetal death 1.09 (0.58-2.08); 0.30 (0.04-2.25) [0.94 (0.50-1.75)]
Oteng-Ntim et al., 2013, UK	**18.5–24.9 (10,101)** 25–29.9 (4349) 30-34.9 (1643) ≥35(850)	GDM 2.36 (1.85-3.02); 4.00 (3.02-5.30); 9.46 (7.19-12.46) [3.58 (2.91-4.40)] CS 1.29 (1.20-1.40); 1.64 (1.47-1.83); 2.28 (1.98-2.63) [1.48 (1.38-1.58)] Haemorrhage 1.27 (1.16-1.38); 1.45 (1.28-1.63); 2.10 (1.80-2.44) [1.40 (1.30-1.51)] PTB 1.20 (1.04-1.37); 1.38 (1.15-1.67); 2.03 (1.64-2.52) [1.34 (1.19-1.50)] Instrumental Delivery 0.68 (0.61-0.76); 0.49 (0.41-0.59); 0.37 (0.28-0.49) [0.60 (0.54-0.65)] Macrosomia 1.39 (1.23-1.56); 1.52 (1.29-1.79); 2.16 (1.78-2.63) [1.50 (1.36-1.67)] Microsomia 0.93 (0.81-1.07); 1.07 (0.89-1.30); 1.39 (1.10-1.75) [1.02 (0.91-1.15)] NICU admission 1.05 (0.92-1.21); 1.41 (1.17-1.70); 1.67 (1.33-2.11) [1.21 (1.08-1.36)] Fetal death 0.96 (0.60-1.55); 1.81 (1.05-3.12); 1.44 (0.65-3.16) [1.22 (0.83-1.80)]
Heude et al., 2012, France	< 18.50 (151) **18.50-24.99 (1172)** 25.00-<30 (311) >30 (152)	PIH 1.78 (0.91-3.48); 5.15 (2.74-9.65) [2.83 (1.67-4.79)] GDM 2.61 (1.65-4.12); 5.18 (3.17-8.48) [3.40 (2.31-5.01)] PTB 0.71 (0.39-1.28); 1.29 (0.68-2.44) [0.90 (0.56-1.42)] SGA 0.80 (0.48-1.31); 0.64 (0.31-1.35) [0.75 (0.48-1.16)] LGA 1.56 (1.02-2.38); 2.58 (1.59-4.19) [1.88 (1.32-2.68)]
Vinayagam and Chandraharan, 2012, UK	>40 (100) 20-25 (100)	CS [2.32 (1.26-4.29)] Haemorrhage [5.93 (2.34-11.98)] PTB [6.31 (0.75-53.48)] Low Apgar [3.09 (1.07-8.94)] Macrosomia [3.11 (1.25-7.79)]
Galan et al., 2011, Spain	<18.5 (168) **20–24.9 (2597)**	PTB [1.01 (0.66-1.56)] IOL [1.54 (1.18-2.00)]

