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Seasonal fluctuations in birth weight and neonatal limb length; does prenatal vitamin D influence neonatal size and shape?

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Abstract

Background: Birth weight is known to fluctuate with season of birth, however, there is little information about seasonal variation in neonatal anthropometric measures.
Aims: The aim of this study was to examine seasonal fluctuations in birth weight and selected anthropometric measures.
Study design and subjects: The birth weight of singletons born after at least 37 weeks gestation was extracted from a perinatal register in south-east Queensland ($n=350{,}171$). Mean monthly birth weights for this period were examined. Based on a separate birth cohort, principal component analysis was undertaken on neonatal anthropometric measures ($n=1233$). Seasonality was assessed by (a) spectral analysis of time series data, (b) monthly and seasonal comparison of outcomes.
Results: Based on register data, birth weight displayed clear annual periodicity. Birth weight differed significantly when compared by month and season. Infants born in October were the heaviest (3484 g), while May-born infants were the lightest (3459 g; $P=0.001$). Based on the cohort anthropometric data, three components were identified related to (a) overall size, (b) limb length, and (c) head size and skin-fold

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thickness. Each of these components displayed significant seasonal variation. In particular, prominent seasonal fluctuations in limb length were identified, with peak limb length associated with winter/spring birth.

Conclusion: Environmental factors that have regular seasonal fluctuation influence both the size and shape of neonates. Animal experiments suggest that prenatal hypovitaminosis D may underlie greater limb length. Because birth weight and limb length are associated with a broad range of important health outcomes, the seasonal exposures underlying these effects warrant further scrutiny from a public health perspective.

1. Introduction

Birth weight has long been acknowledged as an important measure of neonatal health [1]. In addition to providing insights into prenatal development, this variable is known to be associated with a wide range of important cognitive, behavioural and health outcomes in infancy, childhood and adulthood. For example, even within the normal range of birth weights, heavier birth weight has been associated with superior neurocognitive outcomes in several cohort studies [2–6]. There is accumulating evidence linking birth weight and wide range of chronic, adult-onset disorders [7,8].

In addition to birth weight, features of body shape at birth have been explored in order to determine if certain neonatal phenotypes are (a) associated with particular types of prenatal exposures [9] and (b) with particular types of adult disorders [10]. The mechanisms of action underlying shape at birth are far from resolved [11,12]. However, there is agreement that we need to generate candidate exposures that contribute to neonatal shape and size and explore research designs that may help fractionate factors influencing developmental pathways [13].

Clearly, body shape and birth weight are influenced by a complex matrix of genetic and epigenetic factors operating on the maternal–fetal unit. Twin studies are one type of 'natural experiment' that allows us to tease apart genetic and environmental components contributing to variations in neonatal measures [14]. Season of birth studies are another type of natural experiment that can help generate candidate environmental factors. Certain exposures tend to fluctuate in a regular fashion within the year, while, at the group level, other environmental and genetic factors remained relatively stable. Thus, if seasonal fluctuations are linked to an outcome, then they can help generate new candidate exposures.

Most, but not all, studies of season of birth and birth weight have reported that winter and spring births tend to be slightly heavier and slightly longer compared to summer and autumn births. For example, Selvin and Janerich [15] examined birth weight in a sample of 1,524,229 infants born in New York State exclusive of New York City. They found that babies born in summer months (June, July and August) had the lowest birth weights in the year while those born in March, April and May (Spring) had the highest birth weight.

Roberts [16] reported on a general sample of 43,141 births in Hong Kong (latitude 22.2 N), there was a significant within-year fluctuation, with peak birth weight in March (early spring) and a nadir in August (late summer). Matsuda and colleagues [17] examined seasonal fluctuation in birth weight in a large sample of singletons from Japan (n = 16,796,415). Significant annual periodicity was identified, with peak birth weight found in May (spring). In a large Danish study (n = 1,166,206), annual fluctuations in both birth weight and birth length were confirmed [18], with peak birth length found in April (spring).

Based on the Dunedin birth cohort (latitude 45.5S), Waldie and colleagues [19] reported annual periodicity in both birth weight and birth length with peak values for both measures occurring in the southern Hemisphere winter and spring. In a sample from Northern Ireland [20], significant seasonal fluctuations in birth weight were found in singletons born after at least 36 weeks of gestation (n =418,817). The lowest birth weights were found in July (summer) and highest in February (winter). Not all studies have found a seasonal fluctuation in birth weight [21], and some studies have reported paradoxical increased weight in the summer born [22].

We had the opportunity to explore seasonal influences on neonatal anthropometric measures in south east Queensland, a subtropical region in the southern Hemisphere. Based on the literature, we predicted that babies born in winter and spring (i.e., June to November) would be significantly heavier than babies born in summer and autumn (December to May). In addition, we predicted