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Article

Secular Trends of Birth Weight in Twins and Singletons in South Korea from 2000 to 2020

Yoon-Mi Hur
General College of Education, Kookmin University, Seoul, South Korea

Abstract

Whether the decline of birth weight (BW) reported in developed countries in the early 2000s is ongoing remains unknown. Furthermore, despite recent sharp increases in twin births, comparing secular trends of BW between singletons and twins is difficult, as studies have rarely examined secular trends of BW in twins and singletons simultaneously. Therefore, this study aimed to investigate the most recent 20-year trends (2000–2020) of BW in twins and singletons in South Korea. Annual natality files from 2000 to 2020 obtained from the Korean Statistical Information Service were analyzed. A yearly decrease of BW was 3 g among singletons and 5 to 6 g in twins from 2000 to 2020, indicating a widening gap of BW between twins and singletons with increasing years. Gestational age (GA) also decreased in twins and singletons with yearly decreases of 0.28 days in singletons and 0.41 days in twins. Whereas BW decreased in term (GA $\geq$ 37 weeks), and very preterm groups (28 weeks $\leq$ GA $<$ 32 weeks) from 2000 to 2020 in twins and singletons, it increased in moderate to late preterm (32 weeks $\leq$ GA $<$ 37 weeks) groups, indicating a non-linear relationship between BW and GA. The prevalence of macrosomia (BW $>$ 4000 g) in singletons decreased from 2000 to 2020, whereas low birth weight (LBW; BW $<$ 2500 g) increased in twins and singletons. LBW is associated with adverse health outcomes. Effective public health strategies aiming at reduction in the incidence of LBW in the population should be developed.

Keywords: Birth weight; secular trend; low birth weight; twin; gestational age; singleton

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Birth weight (BW) has been identified as an indicator of prenatal development and is associated with infant mortality, morbidity (Wilcox, 2001), and social and health outcomes later in life (Black et al., 2007). Analysis of secular trend of BW is important because it can provide insights into interactions among prenatal growth, genetics, and social environment, and reveal potential maternal and neonatal health problems at the population level.

Earlier studies have reported that BW significantly increased from the 1960s to late 1990s or early 2000s in many developed countries, such as Australia (Lahmann et al., 2009), Denmark (Schack-Nielsen et al., 2006), Norway (Skjaerven et al., 2000), Sweden (Odlind et al., 2003), and the United States and Canada (Ananth & Wen, 2002; Chike-Obi et al., 1996). During this period, annual increments in the mean BW varied by country, but were within the order of 2 g to 4 g. These increases have been suggested to be associated with the reduction in low birth weight (LBW), small-for-gestational-age, and preterm births resulting from improved prenatal and neonatal care (Chike-Obi et al. 1996); increased macrosomia mostly due to maternal determinants, such as increased prepregnancy weight and gestational weight gain; and decreased proportion of smoking women (Bergmann et al., 2003; Surkan et al., 2004).

Conversely, several recent studies provide evidence that the mean BW started to decrease (Celind et al., 2019; Shan et al., 2014; Takemoto et al., 2016), suggesting that BW may have reached a plateau. However, recent BW trends remain unclear because epidemiological studies to date examined secular trends of BW mostly until 2010; therefore, whether the declining trends reported in the early 2000s have continued or stabilized especially after 2010 is yet to be determined. Another limitation in studies of the secular trend of BW is that most of them have focused on singletons, excluding multiples. Thus, knowledge on secular trends of BW among twins is limited, although many recent studies reported that twin births substantially increased worldwide (Monden et al., 2021). Furthermore, as few studies assessed secular trends of BW in twins and singletons simultaneously in the same period, comparing secular trends and related factors between the two groups is difficult. A few existing studies examining twins alone showed that temporal changes of BW depended on gestational age (GA). For example, although overall decreases of BW and GA were observed in twins born during 1967–1995, increased BW was found among twins born from 35 to 40 weeks of gestation (Glinianaia et al., 2000). Similarly, although BW decreased in twins born up to 32 weeks of gestation from 1964 to 2007, it increased after 32 weeks of gestation (Gielen et al., 2010).

