



Original/*Valoración nutricional*

Design and development of a nutritional assessment application for smartphones and tablets with Android® OS

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Abstract

Background & Aims: To design and develop a nutritional application for smartphones and tablets with Android® operating system for using to in- and outpatients that need a nutritional assessment. To check the validity of the results of such software.

Methods: The application was compiled for version 2.1 of the Android® operating system from Google®. A cohort of 30 patients was included for evaluating the reliability of the application. The calculations were performed by staff of the Nutrition Unit of the Complejo Hospitalario Universitario de Vigo, manually and through e-Nutrimet® software on a smartphone and a tablet.

Results: Concordance was absolute between results of different methods obtained using e-Nutrimet® on a smartphone and a tablet (Fleiss index $\kappa = 1$). The same level of concordance was obtained by comparing handmade and e-Nutrimet® made results.

Conclusions: The degree of correlation is good, and it would be extended to all healthcare staff who wants to determine whether a patient has malnutrition, or not. The nutritional assessment software e-Nutrimet® does not replace healthcare staff in any case, but could be an important aid in assessing patients who may be in risk of malnutrition, saving time of evaluation.

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Key words: *Nutrition. Nutritional assessment. Mobile phone. Medical informatics applications. Personal electronic health records.*

DISEÑO Y DESARROLLO DE UNA APLICACIÓN DE VALORACIÓN NUTRICIONAL PARA SMARTPHONES Y TABLETS ANDROID®

Resumen

Introducción y objetivos: Diseñar y desarrollar una aplicación nutricional para smartphones y tablets con Sistema operativo Android® para realizar las valoraciones nutricionales de pacientes ambulatorios y hospitalizados. Verificar y comprobar la validez de los resultados de la aplicación.

Métodos: La aplicación se compile para la versión 2.1 del Sistema operativo Android® de Google®. Para evaluar la fiabilidad de la aplicación se incluyeron a 30 pacientes, a los que se le realizó una valoración nutricional. Todos los cálculos fueron efectuados por personal de la Unidad de Nutrición del Complejo Hospitalario Universitario de Vigo, de forma manual y a través del software e-Nutrimet®, tanto usando un Smartphone como una tablet.

Resultados: Se obtuvo una concordancia absoluta entre los resultados de los diferentes métodos obtenidos utilizando la aplicación e-Nutrimet® en smartphones y en tablets (Fleiss index $\kappa = 1$). El mismo nivel de concordancia se obtuvo comparando el método manual como el automatizado mediante el software e-Nutrimet®.

Conclusiones: El grado de correlación es muy bueno, permitiendo extender la valoración nutricional usando e-Nutrimet® a todo el personal sanitario que quiera determinar si un paciente presenta malnutrición o no. La aplicación de valoración nutricional e-Nutrimet® no sustituye al personal sanitario en ningún caso, pero podría ser de gran ayuda a la hora de valorar pacientes que pudieran estar en riesgo de malnutrición, ahorrando tiempo en estas valoraciones.

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Palabras clave: *Nutrición. Valoración nutricional. Dispositivos móviles. Aplicaciones informáticas médicas. Registros de salud electrónicos.*

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Introduction

Smartphones have become a part of our daily lives. The number of smartphone users worldwide is expected to exceed one billion in 2013¹. Nowadays, 64% of U.S. physicians have a smartphone, and it is expected that this figure will increase to 81% in the year 2012².

Currently, there are two operating systems (OS) that dominate the smartphone market: Android[®] (developed by Google[®]) and iOS[®] (developed by Apple[®]), according to the marketing research company Canalys (http://www.ditic.luz.edu.ve/index.php?option=com_content&task=view&id=200&Itemid=217). In Spanish mobile phones' market, the use of smartphones is approximately 23%³ and it continues to grow according to an analysis of TomiAhonen Consulting (<http://communities-dominate.blogs.com/brands/2011/12/smartphone-penetration-rates-by-country-we-have-good-data-finally.html> - December, 2011).

These devices allow to make a lot of alternatives tasks to traditional mobile phones, partially due to the use of mobile applications and Internet connectivity through different communication networks (WiFi technologies, 3G, Bluetooth, etc.) which ease a fast interconnection, enabling access to the latest news in medical research, even in the point of patients caring⁴.

Increase in computing power coupled with mobility and multimedia capabilities make them ideal for software development oriented to health professionals⁴. Anyone may dispose in its hands a powerful computer available in any situation.

Most of healthcare professionals want to have information as current as possible and a support to everyday clinical decisions².

