

Evaluation of a Mobile Application for Multiplier Method Growth and Epiphysiodesis Timing Predictions

Pablo Wagner, MD,* Shawn C. Standard, MD,† and John E. Herzenberg, MD, FRCSC†

Background: The multiplier method (MM) is frequently used to predict limb-length discrepancy and timing of epiphysiodesis. The traditional MM uses complex formulae and requires a calculator. A mobile application was developed in an attempt to simplify and streamline these calculations. We compared the accuracy and speed of using the traditional pencil and paper technique with that using the Multiplier App (MA).

Methods: After attending a training lecture and a hands-on workshop on the MM and MA, 30 resident surgeons were asked to apply the traditional MM and the MA at different weeks of their rotations. They were randomized as to the method they applied first. Subjects performed calculations for 5 clinical exercises that involved congenital and developmental limb-length discrepancies and timing of epiphysiodesis. The amount of time required to complete the exercises and the accuracy of the answers were evaluated for each subject.

Results: The test subjects answered 60% of the questions correctly using the traditional MM and 80% of the questions

correctly using the MA ($P = 0.001$). The average amount of time to complete the 5 exercises with the MM and MA was 22 and 8 minutes, respectively ($P < 0.0001$).

Conclusions: Several reports state that the traditional MM is quick and easy to use. Nevertheless, even in the most experienced hands, performing the calculations in clinical practice can be time-consuming. Errors may result from choosing the wrong formulae and from performing the calculations by hand. Our data show that the MA is simpler, more accurate, and faster than the traditional MM from a practical standpoint.

Level of Evidence: Level II.

Key Words: multiplier method, growth, epiphysiodesis, limb-length discrepancy, calculation

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From the *Department of Orthopaedic, Clínica Alemana de Santiago, Universidad del Desarrollo, Santiago, Chile; and †International Center for Limb Lengthening, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore, Baltimore, MD.

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Reprints: John E. Herzenberg, MD, FRCSC, International Center for Limb Lengthening, Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore, 2401 W. Belvedere Avenue, Baltimore, MD 21215. E-mail: jherzenberg@lifebridgehealth.org.

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Limb-length discrepancy (LLD) is a frequently encountered complaint in pediatric orthopaedic practice. Common causes include congenital conditions (fibular hemimelia and congenital femoral deficiency), hemihypertrophy, posttraumatic deformities, and posttumor resection sequelae, among others. Accurate LLD prediction at maturity is of utmost importance, given that it will determine the timing and treatment method.

The multiplier method (MM) is a simple and accurate method for discrepancy predictions.^{1–3} It is based on the data presented by Anderson et al⁴ and has been tested with 19 other databases of bone lengths, including anthropologic data of skeletal remains of children.⁵ It was calculated by dividing the bone length at maturity by the length at each age for each age percentile group. This gives a multiplier constant for each age. These multiplier constants are different for boys and girls but are independent of race, nationality, and generation.¹

In 2011, a mobile platform software was developed [“Multiplier App” (MA)] for the Apple iOS and Google Android platforms that is able to calculate the LLD at maturity, timing for epiphysiodesis, foot length, height at maturity, and other clinically relevant values. This software uses the same formulae as the traditional “paper and pencil” MM.

The current study seeks to compare MA with the traditional MM (calculations by hand). The mobile application eliminates the need for cumbersome formulae, paper charts, and calculations using pencil, paper, and a

calculator. It may also reduce the amount of human error during calculations of complex formulae. We hypothesized that the mobile MA is more accurate and faster than the traditional MM done by hand with a calculator.

METHODS

After receiving Institutional Review Board approval, 30 residents who were rotating through our service were asked to participate in this study. Eighteen residents were postgraduate year 1 (PGY-1), 6 were PGY-2, 4 were PGY-3, and 2 were PGY-4 with little or no previous knowledge of the MM. Initially, they attended an introductory training class that taught them about LLD and timing of epiphysiodesis using the MM and MA. In a second class, questions about clinical cases were given to the residents. They solved these questions using the MM and MA while receiving supervision and help from one of the authors. Finally, 2 timed tests were administered at 2-week intervals to the same group of residents who participated in the above-mentioned training classes. For 1 test, the residents solved the questions using the traditional paper and pencil MM. For the other test, the same questions were solved using the MA (Fig. 1). Each resident was randomized as to the method he or she applied first using a “coin flip” for randomization.

The test consisted of 5 clinical examples of hypothetical patients (refer to Supplemental Data File that

shows LLD Exercises, Supplemental Digital Content 1, <http://links.lww.com/BPO/A69>). Residents were asked to calculate developmental and congenital LLD and timing of epiphysiodesis. The amount of time taken to complete the 5 questions was measured for each participant as a quantitative continuous variable. The accuracy of the answers was determined by using an answer key that was prepared by the senior author. The results were tabulated as “correct” or “incorrect” to obtain a quantitative discrete variable. When an incorrect answer was given, the source of the error was recorded. Lastly, after both tests were administered, the residents were asked to choose their preferred method in terms of ease of use and likelihood of using it in future practice. All tests were answered anonymously. Residents were excluded from the study if they did not answer all the questions, did not take both tests, or had previous experience with this topic.

To obtain an adequate sample size, an estimated difference of 20% in accuracy and 100% in time between methods was calculated. To obtain a confidence level of 95% with a power of 80%, an estimated sample size of 30 subjects per group was required.

