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Seasonal Variation of Twin Births in Washington State

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Abstract. Twin births are known to vary across seasons in several countries. It has been hypothesized that this variation may be due to seasonal changes in luminosity leading to pineal gland-mediated multiovulation among susceptible mothers. To describe seasonal variation of twin births in Washington State, all mothers residing in Washington State who gave birth to both a pair of twins and a singleton baby between 1984-1990 (n = 1168) were identified through linkage of computerized State birth certificates. Using a "matched-on-mother" case-control design, the estimated month of conception of twin gestations (the "case" events) were compared to that for their singleton siblings (the "control" events) to determine their relative occurrence during periods of high vs low sunlight in accordance with local climatological data. For the study population as a whole, there was only a slight tendency for twins to have been conceived during the period of high sunlight compared to their singleton siblings (OR = 1.3, 95% C.I. = 1.0-1.7). When stratified by concordant-sex vs discordant-sex, however, more discordant-sex twin pairs were conceived during the light period than corresponding singletons (OR = 1.7, 95% C.I. = 1.0-2.8), whereas no association was found for concordant-sex twins (OR = 1.1, 95% C.I. = 0.8-1.6). The presence of an association only among discordant-sex twins, all of whom are dizygotic, is consistent with the hypothesis that exposure to sunlight may stimulate multiple ovulation, and thus increase the incidence of twin gestations among twin-prone mothers.

Key words: Twinning rate, Seasonality, Confounding, Case-control study, Matched analysis

INTRODUCTION

Although there exists strong support for an inherited susceptibility to twinning [4,14], there are reasons to believe that environmental factors play a role as well. Among the latter are several studies demonstrating cyclic variations in twin births within geographically defined populations [6-8,13,15-17]. One interpretation of such patterns is that they reflect changes in ambient luminosity and subsequent promotion of multiple ovulations in women who are genetically predisposed to twinning [1,2,9,12]. Sunlight is known to influence the production of melatonin through effects on the pineal gland, and it is conceivable that observed variations in gonadotropin levels associated with changes in luminosity [9] could be an end result of this pathway. A prediction of this hypothesis is that among mothers who give birth to twins and singletons (and thus may be considered to be twin-prone), the conception date for the twins should be more likely to fall during periods of greater luminosity. Further, this difference should be greater among dizygotic twins and their singleton siblings, since monozygotic twin rates would be expected to be relatively independent of multiple ovulation. Although some studies have attempted to examine this hypothesis [5,10,15,16], there has been little emphasis on quantifying the strength of the association between exposure to sunlight and twinning while taking into account the effect of potential confounders and the predicted modifying effect of zygosity. To further investigate this hypothesis, we studied the seasonal pattern of twin births in Washington State.

MATERIALS AND METHODS

Study subjects were selected from a computerized linkage of all certificates of live births occurring in Washington State during the years 1984-90. The resultant file contains pregnancy risk factor information about mothers who gave birth to more than one child in the State during this time period, and about their babies. From this file, we selected all 1,168 mothers who had given birth to both a pair of twins (the "case" event) and a singleton child (the "control" event), producing a case-control study where every mother served as her own control.

