Review Paper:

Myopia Progression in Low Birth Weight Infants: A Narrative Review

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ABSTRACT

Context: Low birth weight infants are prone to an altered ocular development in childhood, resulting in refractive errors of the eye. Myopia (short-sightedness) is the most common refractive error of the eye that reduces vision.

Evidence Acquisition: A PubMed literature search was conducted using the following search terms: “low birth weight infant", “myopia", “prematurity", and “refractive error".

Results: The underlying cause of myopia is usually excessive growth of the eye, which is under the influence of early-life pressure on human growth. Children with low birth weight have significantly shallower anterior chamber depth and thicker lens. At the ages of 10-12 years, preterm children have an increased likelihood of all types of refractive errors. However, in low birth weight children, a 1 diopter of myopic change occurs over the first decade of life.

Conclusions: The progression of myopia is higher in children with low birth weight, suggesting that prematurity and low birth weight may simultaneously affect the development of optical components, leading to myopia.

1. Context

The introduction of the intensive care units into newborn nurseries has significantly increased the survival rate of preterm infants, and notable worry that the incidence of severe neurosensory disabilities might increase, too (1, 2). Several studies have shown that the occurrence of myopia in children born prematurely (gestational age [GA] ≤37 weeks) is negatively correlated with GA and birth weight (3-6).

Refractive errors include myopia (spherical equivalent ≥-0.75 diopters [D] extreme), high myopia (spherical equivalent ≥-6.00 D extreme), moderate or mild myopia (-0.75 to -5.99 D), emmetropia (no refractive error, -0.74 to +0.99 D), hypermetropia (long-sightedness, +1.0 D extreme), astigmatism (≥1 D cylinder), and an-

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isometropia (≥1 D difference in the mean spherical equivalent refraction between the two eyes) (7-9). Relative mild to moderate myopia currently affects 25% of populations in western countries, at least 5% in Africa, and up to 80% in Eastern Asia. In contrast, high myopia (very severe and pathologic) affects less than 3% of the worldwide population (10).

Researchers emphasize the association between myopia and low birth weight for gestational age, gender, greater maternal age, maternal smoking, and higher paternal occupational social class confidently. There was some evidence that even a short period of breastfeeding decreases myopia progression (10).

Low Birth Weight (LBW) infants (birth weight less than 2500 g) are exposed to three risk factors that affect their visual outcome: the presence of Retinopathy of Prematurity (ROP), neurological comorbidities, and preterm birth itself. However, little evidence exists about the myopic progression in growing children who were born with low birth weight. In this study, we only present and discuss the findings of recent investigations that assessed the impact of LBW on myopia development during childhood and changes over a wide range of ages.

2. Evidence Acquisition

A PubMed literature search limited to the English language from 1997-2019 was conducted using the following search terms: "low birth weight infant", "myopia", "prematurity", and "refractive error". Herein, we provide the qualitative results taken out from research studies and discuss them.

In the next step, the extracted articles were reviewed to exclude those refractive errors related primarily to normal birth weight, adult cases without any childbirth history, and studies on non-refractive low vision subjects (as these were not the scope of this review). For the aim of this review, case-control, randomized controlled trials, cohort studies, evidence from meta-analyses, and systematic reviews were considered. Case reports or case series would be included only if there were defined as evidence by more than two articles to unify uncommon findings as an index of future research. We excluded articles considering skillful viewpoints and letters to the editors. A total of 615 potentially relevant records were identified. Following the exclusion of 308 reports, 307 full-text papers were retrieved for gloss inspection. Finally, 31 articles matched the eligibility criteria.

3. Results

Risk factors assessment

Patients with LBW often encounter visual impairment. Refractive status is related to multiple optical components: corneal curvature, anterior chamber depth, lens thickness, vitreous thickness, and axial length.

Ouyang et al. showed that the strongest predictors of myopic development are indices of immaturity: short GA and LBW, of which the prematurity and LBW are more important than the others. They concluded that the birth weight had a negative relationship with corneal astigmatism, astigmatism, and corneal refractive power, while it had a positive association with the corneal radius of curvature, vitreous thickness, and ocular axial length (11).

Regarding the conclusions mentioned above, Chen et al. found that the myopia cases who were born prematurely had significantly shallower anterior chamber depth and thicker lens (12). Moreover, O'Connor et al. showed that the refractive state is relatively constant over the first decade of life with a shift towards myopia of 1 diopter in LBW children (13). Particularly more, in premature children, both with and without ROP, elevated corneal curvature, reduced anterior chamber depth, increased lens thickness, and decreased axial eye length have been observed (14, 15).

Also, Zhu et al. revealed in a case-control study that the incidence of myopia was significantly different in preterm children with ROP, preterm children without ROP, and in full-term children aged 6 years (14.29%, 6.73%, and 2.22% respectively). These figures were higher than those reported in children aged 3-5 years (15, 16).

However, the refractive outcome of preterm birth is not confined to this condition, and an increase in all forms of refractive errors have also been reported in other studies. In this regard, Fledelius reported that some cases of early myopia, also called myopia of prematurity, later showed a reduction in the degree of myopia over 1-2 years (17). However, Quinn et al. demonstrated that changes in refractive error distribution occur primarily between 3 months and 1 year and include a decrease in the proportion of eyes with hyperopia and an increase correlated with high degrees of myopia (18).

In other words, in a 3.5-year ophthalmological follow-up study of 248 preterm infants, Holmström et al. compared the subjects with the risk of refractive errors.

Holmstörm stressed that how prematurity, such as cryo-treated infants, was more significantly associated with the onset of myopia compared with the infants born at term (19). Moreover, a cross-sectional study in 10-year-old prematurely born Swedish children revealed that these children had a higher prevalence of hypermetropia of more than 3 D, or myopia of -1 D or less, astigmatism of 1 D or more, and anisometropia of 1 D or more compared with those born at term (20).

