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Early childhood weight trajectory differences in twins, singletons, and gestational-age matched singletons

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ABSTRACT

Objective: Understanding of twin growth in the United States (US) is based on outdated or predominantly non-Hispanic White samples, and the age at which twins catch up to singletons is unclear. In this study, we characterized normative weight trajectories of twins and singletons in a contemporary, diverse cohort.

Methods: Data were from the PROMISE study, an electronic health record-based cohort of pregnant people and their children in the US (2005–2021). The Jenss model was used to characterize weight trajectories from 0 to 24 months of age. Twins (n = 716) were compared to the full cohort of singletons (n = 40,075) and a matched sample with similar gestational age at birth (GA) (n = 7160).

Results: Male and female twins had lower birth weight compared to singletons and experienced a high rate of weight gain throughout infancy. Among males, twins caught up in weight to the full singleton cohort and to GA-matched singletons at approximately 12 and 6 months, respectively. Among females, twins caught up to GA-matched singletons at approximately 15 months but did not fully overcome their birth weight disadvantage to the full singleton sample by 24 months.

Conclusions: These findings highlight that the use of singleton growth charts or preterm singleton growth charts among twins may be inappropriate and suggest the need for a twin-specific growth chart. Future research is needed to understand factors that drive differences in weight trajectories between twins and singletons and to guide twin-specific guidelines.

1. Introduction

Given extensive evidence that both rapid and slow infant weight gain is associated with adverse health outcomes later in life, growth is monitored closely during infancy, with interventions introduced in cases of atypical (i.e., rapid or slow) growth (Pesch et al., 2019; Zheng et al., 2018; Homan, 2016). Twins, however, have been largely excluded from growth research. Rates of twin pregnancies have doubled since 1980 and now account for approximately 3% of live births in the United States (US) (Martin and Osterman, 2019). Despite this growing prevalence, the understanding of normative early childhood weight gain specifically among twin populations remains scant. The absence of appropriate, twin-specific evidence could lead to erroneous interventions (or non-intervention), with potential short- and long-term health consequences

Abbreviations: US, United States; GA, Gestational age; EHR, Electronic health record; PROMISE, Preventing Obesity Through Health Maternal Gestational Weight Gain in the Safety Net; ADVANCE, Accelerating Data Value Across a National Community Health Center Network; PCORnet, Patient-centered outcomes research network; ICD, International Classification of Diseases; FPL, Federal poverty level; WHO, World Health Organization; HSD, Honestly significant difference.

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(Liotto et al., 2020).

While limited existing evidence reports that twins are born at a lighter weight compared to singletons, then undergo more rapid weight gain and have comparable weight to singletons by late childhood (van Dommelen et al., 2008; Buckler and Green, 2004; Gleason et al., 2023; Estourgie-van Burk et al., 2006; Wilson, 1979; Womack et al., 2023), critical knowledge gaps remain. Notably, the degree to and the age at which twins catch up to singletons is inconsistent across studies, which analyze data from the 1950s through 1990s and/or studied non-US cohorts or US cohorts of predominately White infants. This prior evidence may not generalize to the current US population, given vast secular changes and cultural differences in risk factors for rapid or slow early childhood growth, such as infant feeding practices. Additionally, little of this prior research (van Dommelen et al., 2008; Wilson, 1979; Womack et al., 2023) used longitudinal, provider-recorded weight measurements, which can be more accurate and frequent than parent recall or research visits at specific ages (Buckler and Green, 2004; Gleason et al., 2023; Estourgie-van Burk et al., 2006).

A critical methodological challenge in this field of research is how to address differences in gestational age (GA) between twins and singletons. The final weeks of gestation are critical for fetal growth and achieving optimal birth weight (Talge et al., 2014), both important for the trajectory of early childhood growth. GA differences between twins and singletons are well recognized, as are the health risks associated with earlier GA (Tingleff et al., 2023). In 2022, twins and singletons in the US were born at an average GA of 35.1 and 38.4 weeks, respectively (Centers for Disease Control and Prevention, 2023). However, twins are physiologically distinct from singletons, with different drivers of prenatal and postnatal growth. It has been argued that earlier GA near and at term among twins is largely physiological (e.g., driven by uterine space limitations (Muhlhausler et al., 2011; Buckler and Green, 2008)) while earlier GA among singletons is largely pathological. Indeed, several studies have reported higher morbidity and mortality among singletons compared to twins born at the same GA (Jacquemyn et al., 2003; Petit et al., 2011; Cheung et al., 2000), though other studies have found contradictory evidence (Yang et al., 2023; Gezer et al., 2012). Further, earlier GA among twins may be an effect of clinical recommendations: for example, in the US, dichorionic-diamniotic twins are recommended to be delivered at 38 gestational weeks (American College of Obstetricians and Gynecologists' Committee on Practice Bulletins—Obstetrics, Society for Maternal-Fetal Medicine, 2021).