Most common utilities in such devices (e-mail and text messaging software, browser, camera and multimedia player/recorder) are already used in clinical practice for the exchange of information between health professionals and serves for supporting to make decisions, in a practical way. Increasingly development of medical applications for these devices is in benefit of clinicians and might reduce costs of local resources in many cases, which is a great advantage^{5,6}. In addition to bibliographic reference managers in health field, there are specific applications in different areas such as medicine, surgery, neurosurgery, ophthalmology, infectious diseases, pharmacology or psychology⁷.

Within the nutrition field, software tools as Gerinut[®] (Abbott Laboratories SA - Madrid, Spain) are more specific in geriatric nutrition⁸. Also, there are some applications for iPhone[®] as Nutri'Calc (Nestlé Clinical Nutrition France - Noisiel, France), which is more specific for a catalog of products and nutritional supplements. This application allows a simple calculation of some nutritional parameters. It is available in the Apple[®]'s iTunes App Store[®].

Persistent work overload of health professionals in their daily practice does not let for an improvement in the quality of patient care, extending the attention time

of patients and prolonging hospital stays for caring, delaying full recovery of these patients and causing a higher bed occupancy and cost per inpatient.

In the current health care context, it is necessary to develop new processes with the aim of reducing hospitalization time of inpatients and improving in the cost-effectiveness ratio. Mobile devices may help in this task through the development of applications that imply time saving for making decisions of health professionals.

From Nutrition Unit and Thoracic Surgery Department, at Complejo Hospitalario Universitario de Vigo (Vigo University Hospitals, Vigo, Spain), we have launched a protocol for a preoperative nutritional study in primary lung neoplasms since 2009. Patients are assessed for their nutritional status before surgery intervention, among other tests. Several communications support its effectiveness and usefulness⁹⁻¹¹.

The e-Nutrimet[®] software has been developed to make faster the process of nutritional assessment and try to avoid work overload in the Nutrition Unit, where currently all patients candidates for lung resection are assessed.

The present study shows the design and development of e-Nutrimet[®], a software that allows the nutritional assessment of inpatients.

Materials and Methods

Integrated Development Environment (IDE) used for developing the application was Eclipse[®] Java[®] Enterprise Edition (J2E) version 3.7.2 with Android[®] Development Tools (ADT) plugin version r21.1 and Apple[®] Java[®] Virtual Machine (JVM) version 1.6.0_41. Android[®] Software Development Kit (SDK) r21.1 was also used and compiled for Android[®] version 2.1 Eclair[®], Application Programming Interface (API) 7.

This application has been developed for Android[®] versions later than 2.1 Eclair[®], according to data shown by Google[®] Inc. (<http://developer.android.com/about/dashboards/index.html> - collected in November 2012).

The software was based on different nutritional assessment methods described in several scientific publications, and whose daily clinical practice has been proven.

One of them is Chang method^{12,13} which is an objective, cheap and reliable nutritional assessment method¹⁴. This method was qualified as most useful than Patient-Generated Subjective Global Assessment (PG-SGA) in target patients to lung resection¹⁰ at Complejo Hospitalario Universitario de Vigo. e-Nutrimet[®] also implements patients nutritional assessment by other methods, such as Controlling Nutritional status (CONUT)¹⁵ and PG-SGA¹⁶, as well as the daily total calorie value (TCV) due to the addition of several algorithms: Harris Benedict¹⁷, Ireton Jones¹⁸, Mifflin-St Jeor¹⁹, Roza²⁰, Owen^{21,22} and FAO/WHO²³. Chang's method use several anthropometric and biochemical parameters. Among the anthropometric parameters are used height, weight,

percentage of weight loss of the patients with respect to their ideal weight, (mid-)upper arm circumference ((M)UAC), the triceps skin fold (TSF) and (mid-)upper arm muscle area ((M)UAMA calculated from (M)UAC and TSF variables according to the formula:

$$(M)UAMA (mm) = (M)UAC (mm) - (3,14 * TSF (mm))$$

To determine the ideal weight for males and females were used Hammond algorithms²⁴. These algorithms make an estimation of the patient's ideal weight based on the height. Thus, taking the weight and height of the patient measured on a weighing and height scale respectively, the program computes the ideal weight for that patient.

It has been incorporated to e-Nutrimet[®] an option for those cases where it is very difficult to take values of height and weight due to the patient's situation (bedridden, in intensive care, etc...). This option estimates the height and weight of the patient from other anthropometric values, such as knee-heel length (KHL)²⁵ and the calf circumference (CC)²⁶. This will avoid the stress to the patient, as far as possible, during nutritional assessment.

