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Development of mobile application to identify fall risk in the elderly

Desenvolvimento de um aplicativo para identificação do risco de quedas em idosos

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RESUMO | INTRODUÇÃO: A queda pode ocorrer em qualquer fase da vida do indivíduo, porém é mais frequente em idosos, representando um alto impacto social e econômico ao país e ao mundo. Hoje, o sistema de saúde pública incentiva amplamente os estudos científicos que perpassam pela compreensão das causas do cair do idoso, para que a prevenção efetiva deste episódio seja alcançada, diminuindo a demanda e os custos na saúde. **OBJETIVO:** Desenvolver uma ferramenta eletrônica web mobile que auxilie os profissionais de saúde na avaliação do risco de quedas do idoso a partir de instrumentos adaptados para o português do Brasil, validados para a população idosa e com amplo uso na literatura. **MÉTODO:** Trata-se de um projeto de desenvolvimento de um protótipo usando a plataforma Android e a linguagem JAVA. **RESULTADOS:** Após análise dos critérios estabelecidos no estudo os instrumentos selecionados para o desenvolvimento do software foram o Índice Dinâmico da Marcha (Dynamic Gait Index-DGI), a Escala de Equilíbrio de Berg (Berg Balance Scale), o Levantar e Caminhar Cronometrado (Timed up and go-TUG) e o Índice de Equilíbrio de Tinetti (Performance Oriented Mobility Assessment-POMA). Os testes realizados após a finalização do software, apresentaram uma compatibilidade 100% com o referencial escolhido. **CONCLUSÃO:** O aplicativo desenvolvido durante o processo, apresentou-se versátil, rápido, possuindo os principais instrumentos validados na literatura brasileira, para identificar o risco de quedas em idosos, de fácil operação, gerando uma tendência positiva a aderência do profissional de saúde na sua utilização.

PALAVRAS-CHAVE: Informática em saúde. Sistemas de apoio a decisão. Acidentes por quedas. Idosos.

ABSTRACT | INTRODUCTION: A fall can occur at any stage of one's life; however, it is more common in the elderly. The effects of falls are serious, in social and economic terms, in the country and worldwide. Today, the public health system extensively encourages scientific studies that help prevent these accidents effectively, reducing the demand for health services and its associated costs. **OBJECTIVE:** To develop an electronic mobile web tool (app) that helps health professionals to assess risk factors related to falls among elderly people, utilising validated instruments designed for this age group that are widely used in the literature and adapted to Brazilian Portuguese. **METHOD:** This is a project regarding the development of a prototype for use on the Android platform, programmed in JAVA. **RESULTS:** After analysing the criteria set out in the study, the selected tools for software development were the Dynamic Gait Index-DGI, the Berg Balance Scale, the Timed Up and Go (TUG) test and the Tinetti Balance test (Performance Oriented Mobility Assessment-POMA). The tests conducted after the software development phase showed the predetermined requirements were met 100%. **CONCLUSION:** The app that was developed during the process proved to be versatile, fast, includes the main instruments that are validated in the Brazilian literature, identifies the risk of falls in the elderly, is easy to use, which all are positive incentives for health professionals to use the device.

KEYWORDS: Health informatics. Decision support systems. Fall accidents. Elderly.

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Introduction

Brazil´s changing demographics is increasing the demand for medical services, and increasing investments in the search for ways to improve the functional capacity of the elderly, thus, directly affecting its quality of life.[1] Studies reveal that falls are the leading cause of restriction of mobility and social isolation suffered by this age group, whose health problems could contribute to death.[1-4] Data of the Ministry of Health indicate that falls in the elderly over 65 are the leading cause of mortality, being one of the country´s major public health and clinical problems.[5,6]

The World Health Organization (WHO) recommends the implementation of objective measures, tests, and standardized scales, in order to avoid subjectivity when evaluating human function and dysfunction.[4,6,7] Scales for systematic measurement that are adequately defined contribute to prevention and a more suitable treatment for elderly.[1,2] There are, in the literature, 04 scales and tests widely used and validated for the Portuguese language, directed to assess the risk of falls in the elderly and thus can be regarded as appropriate measurement techniques to prevent its occurrence.[8-11] These are The Dynamic Gait Index-DGI, the Berg Balance Scale, the Timed Up and Go (TUG) test and the Tinetti Balance test (Performance Oriented Mobility Assessment-POMA).[8,9,11]

