ACCURACY STUDY OF BLOOD GLUCOSE MONITORING SYSTEMS

Evaluation of the TRUEresult®, OneTouch® Ultra®2, Ascensia® CONTOUR®, and FreeStyle Freedom® Lite Systems

NIPRO DIAGNOSTICS™

INTRODUCTION

Diabetes has reached epidemic proportions in America. According to the CDC, 23.6 million Americans had diabetes in 2007 – a 13.5% increase from 2005.[1] Today, almost one-third of diabetes incidence in the U.S. remains undiagnosed. Type 2 diabetes accounts for 95% of cases, with more than half of these individuals treated with oral medications.[2, 3] Research demonstrates that as diabetes progresses, many type 2 patients receiving oral medications will fail to achieve glycemic goals and require insulin therapy.[4]

Blood glucose monitoring (BGM) – measuring glucose levels by using a blood glucose meter and test strips – has been studied and proven effective in controlling glucose values.[5-7] BGM is useful and necessary so that patients can understand the effects of medications, meal planning, and physical activity on glucose levels. Results of regular testing can be used to help patients achieve optimal health.

In the BGM industry, manufacturers strive to design meters that focus on alleviating barriers to testing. Some barriers have been addressed through the implementation of a more intelligent meter design. Easier-to-use meters help eliminate the possibility of inaccurate results obtained through user error. The goal of meter improvements is to increase testing compliance to align with recommended monitoring regimens from healthcare practitioners.

Significant strides have also been made in developing testing systems that require smaller blood samples, which result in less pain and reduced testing time, thereby adding convenience and removing obstacles for the user.

The advent of enhanced meter performance standards has resulted in greater device accuracy and precision, independent of user error.

While system performance continues to improve, and meters are easier and more convenient to use, one critical barrier to testing remains: the significant cost and financial burden of testing. This study was designed to gather evidence supporting the performance of store-brand blood glucose meters offering features and ease-of-use comparable to more costly name-brand meters.

The purpose of this study was to compare the performance of several, commercially available, blood glucose monitoring systems.

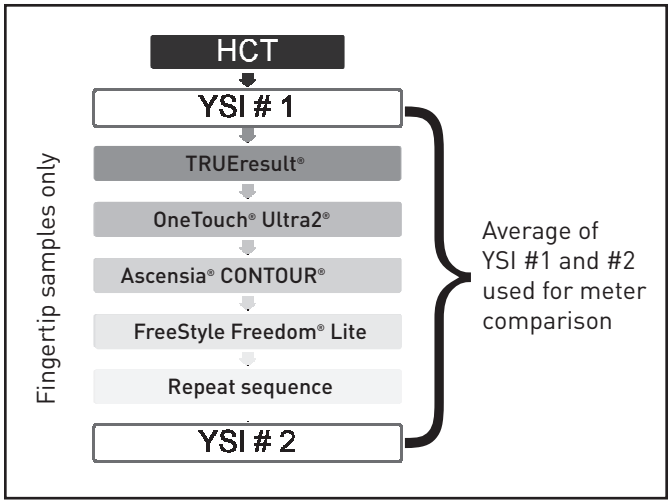
SITE AND SUBJECTS

The clinical evaluation of the TRUEresult® System was conducted at one site.

Two lots of TRUEresult® Test Strips were used in this evaluation, as well as two lots each of OneTouch® Ultra®2, Ascensia® CONTOUR®, and FreeStyle Freedom® Lite test strips. Quality control was performed on all meter systems per manufacturer-recommended instructions. The Yellow Springs Instrument (YSI) glucose reference analyzer's calibration was checked on a daily basis, with standards provided by the manufacturer. There were duplicate samples obtained for the YSI and each meter system.

The data collection sequence was as follows: HCT, YSI, TRUEresult®, OneTouch® Ultra®2, Ascensia® CONTOUR®, FreeStyle Freedom® Lite, TRUEresult®, OneTouch® Ultra®2, Ascensia® CONTOUR®, FreeStyle Freedom® Lite, and YSI. Blood was obtained from subjects' fingertips only.