Finally, the e-Nutrimet[®] software also allows for weight estimation using the height value and an approximate patient's anatomical image. This is specially useful in those isolated individuals whose contact must be minimized. Thus, e-Nutrimet[®] application allows an estimation of the Body Mass Index (BMI) using height values and a estimated weight extracted from a scale of figures²⁷.

Biochemical parameters used by the Chang's method are albumin and lymphocyte count, measured in serum samples.

All variables used by e-Nutrimet[®] application for assessing through Chang's method are shown in table I.

PG-SGA method¹⁶ consists of a questionnaire that must be filled with different aspects of patients feeding and other parameters related to their health status and their health care conditions.

CONUT is a screening method that uses biochemical parameters to determine if the patient is at risk of malnutrition, or otherwise is in a good nutritional status¹⁵. It is a method that warns in case of possible malnutrition, in a specific degree, so a monitorization will be necessary in patient's nutritional status if the result is positive. Biochemical parameters, in serum samples, used with CONUT algorithm are albumin, lymphocyte count and cholesterol.

e-Nutrimet[®] application, as discussed above, computes the daily total calorie value (TCV) through several equations. Depending on the equation, variables to be used will be different, but the program allows selecting various options to get the results in Kcal/day of needs for an individual patient based on their particular conditions. Mifflin-St Jeor algorithm, which seems of consensus for some authors, is the most fitted to the metabolic requirements, when is compared to data quantified by indirect calorimetry²⁸⁻³⁰. Also, Ireton-Jones equation would be the best choice in intensive care unit (ICU) patients¹⁸.

All variables used by e-Nutrimet[®] application to determine the TCV by different equations are shown in table II.

For determining the effectiveness of the e-Nutrimet[®] application, a random sample of 30 patients was selected, who were assessed at the Nutrition Unit of the Department of Endocrinology of the Complejo Hospitalario Universitario de Vigo (NU-CHUVI, Vigo, Spain). All patients underwent nutritional assessment by different methods (Chang, PG-SGA and CONUT), and TCV was calculated using different equations (Harris Benedict, Ireton-Jones, Roza, Mifflin-St. Jeor, Owen, FAO/WHO), either manually or by using the e-Nutrimet[®] software.

All measurements were made by qualified health staff at NU-CHUVI. Harpenden[®] caliper (*Baty International – West Sussex, Great Britain*) was used to measure TSF, and a standard tape-measure was used for measuring (M)UAC parameter through the International System. SECA[®] model 700 (Seca GMHB & CO. KG - Hamburg, Germany) scale was used for measuring patients' weight with an accuracy of ± 0.1 kg. A telescopic measuring rod SECA[®] model 220 (Seca GMHB & CO. KG - Hamburg, Germany) was used for measuring patients' height with an accuracy of ± 5 mm. Various biochemical parameters were collected from bodily fluids samples of patients, performed at CHUVI's medical laboratory.

e-Nutrimet[®] was tested on a Sony Ericsson Xperia Arc[®] smartphone (Sony Mobile Communications AB -

Table I
Variables requested by e-Nutrimet[®] through Chang's algorithm

<i>LIST OF USED VARIABLES</i>	
<i>Concept</i>	<i>Type of variable</i>
<i>Patient</i>	
Patient ID	Alphanumeric
Age (years)	Numerical
Date of birth	Date
Gender	Male / Female
<i>Anthropometry</i>	
Current weight (kg)	Numerical
Usual weight (kg)	Numerical
Height (cm)	Numerical
TSF (mm)	Numerical
(M)UAC (mm)	Numerical
KHL (cm)	Numerical
CC (cm)	Numerical
BMI image number	Numerical
<i>Biochemical parameters</i>	
Albumin (g/dl)	Numerical
Lymphocyte Count (linf/μl)	Numerical

Table II
Variables requested by e-Nutrimet®
for TCV determination

LIST OF USED VARIABLES	
Concept	Type of variable
<i>Patient</i>	
Patient ID	Alphanumeric
Age (years)	Numerical
Date of birth	Date
Gender	Male / Female
<i>TCV</i>	
Mechanical ventilation	Yes/No
Bedrest	Yes/No
Burns	Yes/No
Injuries	No/Cranial/Other type
Infections	No/Low/Medium/High
Surgery	No/Lesser/Higher
Current weight (kg)	Numerical
Height (cm)	Numerical
TSF (mm)	Numerical
(M)UAC (mm)	Numerical
KHL (cm)	Numerical
CC (cm)	Numerical

Tokyo, Japan) and on a Primux Zonda® tablet (Primux Trading S.L. - Galicia, Spain). Smartphone and tablet specifications may be found on respective manufacturer websites (www.sonymobile.com; www.primux.es). OS for testing was Android®: for smartphone with

version 2.3.4 Gingerbread®, and for tablet with version 4.0.3 Ice Cream Sandwich®.