Author for correspondence: Yoon-Mi Hur, Email: ymhur@kookmin.ac.kr
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Therefore, this study aimed to examine the most recent 20-year trends (2000–2020) of BW in twins and singletons in South Korea. By investigating secular trends of BW in twins and singletons simultaneously, the trends and related factors could be compared between the two groups.

Materials and Methods

Data Source

The datasets were derived from the annual natality files from 2000 to 2020 at the Micro Data Integrated Service, the Korea Statistical Information Service, https://mdis.kostat.go.kr/dwnlSvc/ofrSurvSearch.do?curMenuNo=UI_POR_P9240.

Computerized birth records in the natality files are anonymous secondary data approved by the South Korean government to use for research purposes. In total, 9,369,102 live births born from January 1, 2000 to December 31, 2020 in the natality files were reviewed. Infants with BW < 500 g or GA < 20 weeks ($n = 52,157$) and triplets or higher-order births ($n = 4579$) were excluded from data analysis. Cases where the number of births is unknown and other unreliable data ($n = 32,887$) were also excluded. Finally, twins without information on the birth order ($n = 12$) were removed. The final sample for data analyses comprised 9,309,553, including 9,047,145 singletons and 262,408 twins (first-born twins = 131,046, and second-born twins = 131,362). The number of males exceeded that of females in both groups: 50.7% and 51.7% were males in twins and singletons respectively.

Variables of Interest

Variables extracted from natality files included BW, GA in weeks, birth year, sex of newborn, and the number of births (singleton = 1, twin = 2). Following the World Health Organization criteria (WHO, 2004), LBW was defined as BW < 2500 g, term as GA ≥ 37 weeks, and preterm as GA < 37 weeks. Preterm was further divided into moderate to late preterm (32 weeks ≤ GA < 37 weeks) and very preterm (28 weeks ≤ GA < 32 weeks). In addition, rate of macrosomia (BW > 4000 g; Schwartz & Teramo, 1999), regardless of GA, was created in singletons for each year. The macrosomia rate was not calculated for twins because only 37 (0.01%) macrosomic twin babies were born during 2000–2020.

Statistical Analysis

First, descriptive statistics were computed for BW for singletons and for the first- and the second-born twins by sex. Second, to examine the secular trend of BW, the mean BW for singletons and the first- and the second-born twins were calculated for each year during the study period (2000–2020). To determine a yearly change in BW, univariate linear regression analyses for BW were performed with birth year as an independent variable separately for singletons and the first- and the second-born twins. Third, to examine the secular trend of GA, the mean GA for singletons and twins were computed for each year in the study period, and univariate regression analyses for GA were conducted with birth year as an independent variable. Fourth, to compare secular trends of BW in various groups of GA, univariate regression analysis for BW were conducted with birth year as an independent variable in three GA groups (term, moderate to late preterm, and very preterm) in singletons and the first- and the second-born twins in 2000−2020. Finally, the rates of macrosomia and LBW were calculated at an interval of 5 years in the study period. LBW was further divided into preterm and term LBW and the secular changes of the prevalence of preterm and term LBW were compared in the study period.