Therefore, we aimed to fill evidence gaps on normative early childhood weight gain among twins and appropriate comparators for assessing twin growth. The objective of this study was to characterize the growth of twin children in our large, electronic health record (EHR)-based cohort, which includes diverse racial and ethnic group representation and children from predominately low-income families, using two singleton comparison groups: a general and a GA-matched singleton population. Regardless of the singleton comparison group, we hypothesized that twins would be born lighter, on average, but experience more rapid growth in infancy. We also hypothesized sex differences in growth among both twins and singletons, as has been shown in previous research among singletons (WHO Multicentre Growth Reference Study Group, 1992), with females born smaller and remaining smaller than males through our two-year follow-up period.

2. Methods

2.1. Study population

The Preventing Obesity Through Healthy Maternal Gestational Weight Gain in the Safety Net (PROMISE) study cohort (Boone-Heinonen et al., 2024) was derived from EHR data from OCHIN, Inc., supported by the Accelerating Data Value Across a National Community Health Center Network (ADVANCE) Clinical Research Network, a Patient-Centered Outcomes Research Network (PCORnet) member (DeVoe et al., 2014; Boone-Heinonen et al., 2017). ADVANCE integrates EHR data for community-based health care organizations from across the US and contains demographic, utilization, and clinical data. The PROMISE study was approved by the Oregon Health & Science University Institutional Review Board.

The PROMISE cohort contains data from 77,599 pregnancies (among 65,179 individuals) that started between 4/16/2004 and 7/6/2020 in patients 15 years of age or older at pregnancy start and that met the following criteria: GA at delivery between 20 and 42 weeks, available adult height, and had requisite weight measures. Most PROMISE patients lived in California (38.3%) or Oregon (27.2%) while pregnant. Supplemental data from linked (Centers for Disease Control and Prevention, 2024) birth records, including birth weight and select maternal descriptive variables, were obtained for California and Oregon births. Birthing parents were linked to child(ren)'s EHR data using methods developed and validated by a national PCORnet project (Block et al., 2018) and ADVANCE research (Angier et al., 2021). Further details may be found elsewhere (Boone-Heinonen et al., 2024).

2.2. Study variables

2.2.1. Child weight

This study assessed child weight measurements from 0 to 24 months of postnatal life. Implausible weight values were identified using the "growthcleanR" package in R (Daymont et al., 2017) and removed (2.8% of 1,027,182 weight values removed).

2.2.2. Baseline weight

Baseline weight was defined as the minimum weight among available weights from birth (birth record) and from postnatal days 0–5 (clinical visits). This approach accommodated the monotonic growth model (Jenss model, see Statistical analysis), maximized our sample size, and aligned with prior studies that used the Jenss model (Costet et al., 2015; Regnault et al., 2014), although approaches vary (Taine et al., 2021; Ahmed et al., 2021; Botton et al., 2014; Carles et al., 2017; Carles et al., 2016). Implausible birth weights were removed (Supplement A). Other weight values in the first 5 days of life that were not the minimum value were removed.

2.2.3. Demographics and health-related variables

Plurality was determined from the birth record if available (46.7%); otherwise, twins were identified by the presence of at least one International Classification of Diseases (ICD)-9 or ICD-10 diagnosis code indicating a twin pregnancy in the birthing parent's EHR (used only to determine twin status; 1.3%); otherwise, by the number of children who shared the same birthing parent and birth date in the EHR (52.1%). The obstetric estimate of GA from the birth record was used if available (27.2 % of twins and 47.0% of singletons); otherwise, GA from the EHR was used (72.8 % of twins and 53.0 % of singletons).

Child race and ethnicity are examined as descriptive variables that reflect social and cultural differences, including exposure to racism, that can affect health outcomes. Maternal pre-pregnancy diabetes, gestational diabetes, pre-pregnancy hypertension, and hypertensive disorders of pregnancy were defined from the birthing parent's EHR; described elsewhere (Boone-Heinonen et al., 2024). Maternal age at the end of pregnancy, preferred spoken language, income as a percentage of the federal poverty level (FPL) reported at the visit closest to pregnancy start, most prevalent insurance type in the second and third trimesters (Booman et al., 2024), and tobacco use during pregnancy were also obtained from the birthing parent's EHR and used to descriptively compare twins and singletons.