	>35 (251)	Instrumental delivery [0.70 (0.49-1.00)] CS [2.66 (2.02-3.50)] Macrosomia [3.28 (2.04-5.28)] Microsomia [0.85 (0.55-1.30)] Low Apgar [2.62 (0.97-7.04)] NICU admission [1.64 (0.77-3.50)] Fetal death [1.68 (0.88-3.22)]
Magann et al., 2011,USA	**18.50-24.99 (1996)** 25.00-30 (1073) >30 (1183)	Preeclampsia 1.05 (0.76-1.43); 3.14 (2.46-4.00) [2.08 (1.66-2.62)] GDM 2.20 (1.52-3.17); 3.98 (2.88-5.51) [3.11 (2.29-4.22)] PTB 0.79 (0.63-0.99); 1.40 (1.15-1.70) [1.11 (0.94-1.32)] IOL 1.30 (1.06-1.59); 2.12 (1.77-2.54) [1.71 (1.45-2.00)] CS 1.47 (1.24-1.73); 2.12 (1.81-2.48) [1.79 (1.56-2.05)] Haemorrhage 1.67 (1.12-2.51); 2.10 (1.45-3.06) [1.90 (1.36-2.66)] Low Apgar 0.83 (0.60-1.67); 1.54 (1.17-2.04) [1.22 (0.95-1.57)] SGA 0.64 (0.45-0.91); 0.88 (0.65-1.20) [0.77 (0.59-1.00) LGA 2.18 (1.62-2.92); 2.76 (2.10-3.64) [1.37 (1.05-1.80)] Fetal death 0.54 (0.27-1.10); 1.45 (0.88-2.39) [1.02 (0.64-1.61)]
Ovesen et al., 2011, Denmark	≤18.5 (15776) **18.5–24.9 (233160)** 25–29.9 (77250) 30–34.9 (28492) ≥35 (14669)	GDM 3.42 (3.23-3.63); 7.54 (7.09-8.03); 10.83 (10.10-11.61) [5.24 (4.98-5.50)] Preeclampsia 1.67 (1.61-1.74); 2.60 (2.47-2.73); 3.73 (3.52-3.95) [2.13 (2.06-2.20)] Haemorrhage 1.04 (1.01-1.08); 1.00 (0.95-1.05); 1.02 (0.96-1.10) [1.03 (1.00-1.06)] Low Apgar 1.26 (1.14-1.40); 1.35 (1.17-1.57); 1.95 (1.65-2.30) [1.37 (1.25-1.49)] Fetal death 1.42 (1.23-1.64); 1.68 (1.38-2.01); 2.22 (1.76-2.80) [1.58 (1.40-1.78) Macrosomia 1.70 (1.63-1.78); 2.20 (2.08-2.33); 2.73 (2.55-2.94) [1.94 (1.87-2.02)] CS 1.32 (1.29-1.34); 1.61 (1.56-1.66); 1.99 (1.92-2.06) [1.46 (1.43-1.48)]
Knight et al., 2010, UK	A. >50 (659) B. <50 (634)	PIH [5.21 (3.09-8.76)] Preeclampsia [3.94 (2.25-6.91)] GDM [7.18 (3.66-14.08)] IOL [1.91 (1.50-2.44)] PTB [1.50 (1.01-2.25)] CS [3.50 (2.75-4.45)] NICU admission [3.53 (1.30-9.57)] Haemorrhage [2.92 (0.94-9.11)]
Marshall et al., 2010, USA	30-39.9 (53012) 40-49.9 (10047) ≥ 50 (1183)	Preeclampsia 1.38 (1.29-1.49); 1.57 (1.30-1.89) [1.40 (1.31-1.50)] Low Apgar 1.03 (0.79-1.34); 1.97 (1.17-3.32) [1.13 (0.89-1.44)] Macrosomia 1.42 (1.24-1.63); 1.86 (1.35-2.57) [1.47 (1.29-1.67)] Microsomia 1.10 (0.95-1.27); 1.30 (0.91-1.87) [1.12 (0.97-1.29)] Fetal death 1.20 (1.12-1.28); 1.45 (1.22-1.72) [1.22 (1.15-1.31)]
Denison et al., 2009, UK	<25 (375) ≥25 to <30 (170) ≥30 (106)	PIH 2.07 (0.86-4.97); 3.83 (1.61-9.11) [2.73 (1.29-5.75)] Preeclampsia 4.49 (0.82-24.78); 5.43 (0.90-32.94) [4.85 (1.00-23.54)] CS 1.73 (1.13-2.64); 2.32 (1.44-3.75) [1.94 (1.34-2.80)]