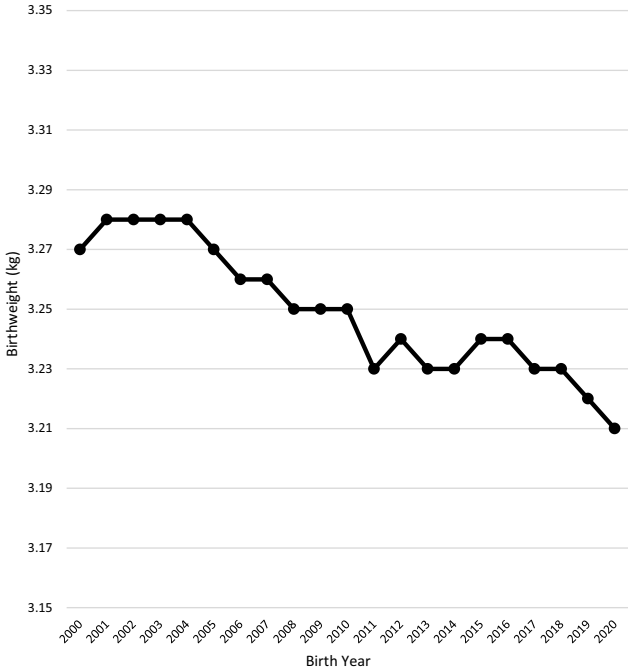

Fig. 1. The secular trend of the mean birth weight in singleton births in South Korea from 2000 to 2020.

Results

Descriptive Statistics of Birthweight in Twins and Singletons

In the total sample, the means (*SD*) of BW were 2.43 (±0.47) kg in the first-born twins, and 2.36 (±0.48) kg in the second-born twins (Cohen's $d = 0.15$), showing that BW is slightly larger in the first- than in the second-born twins. The mean (*SD*) BW of singletons was 3.25 (±0.44) kg in the total sample, showing that BW is larger in singletons than in twins.

The mean BW of males was consistently larger than that of females in singletons, and the first- and the second-born twins in each year during the study period. In the total sample, the male versus female means were 3.30 (±0.44) kg versus 3.20 (±0.43) kg in singletons, 2.47 (±0.47) kg versus 2.38 (±0.46) kg in the first-born twins, and 2.40 (±0.49) kg versus 2.32 (±0.47) kg in the second-born twins. These results were consistent with the literature of BW (e.g., Jelenkovic et al., 2017).

Secular Changes in the Mean Birth Weight in Twins and Singletons During 2000–2020

Figure 1 shows the secular trend of the mean BWs in singletons, and Figure 2 shows the secular trend of the mean BWs in the first- and in the second-born twins during 2000−2020. The mean BW declined from 3.27 kg in 2000 to 3.21 kg in 2020 in singletons, from 2.47 kg to 2.40 kg in the first-born twins, and from 2.40 kg to 2.33 kg in the second-born twins.

Univariate regression analysis revealed that downward trends of BW from 2000 to 2020 were significant in singletons (standardized beta = −.044; $p < .001$), in the first-born twins (standardized beta = −.067; $p < .001$), and in the second-born twins (standardized beta = −.071; $p < .001$). The slope was higher in twins than in

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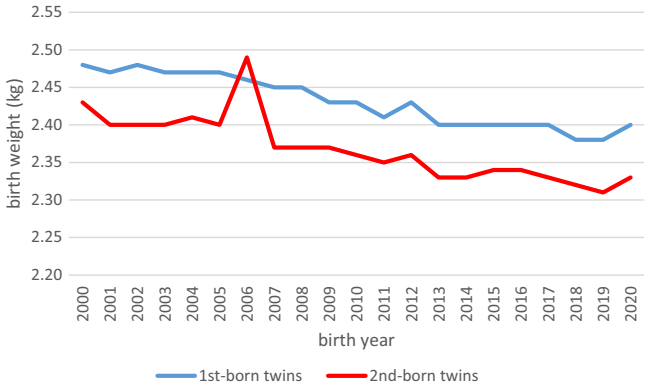

Fig. 2. Secular trends of the mean birth weight in the first- and the second-born twins in South Korea from 2000 to 2020.