The month of conception of each case and control was calculated as the date of birth minus gestational length, as recorded on the birth certificate. We excluded 5.5% of the births (5.2% of cases and 5.7% of controls) for which no data were available for gestational length, and 4.6% of the births (2.7% of cases and 6.5% of controls) for which the recorded gestational length was under 18 weeks or over 43 weeks. Miscarriages and stillbirths (5.8% of cases and 1.3% of controls) were also excluded. Taken together, these excluded births were similar to other births in the study with respect to sex, mother's age, parity and marital status. Each birth among the remaining 2,031 was then classified as having been conceived during the sunniest (March-August) or the darkest (September-February) period of the year; this *a priori* categorization was based on the average monthly luminosity from 1983 to 1990 (in Langleys) as measured daily at the Department of Atmospheric Sciences at the University of Washington, and assumed to apply to the entire State. A "Langley" is a measure of solar radiation equivalent to one gram calorie per square centimeter of irradiated surface. We computed odds ratios (OR) as estimates of the relative risks of a twin birth associated with conception during the most luminous period of the year using standard methods for pair-matched case-control data. To control for potential confounding factors that may not have been accounted for by the matching on mother, we used both multivariate conditional and unconditional logistic regression models to estimate adjusted associations [3]. The former approach retains the matching on mother, but could only be conducted on twin-sibling pairs where both births had complete data for all variables in the model; the latter approach does not retain the matching on mother, but permits inclusion of any birth with complete information on all variables in the model. The values of potential confounding variables for case events (twin births) were taken from one randomly chosen infant in each twin pair. Variables that were considered as potential confounders included maternal age (≤19,20-24,25-29,30-34, ≥35), year of birth (1984 to 1989), parity (0, 1, 2, ≥3), marital status (married, unmarried), sex of the baby, and whether the twin birth occurred before or after the singleton birth (twin order). Ninety-five percent confidence intervals were computed from the estimated variances of the OR. Analyses were conducted on the entire study population as well as separately for matched sets involving concordant-sex and discordant-sex case events (as a marker for whether or not the twin gestation was the result of multiple ovulation), and were performed with SAS and EGRET softwares [18,19].

Table 1 - Distribution (%) of selected characteristics of twin births and matched singleton sibling births according to the type of twin in the matched pair

Maternal Characteristic	Twin type: Concordant-sex (861 matched sets*)		Twin type: Discordant-sex (307 matched sets*)		All twins (1168 matched sets*)	
	% cases	% controls	% cases	% controls	% cases	% controls
Age						
≤19 years	10.1	10.3	3.4	9.4	8.4	10.1
20-24 years	25.9	30.3	26.3	25.1	26.0	28.9
25-29 years	35.2	33.0	35.7	37.5	35.4	34.2
30-34 years	21.7	20.0	26.3	19.9	22.9	19.9
≥35 years	7.1	6.4	8.3	8.2	7.4	6.9
Marital status						
Married	81.7	80.3	86.5	84.3	82.9	81.3
Single	18.2	19.6	15.7	13.5	17.0	18.6
Unknown	0.1	0.1	0.0	0.0	0.1	0.1
Parity						
0	13.6	40.2	10.2	42.3	12.7	40.8
1	37.1	16.4	37.6	15.0	37.2	16.0
2	23.5	20.1	25.9	16.9	24.2	19.3
≥3	12.8	11.3	14.7	15.0	13.3	12.2
unknown	13.0	12.1	11.7	10.9	12.7	11.8

* Original number of matched pairs; miscarriages, stillbirths and births with missing value on gestational length are excluded from this table.

RESULTS

The majority of mothers were white (86.9%); 4.8% were black. The mean gestational length was shorter for twins (259 days) than for singletons (277 days). Mothers of twins, whether of concordant or discordant sex, were slightly older and had more prior live births at the time of the multiple birth than at the time of the singleton birth (Table 1). The marital status of the mother at the twin and singleton pregnancies did not vary. The distribution of the sex of the babies was not different for twins (51.1% male) than for singletons (50.8% male).

Figure 1 displays the estimated month of conception of the 2,031 live twin and singleton births for which length of gestation was known, and the average daily luminosity per month. Although the monthly proportions for twins and singletons are fairly similar, a slightly increased proportion of twins were conceived in June and July (months with highest average luminosity), compared with a decrease in the conception of singletons during that time.