In the current reality of elderly care services, these scales are applied to the patient whereby results and notes are listed on printed paper test forms, obtaining a certain score leading to a classification: high, medium or low risk of falls. This information is then filed in patient records or stratified for future research purposes. In this context, when considering the assessment of the risk of falls in the elderly as an important means to establish ways to prevent these falls and thereby saving costs and keeping the quality of life of elderly up, it is important to develop and implement strategies to make the evaluation of health professionals in clinical practice more efficient.[2,9]

Considering all this, the proposal came to develop an app for mobile devices that will be able to assist health professionals in assessing the risk of falls in the elderly. The development of this app will not only support the assessment of the fall risk, it will also enable management to consult and evaluate patient´s medical records, supporting the development of health projects aimed at preventing falls in the elderly more quickly and effectively.

Method

In order to develop the software, the incremental model of software development was chosen. This is a model with multiple development cycles, following the PRAXIS protocol that divided the process into 04 phases; (1) Concept; (2) Development; (3) Construction and (4) Transition. The incremental model is a methodology with a shorter feedback cycle, allowing smaller portions of the software to be created each time. If errors are found in the system, they can be corrected before proceeding to a new project step.[12] The platform used for the development of the prototype was the Android platform, the programming language was JAVA.

The concept phase includes the steps of identifying the needs and survey of functional and non-functional requirements. The criteria were classified into functional ones connected to the system's functionality and have been described in detail, without the worry of how the system would be built; and the non-functional criteria were directly associated to global software qualities such as ease of maintenance, safety, ease of use and accessibility, and performance. They will be presented in the chapter 'Results'.[12] This phase occurred through observational survey during the sessions and evaluations of elderly patients by health professionals in the period January to December 2013 in an outpatient clinic and two general hospitals in Salvador, Bahia. At the outpatient clinic, elderly patients were treated in the areas of orthopedics, neurology and pulmonology. In the hospital, the ward of choice was the general practice because of its high bed turnover rate. The observations were made during the evaluation of patients, twice a week.

The development phase consisted of two steps: literature research and the choice of a theoretical framework for the construction of an algorithm and decision tree evaluation. A literature review was performed using the databases of the Latin American and Caribbean information on Health Sciences (LILACS) and the Scientific Electronic Library Online (SciELO), via Pubmed and the virtual library CAPES journals, Google and theses in this field. Original articles were included, published from January 2000 to December 2015. Eligible were all the articles that referred to clinical instruments which evaluated the balance disorders in the elderly and that were validated for Brazilian Portuguese. As exclusion criteria, we eliminated those studies that applied instruments to the elderly with specific diseases.

For the choice of the theoretical framework to be used in the software implementation, the following criteria were considered: (a) instruments to assess the risk of falls in the elderly that were translated and validated for the Brazilian Portuguese language; (b) instruments that were disclosed and used in scientific clinical context and the public domain; (c) instruments possessing psychometric characteristics of easy handling, easy understanding and reduced runtime.

The algorithm was based on information from the theoretical framework, according to the choice of the scale or test. In order to build the decision tree of the evaluation, the following steps were taken: (a) definition of input data: assessing fall risk; (B) definition of output data: classification of fall risk; (c) definition of processing: the procedure consisting of the evaluation of input data, the classification of fall risk and forwarding by e-mail (d); definition of variables necessary to establish the fall risk: scale choice, answering questions, final result.

For system programming purposes, a description in pseudo-code was used, in JAVA class, for the implementation of the algorithm and treatment decision tree. During the software testing process, the usability was verified, as well as the performance and its compatibility with the chosen theoretical framework.

Results

During the observation, on site, the following functional requirements for the app have been identified; a patient registration display interface; to edit patient information; to list the registered patients; to view the patient's chart; to allow configuration of e-mail destination; to provide a screen to choose the scales of assessment to identify the risk of patient falls.