Data Collection Sequence



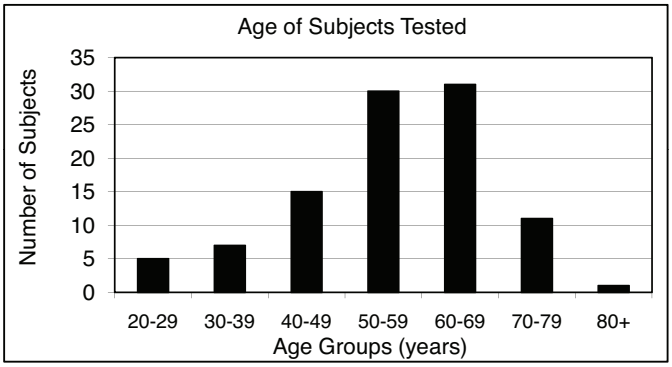
The YSI results performed at the beginning and end of each subject's session were performed using whole blood. These two results were then averaged, and using the formula of Plasma Glucose = Whole Blood Glucose / [1 - (0.0024 x %HCT)], the reference YSI plasma glucose was calculated.

A total of 128 subjects* completed the study protocol. However, the results of 28 subjects were excluded due to the fact that the YSI reference values performed at the beginning and end of each subject's session drifted more than 4% at glucose levels > 100 mg/dL or 4 mg/dL at levels < 100 mg/dL.

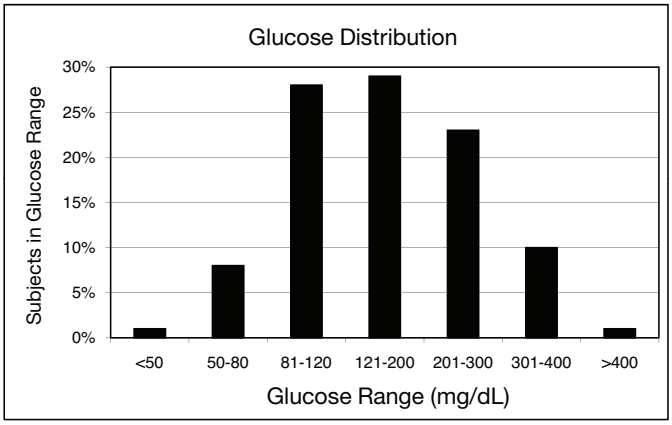
The subjects were mostly people with type 2 diabetes, as well as people with type 1 diabetes, and ranged in age from 23 to 82 years old. There were slightly more females than males in this study. A broad range of glucose values were obtained for this evaluation. Subjects' hematocrit ranges were from 28%-49%.

