

Research Article

New Mobile Application for Categorization of Vertigo in the New Millennium

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Abstract

Introduction: Vertigo is defined as the distortion in the sensation of self-movement when a normal movement of the head is made, for its study the TiTrATE approach is recommended for the general practitioner, which determines the moment of onset, duration, evolution and triggers of vertigo for its study and categorization accurately. **Objective:** to create a progressive web application (PWA) called TiTrATEapp, **Method:** Prospective, observational, longitudinal study. **Result:** creation of a progressive web application (PWA) called TiTrATEapp, based on the TiTrATE algorithm, comparing the calculation time of the application of the algorithm manually and digitally, resulting in the digital application being faster and more efficient. **Discussion:** Vertigo is a difficult symptom to decipher in the emergency room, due to the subjective description of patients and the wide variety of probable causes, the digitization of TiTrATE allows to rule out potentially dangerous causes, quickly, accurately. At present there are no studies that measure the effectiveness of mobile applications for the study of vertigo. **Conclusion:** Mobile applications are an objective tool that helps health professionals diagnose and make clinical decisions in a practical way based on scientific evidence, the digitalization of TiTrATE allows resident doctors to make an accurate diagnosis quickly and guide the patient's referral to the correct specialty and resource efficiency.

Keywords

Vertigo, Progressive Web Application, Digitization, TiTrATE

1. Introduction

Mobile applications are defined as programs that are downloaded from the Web, installed, through the use of the internet, on phones, computers, tablets and MP3 players. In recent years, there has been a constant development in the use of information and communication technologies, especially in the use of mobile devices for access to web and mobile applications, whether they are related to e-commerce, entertainment, productivity and health-related issues, over the years, as a result of technological advances, progressive mobile applications (PWA) have emerged, which differ in

that application stores such as Google Play or App Store are not necessary, because they run in the device's browser, without the use of internet. [1, 2].

Progressive Web Applications from the English Progressive Web Application (PWA) are web applications that, in the user's view, function like native applications. The main characteristics of the PWA are: ability to access content without internet (offline), sending push notifications, which are direct and instant messages, free, personalized and unlimited from the application directed to the device, as well as

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it can be added to the desktop like any other application [3].

Currently, there is no mobile application that allows medical personnel to have a standardized algorithm in real time, and to solve these problems, the TiTraTe (Timing-Triggers-Targeted-Examination) approach, created by David E. Newman-Toker, was proposed. The first point in approaching these patients is to establish whether the reason for the consultation really corresponds to a vertigo [4, 5].

Van Bonn et al (2022) The goal of this study, was to develop a smartphone-based app that can diagnose and qualify nystagmus, their work published by Smartphone-based: nystagmus diagnostics: development of an innovative app for the targeted detection of vertigo, developed an application that performs the differentiation between central and peripheral vertigo, as well as the evaluation of nystagmus characteristics in order to make a rapid differential diagnosis during the initial physical examination [6].

Vertigo presents a series of difficulties at the time of its evaluation, this causes overuse of resources, diagnostic errors and loss of windows of opportunity in the face of dangerous pathologies. Vertigo is defined as the perception of distorted self-motion, when a normal head movement is performed, most patients tend to confuse it with dizziness, syncope or presyncope, the estimated prevalence of vertigo in the general population is 3-7%, but if the feeling of instability is added, it increases to the point of 17-30% [7, 8].

Patients fall into 1 of 4 major syndrome categories, each with its own differential diagnosis and set of targeted examination techniques that help make a specific diagnosis. Because, in most cases, the causes of vertigo are very varied, and it is rare to find a single etiology, algorithms have been created in order to group the most probable causes, as well as to differentiate the serious from the benign, of vestibular or central origin, using the least amount of resources possible (7, 8), such as the TiTraTE algorithm, supported by the international committee that groups specialists dedicated to vestibular research. [5, 9]

The acronym TiTraTE means: Triage: signs and symptoms compatible with life-threatening diseases are evaluated, when there is alteration of the neurological evaluation and vital signs, vertigo as a symptom takes a back seat and all attention should be directed to finding the cause of the serious pathology.

Timing: is the moment of onset of symptoms, it can be acute, episodic, chronic;

Triggers: it is about finding the pathophysiological mechanism that triggers vertigo, for example: positional changes, or exposure to trauma or toxins;

Targeted Examination: benign causes should be differentiated from dangerous causes, using vestibular tests and directed examination of eye movement;

Testing: involves laboratory tests or imaging studies that have to be performed if after all the algorithm there are diagnostic doubts. [5]

Vertigo can be categorized into 2 main vestibular syn-

dromes: 1-Episodic Vestibular Syndrome (EVS): involves intermittent vertigo with a duration of seconds, minutes or hours, can be multiple spaced episodes, based on its characteristics it can be divided into: triggered episodic vestibular syndrome (t-EVS) and acute episodic vestibular syndrome (s-EVS).