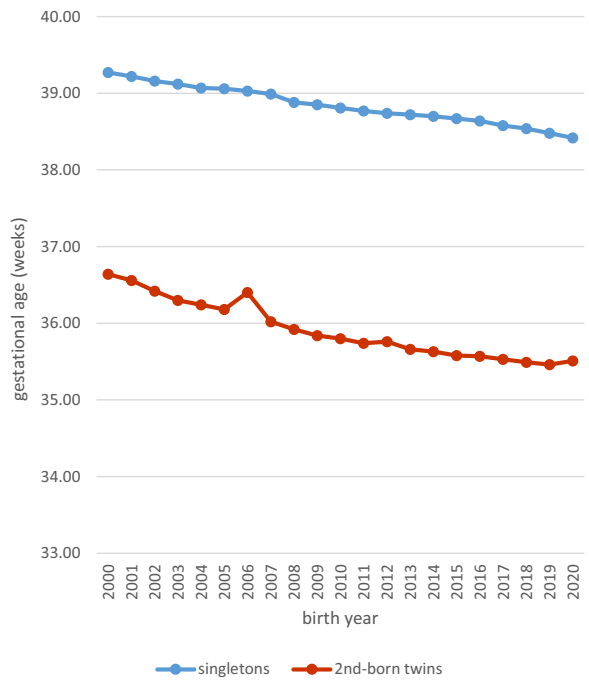

Fig. 3. The secular trend of the mean gestational age in weeks in singletons and the second-born twins in South Korea from 2000 to 2020.

singletons, suggesting that BW has decreased faster in twins than in singletons in the past two decades. Regression analysis showed that a yearly decrease was 3 g among singletons, 5 g in the first-born twins, and 6 g in the 2nd-born twins. No sex difference was found in the amount of yearly decrease in singletons or twins.

Secular Changes of Gestational Age in Singletons and Twins During 2000–2020

Figure 3 shows secular changes of GA in singletons and twins during 2000–2020. GA for twins in Figure 3 was based on the second-born twins as sample size was slightly larger in the second- than in the first-born twins. As indicated in the figure, GA decreased in twins and singletons from 2000 to 2020. Regression analysis suggested that GA decreased by 0.28 days per year (around 5.6 days in 20 years) in singletons and by 0.41 days per year in twins (around 8.2 days in 20 years), indicating that as with BW, GA has decreased faster in twins than in singletons in the past two decades. The amount of yearly decrease was the same for both sexes in twins and singletons.

Table 1. Results of regression analysis for birthweight with birth year as an independent variable in three gestational age (GA) groups in singletons and the first- and the second-born twins during 2000–2020

	GA group	GA in weeks	Standardized Beta	Unstandardized Beta
singletons	Term	GA ≥ 37	−0.037	−0.002
	Moderate to late preterm	32 ≤ GA < 37	0.013	.001
	Very preterm	28 ≤ GA < 32	−0.324	−0.040
1st- born twins	Term	GA ≥ 37	−0.030	−0.002
	Moderate to late preterm	32 ≤ GA < 37	0.043	0.003
	Very preterm	28 ≤ GA < 32	−0.083	−0.005
2nd- born twins	Term	GA ≥ 37	−0.038	−0.002
	Moderate to late preterm	32 ≤ GA < 37	0.033	0.002
	Very preterm	28 ≤ GA < 32	−0.089	−0.005

Note. All Beta values are significant at $p < .01$.

Secular Trends of Birth Weight in Various Gestational Age Groups in Singletons and Twins During 2000–2020

Table 1 presents results of univariate regression analysis for BW with birth year as an independent variable in three GA groups (term, moderate to late preterm, and very preterm) in singletons and the first- and the second-born twins in 2000–2020. In term (GA ≥ 37 weeks) babies, BW decreased by 2 g per year in all three groups from 2000 to 2020. Very preterm (28 weeks ≤ GA < 32 weeks) babies also showed decreases in BW in all three groups (5 g per year in twins and 4 g per year in singletons). However, moderate to late preterm babies (32 weeks ≤ GA < 37 weeks) indicated increases of BW in all three groups from 2000 to 2020. The increases were more pronounced in twins than in singletons (2 to 3 g per year in twins vs. 1 g per year in singletons). These results suggested that yearly changes in BW differed across subgroups of GA, indicating a nonlinear relationship between GA and BW in twins and singletons.

Secular Changes in the Prevalence of Macrosomia and Low Birth Weight (LBW) in Singletons and Twins During 2000–2020

Figure 4 depicts the secular trend of the prevalence of macrosomia (BW > 4000 g) in singletons between 2000 and 2020 at an interval of 5 years (Supplementary Table 1). The prevalence of macrosomia was stable until 2005 (about 3.7%), but thereafter, it continued to fall to 2.50% in 2020.