Gender		Diabetes Type	
Male	46.0%	Type 1	26.0%
Female	54.0%	Type 2	74.0%

Age distribution of the 100 subjects enrolled in the study



Glucose distribution of 100 subjects enrolled in the study

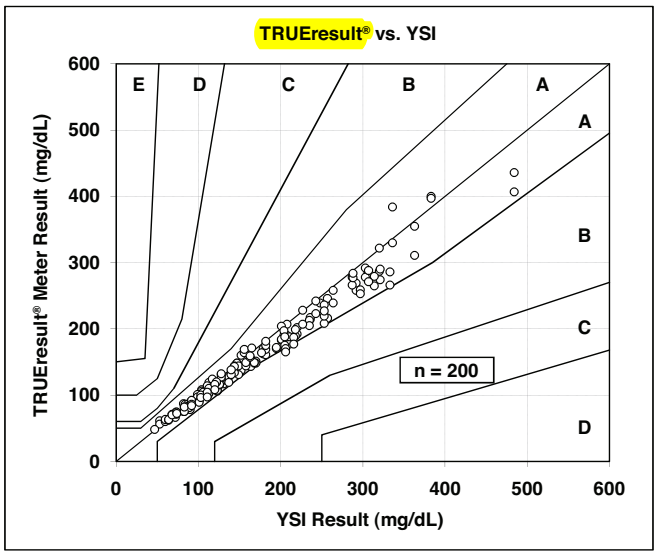


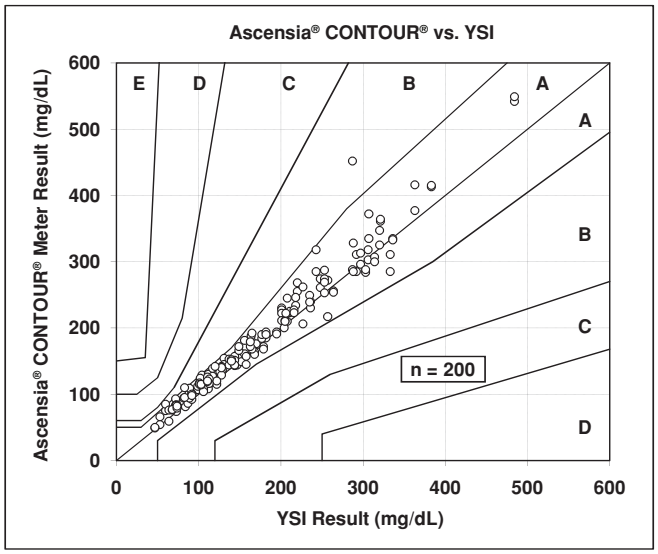
* Only 99 subjects were used in the data analysis for the OneTouch® Ultra®2 due to one subject's hematocrit of 28% being less than the manufacturer's lower limit of 30% for that system.

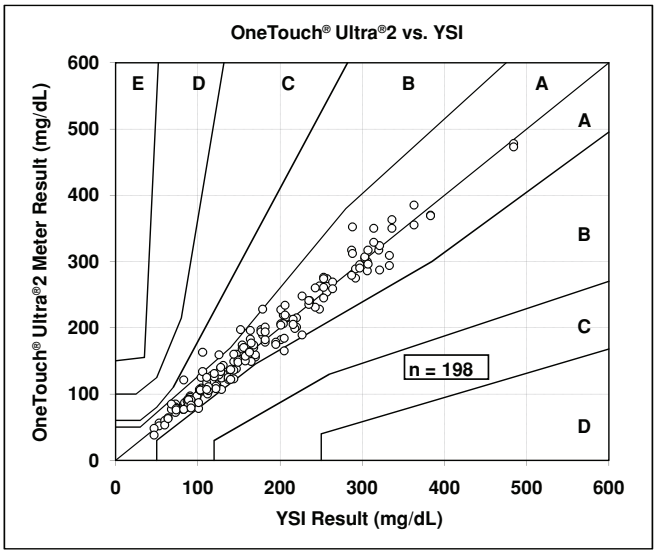
TOPLINE RESULTS USING PARKES ERROR GRID

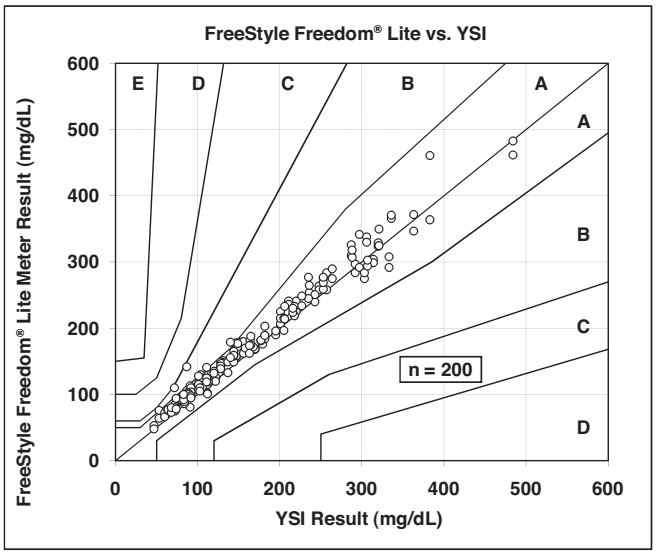
The TRUEresult® System is proven to provide accurate results, comparable to the results obtained using the OneTouch® Ultra®2, the Ascensia® CONTOUR®, and the FreeStyle Freedom® Lite. Each system's performance data has been plotted on a Parkes Error Grid[8] for comparison below.

	% Results in Zone A	% Results in Zone B
TRUEresult®	98.5	1.5
OneTouch® Ultra®2	96.5	3.5
Ascensia® CONTOUR®	98.5	1.5
Freestyle Freedom® Lite	97.0	3.0









* Parkes Error Grids[5] are divided into five different Zones representing the degree of risk posed by the incorrect measurement: Zone A represents no effect on clinical action; Zone B represents altered clinical action – little to no effect on clinical outcome; Zone C represents altered clinical action – likely to affect outcome; Zone D represents altered clinical action – could have significant medical risk; and Zone E represents altered clinical action – could have dangerous consequences.