2- Acute Vestibular Syndrome (AVS): is the set of signs and symptoms that involve acute and persistent vertigo with a duration of days or weeks that in some cases can leave persistent sequelae from the moment of its appearance.

Depending on the type of exposure, they are classified as: Traumatic/toxic acute vestibular syndrome (t-ASV) and Spontaneous acute vestibular syndrome (s-ASV). [9]

The objective of the research was the development of a prototype of a progressive mobile application that achieves the digitization of the TiTraTE algorithm and apply it in patients of the otorhinolaryngology service of the Hospital Universitario de Caracas from the month of February 2023. The specific objectives are: create a web application prototype with the TiTraTE algorithm and apply it in patients with vertigo who attend the emergency consultation, calculate the TiTraTE manually in patients with vertigo who attend the emergency consultation and determine the effectiveness measured in time of the digital TiTraTE calculation with the mobile application prototype compared to the manual calculation of the TiTraTE.

2. Methods

The research is prospective, experimental, observational, comparative analysis; in the Otorhinolaryngology Service of the Hospital Universitario de Caracas.

Population and sample: data were collected from the evaluation of patients examined in the emergency room of the Otorhinolaryngology service in the month of February 2023. All the information obtained is kept in absolute confidentiality out of respect for the patient and in accordance with the bioethical principles of research in humans.

The project was approved by the institutional ethics committee.

Inclusion criteria:

- a) Patients with vertigo, nystagmus or sensation of instability, who attended the emergency room of the Hospital Universitario de Caracas, in the period of time indicated above.
- b) Patients with vertigo, referred from other hospitals, who attended the emergency room of the Hospital Universitario de Caracas.

Exclusion criteria:

- a) Patients with sequelae of neurodegenerative diseases.
- b) Patients who are under the effects of psychotropic medications that mask the clinical picture.
- c) Patients under 18 years of age.
- d) Patients with neurodevelopmental disorders.

Procedures:

Design and creation of a progressive web application prototype that uses the TiTrATE algorithm, for the categorization of patients with vertigo, the information was obtained from the data collected from the evaluation of patients with this symptom, who attended the emergency room of the Otorhinolaryngology Service of the Hospital Universitario de Caracas, during the month of February 2023. See [Table 1](#).

Table 1. Classification according to age. Otorhinolaryngology Service, University Hospital of Caracas, February 2023.

	Chronological Age
N°	Valid 30
	Missing 0
Mean	56.60
Median	60.00
Mode	60
Standard Deviation	12.730
Variance	162.041
Minimum	28
Maximum	74

In this study, data collected from the evaluation of patients with vertigo attending the emergency room were analyzed. The time of application of the manual TiTrATE algorithm was recorded with a stopwatch, and then the calculation time of the TiTrATE algorithm in digital form, with the mobile application, was established, and the results obtained were compared to verify the effectiveness of the digital tool designed. The sample collection was carried out using the TiTrATE algorithm ([Figure 1](#)). The digital algorithm in the TiTrATE app is attached. (See [Figure 2](#)).

Statistical treatment: The information was recorded in a collection instrument and the results were processed using Excel 2018 for Windows. The selected variables were exported to the SPSS-IBM version 24 statistical package, where all calculations were performed for subsequent analysis. The absolute totals of each variable, with their respective percentages, were obtained. A correlation matrix of variables was created to determine if there was any influence between the studied variables with a 95% confidence interval. The Student's t-test ($p=0.05$) was applied to compare the calculation time of the TiTrATE algorithm application manually and digitally.

