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Different methods for assessment of nutritional status in newborn infants based on physical and anthropometric indexes: a short review article

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ABSTRACT

Several complications during childhood is associated with nutritional status of infants at birth. Therefore, nutritional status of newborns must be evaluated properly after birth. Assessment of the nutritional status of neonates based on anthropometric and physical indices is simple and inexpensive without the need for advanced medical equipment. However, no previous studies have focused on the assessment methods of the nutritional status of infants via anthropometric and physical indices. This study aimed to review some of the key methods used to determine the nutritional status of neonates using anthropometric and physical indices. To date, most studies have focused on the diagnosis of fetal malnutrition (FM) and growth monitoring. In order to diagnose FM, researchers have used growth charts and Ponderal index (PI) based on anthropometric indices, as well as Clinical Assessment of Nutritional (CAN) Score based on physical features. Moreover, in order to assess the growth status of infants, growth charts were used. According to the findings of this study, standard intrauterine growth curves and the PI are common measurement tools in the diagnosis of FM. Furthermore, CAN score is widely used in the evaluation of the nutritional status of neonates. Given the differences in the physical features of term and preterm infants, this index should be adjusted for preterm neonates. Longitudinal growth charts are one of the most prominent methods used for monitoring of the growth patterns of infants.

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Introduction

Lack of diagnosis or proper assessment of the nutritional status of neonates at birth could lead to nutritional disorders, which adversely affect the development and health of infants (1-3). Anthropometric and physical indices of neonates upon birth provide an accurate evaluation of the nutritional status of newborns. On the other hand, anthropometric and physical indices could be applied in screening processes in order to determine the nutritional status of neonates (4). Previous studies in this regard have proposed an association between unfavorable nutritional status of infants at birth and incidence of different conditions, such as heart diseases (4) and non-insulin-dependent diabetes mellitus (5). Therefore, early diagnosis of nutritional disorders at birth could effectively re-

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duce the associated problems during the neonatal period.

Assessment of the nutritional status of neonates based on anthropometric and physical indices is simple and inexpensive without the need for advanced medical equipment. This study aimed to review some of the methods used to evaluate the nutritional status of newborns based on anthropometric and physical indices.

Literature review

Infant growth charts

Common methods for assessment of the nutritional status of infants are based on the use of growth charts. In these charts, newborn infants with intrauterine growth restriction (IUGR) (infants measuring below the 10th percentile) are diagnosed with FM (6). Various infant growth curves including the standard (7), reference (8), cross-sectional (9,10), longitudinal (11) and intrauterine (7,12) growth curves are used for assessment of nutritional status.

Standard of intrauterine growth curves is a tool for the diagnosis of FM (6). Furthermore, these charts describe the ideal growth pattern of infants. Drawn curve is considered standard if the inclusion and exclusion criteria are applied (12). In the absence of these restrictive exclusion criteria, standard intrauterine growth charts are considered as reference growth curves, which describe the actual growth pattern of neonates (12). Each of these curves are associated with certain strengths, limitations, and applications (13). However, reference growth curves are often mistakenly used and considered as standard growth curves (14).

Most diagnostic tools for FM, such as mid-arm/head circumference ratio, PI (15), and preterm infant growth charts (6) are based on IUGR. Therefore, the standard curves are used in cases where uterus-related data are collected (12). Furthermore, the term "retardation" implies that fetuses with normal growth are the basis of comparison in neonates. As such, it could be concluded that standard intrauterine growth curves are appropriate tools for the diagnosis of FM in newborns (16). Results of the review of the evaluation methods for the nutritional status of neonates are presented in Table 1.

PI

Traditionally, FM was diagnosed based on the presence or absence of IUGR using standard growth curves (7). As a marker of intrauterine growth, PI is calculated based on the following formula (7):

$$PI = \text{weight (g)} \times 100 / \text{length (cm)}^3$$

In cases that the gestational age and differences in the gender of neonates are not specified, standard growth curves cannot be used for the evaluation of nutritional status of infants(21). PI could be used in cases where data regarding the gestational age and gender of term infants are lacking (21).

Term infants with PI of <2.2 are normally diagnosed with FM. As such, specification of FM at the infant's bedside through the comparison of the PI with the standard value is considered an advantage for the accurate diagnosis of FM (20).

Table 1. Methods of nutritional status assessment in newborns based on physical and anthropometric indices.

Growth charts	Intrauterine growth chart	Comparison of length, weight and head circumference of infants with fetus of same gestational age and FM[1](6)
	Standard growth chart	Comparison of length, weight and head circumference of infants with ideal growth patterns to determine how the proper growth of infants should be (12)
	Reference growth chart	Comparison of length, weight and head circumference of infants with normal range of society (not how it should be) (12)
	Longitudinal growth chart	Growth monitoring and investigation of growth pattern in newborn infants (17)
	Cross sectional growth chart	Investigation of physical development of infants on first visit (18)
Other methods	CAN scores[2]	Diagnosis of FM based on physical features in term neonates (19)
	PI[3]	Diagnose of FM and infer of etiology of its (20)

[1]FM: Fetal malnutrition, [2]CAN scores: Clinical Assessment of Nutritional scores, [3]PI: Ponderal Index

As for preterm infants, some studies have considered this cut-off point for the diagnosis of FM (16), while some researchers have interpreted the PI of below the 10th percentile (22) on the Lubchenco growth chart (23) as the presence of IUGR and FM.