		IOL 1.54 (1.06-2.24); 1.92 (1.24-2.98) [1.65 (1.20-2.28)] PROM 1.49 (1.02-2.17); 1.71 (1.10-2.66) [1.57 (1.14-2.17)]
Farah et al., 2009, Ireland	<18.5 (162) 18.5–24.9 (3146) 25–29.9 (1641) 30–40.0 (780) >40 (95)	IOL 1.16 (1.01-1.33); 1.45 (1.22-1.73); 2.36 (1.56-3.58) [1.29 (1.14-1.45)] Instrumental delivery 0.79 (0.67-0.92); 0.75 (0.61-0.93); 0.69 (0.39-1.23) [0.77 (0.67-0.89)] CS 1.35 (1.15-1.58); 1.97 (1.63-2.38); 4.92 (3.24-7.45) [1.62 (1.42-1.86)]
Kalk et al., 2009, Germany	<18.5 (163) 18.5 – 24.9 (1446) 25- 29.9 (309) >30 (126)	PIH 2.72 (1.74-4.25); 3.99 (2.14-7.44) [3.09] CS 1.73 (1.31-2.28); 1.82 (1.20-2.77) [1.76] Macrosomia 1.54 (1.06-2.24); 2.07 (1.25-3.42) [1.69] PTB 1.65 (1.10-2.49); NS [1.65] LGA 1.62 (1.14-2.32); 2.57 (1.64-4.04) [1.90] SGA 0.49 (0.29-0.83); NS [0.49] NICU admission 1.47 (1.09-1.99); 2.22 (1.47-3.36) [1.63]
Khashanand Kenny, 2009, England	<18.5 (2453) 18.5–24.9 (43095) 25–29.9 (24219) 30–40.0 (13721) >40 (1550)	Fetal death 0.87 (0.72-1.05); 1.00 (0.80-1.25); 1.61 (1.01-2.57) [0.95 (0.81-1.11)] PTB 0.91 (0.85-0.97); 0.94 (0.87-1.02); 0.95 (0.78-1.16) [0.92 (0.88-0.97)] CS 1.35 (1.31-1.38); 1.69 (1.63-1.74); 2.21 (2.08-2.35) [1.67 (1.62-1.73)] Macrosomia 1.78 (1.57-2.01); 2.91 (2.57-3.30); 5.34 (4.31-6.61) [2.34 (2.10-2.61)] SGA 1.05 (0.99-1.11); 1.02 (0.95-1.10); 0.89 (0.72-1.10) [1.04 (0.98-1.10)] LGA 1.15 (1.06-1.24); 1.65 (1.53-1.79); 3.10 (2.69-3.58) [1.42 (1.33-1.52)]

BMI: Body mass index; CS: Cesarean section; GDM: Gestational diabetes mellitus; IOL: Induction of labor; LGA: Large for gestational age; NA: Value not available; NICU: Neonatal intensive care unit; NS: Not significant; PIH: Pregnancy induced hypertension; PROM: Premature rupture of membrane; PTB: Pre term birth; SGA: Small for gestational age.

Synthesis of results: Among 8 maternal complications (OR for overweight/obese pregnant women) (Supplementary 1), GDM is the highest OR in Indian and Western Studies (mean ± SD is 6.81±5.49 Vs 5.47±4.03). PIH is the highest OR for other Asian studies (3.78±1.87 in obese pregnant women) which is lower than Indian studies (4.57±3.10) and slightly higher than Western studies (3.55±1.57). Preeclampsia/eclampsia is highest OR in Indian studies (6.41±6.03) followed by Western studies (2.75±1.37) and other Asian studies (2.29±0.64). Even though odds for Indian overweight/obese pregnant is one to four times higher than other Asian or Western overweight/obese pregnant women, when extreme values were removed from calculation [references 9, 10 for eclampsia; 12, 26 for GDM; 10 for PIH] OR values are comparable to each other. CS is reported by maximum number of studies, 31 out of 37, with odds of 2.88±0.45, 2.10±0.95, 1.85±0.17 for overweight/obese pregnant women of Indian, other Asian, Western studies respectively. Odds of haemorrhage in Indian and Western studies are comparable to each other (OR 2.42±1.83, 2.10±1.35 respectively). OR for IOL is comparable to each other in Indian and other Asian studies (2.53±1.45, 2.59 ±1.58 respectively). OR for ID and PROM is reported by less number of studies and is less than 2.0 (1.73±0.79, 1.58±0.28 respectively in Indian studies).

