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ORIGINAL ARTICLE

Estimated Birth Weight by Current Weight and Age During the First Five Days of Life

by

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Abstract

In the developing countries, measurement of birth weight is subjected to methodological problems. The main issue is the difficulty of measuring birth weight soon after delivery. Two relevant questions are proposed by this study : 1) can a birth weight be estimated several hours or days after a baby was delivered ?, and 2) can an estimated birth weight be collected by paramedical personnel with reliable results ?.

To answer these questions, we conducted a study at Dr. Sardjito Hospital, Yogyakarta, to evaluate agreement between two paramedical personnel in the routine measurements of neonatal weight in the rooming-in ward. The behavior of these two paramedical personnel was observed for one month when they examined 32 neonates. Both of them weighed the neonate at 7.00 hours and one weighed the neonate at 15.00 or 21.00 hours. The order of the last two measurements was made alternatingly.

This resulted in 156 pairs of measurement for agreement analysis. There was a strong evidence that the two raters have almost perfect agreement on measuring neonatal weights (intraclass correlation coefficient = 0.978). The second part of this study looked at neonatal weight during the first five days of life. The neonatal weights were measured three times a day up to age of five days. We constructed a formula for estimating their birth weight based on a current neonatal weight and age in days. Birth weight can be estimated using formula : Birth weight = 51 + 1.029 x current weight - 10 x age in days. The data fitted very well to this least square estimate with a coefficient of determination (R^2) = 0.95.

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Introduction

Birth weight of an infant, simple as it is to measure, is very important for at least two reasons. First, birth weight is strongly affected by the health and nutritional status of the mother; and second, it is an important determinant of changes of the newborn to survive and to experience a healthy growth and development [1,2]. For these reasons, in Indonesia increasing attention has been given to birth weight distribution, especially to the frequency of low birth weight (LBW) as a general indicator of maternal and child health service in the population [3,4]. Many studies have been conducted to measure the incidence of LBW. In a rural area of Yogyakarta, the incidence of LBW was reported to be 8.7 percent [4]. This number is relatively small compared to previous numbers estimated by WHO [1,2]. Furthermore, there is a strong indication that the incidence varies considerably between studies [3,4,5].

There are many issues which can be associated with the variation of LBW incidence. These include the reliability of data collected and the lag time between time at birth and the time of actual birth weight collected. In rural areas where 80 percent of Indonesian people live, 80 to 90 percent of babies are delivered at home and more than 80 percent are delivered by the traditional birth attendant (TBA) [3,4,6]. Often birth weight could not be measured directly at time of birth, because the birth attendant came late, that is when the baby has already been born [6]. Moreover, many TBAs are illiterate and/or untrained for this task. Thus not only the reliability of the birth weight measure should become our concern, but the physiological variability of neonatal weight within the early period of life should also be taken into account. However, little is known about this physiological variability of neonatal weight reported from developing countries.

In practice, if the task of measuring of birth weight can not be given to TBA's, then paramedical personnel or a village health worker would be a possible alternative. As a consequence, it is very likely that birth weight can not be measured directly at the time of delivery. Thus a birth weight should be estimated from a neonatal weight measured several hours or days after birth. From the methodological stand point, two questions arise : first, can birth weight be estimated several hours or days after birth ?; and second, can birth weight be estimated by paramedical personnel or village health worker with reliable results ? This study is addressed to the basic theory behind those methodological questions described. The specific aims of our study are : (1) to evaluate inter-observer agreement of two paramedical personnel in doing a routine task of measuring a neonatal weight, and (2) to look at the physiological variability of a neonatal weight during the first five days of life.

Materials and Methods

This study was conducted in the perinatology ward, Dr. Sardjito Hospital, Yogyakarta. All breast-fed babies (rooming-in program) admitted to this ward between January 11, 1989 and Februari 11, 1989 were considered as subjects of our study. There were 32 babies born in the hospital during the study period and satisfied our selection criteria. The babies were normal babies whose birth weights were available, and continued to be healthy during the period of observation. It should be noted that Dr. Sardjito Hospital is considered as a tertiary state Government's Hospital and also a teaching hospital. Therefore many patients are referred from different places with various social economic backgrounds. The hospital stay of these babies very from 2 to 6 days, but our study was limited only up to 5 days of observation.

Only babies admitted in physiological conditions were included in our study. We defined a physiological condition related both to the mother's and child's factors. Thus baby who was not delivered by a normal process, such as by cesarean section, vacuum extraction, forceps etc., were excluded from our study.

If within 5 days of observation the babies showed pathological symptoms and signs, they were carefully examined and diagnosed by a perinatologist, and then excluded from the study. Some specific laboratory tests were conducted on them whenever necessary. In addition, a low birth weight was also considered as an exclusion criterion, since a low birth weight baby was under a special care nursery. Thirty two babies were finally considered as the sample of our study.