RESULTS

Thirty residents each took the same test 2 times: once using the MM and once using the MA. The average



FIGURE 1. The study participants were given the following clinical problem about limb-length discrepancy (LLD). A 6-year-old girl with proximal focal femoral deficiency of the right femur has bone lengths of 15 cm (right femur) and 20.3 cm (left femur). What will be the difference at maturity? A, To solve this problem using the Multiplier App, the study participant would first select the “Lower Extremity” option from the main menu. B, From the “Lower Extremity” screen, the participant would then select “LLD (congenital)”. C, The “LLD (congenital)” screen allows the user to input data. The participant enters the limb segment (femur), sex (female), age (6y), and LLD (20.3 – 15.0 cm = 5.3 cm LLD). No information is provided about prior lengthening amounts in the question, so the participant leaves this field blank and then presses the calculate button. D, The results screen shows that the discrepancy will be 8.0 cm at maturity. To see the LLD at every age, the participant presses the “LLD (congenital) at every age” button. Reprinted with permission. Copyright 2015 [Rubin Institute for Advanced Orthopedics, Sinai Hospital of Baltimore, Baltimore, MD]. All permission requests for this image should be made to the copyright holder.

amount of time required to complete the test using the traditional MM and the MA was 22 (range, 15 to 45) minutes and 8 (range, 4 to 15) minutes, respectively ($P < 0.001$). Regarding the accuracy, an average of 3 (60%) of 5 questions (range, 20% to 100%) were answered correctly using the MM and 4 (80%) of 5 questions (range, 40% to 100%) using the MA ($P = 0.001$). The most common errors for the MM were arithmetic errors (23 errors), incorrect choice of the appropriate formula (10 errors), selecting the wrong limb segment for the location of epiphysiodesis (8 errors), and using the current discrepancy instead of the discrepancy at maturity for the timing of epiphysiodesis calculations (7 errors). The most common errors observed for the MA were using the current discrepancy instead of the discrepancy at maturity for the timing of epiphysiodesis calculations (9 errors), inputting the patient's sex incorrectly (8 errors), and selecting the wrong limb segment for the location of the epiphysiodesis (7 errors). No difference in accuracy or time taken to answer the questions for the 2 test groups was observed ($P > 0.05$) when the results were separated on the basis of whether participants took the first test using the MA or MM. All residents stated that they would prefer to use the MA in the future instead of the MM.

DISCUSSION

In pediatric orthopaedic practices, LLD is a frequent clinical challenge. Parents need to know what the predicted discrepancy will be at skeletal maturity, and when, if advisable, epiphysiodesis should be performed.

There are 4 main methods used for discrepancy prediction: the arithmetic method; the growth-remaining method^{4,6}; the straight-line graph method⁷; and the MM.¹ Anderson et al⁴ presented longitudinal data in 1963 that included the lengths of femora and tibiae in boys and girls according to chronological age from 1 year to the age at skeletal maturity. All current methods that predict LLD are based on these data. The Moseley method⁷ converts the data from the study by Anderson et al⁴ into a straight line by modifying the age scale. This method requires at least 2 or 3 data points obtained at least 1 year apart to accurately predict the LLD.

Several reports state that the traditional MM is quick, accurate, and easy to use in comparison with other methods^{1,2,8-11} for calculating limb discrepancies in prenatal patients, upper-limb and lower-limb discrepancies, and timing of epiphysiodesis. It has been shown that a more accurate discrepancy prediction can be obtained when bone age is used instead of chronological age in the MM.¹² Recently, a study that compared the remaining growth, straight line, and MMs showed that the Green-Anderson growth remaining method was the most accurate approach for predicting the timing of epiphysiodesis.¹³

Our results demonstrate a clear advantage for the MA in the time needed to answer the 5 clinical questions (almost 3 times faster) and in its accuracy (20% more accurate). In clinical practice, performing the calculations

can be cumbersome and time-consuming. Some attempts have been made to simplify these calculations. Sanders et al¹⁴ published an Excel spreadsheet (Microsoft Inc., Redmond, WA) to help with the MM calculations. The most common mistakes observed using the MM were mathematical errors followed by incorrect application of formulae. This is one of the greatest advantages of the MA: it helps prevent arithmetic errors and the specific formulae do not have to be selected by the clinician.

The MA was developed in an attempt to further simplify and streamline these calculations for a mobile platform. It is available for free under the name "Multiplier" for both the Apple iOS and Google Android platforms. Since the launch of the app in 2011, several updates have been released to make it easier to use and more attractive. Also, more detailed explanations and additional functionality have been added as well as improvements in the interface to prevent human errors when inputting data and choosing the correct formula. When the test was administered for this research, a default sex (male) was preselected in the MA data entry screens. Inputting the patient's sex incorrectly was the second most common mistake with the MA. On the basis of these results, the developers (S.C.S., J.E.H.) modified the MA so that no default sex was preselected and an alert message was generated if the user did not indicate the patient's sex.

The strengths of our study include that it is a well-designed, prospective, randomized trial, with an adequate power to answer the hypotheses. A potential weakness is that residents are familiar with smartphones and their applications, but they may not be as adept at performing mathematic calculations. In summary, the free MA is simpler and more accurate in practice than the traditional pencil and paper MM. No method is foolproof, as the clinician still has to have a thorough understanding of the subject matter to use either method.

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