Among 8 fetal complications OR in obese/overweight pregnant women (Supplementary 2), macrosomia is the highest OR in other Asian and Western studies (3.02±2.45, 2.33±0.95 respectively). Indian studies have higher OR (3.95±1.52) for macrosomia, but surprisingly microsomia is the highest OR (7.89±7.46). Other Asian studies OR for microsomia is higher than 1.0 (1.21±0.16, but Western studies have lower odds (0.91±0.14) for overweight/obese pregnant women. NICU admission of children of obese mothers is higher in Indian studies (3.39±2.04) than Western studies (1.67±0.84). OR for low Apgar score is 2.34±1.61 in Indian studies, 1.52±0.71 in Western studies. PTB is the most commonly, 24 out of 37, reported fetal complication. OR for PTB is also higher in both Indian as well as Western studies (2.18±1.45, 1.57±1.52 respectively). After removing extreme value[11] both Indian (1.66±0.75) and Western studies are comparable to each other. OR for stillbirth/ perinatal death is more in Indian (3.17±2.77) than Western (1.47±0.68) studies. But after removing extreme values[10,26], result is comparable to each other (1.80±0.46, 1.30±0.34 respectively).

Risk of bias across studies: Among 37 included studies, 12 studies included different BMI level in control[11,13,19,30,38,39] or extreme BMI values in BMI groups[26,27,34,35,41,43] which may not be comparable to other 26 studies and find a conclusion. Overall Indian studies used less pregnant women (median 250) than other Asian (median 1418) or Western counterparts (median 2810). BMI classification across the studies is not standardized leaving difficulty in finding inference from studies.

Discussion

Summary of evidence: We compared the maternal as well as fetal complications between Indian, Asian and the western population. The aim was to see how the chances of having delivery complications differed from one region of the world to the other depending on BMI status of women in reproductive age. In general among 8 maternal complications, OR for GDM is highest followed by PIH and preeclampsia/eclampsia in overweight/obese pregnant women of all three regions. Among 8 fetal complications in overweight/obese pregnant women, macrosomia has the highest OR followed by NICU admission, low Apgar in both Indian as well as Western studies. But microsomia and perinatal death are the two unique complications in obese Indian pregnant women. The most shocking thing to find after comparing the Indian, Asian and the western studies was that Indian studies showed almost equal or even more chances of pregnancy and delivery related complications as compared to their western counterparts with similar BMI.

Hence, Healthcare providers play a primary prevention role in female's early reproductive age. Encouraging women to adopt a healthy lifestyle, taking a balanced diet and involving in regular physical activity will help them overcome the obesity related complications in mother and child[44]. Women should be counseled to start their pregnancy in a normal BMI category and to maintain their weight gain within recommended limits during and after pregnancy[45]. Physical therapy can play a very important role in managing this phase of a women's life, without any adverse effects. Though as per Indian scenario where any kind of physical activity is avoided or reduced to minimal levels during pregnancy, encouraging physical therapy for expecting women is a challenge in itself. But, it is the only way to curb this rising menace of obesity associated chronic diseases which are rising due to lifestyle changes. Many western studies have shown the benefitting effects of exercising before, during and after pregnancy. Maintaining an active lifestyle during pregnancy can prevent excessive weight gain during pregnancy; post-partum weight retention; gestational diabetes[45,46].

Conclusion

Though Indian women have less BMI and less well built body stature as compared to their western counterparts, they showed almost equal or in certain cases even more chances of having pregnancy related complication. Hence promoting physical activity preferably by a physical therapist can be of great help for women in her childbearing years.

Conflict of Interest: We declare that we have no conflict of interest.

Acknowledgement

We would like to thank Late Prof. Satish Kumar Verma, Dept. of Sports Sciences, Punjabi University, Patiala for sharing his knowledge and guiding this review during the initial phase.