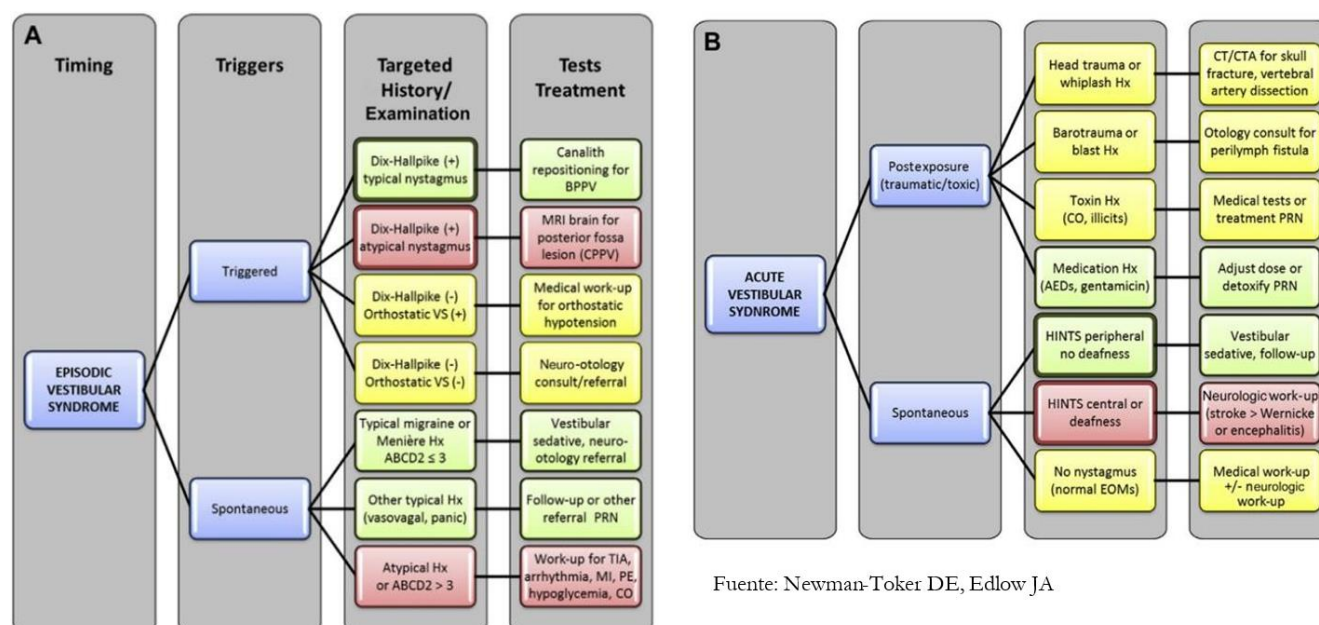


Figure 1. Algoritmo TiTrATE.

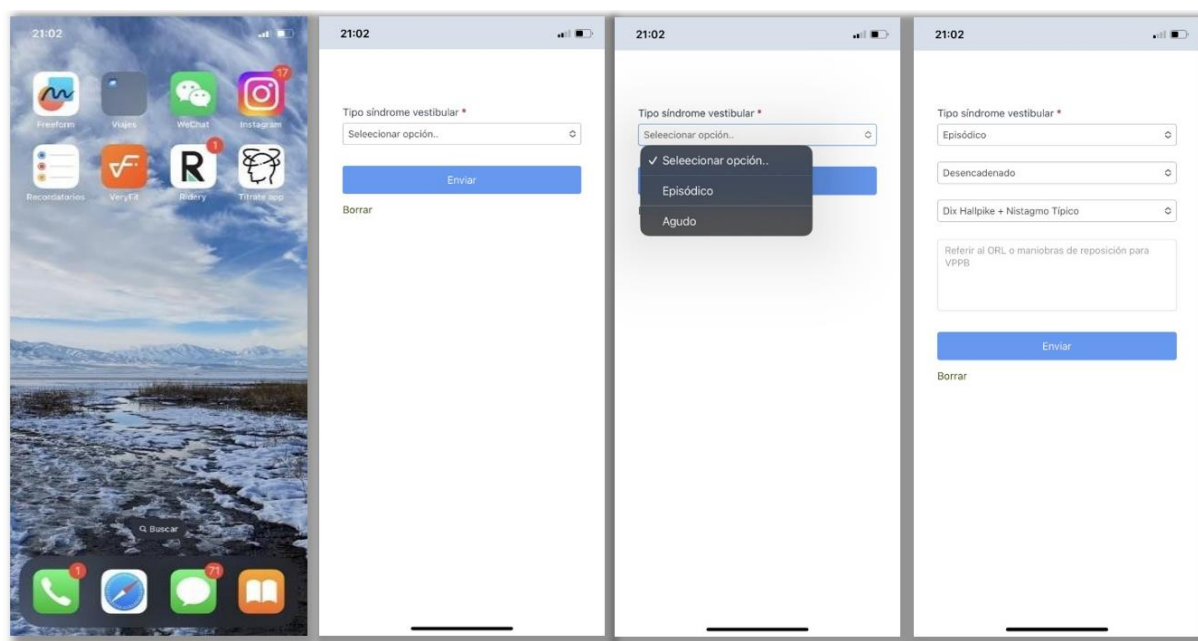


Figure 2. Mobile app. Suggestions for patient management.

Material resources: TiTrATE app mobile application, Android and iOS software smartphone, TiTrATE algorithm. The TiTrATE algorithm applied in the app is attached.

3. Results

A mobile application prototype was designed, using efficient forms that provide high response rates by employing conditional logic and form branching. The purpose of the smart forms is to simplify categorization by showing and hiding fields. They also display personalized messages based on user responses, generating alerts, and enable the user to work with data in real time.

Form completion experiences are shown to be rapid, compared to visual surveys, reducing the loss of attention and achieving fast and reliable calculations. Furthermore, with the application's exceptional condition's function, options can be hidden or shown according to the answers given to previous questions, storing data.