Inter-observer study. We asked two paramedical personnel who have just finished from their formal training to be raters in this study. The behavior of these two paramedical personnel was observed for one month beginning January 11, 1989 when they examined 32 neonates. Both weighed the neonate at 7:00 and each one weighed the neonate at 15:00 or 21:00. The order of the last two measurements were alternating. This resulted in 156 pairs of measurements for agreement analysis. They used the same baby scale which was calibrated every week. In order to maintain an independent assesment, we decided to record neonatal's weight using a small card instead of using the ordinary medical record. Every time a rater finished writing a neonatal weight on the card, it was inserted into a box locked by the principal investigator. In order to calculate the exact baby's age in hours, we also asked the rater to record the time when the measurement was done. In addition, they weighed the baby according to our list which was read following an ascending order for one rater and descending for the other. For simplicity, a list of subjects was made every day based on their order in medical record. We hoped that by using this order they would not have any chances to copy the birth weight data one another and thereby reduce biases.

The measurement of neonatal weight was repeated three times for every subject. Only its average weight will be considered in the final analysis. Thus each baby had a pair of data recorded by the two raters, and the total observation depended on the duration of the individual stay in the hospital. In this case, we assumed that there was no interaction between raters and the subjects of the study. Therefore the duration of the hospital stay was not taken into account in the analysis. We only focused on inter-observer agreement according to the number of baby weight observed every morning within a one month period.

Physiological variability of birth weight. The second part of this study is to look at the physiological variability of neonatal weight during the first five days of life. All babies from the inter-observer study were included in this assessment. Baby's weight was recorded 3 times a day with an interval of about 8 hours. We recorded a neonatal weight at an exact age in hours. Our raters were two paramedical personnel who were also the raters in the inter-observer study. Rater's effect would not be taken into account in the analysis. All data recorded were from an average of three repeated measures, and the unit of measurement was given in grams.

Before we applied a proper analytical technique for inter-observer study, we examined a simple correlation between two pairs of data collected by the two raters. We also looked at this relationship using a scatterplot. From this analysis we could estimate the pattern of an actual agreement between the two raters.

In order to examine an exact agreement between the two raters, we should use an intra-class correlation coefficient (RI). Using this technique we can examine the errors due to factors from the observer and method used. The method of calculation follows Kramer & Feinstein (1981) [7], and further general methods which can be obtained in other publication as well [8]. Physiological variability of birth weight was estimated by an ordinary least square method using a SAS software [9]. Using this technique we then derived a formula for estimating birth weight from current weight and age in hours. Even though the statistical assumption may be violated, this technique seems to be appropriate for simple purposes.

Results

The simple correlation of the two pairs of data collected by the two raters is almost perfect and statistically very significantly different from 0 ($r = 0.998$ with $P = 0.0001$ and $N = 156$). Figure 1 shows that the pattern of agreement between the two raters supports the coefficient of correlation. From this scatterplot (Figure 1) we can see that the estimate line starts from about zero axis and ordinate, and moves to the upright corner with an angle of about 45 degrees. This indicates that the agreement is almost perfect. If there was a biased observation between the two raters, the correlation coefficient could be perfect but the estimate line would not make 45 degrees angle. For example the dotted line is an hypothetical example of bias between two raters. In this case rater 1 always gives a higher value than rater 2, yet the correlation coefficient can be close to unity. In other words, a perfect correlation does not necessarily tell us anything about bias or an actual agreement between two raters. However, in this study, a regression line in Figure 1 indicates unbiased correlation between the two raters. This line has an equation : *Rater 1 = 38 + 0.99 rater 2.*

Statistical F-test resulted in $F = 48685$ with 1, 154 degrees of freedom (d.f.) and $P = 0.0001$, and a statistical test that slope is equal to 0 was rejected with $P = 0.0001$.

Further analysis by calculating an intra-class correlation coefficient shows that the correlation is almost perfect ($RI = 0.978$). Thus these two raters were performing in almost perfect agreement [8].

Statistical test shows that the subject variation is significant ($F = 1227.9$, d.f. = 155, 155, and $P = 0.0001$), but the method variation is not significant ($F=1.21$, d.f. = 1, 155, and $p > 0.10$). This suggests that agreement by chance is smaller than actual agreement. In conclusion, there is a strong evidence that the two raters have a perfect agreement on measuring birth weight for one observation.

The physiological variability of neonatal weight was assessed by a linear regression method. We used birth weight as the dependent variable and current weight, age, and sex as the independent variables in the model. We hoped that by using this relationship we can predict birth weight when it is not known at the time of admission in the hospital. A multiple regression analysis suggested that the variation of birth weight can be explained very well by current weight and age. In this case, age was expressed in the unit of hour. However, the expression of age in hours is inconvenient for practical purposes, especially to the current situation in the developing countries. Then we decided to recode age in the interval scale within days. Since both scales still gave a good prediction ($R^2 > 0.90$) we preferred to use day instead of hour as a scale. Using two predictors, current weight and age, birth weight can be estimated according to equation below : *Birth weight = 51 + 1.029 x current weight - 10 x age in day.* This regression equation has $R^2 = 0.94$ and statistical test to overall regression resulted in $F = 2833$, d.f. = 2,351, and $P = 0.0001$. Age was added to current weight because it improves the R^2 but when we tried to include sex in the regression equation, it does not improve substantially to the prediction. We also looked at the effects of time variation in the model, but it was found to be not significant. It was our concern that during the peak of the day (12.00 a.m.) an elevation of ambient temperature greater than 1° C above the range of neutral thermal environment will result in a significant insensible water loss, which can cause variability of body weight with time.