Non-functional requirements are related to the use of the application in terms of performance, usability, reliability, security, availability, maintainability and technologies involved. The software was developed for version 2.3 of Android devices or higher. All information of patients and their ratings are saved and displayed on the device in which it was registered. No data was stored on servers.

From the search in the established database, using the selected descriptors, the following instruments to predict the risk of falls in elderly people were returned: the Fall risk score Dowton, Falls Efficacy Scale (FES-I), the Barthel Index, Functional reach Test-FRT, the Morse fall scale (MFS), the Berg Balance Scale, the Tinetti Balance test (Performance Oriented Mobility Assessment-POMA), Dynamic Gait Index -DGI, and the Timed Up and Go- TUG[13-24].

Among the most commonly used clinical tests for the objective and functional assessment of balance and gait in the literature and validated for the Portuguese language, the following instruments stood out: the Dynamic Index Macha (Dynamic Gait Index-DGI), the Berg Balance Scale, the Timed Up and Go -TUG and the Tinetti Balance Index (Performance Oriented Mobility Assessment-POMA). These assessment tools were identified as the most widely used for the analysis of functional balance on a national and international level. These tests were selected for this study because of the broad applicability in a clinical and scientific context. They represent a high reliability, and because of the possession of psychometric characteristics, such as easy to use, easy to understand, rapid implementation and being in the public domain, they were meeting all criteria listed for the construction of software.[8,9,10,13,18]

The software provides the healthcare professional with an algorithm that appears on the initial screen, the system shows the user a display menu with the following options: Register/search patient or set up email. The information of the new patient is registrated by the software, the data is saved only on the source device. By registering the patient, the user will get access to a follow-up screen with a choice of where the evaluation will take place, and a menu of the evaluation tests presented by the software. The user will conduct the patient evaluation according to the selected evaluation test, and can only select one tool or all evaluation tools.

Then the questions of the scales will appear in a predefined order in the software. At the end of the evaluation, the app displays the results of the test or the scale. Each question must be answered before the next question is displayed until the evaluation is fully completed.

The software displays a screen for each question of the evaluation instruments: the Berg Balance Scale, the Tinetti Scale and the Dynamic Gait Index. In the Timed Up & Go test, a stopwatch was used to check and calculate the result automatically, as well as buttons to start, stop and reset the count, if necessary.

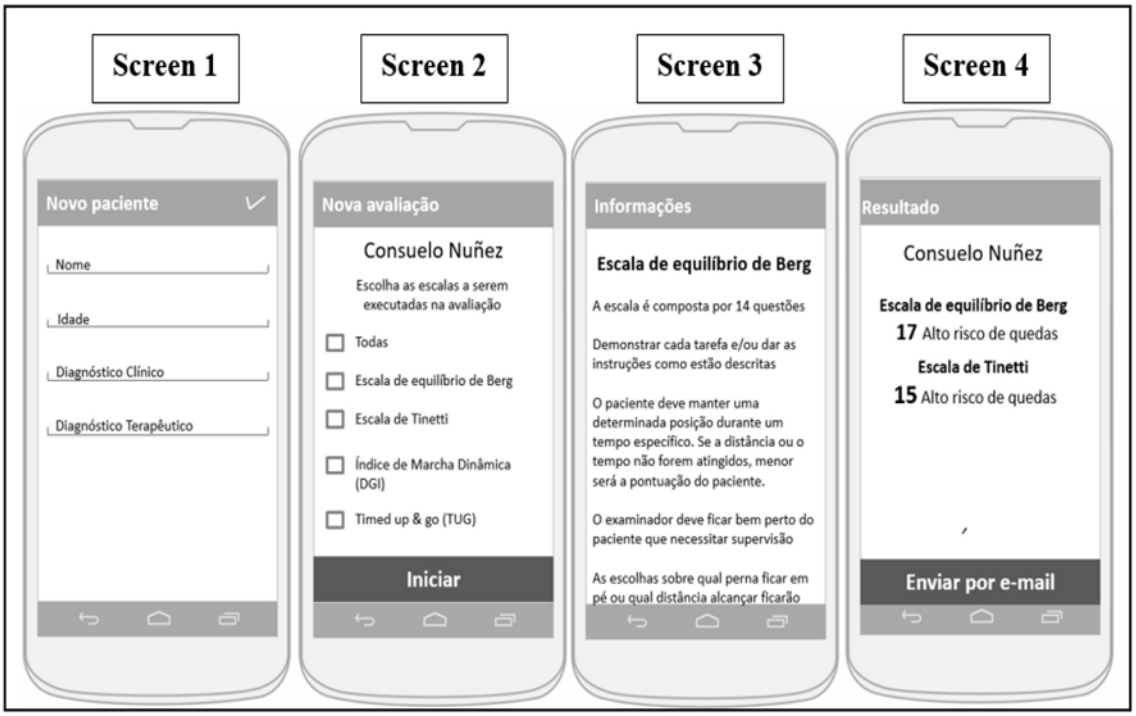
In addition to this, when a question of one of the evaluation tests appears on the screen, there is an icon (INFO) where the user can get information and guidance on how to carry out the test or evaluation.