References

1. World Health Organization. (2014). Obesity and overweight 2014 (Internet updated January 2015). Retrieved from: http://www.who.int/mediacentre/factsheets/fs311/en lastly assessed on 30-04-16.
2. Joshi SR (2003) Metabolic syndrome - emerging clusters of the Indian phenotype. J Assoc Physicians India 51(5):445-446.
3. Orr-Walker B, Evans MC, Reid IR, Cundy T (2005) Increased abdominal fat in young women of Indian Origin. Asia Pac J Clin Nutr 14(1):69-73.
4. Bhardwaj S, Misra A, Misra R, Goel K, Bhatt SP, Rastogi K, Vikram NK, Gulati S (2011) High Prevalence of Abdominal, Intra-Abdominal and Subcutaneous Adiposity and Clustering of Risk Factors among Urban Asian Indians in North India. PLoS One 6(9):e24362. doi:10.1371/journal.pone.0024362.
5. Pradeepa R, Anjana RM, Joshi SR, Bhansali A, Deepa M, Joshi PP et al (2015) Prevalence of generalized & abdominal obesity in urban & rural india- the ICMR-INDIAB study (Phase-I) [ICMR-INDIAB-3]. Indian J Med Res 142(8):139-150. doi: 10.4103/0971-5916.164234.
6. Lyu LC, Lo CC, Chen HF, Wang CY, Liu DM (2009) A prospective study of dietary intakes and influential factors from pregnancy to postpartum on maternal weight retention in Taipei, Taiwan. Br J Nutr 102(12):1828-1837. doi: 10.1017/S0007114509991243.
7. Dasgupta A, Harichandrakumar KT, Habeebullah S (2014) Pregnancy outcome among obese Indians- A prospective cohort study in a tertiary care centre in south India. International Journal of Scientific Study 2(2):13-18.
8. Kumari P, Gupta M, Kahlon P, Malviya S (2014) Association between high maternal body mass index and feto-maternal outcome. Journal of Obesity and Metabolic Research 1(3):143-148. doi: 10.4103/2347-9906.141140.
9. Gaur K, Yadav A, Raj D, Jain A (2013) Study the association of body mass index with pregnancy outcome. International Journal of Innovative Research & Development 2(7):65-70.
10. Meenakshi, Srivastava R, Sharma NR, Kushwaha KP, Aditya V (2012) Obstetric behavior and pregnancy outcome in overweight and obese women. Maternal and fetal complications and risks in relation to maternal overweight and obesity. J Obstet Gynecol India 62(3):276-280. doi: 10.1007/s13224-012-0215-z.