Statistical analysis

For statistical analysis of data, we used IBM Statistics Package for Social Sciences (IBM SPSS Statistics®) version 19.0 for Windows®. Fleiss' kappa index was used to assess the concordance level of the nutritional assessment computed with e-Nutrimet®, in comparison with manually performed.

Results and discussion

Below, various figures are shown with different sections and corresponding outputs of e-Nutrimet®.

In figure 1 is found the main screen. Various modules are accessed from there, as well as other options such as “Bibliography”, in which scientific articles are included, that describes different methods and techniques implemented in e-Nutrimet®. Other options are “Acknowledgements” and “Help/About...”. This latter is a brief summary of characteristics of the application and which indicates the current version.

In figure 2 is found the output of Chang’s method. In this figure, a patient shows a moderate mixed malnutrition, according to types and degrees included in mentioned method^{12,13}, between other relevant information. “Save Patient” option will be used for keeping information.

In the nutritional assessment by PG-SGA algorithm, as shown in figure 3, some variables consist of a dropdown menu in which the clinician may choose the appropriate option. Other variables are logical, for



Fig. 1.—e-Nutrimet® main screen.methods.



Fig. 2.—Example of output screen after Chang’s method application.

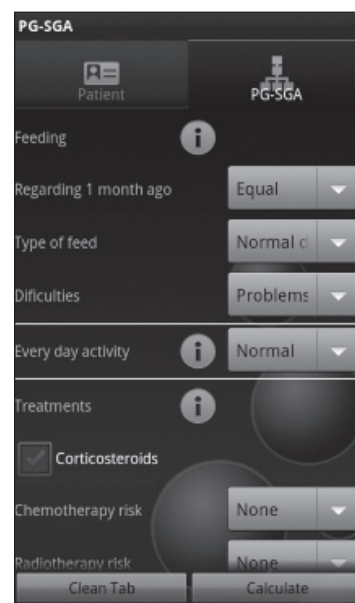


Fig. 3.—Input screen for PG-SGA algorithm.

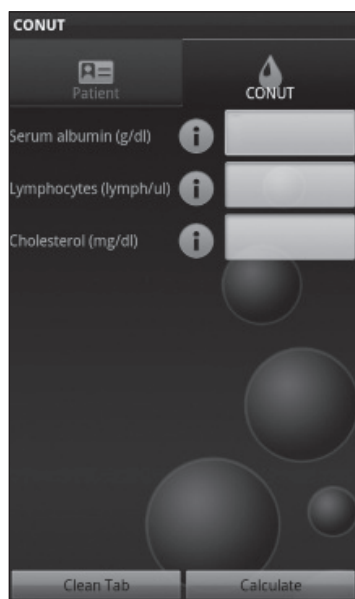


Fig. 4.—Input screen for CONUT algorithm.



Fig. 5.—Input screen for TCV algorithm.

TCV according		Kcal/day
Harris-Benedict		1657,0
Harris-Benedict (with corrections)		2953,0
Ireton-Jones		1994,0
Owen		1593,0
Mifflin-St. Jeor		1611,0
Roza		1658,0
FAO/WHO		1691,0

Fig. 6.—Example of output screen with TCV results.

clicking on/off in the check box. All variables have a help button (“i” button) that explains what is each variable and with a brief description for using it.

The CONUT nutritional screening tool consists of a warning system, which indicates whether the patient has nutritional risk, and what kind is it¹⁵. It uses three biochemical variables (albumin, lymphocytes count and cholesterol), as shown in figure 4.

TCV is a module in which is possible to select different health conditions of the patient, and introduce a series of anthropometric variables such as weight or height, for computing the number of Kcal that one patient need every day. Results output is obtained using different verified equations of use in clinical hospitals. These results are well suited for computing an indirect calorimetry. Figure 5 and figure 6 show data input and output screens, respectively.

To verify the reliability of the calculations using the application on smartphones or tablets in comparison with the traditional method (handmade method), we used a set of statistical tests to check for significant differences. 30

patients has been nutritionally assessed using the Chang’s method, which is the most used in hospital environment, in handmade mode and by applying e-Nutrimet.

Paired Wilcoxon Signed-Rank test had a p value of 0.000, indicating a strong statistically significant difference between the 2 methods.

In the figure 7, different times needed to perform nutritional assessment are shown by the Chang’s method, using e-Nutrimet application and by the handmade method in the 30 patients.

The figure 8 shows the same data in which 2 regions are shown clearly separated between them. The X axis represents the time needed to perform nutritional assessment by the Chang’s method using e-Nutrimet application, and the Y axis represents the time needed to perform nutritional assessment by the handmade method. Four distinct groups are observed, two directly and two inversely proportional.