2.2.4. Analytic sample

This study was limited to liveborn male and female children linked to a birthing parent in PROMISE (N = 55,743) (Fig. 1). The study was further limited to singletons and twins, excluding 30 triplets and 177

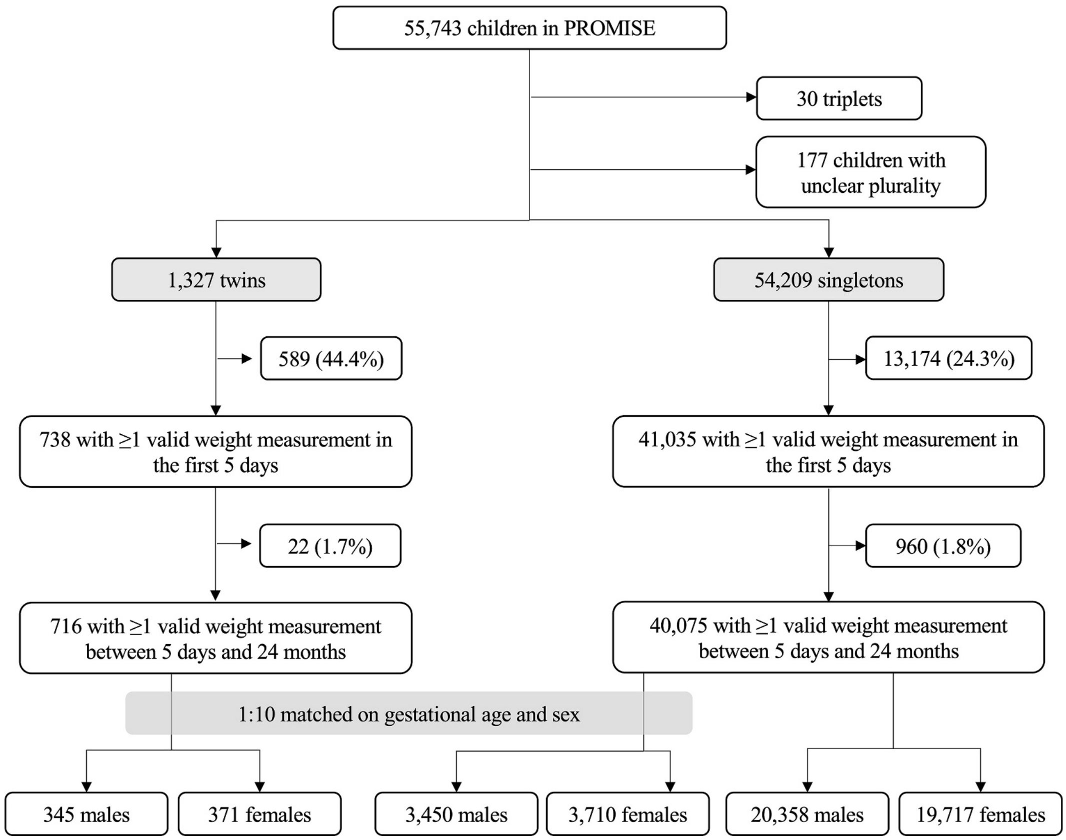

Fig. 1. Selection of the analytic sample of twins and singletons (0–24 months of age) in the PROMISE study (United States), 2005–2021.

children with unclear plurality, then limited to children who had an available baseline weight (44.4% of twins and 24.3% of singletons excluded) and at least one valid weight measurement between five days and 24 months of life (1.7% of twins and 1.8% of singletons excluded).

2.2.5. *Analytic sample: matching*

We compared the early childhood growth among twins to two singleton comparison groups: one general singleton population and another singleton population matched to twins on GA. The former allowed us to compare normative early childhood growth in the two groups, but at the expense of an inability to comment on the effect of GA. The latter allowed us to assess the differences in early childhood growth that are not driven by differences in GA, but at the expense of comparing a general twin population to a likely higher risk singleton population. Singletons were matched to twins on GA (nearest neighbor matching) and sex (exact matching) in a 10:1 ratio, without replacement. The 10:1 matching ratio was performed to leverage the large sample size of singletons in this study population, to increase confidence in comparisons, and to narrow confidence intervals. Most (76.7 %) matches were perfect on completed weeks of gestation and sex for all 10 matched singletons. Given that early childhood growth among singletons has been comprehensively studied (e.g., the World Health Organization [WHO] growth standards (WHO Multicentre Growth Reference Study Group, 1992)), our interpretation of results largely focuses on twins.