11. Sujatha VV, Sharma KVLN, Rajesh K (2012) High body mass index in pregnancy, its effects on maternal and fetal outcome. J Clin Gynecol Obstet 1(1):15-18. doi: 10.4021/jcgo2w.
12. Verma A, Shrimali L (2012) Maternal body mass index and pregnancy outcome. J Clin Diagn Res 6(9):1531-1533. doi: 10.7860/JCDR/2012/4508.2551.
13. Mandal D, Mandal S, Rakshit A, Dey RP, Biswas SC, Banerjee A (2011) Maternal obesity and pregnancy outcome: A prospective analysis. J Assoc Physicians India 59:486-489.
14. Liu L, Hong Z, Zhang L (2015) Associations of pre-pregnancy body mass index and gestational weight gain with pregnancy outcomes in nulliparous women delivering single live babies. Sci Rep 5:12863. doi: 10.1038/srep12863.
15. Sun D, Li F, Zhang Y, Xu X (2014) Association of the pre-pregnancy BMI and gestational BMI gain with pregnancy outcomes in Chinese women with gestational diabetes mellitus. Int J Clin Exp Med 7(12):5784-5789.
16. Ebrahimi-Mameghani M, Mehrabi E, Kamalifard M, Yavarikia P (2013) Correlation between body mass index and central adiposity with pregnancy complications in pregnant women. Health Promot Perspect 3(1):73-79. doi: 10.5681/hpp.2013.009.
17. Li N, Liu E, Guo J, Pan L, Li B, Wang P, Liu J, Wang Y, Liu G, Baccarelli, AA, Hou L, Hu G (2013) Maternal prepregnancy body mass index and gestational weight gain on pregnancy outcomes. PLoS One 8(12):e82310. doi: 10.1371/journal.pone.0082310.
18. Yazdani S, Yosofniyapasha Y, Nasab BH, Mojaveri MH, Bouzari Z (2012) Effect of maternal body mass index on pregnancy outcome and newborn weight. BMC Res Notes 5:34. doi: 10.1186/1756-0500-5-34.
19. Choi SK, Park IY, Shin JC (2011) The effects of pre-pregnancy body mass index and gestational weight gain on perinatal outcomes in Korean women: A retrospective cohort study. Reprod Biol Endocrinol 9:6. doi: 10.1186/1477-7827-9-6.
20. Meher-un-nisa, Aslam M, Ahmed SR, Rajab M, Kattea L (2009) Impact of obesity on fetomaternal outcome in pregnant Saudi females. Int J Health Sci (Qassim) 3(2):187-195.
21. Linden ELVD, Browne JL, Vissers KM, Antwi E, Agyepong IA, Grobbee DE, Klipstein-Grobusch K (2016) Maternal body mass index and adverse pregnancy outcomes: A Ghanaian cohort study. Obesity (Silver Spring) 24(1):215-222. doi: 10.1002/oby.21210.
22. Stuber TN, Eunzel EC, Zollner U, Rehn M, Wockel A, Honig A (2015) Prevalence and associated risk factors for obesity during pregnancy over time. Geburtshilfe Frauenheilk 75(9):923-928. doi: 10.1055/s-0035-1557868.
23. Fouelifack FY, Fouedjio JH, Fouogue JT, Sando Z, Fouelifa LD, Mbu RE (2015) Associations of body mass index and gestational weight gain with term pregnancy outcomes in urban Cameroon: A retrospective cohort study in a tertiary hospital. BMC Res Notes 8:806. doi: 10.1186/s13104-015-1765-9.
24. Morgan KL, Rahman MA, Hill RA, Zhou SM, Bijlsma G, Khanom A, Lyons RA, Brophy ST (2014) Physical activity and excess weight in pregnancy have independent and unique effects on delivery and perinatal outcomes. PLoS One 9(4):e94532. doi: 10.1371/journal.pone.0094532.
25. Vinturache A, Moledina N, McDonald S, Slater D, Tough S (2014) Pre-pregnancy body mass index (BMI) and delivery outcomes in a Canadian population. BMC Pregnancy and Childbirth 14:422. doi: 10.1186/s12884-014-0422-y.
26. Crane JMG, Murphy P, Burrage L, Hutchens D (2013) Maternal and perinatal outcomes of extreme obesity in pregnancy. J Obstet Gynaecol Can 35(7):606-11.
27. Denison FC, Norwood P, Bhattacharya S, Duffy A, Mahmood T, Morris C, Raja EA, Norman JE, Lee AJ, Scotland G (2014) Association between maternal body mass index during pregnancy, short-term morbidity, and increased health service costs: A population-based study. BJOG 121(1):72-82. doi: 10.1111/1471-0528.12443.
28. Gaillard R, Durmus B, Hofman A, Mackenbach JP, Steegers EAP, Jaddoe VWV (2013) Risk factors and outcomes of maternal obesity and excessive weight gain during pregnancy. Obesity (Silver Spring) 21(5):1046-1055. doi: 10.1002/oby.20088.
29. Iyoke CA, Ugwu GO, Ezugwu FO, Lawani OL, Onyebuchi AK (2013) Retrospective cohort study of the effects of obesity in early pregnancy on maternal weight gain and obstetric outcomes. Int J Womens Health 5:501-507. doi: 10.2147/IJWH.S49909.
30. Minsart AF, Buekens P, Spiegelaere MD, Englert Y (2013) Neonatal outcomes in obese mothers: A population-based analysis. BMC Pregnancy Childbirth 13:36. doi: 10.1186/1471-2393-13-36.
31. Mochhoury L, Razine R, Kasouati J, Kabiri M, Barkat A (2013) Body mass index, gestational weight gain, and obstetric complications in Moroccan population. J Pregnancy Article ID: 379461. doi: 10.1155/2013/379461.
32. Oteng-Ntim E, Kopeika J, Seed P, Wandiembe S, Doyle P (2013) Impact of obesity on pregnancy outcome in different ethnic groups: Calculating population attributable fractions. PLoS One 8(1):e53749. doi: 10.1371/journal.pone.0053749.
33. Heude B, Thiebaugeorges O, Goua V, Forhan A, Kaminski M, Foliguet B, Schweitzer M, Magnin G, Charles MA et al (2012) Pre-pregnancy body mass index and weight gain during pregnancy: Relations with gestational diabetes and hypertension, and birth outcomes. Matern Child Health J 16:355-63. doi: 10.1007/s10995-011-0741-9.
34. Vinayagam D, Chandraharan E (2012) The adverse impact of maternal obesity on intrapartum and perinatal outcomes. ISRN Obstet Gynecol Article ID: 939762. doi: 10.5402/2012/939762.
35. Galan SM, Hernandez AS, Zuniga IV, Criado MSL, Llorens AP, Vallejo JLG (2012) Abnormal maternal body mass index and obstetric and neonatal outcome. J Matern Fetal Neonatal Med 25(3):308-312. doi: 10.3109/14767058.2011.575905.
36. Magann EF, Doherty DA, Chauhan SP, Klimpel JM, Huff SD, Morrison JC (2011) Pregnancy, obesity, gestational weight gain, and parity as predictors of peripartum complications. Arch Gynecol Obstet 284:827-836. doi: 10.1007/s00404-010-1754-0.
37. Ovesen P, Rasmussen S, Kesmodel U (2011) Effect of pre-pregnancy maternal overweight and obesity on pregnancy outcome. Obstet Gynecol 118:305-312. doi: 10.1097/AOG.0b013e3182245d49.
38. Knight M, Kurinczuk JJ, Spark P, Brocklehurst P (2010) Extreme obesity in pregnancy in the United Kingdom. Obstet Gynecol 115(5):989-997.
39. Marshall NE, Guild C, Cheng YW, Caughey AB, Halloran DR (2010) Maternal super-obesity and perinatal outcome. Acta Obstet Gynecol Scand 89(7):924-930. doi: 10.3109/00016341003657884.
40. Denison FC, Norrie G, Graham B, Lynch J, Harper N, Reynolds RM (2009) Increased maternal BMI is associated with an increased risk of minor complications during pregnancy with consequent cost implications.