A recent cohort study of very LBW infants at 27-29 years in New Zealand identified that a history of untreated ROP was associated with a greater likelihood of high myopia (>5D) progression (21).

A Randomized controlled clinical trial study demonstrated that nearly 70% of the eyes with high-risk pre-threshold ROP are prone to myopia during childhood and that the proportion with high myopia increases between the ages of 6 months and 3 years (22). Another report of this early treatment for retinopathy of prematurity trial group also showed that approximately two-thirds of eyes with high-risk pre-threshold ROP during the neonatal period are likely to be myopic into the 6 years of life. They also confirmed that conventional management, in comparison with the earlier treatment of eyes with high-risk pre-threshold ROP, did not impress more refractive errors' development (23).

The Apgar score is broadly used as an index of the health status of neonates immediately at birth and can be used as a predicting mortality factor in extremely low birth weight infants (24). Comparing with the term infants, premature neonates are more susceptible to birth problems. This finding highlighted the Pan et al. result that showed the influence of the low Apgar score and the risk for the child of developing myopia (25).

According to the National Vital Statistics Report, the risk of preterm birth was 12 times higher in twins than singletons (26). Given the results of Avnon et al. study, comparison of refraction errors between preterm infants from singletons and multiples pregnancy disclosed no differences at the age of 6 months old, while at the ages of 8-12 years, multiples had significantly more myopic refractive errors (27).

Hence, we should consider myopia as a more complex pattern, where prematurity and low birth weight are crucial to its development ase. Table 1 presents earlier studies implicated refractive states with and without

Table 1. Characteristics of included studies of low birth weight myopic progression

Study	Refractive Errors	Age	ROP Prevalence	BW/GA
EXPRESS, 2013 (28) Sweden study	25.6%, all myopia of 6 D or more was found in 2.5%	30 months	73.7% (20.4% treated)	<27 weeks 348-1315 g
CRYO-ROP Study, 2000 (29)	Moderate myopia (≥2 D to <6 D): Treated eyes 20.5% Untreated eyes 15.5% High myopia (≥6 D): Treated eyes 37.7% Untreated eyes 27.2%	3.5 years	All reached threshold (82.5% bilateral)	<1251 g
ETROP 2000-2002 (30)	Myopia ≥65% in all treated eyes, high myopia ≥35% in all treated eyes	6 years	High-risk pre-threshold	<1251 g
Larsson and Holmström, 2003 (20)	Moderate myopia 3.8%, moderate hypermetropia 4.2%, astigmatism 21%	10 years	39%	<1501 g
O'Connor et al., 2005 (13)	Mild myopia 15.2%, moderate myopia 3.8%, moderate hypermetropia 6.6%	10-12 years	50%	<1701 g
The NZ 1986 VLBW follow-up study, 2017 (21)	No differences in myopia (>2 D) between the groups but high myopia (>5 D) was confined to those with ROP.	27-29 years	21%	<1500 g
Ouyang et al., 2009 to 2011 (11)	Myopia was seen in 5.08% of the ROP group but not in the control group. Hyperopia and astigmatism were the highest in the control group, followed by the ROP group.	3-4 years	23%	<2500 g
Fieß A et al., Gutenberg Health Study in Germany 2019 (31)	A comparison between three groups in a cohort study showed individuals with LBW are more likely to have lower visual acuity and a higher myopic refractive error in adulthood.	35-74 years	Data not available	Low: <2500g; normal: between 2500 and 4000 g; and high: >4000 g

BW: birth weight; D: diopter; GA: gestational age; ROP: retinopathy of prematurity.

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ROP according to the age of examination to the progression of myopia. The study samples varied from infancy to adult age group.

Impact on the ocular structure and refractive status

More immature preterm newborns are more likely to develop adverse visual effects other than those imputable to ROP. The shortened gestational periods up to 40% points out that other features of the visual system, e.g., cerebral white matter is vulnerable to disturbances (32).

Emmetropization is the mechanism in the development of the eye, whereby ocular growth happens in a harmonized manner to make an eye without refractive error (33). This precise visually set process is threatened in a preterm baby because of the following reasons: first, the effect of being born with an LBW and second, as a sequel of ROP.

The shortened intrauterine period in preterm birth deprives the fetus of a protective environment that normally promotes visual growth and development. Fledelius reported that the eyes of preterm babies, even without ROP, do not grow naturally (34).

Studies have shown that the anterior segment of the eye which plays a fundamental role in focusing the light onto the retina, was different between term and preterm infants; corneas of preterm children are more curved, and the lens is thicker, both of which increase the focusing power of the eye, leading to low degree myopia. This is not due to ROP and is referred to as the myopia of prematurity (34, 35).

4. Conclusions

This review indicates an association between LBW and altered ocular geometry in the long term, and suggest that birth weight and the associated factors are essential in refractive errors evolution. Severe ROP increases the risk of myopia. A mild degree of ROP does not contribute more than prematurity to this defect. Early treatment of ROP may improve retinal pathology but could not influence refractive error development, although it is clear that the incidence of myopia varies when the zone of ROP or comorbidity is noted. In general, premature newborns, with or without ROP, are susceptible to myopia. These findings support the importance of repeated assessment of refractive errors over the first decade of life in infants with LBW.

Ethical Considerations

Compliance with ethical guidelines

This research had no ethical consideration.

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Authors contributions

All authors contributed to the literature search, compiling and approving the final manuscript.

Conflict of interest

The authors have no financial or personal relations that could state a conflict of interest.

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