2.3. *Statistical analysis*

2.3.1. *Descriptive analysis*

All statistics are reported by sex and plurality. Descriptive statistics are reported as means with standard deviations or as percentages.

2.3.2. *Early childhood weight trajectory*

We modeled early childhood weight gain using the Jenss model, a four-parameter mixed effects model that was developed to fit growth trajectories from birth to 6–8 years. The model differentiates the pattern of growth into two periods: nonlinear growth during infancy and linear growth in childhood, and has shown to fit childhood growth data well (Regnault et al., 2014; Botton et al., 2014; Van Dommelen et al., 2005). We use the terms “infancy” to refer approximately to ages 0–12 months and “childhood” to refer approximately to ages 12–24 months. While studies assessing singleton growth have used the Jenss model (Costet et al., 2015; Taine et al., 2021; Carles et al., 2017; Van Dommelen et al., 2005), we are the first, to our knowledge, to apply this model to a population of twins. The Jenss model fit observed weight values well, providing a similar fit to previous studies (Costet et al., 2015; Regnault et al., 2014) and generally following the WHO growth standards. See Supplement B for further details.

Parameter a from the Jenss model reflects the predicted weight when $t = 0$; parameter c reflects nonlinear growth in early infancy; parameter d reflects the deceleration of growth in late infancy; and parameter b reflects the linear rate of growth in early childhood (Taine et al., 2021; Botton et al., 2014; Van Dommelen et al., 2005). Parameter a cannot necessarily be interpreted as birth weight and is instead referred to as the “starting value.” Our interpretation of parameters b and d reflects their negation in the Jenss model, e.g., a greater value for parameter b indicates a lower rate of growth in early childhood.

Parameters estimated by the Jenss model were compared between groups using one-way ANOVA. If significant at the 0.05 level, a post hoc Tukey’s honestly significant difference (HSD) test was used to determine which groups were statistically significantly different. Predicted weight (kg) and velocity of weight gain (kg/month) were computed at 3, 6, 12, 18, and 24 months for all groups and descriptively compared. Analyses were conducted using R version 4.3.2 (R Core Team, 2023).

2.3.3. *Sensitivity analysis*

We conducted a sensitivity analysis which excluded twins and singletons who did not have at least one weight measurement after 12 months of age.

3. Results

The final study sample included 345 male twins, 3,450 GA-matched male singletons, 20,358 male singletons (including GA-matched male singletons), 371 female twins, 3,710 GA-matched female singletons, and 19,717 female singletons (including GA-matched female singletons). Twins and GA-matched singletons were born at a mean of approximately 37 gestational weeks, while the full sample of singletons were born at a mean of approximately 39 weeks (Table 1). Female twins had a higher occurrence of preterm birth (31.0%) compared to their GA-matched female singleton counterparts (21.6%). Twins had lower birth weight compared to both singleton comparison groups regardless of sex. Twins were more likely to be of non-Hispanic Black race compared to both singleton groups; however, the majority of the sample were of Hispanic ethnicity (55.1%–64.4%). Compared to both singleton groups, twins were more likely to be born to birthing persons ≥35 years of age and who preferred a language other than English or Spanish. Birthing parents of twins and GA-matched singletons were more likely to have had pre-pregnancy diabetes and hypertension than birthing parents of the full singleton group; birthing parents of GA-matched singletons additionally had the highest prevalence of gestational diabetes and hypertensive disorders of pregnancy. The timing of weight measurements exhibited recurring peaks corresponding to a typical well-child exam schedule (**Fig. S2**). A median of 10–11 measurements were available per child.

Twins had a lower starting value (parameter *a*) compared to both groups of singletons, regardless of sex (Table 2). Male twins then underwent more rapid weight gain in early infancy compared to both GA-matched male singletons and the full sample of male singletons (parameter *c*; 1.66 (95 % confidence interval [CI]: 1.61, 1.71), 1.54 (1.53, 1.56), and 1.50 (1.50, 1.51), respectively) and a lower degree of deceleration in their growth in late infancy (parameter *d*; 4.78 (4.71, 4.84), 4.64 (4.62, 4.65), and 4.61 (4.60, 4.62), respectively). Female twins did not significantly differ in these early life growth parameters compared to their GA-matched singleton counterparts. However, female twins grew significantly faster in early infancy when compared to all female singletons (parameter *c*; 1.48 (1.43, 1.54) and 1.39 (1.39, 1.40), respectively) and had a lower degree of deceleration in growth in late infancy (parameter *d*; 4.79 (4.72, 4.86) and 4.71 (4.70, 4.72),

Table 1
Descriptive characteristics of early childhood (0–24 months) study groups from the PROMISE study (United States), by plurality and sex, 2005–2021 ($N = 47,951$).