TOPLINE RESULTS USING ISO GUIDELINES

To further measure meter performance, all systems were evaluated by using the International Standards Organization (ISO) 15197:2003 criteria for measuring accuracy in blood glucose monitoring devices. ISO combines two sets of accuracy criteria based on glucose value; values less than 75 mg/dL and values greater than or equal to 75 mg/dL.

Summary of all systems' accuracy against the YSI reference method **for YSI readings below 75 mg/dL (calculated plasma readings).**

Meter System	Within ± 15 mg/dL
TRUEresult®	18/18 (100%)
OneTouch® Ultra®2	17/18 (94%)
Ascensia® CONTOUR®	16/18 (89%)
Freestyle Freedom® Lite	15/18 (83%)

Summary of all systems' accuracy against the YSI reference method **for YSI readings at 75 mg/dL and above* (calculated plasma readings).**

Meter System	Within ± 20 %
TRUEresult®	181/182 (99%)
OneTouch® Ultra®2	171/180 (95%)
Ascensia® CONTOUR®	173/182 (95%)
Freestyle Freedom® Lite	172/182 (95%)

* One subject's duplicate results using the OneTouch® Ultra®2 were omitted from the data analysis due to the subject's 28% HCT being less than the manufacturer's lower limit of 30% for that system.

Precision was evaluated by the standard deviation calculated using the difference between duplicate samples.[7] The TRUEresult® System has a smaller average deviation than the OneTouch® Ultra®2, the Ascensia® CONTOUR®, and the FreeStyle Freedom® Lite.

Meter System	Average Deviation (mg/dL)
TRUEresult®	9.0
OneTouch® Ultra®2	12.0
Ascensia® CONTOUR®	15.7
Freestyle Freedom® Lite	11.7

Note: The standard deviation of duplicates is an assessment of the system's reproducibility. The formula used to calculate the standard deviation is below.

Standard Deviation = $$S = \sqrt{\frac{d^2}{2n}}$$

Where "d" represents the difference between the pair of duplicates, and "n" is the number of samples.

DISCUSSION

Regardless of an individual's specific insurance situation, patients with diabetes continue to look for ways to cope with the high cost of managing the disease. At the same time, they search for ways to better manage overall household expenses and budgets. Some patients cut back on a prescribed testing regimen to extend the life of their test strip supplies. Others completely eliminate testing. Due to cost, U.S. patients failed to fill 6.8% of the name-brand prescriptions their doctors requested in the 2008 fourth quarter, a 22% increase from the first quarter of 2007.[10]

Actions like these come at the expense of patient health and add to the annual economic cost of the disease – $174 billion in 2007. This figure includes $27 billion for diabetes care, $58 billion for chronic diabetes-related complications, and $31 billion for excess general medical expenses. Indirect costs resulting from increased absenteeism, reduced productivity, disease-related unemployment disability, and loss of productive capacity due to early mortality add up to $58 billion.[11]

Not all blood glucose monitoring systems are cost-prohibitive. Store-brand blood glucose monitoring systems, such as the TRUEresult® Meter and TRUEtest™ Strips – manufactured by Nipro Diagnostics, Inc. for the nation's leading pharmacies, pharmacy wholesalers, medical products distributors and mail-service providers – provide an advanced performance alternative that can annually save people with diabetes (on average) over $400 on test strips alone (compared to name-brand strips).[12]

In the past, lower-cost alternatives like these have been correlated with lower quality and performance. However, this study demonstrates that a specific store-brand system delivers comparable accuracy and performance when tested against name brands. Nipro Diagnostics products sell at price points significantly below those of name brands. Through minimized advertising and marketing expenses, Nipro Diagnostics sells for less, makes less, and receives lower margins on every meter and test strip.

Store-brand systems are subject to the same, rigorous, clinical substantiation and approval process as the name brands, as mandated by the U.S. Food and Drug Administration. The TRUEresult® System (store brand) has also been evaluated for accuracy and ease of use against International Organization for Standardization (ISO) guidelines and has met, or exceeded, the minimum requirement for accuracy.