The final screen of every test classifies the risk of falls in high, medium or low.

Each result is stratified into a fall risk category by the software, and a final report is produced which can be send via email or will be stored on the same device to be consulted later.

The user can systematically evaluate his or her patient, and after each evaluation report, results can be sent via email and added to previous test results of the patient, and be updated with respective dates, schedules and information about locations of the tests or evaluations. (Figure 01)

Figure 1. Screens of the developed app. Illustration by authors



After each incremental step of the development of the scale, the software was tested. While testing the performance and usability, the selected devices have had a good response on the execution of software.

After each incremental step of the development of the scale, the software was tested. While testing the performance and usability, the selected devices have had a good response on the execution of software. The test was not interrupted due to unavailability or instability, however, it is noteworthy that the connection was made locally and that the devices were connected to Wi-Fi during the test to send the report by email. During the compatibility tests of the theoretical framework, a review of all information on the semantic and syntactic level was performed and the compatibility with the software was verified. During the TUG test, the timer and its menu has been checked: start, stop, go back and reset.

Discussion

The creation of a tool that supports clinical decision making, which enables the management of patients known as "fallers" in the community, and that assist health professionals in the early detection and prevention of falls in the elderly population, contributes to health promotion in general and especially to family health programs, minimizing the number and costs of these unfortunate events.[1-3,5,9] Studies use these scales as a method to assess elderly in communities with a high fall risk with the aim to implement physical exercise programs. These programs help to prevent falls, because they improve balance, functional capacity, strength, coordination and pace of movements of the elderly, providing an effective and low-cost intervention.[1-3,5,9]

The information collected with this app enables agility evaluation, to organize information and most importantly provides historicity of previous evaluations of the elderly. Another benefit derived from a computerized system via mobile devices is the possibility to record information in less time and with decrease of probable errors. Immediate access to patient data during the process of the evaluation test, enables better monitoring of this population.[25]

The software was developed for mobile devices, on the Android platform, with offline use and the possibility of generating follow-up reports which can be sent via email when online. This software can track elderly people with balance problems in the community, and facilitate the implementation of prevention programs in order to avoid these unfortunate events to occur in this population. The instruments that are used to develop the software -the Dynamic Gait Index-DGI, the Berg Balance Scale, the Timed up and go-TUG test and the Tinetti Balance test (Performance Oriented Mobility Assessment-POMA)[8,9,11,13] - are validated in the literature, and used widely by many health professionals, and are easy to apply in clinical practice and research.

Because of the possibility to archiving information and to use historical data, it is possible to monitor the treatment progress of elderly with the integrated email functionality. When conducting research with the use of evaluation tests, results are stored in a safe place and are easily accessible. The technology that was chosen for the development allows access via the mobile device at any time, online or offline. The tests that were conducted after the software was ready, showed a 100% compatibility with the results. This is due to the chosen process, the systems development life cycle, an incremental model, which enabled a semantic and syntax evaluation after each addition to the instruments used for testing.

The usability and performance reached an acceptable level during the utilised tests. There was no instability or downtime during the execution of the tests.

Moreover, the system proved to be versatile, fast, having the main instruments validated to identify fall risks in elderly, is easy to use, which all are positive incentives for health professionals to use the device.