BJOG 116:1467-1472. doi: 10.1111/j.1471-0528.2009.02222.x.

41. Farah N, Maher N, Barry S, Kennelly M, Stuart B, Turner MJ (2009) Maternal morbid obesity and obstetric outcome. Obes Facts 2(6):352-354. doi: 10.1159/000261951.
42. Kalk P, Guthmann F, Krause K, Relle K, Godes M, Gossing G, Halle H, Wauer R, Hocher B (2009) Impact of maternal body mass index on neonatal outcome. Eur J Med Res 14:216-222.
43. Khashan AS, Kenny LC (2009) The effects of maternal body mass index on pregnancy outcome. Eur J Epidemiol 24:697-705. doi: 10.1007/s10654-009-9375-2.
44. Thangaratinam S, Rogozinska E, Jolly K, Glinkowski S, Roseboom T, Tomlinson JW, Kunz R, Mol BW, Coomarasamy A, Khan KS (2012) Effects of interventions in pregnancy on maternal weight and obstetric outcomes: Meta-analysis of randomized evidence. BMJ 344:e2088. doi: 10.1136/bmj.e2088.
45. Streuling I, Beyerlein A, Von Kries R (2010) Can gestational weight gain be modified by increasing physical activity and diet counseling? A meta-analysis of interventional trials. Am J Clin Nutr 92(4):678-687. doi: 10.3945/ajcn.2010.29363.
46. Mudd LM, Owe, KM, Mottola, MF, and Pivarnik JM (2013) Health Benefits of Physical Activity during Pregnancy: An International Perspective. Med Sci Sports Exerc 45(2):268–277.