The TRUEresult® System continues to be studied and reviewed in unbiased clinical studies that demonstrate that this product achieves accuracy and ease of use comparable to that of the leading name-brand systems.

Store-brand blood glucose monitoring systems continue to gain greater patient and professional acceptance. Today, the entire healthcare system is looking for cost savings through solutions that offer outstanding performance combined with exceptional value and savings. Not only does this help patients save money on their testing supplies, it helps reduce overall healthcare expenses for insurers, Medicare and Medicaid. This is an important consideration and advantage as our country looks toward healthcare reform in an effort to lower the overall costs and burden on our economic system.

In 2008, the number of uninsured Americans reached 46.3 million people, or 15.4% of the population.[13] The quality and savings offered by store-brand blood glucose monitoring systems provide significant value to cash payers, the underinsured and uninsured.

Overall, store-brand blood glucose monitoring systems – such as the TRUEresult® Meter and TRUEtest™ Strips from Nipro Diagnostics, Inc. – are proven to deliver comparable performance to name-brand systems, while helping patients achieve meaningful savings on diabetes testing supplies. This bottom-line advantage is a combination of value and performance that sets these store-brand systems apart from competitors.

CONCLUSIONS

The performance of the TRUEresult® System exceeds the minimum performance criteria outlined in the ISO protocol with 199 out of 200 (99.5%) results within the ISO stated accuracy limits.

The TRUEresult® System showed excellent accuracy with 98.5% of glucose results within Zone A of the Parkes Error Grid, which was comparable to the Ascensia® CONTOUR®.

The TRUEresult® System showed good reproducibility with 100 duplicate samples compared to the measured precision of OneTouch® Ultra®2, Ascensia® CONTOUR®, and Freestyle Freedom® Lite.

Overall, the performance of the TRUEresult® System was comparable to OneTouch® Ultra®2, Ascensia® CONTOUR®, and FreeStyle Freedom® Lite when tested on people with diabetes.

1. American Diabetes Association Web site, "Direct and Indirect Costs of Diabetes in the United States." 2. Snyder, J., "Ways to Save on Test Strips With the High Cost of Diabetes." www.articlesbase.com, March 24, 2009. 3. 2004-2006 National Health Interview Survey 4. Bloomgarden, Zachary T., "Achieving Glycemic Goal in Type 2 Diabetes." Diabetes Care 2007; 30(1):174–180. 5. Stades A.M., Hoekstra J.B., van den Tweel I., Erkelens D.W., Holleman F.; Stability Study Group: "Additional Lunchtime Basal Insulin During Insulin Lispro Intensive Therapy in a Randomized, Multicenter, Crossover Study in Adults: A Real Life Design." Diabetes Care 2002; 25:712–717. 6. Riddle M., Rosenstock J., Gerich J.; Insulin Glargine 2002 Study Investigators: "The Treat-to-Target Trial: Randomized Addition of Glargine or Human NPH Insulin to Oral Therapy of Type 2 Diabetic Patients." Diabetes Care 2003; 26:3080–3086. 7. Albisser A.M., Sakkal S., Wright R.N.: "Home Blood Glucose Prediction: Validation, Safety, and Efficacy Testing in Clinical Diabetes." Diabetes Technol Ther 2005; 7:487–496. 8. Parkes J.L., Slatin S.L., Pardo S., Ginsberg B.H.: "A New Consensus Error Grid to Evaluate the Clinical Significance of Inaccuracies in the Measurement of Blood Glucose." Diabetes Care 2000; 23(8):1143–1148. 9. Westgard, James O., "Basic Method Validation" as cited at http://www.westgard.com/lesson22.htm. 10. Jonathan D. Rockoff; April 8, 2009, Wall Street Journal, http://online.wsj.com/article/SB123915436586599765.html. 11. American Diabetes Association Web site, "Direct and Indirect Costs of Diabetes in the United States." 12. Calculations on file based on testing 3 times per day. 13. Commins, John; "Uninsured Population Hits 46.3 Million in 2008." HealthLeaders Media, September 10, 2009.

This study was performed by the staff at the International Diabetes Center in Minneapolis, MN, under the direction of the Principal Investigator, Richard Bergenstal M.D.

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