	Males			Females		
	Twins (N = 345)	GA-Matched Singletons (N = 3450)	All Singletons (N = 20,358)	Twins (N = 371)	GA-Matched Singletons (N = 3710)	All Singletons (N = 19,717)
Gestational Age at Birth (wks) (mean (SD))	37.3 (2.3)	37.4 (2.2)	38.9 (1.5)	37.2 (2.3)	37.4 (2.1)	39.0 (1.5)
Preterm Birth (%)	28.1	28.1	5.0	31.0	21.6	4.1
Birth Weight (grams) (mean (SD))	2570 (547)	3050 (635)	3410 (528)	2440 (549)	3010 (632)	3320 (505)
Missing (%)	53.6	36.1	37.6	46.9	36.7	38.0
Child Race and Ethnicity (%)						
Hispanic	55.1	62.6	61.3	58.2	64.4	62.3
AA/PI	~4	4.1	4.3	~3	4.1	4.3
NH Black	11.3	7.3	7.1	14.0	7.1	7.3
NH White	20.6	18.8	19.8	19.1	17.1	18.3
Other	~1	1.1	1.3	~1	1.3	1.4
Missing	8.1	6.1	6.1	5.1	6.1	6.4
Maternal age, end of pregnancy (yrs) (%)						
≤18	~1	4.1	3.6	~1	3.2	3.8
19–24	~20	28.3	28.5	~20	26.9	27.8
25–34	54.8	52.1	52.8	51.2	50.5	52.7
≥35	24.1	15.5	15.1	27.8	19.4	15.7
Maternal Preferred Spoken Language (%)						
English	53.6	49.7	49.9	48.8	48.5	49.5
Spanish	38.6	44.9	43.2	42.3	45.8	43.8
Other	7.8	~5	~7	8.9	5.6	~7
Missing	0.0	~0	~0	0.0	0.0	~0
Maternal Pre-Pregnancy Diabetes (%)	~2	2.2	1.4	3.0	2.8	1.5
Maternal Gestational Diabetes (%)	13.6	17.1	13.5	14.6	17.2	13.6
Maternal Pre-Pregnancy Hypertension (%)	4.1	4.1	2.8	4.9	5.6	3.0
Maternal Hypertensive Disorders of Pregnancy (%)	8.1	10.8	8.1	11.6	12.6	8.1
Maternal Income (% FPL) at Pregnancy Start (%)						
≤50 %	22.6	25.5	25.4	26.4	25.1	25.5
51–100 %	30.4	22.9	22.8	21.0	23.7	22.7
101–200 %	16.8	19.8	20.5	17.3	20.5	20.3
>200 %	4.9	6.4	6.8	5.9	6.4	6.3
Missing	25.2	25.4	24.5	29.4	24.3	25.1
Maternal Insurance During Pregnancy (%)						
Medicaid	86.4	82.3	81.8	81.9	82.7	81.6
Medicare/Other Public	~1	0.9	1.0	~1	0.6	0.8
Private	7.8	9.0	9.7	11.3	8.8	10.0
Uninsured	4.1	7.1	7.0	4.9	7.1	7.1
Missing	~1	0.6	0.5	~1	0.7	0.6
Maternal Tobacco Use During Pregnancy (%)						
Current	7.8	7.9	7.3	5.7	8.6	7.3
Former	9.3	10.9	11.3	14.6	10.9	11.2
Never	67.5	66.4	66.9	67.9	67.1	67.3
Missing	15.4	14.8	14.5	11.9	13.5	14.2

Note: ~ indicates a rounded number applied to percentages calculated from cell sizes less than 10.
SD: standard deviation. Wks: weeks. AA/PI: Asian American/Pacific Islander. NH: non-Hispanic. "Other" race/ethnicity includes American Indian, Alaska Native, multiple race, "other" race or ethnicity, or unknown race/ethnicity. Yrs: years. FPL: federal poverty level.

Table 2
Early childhood (0–24 months of age) weight gain trajectory model parameters (estimate (95 % confidence interval)) among child study groups from the PROMISE study (United States), by plurality and sex, 2005–2021 (N = 47,951).