According to the studies in which FM was diagnosed through determining PI, malnutrition had a lower prevalence compared to the standard methods used for FM calculation (6, 16, 20). This is because the diagnosis of FM was based on the presence of IUGR in infants(24), and in case of IUGR, the infants were diagnosed with FM(25). Considering that IUGR is categorized into two types of asymmetrical and symmetrical, PI could only identify neonates with asymmetrical IUGR (6). This is due to the fact that in neonates with asymmetrical IUGR, PI is lower compared to symmetrical IUGR (26). Therefore, the prevalence rate of FM in the mentioned studies was lower compared to other studies where FM was evaluated using standard methods(16).

Asymmetrical IUGR is the growth retardation induced by uteroplacental failure, while symmetrical IUGR is the growth retardation caused by maternal smoking, medication use during pregnancy, congenital anomalies, and intrauterine infections (27). Therefore, by using PI in preterm infants, we could infer the etiology of FM; for instance, in neonates with low PI, the occurrence of FM could be attributed to uteroplacental failure.

In newborns, PI is considered an index of weight-to-height similar to body mass index (BMI) (kg/m2)(25). In other words, both these indices are calculated based on the weight-to-height ratio of neonates. However, use of BMI is less common in newborns. Dietitians and nutritionists have defined children with BMI of lower than the 15th percentile as thin, while 15th percentile ≤BMI<85th percentile is considered as normal weight, 85th percentile ≤BMI<95th percentile is defined as overweight, and BMI of ≥95th percentile of the reference value is considered as obese (28). Based on the percentile of the PI, newborns are categorized as small-for-length (<10th percentile), appropriate-for-length (10th-90th percentile), and large-for-length (>90th percentile) (25). So, like BMI used for classifying children into skinny, normal, over weight and fat, PI is used for such a classification wherein low PI is indicative of the low birth weight of neonates (6), which could be associated with inappropriate nutritional status.

CAN scores

Standard intrauterine growth charts and PI could diagnose FM in the presence of IUGR and in case of small-for-gestational-age (SGA) infants. However, the term FM differs from IUGR or SGA (29), while the prevalence of FM has been reported to be higher in SGA infants and those with IUGR(30,31). It is noteworthy that SGA neonates may also experience FM (29,32), which might remain undiagnosed in preterm infant growth charts or PI (24).

In 1994, Metcoff designed the CAN scores, which consist of nine clinical signs in different body parts of neonates (hair, cheeks, neck, arms, chest, abdomen, back, buttocks, and legs) (31). In this scale, each of the body parts are scored with four points in terms of the clinical signs, and in term infants, total score of <25 is interpreted as the presence of FM (31).

Since it has been defined for term infants, use of this cut-off point for both term and preterm infants in CAN score might be misleading in the accurate description of malnutrition (16). This is due to the differences in the physical characteristics of preterm and term neonates (16). Although some studies have used this cut-off point for preterm infants, it requires further adjustment (16,29).

Since the CAN score is an evidence-based clinical method (contrary to growth charts and PI), it could identify FM in both SGA and premature infants who are appropriate-for-gestational-age (AGA)(24). Furthermore, CAN score is a simple, systematic, scientific and objective approach highly applicable for FM neonatal screening (6), especially in term infants.

Growth monitoring

Low in-hospital growth velocity is associated with an increased risk of neuro-developmental impairment and cerebral palsy, as well as the mental developmental index and psychomotor developmental index scores of less than 70 (33). Theoretically, the intrauterine growth curves are considered ideal for the growth monitoring of preterm infants (34) despite a few limitations since the initial weight loss after birth differs from the intrauterine curve (17). Moreover, preterm infants are commonly born smaller compared to the neonates born at the same gestational age (18). On the other hand, growth environment of preterm infants and fetus are significantly different (17); therefore, use of the longitudinal growth curves is believed to be methodologically more efficient in the growth monitoring of premature neonates (17).

Cross-sectional growth curves have been designed based on the primary anthropometric measurement of newborns (18). As such, these charts may not be appropriate for identifying the growth pattern of preterm neonates within a specific time (35,36).

Since longitudinal growth curves are also designed based on the measurement of the anthropometric parameters, they are methodologically efficient in the growth monitoring of preterm infants (17). On the other hand, longitudinal growth curves are more appropriate for following the growth pattern of neonates within a specific time period, while cross-sectional growth curves are more useful in investigating the growth pattern only once (35).

Conclusion

Intrauterine growth curves, PI and CAN score are common diagnostic tools for FM. Due to the differences in the physical features of preterm and term neonates, adjustment of CAN score is required for preterm infants. Researchers have managed to infer the etiology of FM using the PI, which is also a practical method to assess the nutritional status in cases that the gestational age and gender of infants are not specified. Previous studies have suggested that the efficacy of longitudinal growth charts is methodologically higher for the monitoring of growth compared to other approaches in newborns.

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Conflict of Interest

The authors declare no conflict of interest.

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