Figure 5 presents secular trends of the prevalence of LBW (BW < 2500 g) divided into preterm (GA < 37 weeks) and term (GA ≥ 37 weeks) singletons and the first- and the second-born twins between 2000 and 2020 at an interval of 5 years (Supplementary Table 1). All three groups showed upward trends

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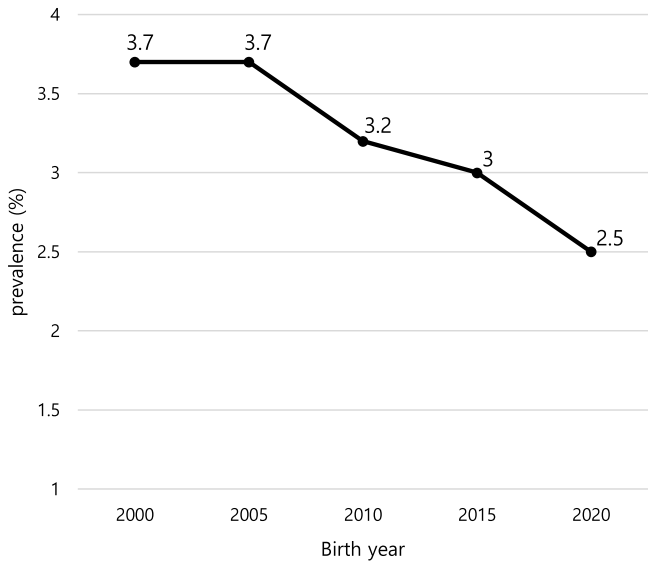

Fig. 4. Secular trend of the prevalence of macrosomia (birthweight > 4.0 kg) in singletons in South Korea from 2000 to 2020 at 5-year intervals.

from 2000 to 2020, indicating that the prevalence of LBW increased with increasing years. However, prevalence of LBW for each year was much higher in twins (46.1% to 54.0% for the first-born twins and 51.9% to 61.4% for the second-born twins) than in singletons (3.0% to 4.1%), and secular changes of LBW were more obvious in twins than in singletons (8–10% vs. 1%). When LBW was divided into term and preterm LBW, the prevalence of preterm LBW increased with increasing years across all three groups. In contrast, the prevalence of term LBW slightly declined with increasing years. Taken together, these results suggest that increased LBW in twins and singletons in South Korea during the last two decades were largely driven by increased rates of preterm than term LBW in twins.

Discussion

Five main points emerged from analyses of annual natality files in South Korea from 2000 to 2020. First, BW has decreased in twins and singletons in the study period. The secular reduction in twins was about twice as much as that in singletons (3 g/year in singletons and 5 to 6 g/year in twins), leading to increased gaps in BW between twins and singletons in recent years. Second, GA also decreased in twins and singletons from 2000 to 2020: A yearly decrease was 0.28 days (around 5.6 days in 20 years) in singletons and 0.41 days in twins (around 8.2 days in 20 years), indicating that GA has decreased more quickly in twins than in singletons. Third, whereas BW of twins and singletons decreased in term (GA $\geq$ 37 weeks) and very preterm groups (28 weeks $\leq$ GA < 32 weeks) from 2000 to 2020, BW slightly increased in moderate to late preterm (32 weeks $\leq$ GA < 37 weeks) groups. Fourth, the prevalence of macrosomia (BW > 4.0 kg) in singletons decreased from 2000 to 2020. Finally, singletons and twins showed upward trends of LBW from 2000 to 2020, and these trends were largely due to increased rates of preterm than term LBW.

The patterns of changes in the prevalence of macrosomia and LBW, and GA in twins and singletons during 2000–2020 pointed equally in the direction of decreasing BW: reduction of macrosomia and GA and an increase of LBW over the years. However, the secular changes in singletons were relatively small as compared to those found in twins, perhaps because the proportions of LBW and macrosomia are fairly small in singletons (2.5% to 4.1% respectively).