Parameter	Males			Females			*P* value
	Twins (N = 345)	GA-Matched Singletons (N = 3450)	All Singletons (N = 20,358)	Twins (N = 371)	GA-Matched Singletons (N = 3710)	All Singletons (N = 19,717)	
a: Starting value	0.91 (0.88, 0.93)	0.98 (0.97, 0.99)	1.10 (1.10, 1.11)	0.86 (0.84, 0.89)	0.97 (0.96, 0.98)	1.09 (1.08, 1.09)	<0.001[1, 3, 4, 5, 6, 7]
c: Growth in early infancy	1.66 (1.61, 1.71)	1.54 (1.53, 1.56)	1.50 (1.50, 1.51)	1.48 (1.43, 1.54)	1.46 (1.44, 1.47)	1.39 (1.39, 1.40)	<0.001[1, 2, 3, 4, 6, 7]
d: Decreasing rate of growth in late infancy	4.78 (4.71, 4.84)	4.64 (4.62, 4.65)	4.61 (4.60, 4.62)	4.79 (4.72, 4.86)	4.76 (4.74, 4.78)	4.71 (4.70, 4.72)	<0.001[2, 3, 4, 6, 7]
b: Growth in early childhood	5.10 (5.03, 5.17)	5.04 (5.02, 5.06)	5.05 (5.04, 5.06)	5.06 (5.00, 5.13)	5.12 (5.09, 5.14)	5.09 (5.08, 5.10)	<0.001[2, 3, 4]

Note. Values given as coefficient estimate (95 % confidence interval). Statistical comparison made with one-way ANOVA. Significance determined with a *P* value <0.05. The Jenss model is given by $y = e^{a} + e^{-b}*t + e^{c}*\left(1 - e^{-e^{-d}*t}\right)$.
[1]: significant male-female difference among twins.
[2]: significant male-female difference among GA-matched singletons.
[3]: significant male-female difference among all singletons.
[4]: significant twin-GA-matched singleton difference among males.
[5]: significant twin-GA-matched singleton difference among females.
[6]: significant twin-singleton difference among males.
[7]: significant twin-singleton difference among females.
[1–7]: calculated from *post-hoc* Tukey's honestly significant difference tests.

respectively).

By early childhood, rate of weight gain was slower among male twins compared to GA-matched male singletons, but did not differ from all male singletons (parameter *b*; 5.10 (5.03, 5.17), 5.04 (5.02, 5.06), and 5.05 (5.04, 5.06), respectively). Rate of weight gain in early childhood among female twins was nonsignificantly faster compared to that of GA-matched female singletons and did not differ compared to that of all female singletons (5.06 (5.00, 5.13), 5.12 (5.09, 5.14), and 5.09 (5.08, 5.10), respectively). These group differences were statistically significant except where otherwise noted (Tukey's HSD $P < 0.05$).

Predicted weights and velocity of weight gain show that male twins had consistently faster growth compared to both male singleton comparison groups for the first 6 months, while female twins were growing faster compared to all singletons, but not when compared to GA-matched singletons (Table 3, Fig. 2). Male and female twins caught up to their GA-matched singleton counterparts in weight at around 6 and 15 months, respectively. Male twins caught up to all male singletons at around 12 months, while female twins did not quite catch up to all female singletons by the end of follow-up at 24 months of age. Final predicted weight at 24 months was nearly identical among all males and

Table 3
Predicted weight and velocity of weight gain at selected ages during early childhood (0–24 months of age) among child study groups from the PROMISE study (United States), by plurality and sex, 2005–2021 (N = 47,951).

	Males			Females		
Age (months)	**Twins (N = 345)**	**GA-Matched Singletons (N = 3450)**	**All Singletons (N = 20,358)**	**Twins (N = 371)**	**GA-Matched Singletons (N = 3710)**	**All Singletons (N = 19,717)**
Predicted Weight (kg)[a]						
3	5.86	6.00	6.28	5.29	5.51	5.78
6	7.72	7.72	7.95	6.97	7.12	7.33
12	9.72	9.57	9.73	8.88	8.93	9.09
18	11.02	10.86	11.00	10.19	10.17	10.34
24	12.17	12.07	12.18	11.38	11.30	11.48
Predicted Velocity of Weight Gain (kg/month)[b]						
3	0.81	0.77	0.74	0.71	0.69	0.67
6	0.48	0.43	0.42	0.44	0.42	0.40
12	0.25	0.24	0.23	0.25	0.23	0.23
18	0.20	0.20	0.20	0.20	0.19	0.20
24	0.19	0.20	0.20	0.19	0.18	0.19

[a]: Predicted weights were calculated by inserting population parameter values into the Jenss model: $y = e^{a} + e^{-b}*t + e^{c}*\left(1 - e^{-e^{-d}*t}\right)$.