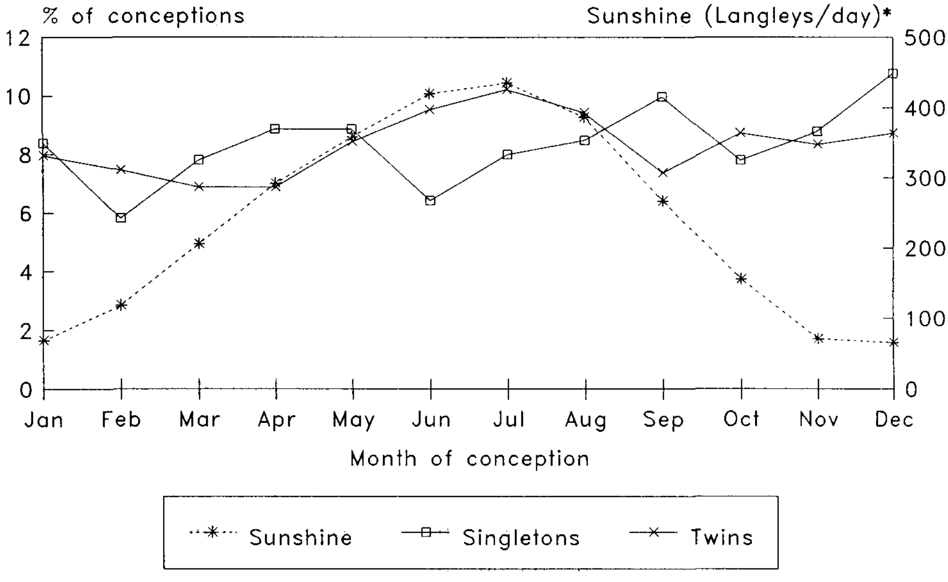

Fig. 1. Estimated month of conception for twin and singleton sibling births (n = 2031); WA, 1984-90.

* Source: Monthly average of daily luminosity, 1983-90, Department of Atmospheric Sciences, UW.

Figures 2 and 3 show the monthly variations in the proportion of twin and singleton events separately for concordant-sex and discordant-sex twin and singleton gestations. There was little difference in the estimated month of conception between concordant-sex twins and their corresponding siblings (Figure 2), whereas discordant-sex twins were much more likely to have been conceived between April and August than their singleton

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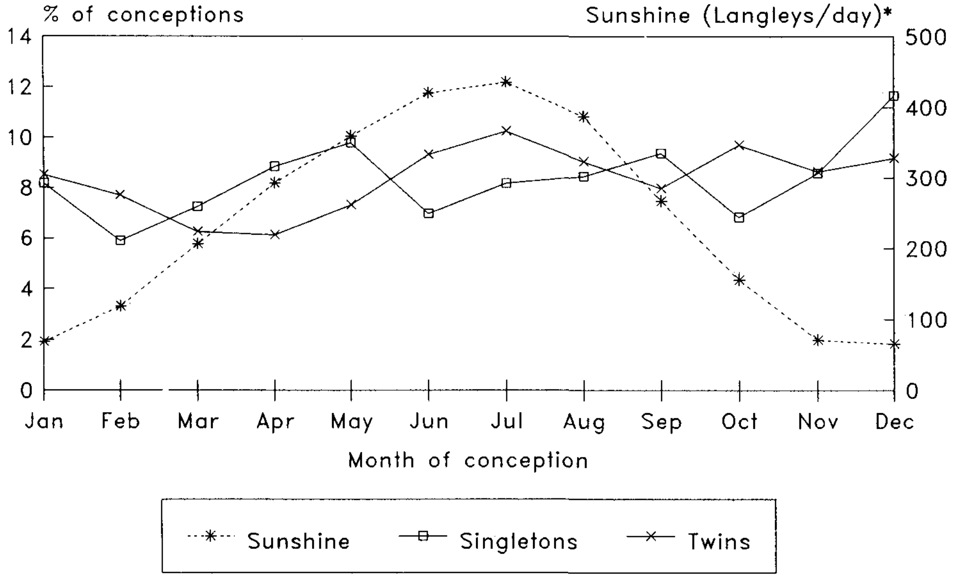

Fig. 2. Estimated month of conception for concordant-sex twin and singleton sibling births (n = 1498); WA, 1984-90.

* Source: Monthly average of daily luminosity, 1983-90, Department of Atmospheric Sciences, UW.