The results of the present study suggest that the BW reduction observed in many developed countries in the early 2000s likely continued until recently rather than stabilized. Furthermore, the gap of the mean BW between twins and singletons has become greater with increasing years in the past two decades because BW has declined faster in twins than in singletons. The rate of decline in GA in twins (0.41 days per year) found in the present study was much higher than that found in twin cohorts (0.25 days per year) from Belgium and the Netherlands during 1964–2007 (Gielen et al., 2010). As the cohorts in the Gielen et al. study (2010) were older than the cohort in the present study, the discrepancy in findings may suggest that as with BW, the decline in GA in twins is ongoing. However, it is also possible that the differences may be due to ethnic differences in samples and/or differences in obstetric practice in the country.

Prior studies (e.g., Glinianaia et al., 2000; Gielen et al., 2010) found increasing trends of BW in twins born after 32 or 35 weeks of gestation from the late 1900s to 2007 and decreasing trends of BW in twins born up to 32 or 35 weeks of gestation. The present cohort also showed similar patterns. In the present study, however, BW decreased again in twins and singletons born at or after 37 weeks of gestation. Further studies are needed to replicate the finding of reduction in BW in full term twins and singletons.

Consistent with previous studies in many developed countries (Pollock et al., 2021; Takemoto et al., 2016), the present study demonstrated that the prevalence of LBW increased substantially in South Korea in recent years. Specifically, the results suggested that the increased prevalence reflected increased rates of preterm LBW because term LBW slightly decreased over the years, whereas preterm LBW increased. Recent advancements in obstetric and neonatal care possibly decreased the prevalence of term LBW and improved the survival rates of twins and singletons with preterm LBW.

Decreased GA and macrosomia found in the present study may be associated with increased rates of labor induction and prelabor cesarean delivery in South Korea in recent years. The cesarean section rate in South Korea increased from 39.2% in 2003 to 54% in 2020 (the Korean Statistical Information Service, 2022). Prelabor cesarean delivery may have been increased to prevent pregnancy complications associated with large fetuses or twins by delivering them at an earlier GA. Decreased macrosomia observed in South Korea in the past 20 years may be partly due to low gestational weight gain among pregnant women in South Korea (Choi et al., 2020; Wie et al., 2017), given that excessive gestational weight gain is known to be a risk factor for the birth of macrosomic babies (Schwartz & Teramo, 1999).

Although the rate of LBW increased in both singletons and twins during the study period, secular changes of LBW were considerably higher in twins than in singletons. The number of twin pregnancies increased substantially in South Korea in recent years (Hur, 2021). Thus, it can be concluded that increased twin births — specifically, the increased rate of LBW in twins and decreased GA associated with increased cesarean section and labor induction — likely resulted in overall reduction of BW in South Korean neonates in the past two decades.

Secular trends of BW can differ across countries under various influences. In Japan, a stable negative BW trend concomitant with increased LBW in singletons has been reported from 1979 to 2010 (Takemoto et al., 2016). The authors suggested that these changes