[b]: Predicted velocities of weight gain were calculated by inserting population parameter values into the derivative of the Jenss model: $\frac{dy}{dt} = e^{-b} + e^{c-d-e^{-d}*t}$ and multiplying by 30.427 (average number of days per month).
Note. For values of *t*: 3 months = 91.25 days; 6 months = 182.5 days; 1 year = 365.25 days; 1.5 years = 547.5 days; 2 years = 730 days.

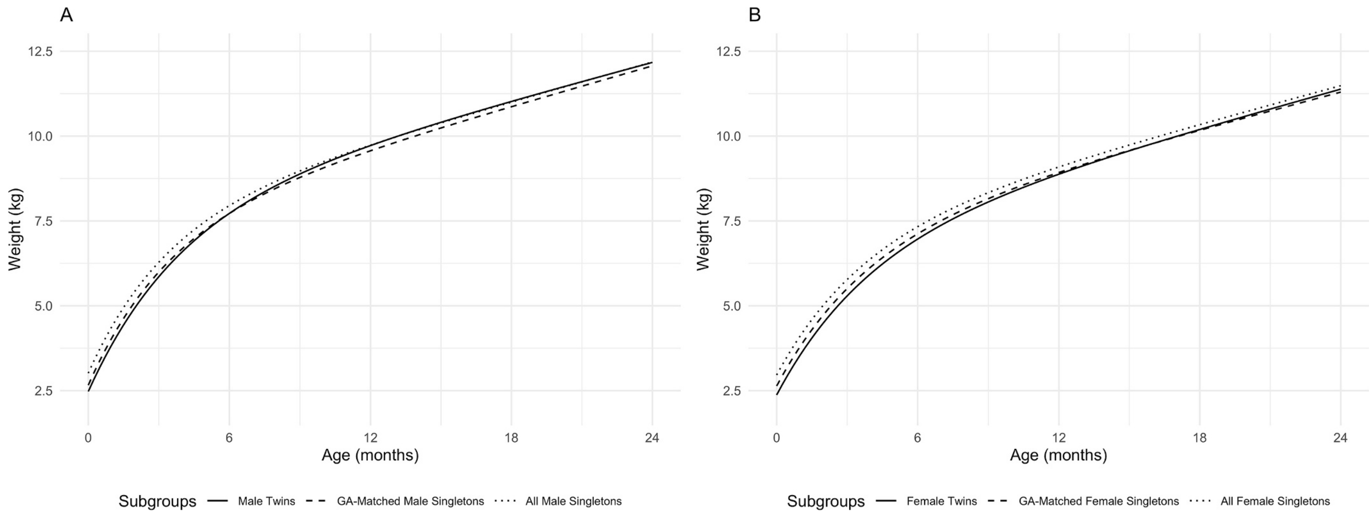

Fig. 2. Early childhood (0–24 months of age) weight trajectory for 47,951 (**A**) male twins, GA-matched male singletons, and all male singletons and (**B**) female twins, GA-matched female singletons, and all female singletons from the PROMISE study (United States), 2005–2021.

among all females.

In the sensitivity analysis excluding children without at least one weight measurement after 12 months, the fit of the Jenss model and observed trajectories did not meaningfully differ compared to the main analysis (**Table S1, Fig. S3**).

4. Discussion

Our results support our hypotheses and indicate that differences in normative growth between twins and singletons exist both overall and independent of differences in GA from 0 to 24 months. Though they were born smaller compared to all male singletons and to GA-matched male singletons, male twins experienced a higher rate of weight gain in early infancy and less deceleration in their growth in late infancy, catching up in weight at approximately 12 and 6 months, respectively. Female twins had significantly faster growth compared to all female singletons through late infancy but still did not regain their birth weight disadvantage through 24 months of follow-up. They were, however, growing nonsignificantly faster compared to their GA-matched singleton counterparts, catching up in weight at approximately 15 months.

Previous studies have compared early life growth between twins and singletons with mixed findings. One study among children in the Netherlands reported that the difference in weight between twins and singletons narrowed by 2 years but did not disappear (van Dommelen et al., 2008). Other studies reported that differences in weight between twins and singletons disappear by 4 years in a different Dutch population (Estourgie-van Burk et al., 2010), 7–9 years in New York (Gleason et al., 2023), and 8 years in Kentucky (Wilson, 1979). These studies, however, were limited in sample size, generalizability to the current US population, data generation, and/or methods used to examine growth. Twins in our study may have caught up in weight earlier than has been reported in previous studies due to geographic, socioeconomic, or secular differences in factors such as feeding practices or prevalence of assisted reproductive technologies, both of which have been shown to impact early childhood weight trajectories (Giugliani, 2019; Standish and Parker, 2022; Elhakeem et al., 2022) but which may differ in our contemporary and predominately low-income sample. Future research is needed to assess if the patterns identified here remain in later childhood and if the prevalence of health outcomes associated with infant growth (e.g., obesity) is higher in twins compared to singletons because of their more rapid growth.