The correlation between these data, using the Pearson statistic, had a p-value of 0.731.

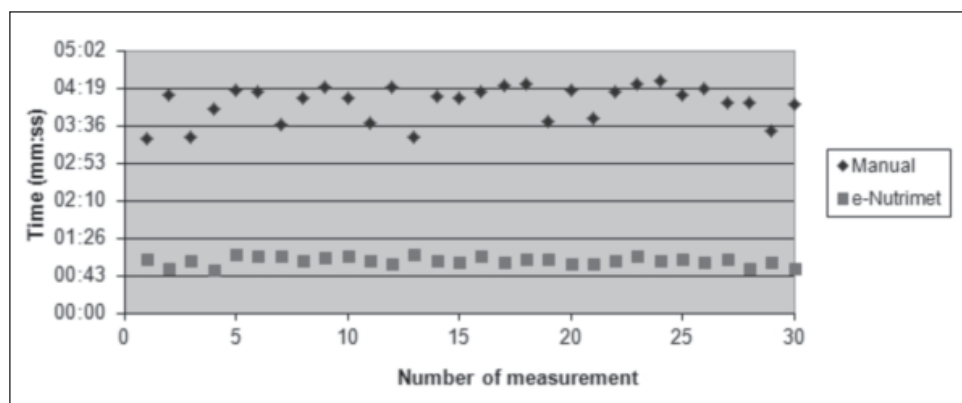


Fig. 7.—eNutrimet® and classic method time values needed to perform nutritional assessment. eNutrimet® and classic method time values needed to perform nutritional assessment.

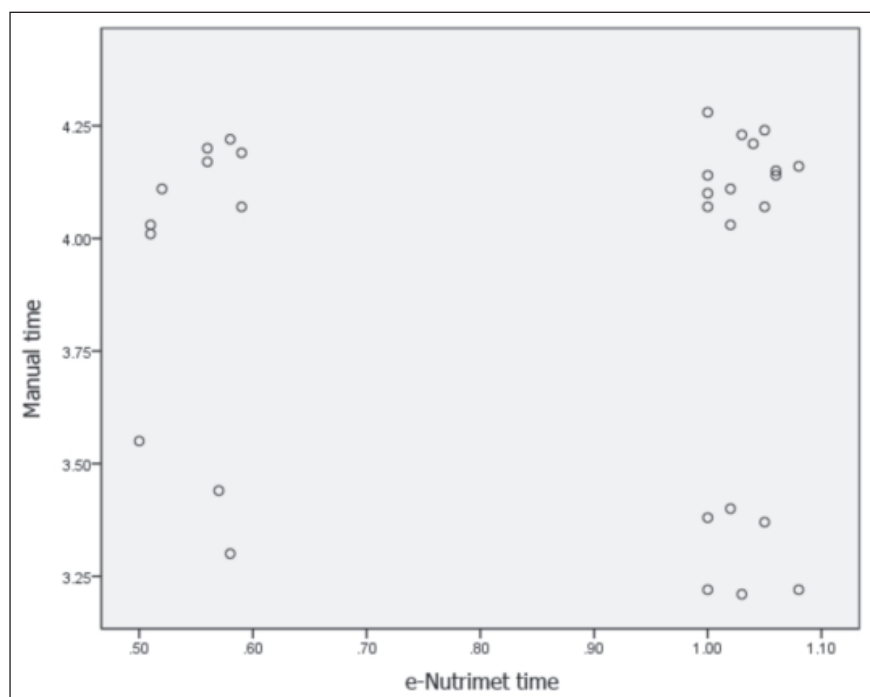


Fig. 8.—Graphic comparing nutritional assessment time values using both methods.

Conclusions

We have already spoken of the great importance of mobile devices like smartphones and tablets in health care daily work. The use of mobile devices does not replace the work of the clinician, but they are a great help to save time in the assessment of patients. Furthermore, these devices reduce possible errors when measuring a patient in comparison with handmade calculations. Another advantage of using a mobile device is derived of having in the palm of the hand an important assessment tool, not being necessary the use of a personal computer, which in many cases is not immediately available.

In the design and making of e-Nutrimet® software for nutritional assessment, implemented on smartphones and tablets, we have achieved a level of absolute concordance, with top reliability for nutrition evaluation. In this sense, the clinician will have more time for interpretation of results and performing other health care tasks, reducing the assessment time of patients in the medical office.

Further studies are necessary to determine if e-Nutrimet® application might to save health system resources, establishing it as a new standard assessment tool in the future.

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