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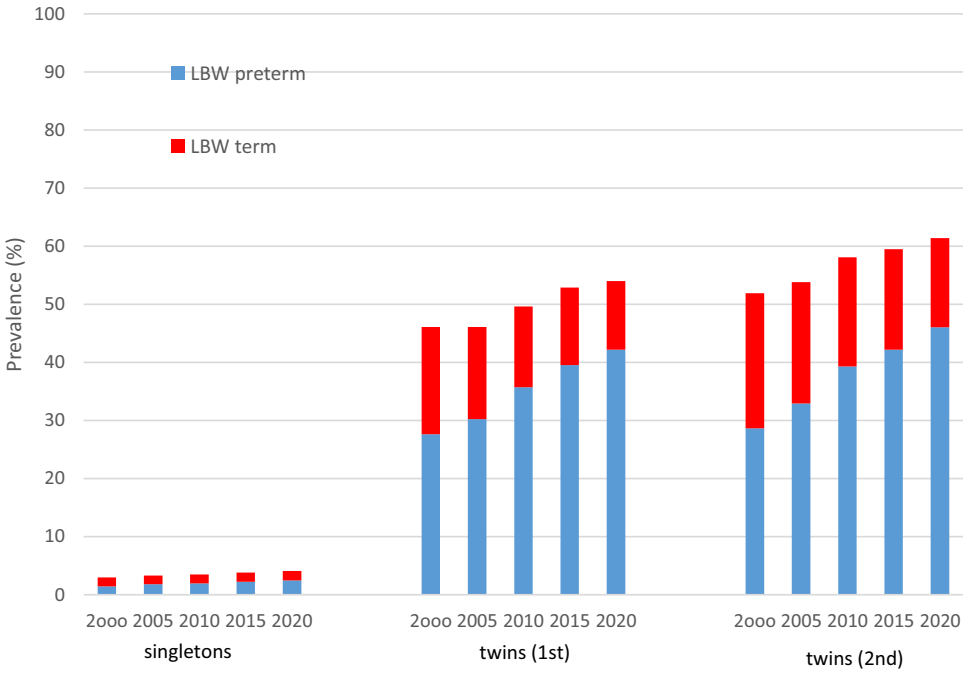

Fig. 5. Secular trends of the prevalence (%) of LBW (birthweight < 2500 g) divided into preterm (blue; gestational age < 37 weeks) and term (red; gestational age ≥ 37 weeks) singletons and the first- and the second-born twins from 2000 to 2020.

were mainly due to increased prevalence of underweight women of reproductive age and strict limiting on weight gain during pregnancy common in Japanese obstetrical practice (Takemoto et al., 2016). In China, like many other developed countries, the mean BW of singletons continuously increased from the 1980s to around the early 2000s, and thereafter, the increasing trend was noted to slow down (Shan et al., 2014; Zhang et al., 2019). The increasing phase was largely attributed to an increasing prevalence of macrosomia resulting from improved maternal diet and increased maternal body size associated with economic development in China. The decreasing phase was due to increased prevalence of preterm births and decreased prevalence of macrosomia associated with rising rates of prelabor cesarean section and medically induced labor in China (Shan et al., 2014; Zhang et al., 2019).

The natality files used in the present study included maternal and paternal ages in years at childbirth, maternal and paternal education, and parity. However, none of the associations between these variables and BW were sizable in twins and singletons ($r = -.008$ to .04), and appeared to be significant due to the large sample. These findings were consistent with results from the Gielen et al. (2010) study but not with findings of other studies (e.g., Silvestrin et al., 2013; Takemoto et al., 2016). Discrepancies in findings may be in part attributable to differences in sociodemographic factors in various countries.

Limitations of the present study should be noted. First, because natality files in South Korea do not include the use of assisted reproductive technology (ART), maternal smoking, diet or drinking, the impacts of these variables cannot be examined. Prior studies showed that neonates born after ART had shorter GA and lower BW than those born after spontaneous pregnancies (CDC, 2009). However, it was concluded that ART alone could not completely explain recent decreases in BW (CDC, 2009). Maternal smoking is not likely a significant contributor to the secular reduction of BW because smoking rates in South Korean females have been relatively constant during the past two decades (Korea Centers for Disease Control and Prevention, 2019). Second, the current standard of macrosomia has been criticized to not be applicable to Asians due to ethnic differences in intrauterine growth (Harvey et al., 2021). Thus, a better index may have to be developed in the future to understand the causes of the secular trends of BW in Asians.

In conclusion, the present study examined South Korean natality files from 2000 to 2020 and found decreasing trends of the mean BW in singletons and twins, and, simultaneously, increasing gaps of BW between twins and singletons. LBW is related to short- and long-term adverse health outcomes, including growth retardation (Ford et al., 2000). Policymakers should develop effective public health strategies to reduce LBW in the future.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/thg.2023.16

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