These results indicate that factors beyond GA may differentially influence normative early childhood growth among twins and singletons. Some of these factors are unique to twin pregnancies such as zygosity and chorionicity, which have been shown to affect fetal and postnatal growth among twins with, for example, lower birth weight among monozygotic twins (Jelenkovic et al., 2018) and more disparate postnatal growth trajectories among dizygotic twins (Buckler and Green, 2011), though differences have been shown to disappear within the first six months of life (van Dommelen et al., 2008). Additionally, formula-fed infants grow faster than breastfed infants (Giugliani, 2019). We expect the prevalence of breastfeeding to be lower and formula-feeding to be higher among twins compared to singletons (McDonald et al., 2012), which could be driving the rapid weight gain among twins in our study. Our data source did not include these important factors, and their contribution to observed infant growth trajectories is a critical direction for future research. Additionally, the higher prevalence of maternal pre-pregnancy diabetes and hypertension among twins and GA-matched singletons likely reflects the influence of these conditions on GA/preterm birth; while these maternal conditions may have contributed to twin-singleton differences in growth, these differences were also observed for GA-matched comparisons, suggesting that plurality *per se* influences early childhood growth. Additionally, the prevalence of these disorders was low in our sample, and we do not expect maternal pre-pregnancy diabetes or hypertension to have substantially influenced the observed growth patterns.

The observation that twins grew differently compared to both singleton comparison groups highlights the importance of twin-specific research and recommendations for early childhood growth. The use of singleton growth charts (e.g., the WHO growth standard (WHO Multicentre Growth Reference Study Group, 1992)) or preterm singleton growth charts (e.g., the Fenton growth chart (Fenton, 2003; Fenton and Kim, 2013)) among twins is likely inappropriate: the growth of twins should be evaluated using a twin-specific growth chart. However, the most appropriate singleton comparison group when assessing twin growth remains an open question. While the two comparison groups used in this analysis each present with their own limitations for interpretation, they provide two sets of largely similar estimates and a starting point for future research seeking to define the most appropriate comparison group. Additionally, further research is needed to assess the extent to which early GA among twins is physiological or pathological through the assessment of, for example, biomarkers and placental function, and large longitudinal cohort studies.

This research was met with few limitations. A notable 44.4% of twins were excluded from our analytic sample due to a missing weight measurement in the first 5 days of postnatal life, compared to 24.3% of singletons. Correctly linking two child records to one birthing parent rather than incorrectly classifying the records as duplicates and removing one is a known complication of EHR research and is a limitation of these data (Office of the Assistant Secretary for Planning and Evaluation, 2023). However, we do not expect the remaining twin to meaningfully differ from the removed twin, and results can be confidently interpreted on this subset of twins.

A notable strength of our study was the use of provider-recorded longitudinal weight measurements which provides more varied ages at weight measurements, allowing higher confidence in the fitted trajectory and a greater average number of weight measurements per child. For example, in a recent study among the Upstate KIDS cohort, children had an average of 5 parent-reported measurements between 0 and 3 years of age (Gleason et al., 2023), while in our study, children had a median of 10–11 clinician-measured measurements between 0 and 2 years of age.

5. Conclusion

This study described normative early childhood weight trajectories among twins compared to singletons and GA-matched singletons. We reported that both male and female twins grew more rapidly than their GA-matched singleton counterparts, catching up in weight by 6 and 15 months, respectively, but that only male twins caught up in weight to the general singleton comparison group, at 12 months. These findings suggest the differential influence of factors beyond GA on early childhood growth in twins compared to singletons and highlight the need for further twin-specific research and clinical recommendations.

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CRediT authorship contribution statement

Anna Booman: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Byron A. Foster:** Writing – review & editing, Conceptualization. **Kristin Lyon-Scott:** Writing – review & editing, Data curation. **Miguel Marino:** Writing – review & editing, Conceptualization. **Jonathan M. Snowden:** Writing – review & editing, Conceptualization. **Janne Boone-Heinonen:** Writing – review & editing, Supervision, Resources, Project administration, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2025.102984.

Data availability

The data that has been used is confidential.

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