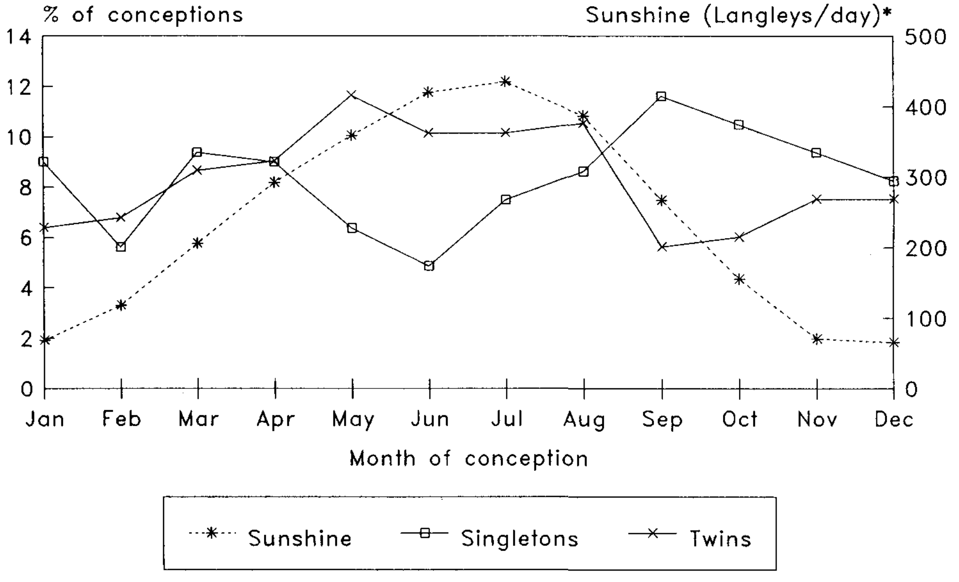

Fig. 3. Estimated month of conception for discordant-sex twin and singleton sibling births (n = 533); WA, 1984-90.

* Source: Monthly average of daily luminosity, 1983-90, Department of Atmospheric Sciences, UW.

siblings (Figure 3). As a result, the seasonal pattern of discordant-sex twin conceptions more closely resembled (but was less cyclical than) the seasonal pattern of luminosity than either the pattern for concordant-sex twins or for singleton siblings.

The OR for the association of any concordant-sex and discordant-sex twin event with conception occurring in a period of high luminosity (March-August) vs low luminosity (September-February) are shown in Table 2. Even after adjustment for maternal age, parity and year of birth, there is a 70-80% increase in the likelihood of a twin conception in March-August for discordant-sex twins and no increase among concordant-sex twins. These results were unaffected by further adjustment for maternal marital status, sex of the babies, and twin order or by exclusion of paired birth events wherein at least one event had a missing value for a key variable (matched vs crude analysis or unconditional logistic regression analysis).

Table 2 - Association (OR) of concordant-sex, discordant-sex, and all twin birth events with conception during March-August, by type of analysis

Analysis	All n=2336 OR (95% C.I.)	Concordant-sex n=1722 OR (95% C.I.)	Discordant-sex n=614 OR (95% C.I.)
Crude analysis[1]	1.1 (0.9–1.3)	0.9 (0.8–1.2)	1.7 (1.2–2.4)
Matched analysis[2]	1.1 (0.9–1.4)	0.9 (0.7–1.2)	1.7 (1.1–2.5)
Logistic regression (unconditional)[1-3]	1.2 (0.9–1.4)	1.0 (0.8–1.2)	1.8 (1.2–2.7)
Logistic regression (conditional)[2-3]	1.3 (1.0–1.7)	1.1 (0.8–1.6)	1.7 (1.0–2.8)

[1] Analysis based on 1783 live births (1310 concordant-sex twins and corresponding singletons; 473 discordant-sex twins and corresponding singletons) without missing values on gestational length and parity.

[2] Analysis based on 702 pairs, the remaining 466 having at least one birth with at least one key variable missing.

[3] Adjusted for birth year (84-90), maternal age at birth (≤ 19, 20-24, 25-29, 30-34, ≥ 35 years) and parity at birth (0, 1, 2, ≥ 3 prior live births).