A number of apps were found to be available for Android in Spanish and English; the "Test to go" – referring to the TUG, this test however didn´t have any cut off point for the elderly; the "EZ Berg" - in English, had no fall risk stratification functionality; the "FYC ISEM tests" - in Spanish, only consisted of the Tinetti test. It is noteworthy that these verified applications don´t have validated scales and are not developed for Brazilian Portuguese. They were also lacking the

possibility to choose between four evaluation tests to assess the balance of elderly by checking their mobility in combination with the possibility to stratify fall risk in the elderly population.

Conclusion

The app that was developed during the process proved to be functional after the tests, being a viable tool for the process of the evaluation tests, for monitoring and research of fall risk in the elderly, with flexibility to expand its scope to other features such as synchronising with electronic medical records. This mobile web tool will make data available, anytime and anywhere, in a fast way and results can be stored on the device itself or in a previously registered e-mail. Thus, it is expected that the developed app will be used extensively by health professionals.

Author contributions

Nuñez Filha MCA participated in the study design and writing of the paper. Pinto EBC and Leite HJD participated in the study design, supervised the study, offered substantial critical review and approved the manuscript in its final version.

Competing interests

Pinto EBC reports a patent BR 51 2016 000963-2 licensed to BAHIANA - School of Medicine and Public Health, and a patent BR 51 2016 000963-2 licensed to Federal Institute of Education, Science and Technology of Bahia. Leite HJD reports a patent BR 51 2016 000963-2 licensed to BAHIANA - School of Medicine and Public Health, and a patent BR 51 2016 000963-2 licensed to Federal Institute of Education, Science and Technology of Bahia. Nuñez Filha MCA reports a patent BR 51 2016 000963-2 licensed to BAHIANA - School of Medicine and Public Health and a patent BR 51 2016 000963-2 licensed to Federal Institute of Education, Science and Technology of Bahia.

References

1. Gonçalves AK, Hauser E, Martins VF, Possamai VD, Griebler EM, Blessmann EJ et al. Postural balance program: variables related to falls in elderly. J Phys Educ. 2017;28:01-10. doi: 10.4025/jphyseduc.v28i1.2808

2. Fhon JRS, Rodrigues RAP, Neira WF, Huayta VMR, Robazzi MLCC. Fall and its association with the frailty syndrome in the elderly: systematic review with meta-analysis. Rev Esc Enferm USP. 2016;50(6):1005-1013. doi: 10.1590/s0080-623420160000700018

3. Vieira LS, Gomes AP, Bierhals IO, Farías-Antúnez S, Ribeiro CG, Miranda VIA et al. Falls among older adults in the South of Brazil: prevalence and determinants. Rev Saude Publica. 2018;52(22):01-13. doi: 10.11606/s1518-8787.2018052000103

4. Nakagawa HB, Ferraresi JR, Prata MG, Scheicher ME. Postural balance and functional independence of elderly people according to gender and age: cross-sectional study. São Paulo Med J. 2017;135(3):260-265. doi: 10.1590/1516-3180.2016.0325280217

5. Pereira SG, Santos CB, Doring M, Portella MR. Prevalence of household falls in long-lived adults and association with extrinsic factors. Rev Latino-Am Enfermagem. 2017;25:e2900. doi: 10.1590/1518-8345.1646.2900

6. Brasil. Ministério da Saúde. Portaria GM n. 2.528, de 19 de outubro de 2006. Institui a Política Nacional de Saúde da Pessoa Idosa, a ser implantada em todas as redes Estaduais de Assistência à Saúde do Idoso. Brasília: Ministério da Saúde; 2006.

7. World Health Organization. Envelhecimento ativo: uma política de saúde. Brasília: Organização Pan-Americana da Saúde; 2005.

8. Melzer I, Kurz I, Oddsson LIE. A retrospective analysis of balance control parameters in elderly fallers and non-fallers. Clinical Biomechanics. 2010;25(10):984-988. doi: 10.1016/j.clinbiomech.2010.07.007

9. Tinetti ME. Performance-oriented assessment of mobility problems in elderly patients. J Am Geriatr Soc. 1986;34(2):119-126.