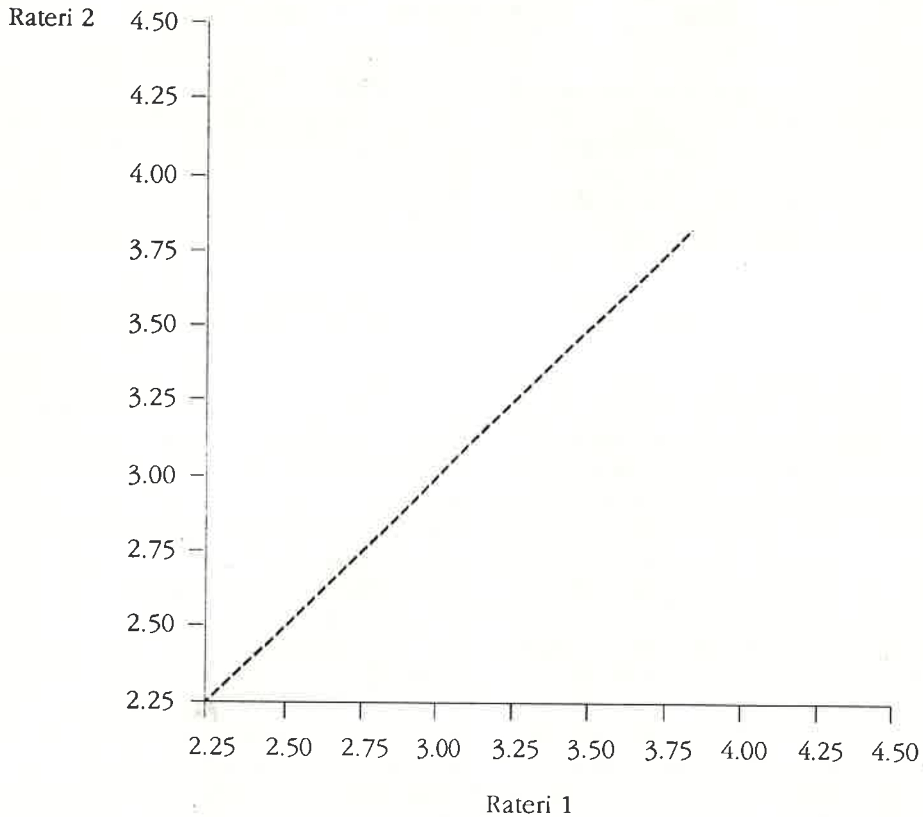

Figure 1. *Scatter plot of birth weight measured by Rater 1 and Rater 2 in kilogram*

Discussion

We have demonstrated with an experimental setting that variability of birth weight was hardly affected by the rater's errors. If paramedical personnel is really well motivated, the routine task of measuring baby's weight will not result in a serious problem. Statistically it has been demonstrated that the agreement between two raters was not caused by chance; but it shows an actual agreement between two raters. One may use this study result as a basic agreement that under an ideal condition, measurement errors should not become our concern. However, the question then arises: how can we obtain the performance of paramedical personnel in the community as good as the performance in the hospital setting. This issue is of course beyond the scope of this study. Although studies related to this question have been reported as well, they were not able to show an actual agreement between two raters in the measuring of neonatal weight [6.10]. Further specific study should be done to answer this question.

The physiological variability of the decrease of birth weight is a complex issue. Body weight is the most simple and convenient method for expressing growth rates in the early stage of development until a neonatal stage. In the early stage of development growth is always largely a matter of cell division, with a little or no increase of average cell size, so at first the embryo only grows as fast as its cells divide. In the newborn, however, it is mostly the average cell size which affects the body weight. As we know the cell size is also determined by its metabolism. In this case the concept of energy balance is becoming the central issue of the decrease of neonatal weight during the first five days of live. We may explain that the weight loss during this period can be related to the expression of: Energy intake = energy excreted + energy expended + energy stored. So if an energy intake is relatively decreased compared to the intrauterine supply, the energy stored in the body will become negative. This eventually results in the degradation of a fat storage since excretion and expenditure are relatively increased. The increase of expenditure can be attributed to the neonate's activity outside an uterine cavity, environmental changes and results of independent metabolism from the previous placental maternal complex system. The environmental effect, such as temperature, is considered an important factor in decreasing weight. In this study, however, we used a similar ward which has a relatively constant temperature from time to time. Therefore this result may not be transferable to other environment where temperature and humidity varies from baby to baby or time to time. In addition one should carefully consider the fact that this study was limited to the period of the first 5 days of life so an extrapolation to older ages will not be appropriate.

In general, this study concludes that the birth weight reported based on a neonatal weight of a few days after being born will not be appropriate, unless the weight is correted by the age of the baby. Considering the small sample size used in this study, the application of our formula should be limited to certain situations which is similar to our setting. However, one may conduct a similar study to obtain a formula which satisfies a local condition.

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