DISCUSSION

In this study of women who gave birth to both a pair of twins and a singleton baby, we observed that discordant-sex twins were 70-80% more likely to have been conceived during the sunniest period of the year compared to their singleton siblings. A similar finding was not observed for concordant-sex twins.

Previous studies have found evidence supporting the existence of seasonal variation in twin births; however, there has been little consistency as to the period of the year in which twin births occur with the greatest frequency [8]. Twin births have been reported to cluster in spring (Finland, Hungary and Japan), summer-fall (England and Wales, Japan), summer or winter (Germany) and winter (Canada) [7,8,15,17]. It is possible that this wide variation could be explained by differing seasonal patterns of sunlight among countries, failure to consider monozygotic and dizygotic twins separately, or misclassification of twin type in analyses that examined the modifying effect of this characteristic. For example, an increase in the Canadian twin birth rate was found from August to November, but only for dizygotic twins [5]. That we observed an association solely for discordant-sex twins (all of whom would have been the result of multiple ovulation, in contrast to concordant-sex twins) is consistent with the hypothesis that dizygotic twinning may, in part, be influenced by an effect of sunlight on the release of gonadotropins [9].

Although the seasonal variation we observed would be consistent with an effect of sunlight, other explanations for the patterns observed need to be considered. Our study population included only those women who remained in Washington sufficiently long enough to deliver two live births during the seven year period. It seems implausible, however, that there would have been selective migration of mothers that depended jointly on month of conception, type of pregnancy (twin vs singleton) and twin type (concordant-sex vs discordant-sex). Further, for comparability with prior studies, we did not include twin gestations that resulted in stillbirth or miscarriage. Including the latter, however, yielded similar results (data not shown).

We relied on data routinely collected on birth certificates and the potential errors of this source of information could have influenced our findings. For example, we estimated month of conception based on the date of last menstrual period. There are certainly inaccuracies in the recording of this characteristic (for example, due to the incorrect recall of the mother), and we cannot exclude the possibility of differential misclassification of last menstrual period for twin as opposed to singleton pregnancies (as the rates of length of gestation below 18 weeks and above 43 weeks might suggest). However, differential misclassification of date of last menstrual period would need to have occurred principally among discordant-sex twins and singleton pairs to account for our results, a possibility that we consider highly unlikely. To the extent that non-differential misclassification has occurred, the associations we observed are weaker than truly exist. The only information on the birth certificate that permitted us to examine differences by zygosity was data on the gender of each twin. Based on the Hardy-Weinberg law [4], we could expect that approximately one third of the concordant-sex twins were dizygotic. If the pattern of conception months among concordant-sex dizygotic twins is similar to the pattern among discordant-sex dizygotic twins, then we may actually be observing less than the true difference in the patterns between twins resulting from single vs multiovulations.

Influences on the seasonal patterns of twin births and singleton births that we could not address include the postulated "vanishing twin" phenomenon that has been hypothesized to be due to infectious agents mostly active during the winter [11]. However, we would expect this phenomenon to obscure higher rates for twin conceptions during sunny periods, rather than create them.

Although a matched design presumably accounted for many unmeasured host factors that could have confounded the relationship between season of conception and twin birth, our ability to address confounding by other characteristics was limited to those ascertainable through the birth certificates; factors such as changes in diet between pregnancies that are also associated with seasons, for example, could not be incorporated into our analyses. Interestingly, the crude comparisons (based on either the matched or unmatched data) were essentially unaffected by adjustment for potential confounders available to us.

Finally, we recognize that our measure of exposure to sunlight during conception is at best a crude marker for a more complex mechanism through which some aspect of luminosity might influence multiple ovulations. Large population-based studies such as ours cannot distinguish the extent to which specific aspects of sunlight may be involved, such as the absolute level of light versus a change in sunlight intensity that accompanies the changing seasons. Nevertheless, the likely non-selective misclassification of the true index of sunlight that "season" represents implies that any true relationship of sunlight to multiple ovulation is likely to be much stronger than we have observed. Thus, our findings add support for a direct effect of sunlight on the conception of twins in some women and provide further evidence in favor of the role of chronobiologic factors in human reproduction.

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