10. Miyamoto ST, Lombardi Junior I, Berg KO, Ramos LR, Natouri J. Brazilian version of the Berg balance scale. Braz J Med Biol Res. 2004;37(9):1411-1421. doi: 10.1590/S0100-879X2004000900017

11. Gomes GS. Tradução, adaptação transcultural e exame das propriedades de medida da escala "Performance-Orientes Mobility Assessment"(POMA) para uma amostra de idosos brasileiros institucionalizados [dissertação]. Campinas, SP: Universidade Estadual de Campinas; 2003.

12. Paula Filho WP. Engenharia de software: fundamentos, métodos e padrões. 3.ed. Rio de Janeiro: LTC; 2009.

13. Berg KO, Norman KE. Functional assessment of balance and gait. Clinics in Geriatrics Medicine. 1996;12(4):705-723.

14. Pua YH, Ong PH, Clark RA, Matcher DB, Lim ECW. Falls efficacy, postural balance, and risk for falls in older adults with falls-related emergency department visits. BMC Geriatrics. 2017;17:(291):1-7. doi: 10.1186/s12877-017-0682-2

15. Worms JLAM, Stins JF, Wegen EEHV, Loram ID, Beek PJ. Influence of focus of attention, reinvestment and fall history on elderly gait stability. Physiol Rep. 2017; 5(1): e13061. doi: 10.14814/phy2.13061

16. Portnoy S, Reif S, Mendelboim T, Rand D. Postural control of individuals with chronic stroke compared to healthy participants: Timed-Up-and-Go, Functional Reach Test and center of pressure movement. Eur J Phys Rehabil Med. 2017;53(5):685-693. doi: 10.23736/S1973-9087.17.04522-1

17. Alshammari AS, Alhassan AM, Aldawsari MA, Bazuhair FO, Alotaibi FK, Aldakhil AA, et al. Falls among elderly and its relation with their health problems and surrounding environmental factors in Riyadh. J Family Community Med. 2018; 25(1):29-34. doi: 10.4103/jfcm.JFCM_48_17

18. Castro SM, Perracini MR, Ganança FF. Versão brasileira do Dynamic Gait Index. Rev Bras Otorrinolaringol. 2006;72(6):817-825. doi: 10.1590/S0034-72992006000600014

19. Yardley L, Beyer N, Hauer K, Kempen G, Piot-Ziegler C, Todd C. Development and initial validation of the falls efficacy scale-international (FES-I). Age and Ageing. 2005;34(6):614-619.

20. Camargos FFO, Dias RC, Dias JMD, Freire MTF. Adaptação transcultural e avaliação das propriedades psicométricas da Falls Efficacy Scale: International em idosos brasileiros (FES-I-BRASIL). Rev Bras Fisioter, São Carlos. 2010; 14(3): 237-243. doi: 10.1590/S1413-35552010000300010

21. Minosso JSM, Amendola F, Alvarenga MRM, Oliveira MAC. Validação, no Brasil, do Índice de Barthel em idosos atendidos em ambulatórios. Acta Paulista Enferm. 2010;23(2):218-223. doi: 10.1590/S0103-21002010000200011

22. Duncan PW, Weiner DK, Chandler J, Studenski S. Functional reach: a new clinical measure of balance. J Gerontol. 1990;45(6):192-197.

23. Berg KO, Wood-Dauphinee SL, Williams JI, Maki B. Measuring balance in the elderly: validation of an instrument. Can J Public Health. 1992;83(supl 2):07-11.

24. Urbanetto JS, Creutzberg M, Franz F, Ojeda BS, Gustavo AS, Bittencourt HR, et.al. Morse Fall Scale: tradução e adaptação transcultural para a língua portuguesa. Rev Esc Enferm. 2013;47(3):569-575. doi: 10.1590/S0080-623420130000300007

25. Lee K, Kwon H, Lee B, Lee G, Lee JH, Park YR, et al. Effect of self-monitoring on long-term patient engagement with mobile health applications. PLoS ONE. 2018;13(7): e0201166. doi: 10.1371/journal.pone.0201166