Table 1 represents the age variable. An average age of 56.6 years was obtained, with a mode of 60 years, where the minimum age was 28 years and the maximum age was 74 years. In **Table 2**, the sex variable was evaluated, where it is evident that in the study population of 30 people, 63.33% of them represented the male sex (19) and 36.67% of the people, the female sex (11).

In **Table 3**, the time of the manual application of the TiTrATE algorithm was graphed. An average of 87.37 seconds (approximately 1.7 minutes) was obtained, which is the same time it takes to perform the calculation manually. A median of 90 was calculated; the value or time that repeats the most with the manual application of the TiTrATE algorithm is 60 seconds (approximately 1 minute). It presents a standard deviation

of 23.49, with a variance of 551.826. The minimum value was 60 seconds, and the maximum value was 120 seconds.

Table 2. Classification according to sex. Otorhinolaryngology Service, University Hospital of Caracas, February 2023.

	Male	Female
Valid N °	19	11
Percentage (%)	63.33	36.67

Table 3. Calculation time for the manual application of the TiTrATE algorithm. Otorhinolaryngology Service, University Hospital of Caracas, February 2023.

Statistic	Value
N °Valid	30
Missing	0
Mean	87.37
Median	90.00
Mode	60
Standard Deviation	23.491
Variance	551.826
Minimum	60
Maximum	120

In Table 4, an average of 3.71 seconds is shown, which is the time it usually takes to perform the calculation with the digital TiTrATE algorithm application using the TiTrATE app, with a median of 3.60. The value or time that repeated the most, calculated by using the application, is 4 seconds. It presents a standard deviation of 0.660. A variance of 0.436 is obtained. The minimum value was 3 seconds, and the maximum value was 5 seconds.

Table 4. Calculation time of digital application of the TiTrATE algorithm, with the mobile app. Otorhinolaryngology Service, University Hospital of Caracas, February 2023.

Statistic	Value
N °Valid	30
Missing	0
Mean	3.71

Statistic	Value
Median	3.60
Mode	4
Standard Deviation	660
Variance	436
Minimum	3
Maximum	5

If the average or mean of both evaluated variables is observed, it can be determined that they have a very significant difference. Therefore, the application is optimal and reliable if it is desired to reduce time. See Table 2. To verify that the application is indeed an optimal variable through other statistical methods, see Table 5.

Table 5. Difference of means of the time calculated manually and using the mobile application of the TiTrATE algorithm. Otorhinolaryngology Service, Hospital Universitario de Caracas, February 2023.

Statistic	t	df	Sig. (Two-tailed)	Mean Difference	95% Confidence Interval of the Difference - Lower	95% Confidence Interval of the Difference - Upper
Tiempo calculado de forma manual (Manually Calculated Time)	20.731	29	0	87.367	78.59	96.14
Tiempo calculado de forma digital utilizando la aplicación móvil (Time Calculated Digitally Using the Mobile Application)	30.771	29	0	3.7100	3.463	3.957

In this sample of 30 patients, we assume that it is distributed as a normal distribution, and when performing the test, it uses the T-Student with such value and degrees of freedom for each variable. A difference of means was performed, and with the application of a 95% confidence interval. It is observed that the difference of means is very significant, and this causes the confidence intervals not to intersect, due to the large difference between them; therefore, they are never related. This yields an easy decision to make since the one with the shortest time or lowest mean is usually chosen.

4. Discussion

Dizziness was traditionally classified into four categories based on the patient's description: vertigo, presyncope, disequilibrium, and light-headedness. However, current approaches do not include presyncope and do not use the vague term

light-headedness. Patients have difficulty describing the quality of their symptoms but can more consistently identify the timing and triggers. Symptom quality does not reliably predict the cause of dizziness. Physicians are cautioned against overreliance on a descriptive approach to guide the diagnostic evaluation. Alternatively, attention to the timing and triggers of dizziness is preferred over the symptom type because patients more consistently report this information. [13]

Many types vestibular pathologies result in symptoms that can occur when the head is kept still (static deficits) or when the head is moving (dynamic deficits) [15].

Artificial intelligence has a long history, full of innovations that have resulted in different resources high-performance diagnostics, which are currently available. The field of Otorhinolaryngology is in constant growth and development; the rise in the use of artificial intelligence, robotic surgery, and the development of applications for patient management aim

to optimize patient diagnosis time, management, and the rational use of resources [10]. When a patient is suspected of having vertigo, cardiovascular psychiatric, metabolic, neurological, and medication-related causes are frequently overlooked; therefore, it is affirmed that there is an approximate 81% diagnostic error when a patient presents with vertigo, avoiding the possibility of diagnosing potentially fatal pathologies in 15% of cases (2). Because vertigo is a common symptom reported by patients and mostly confused with other symptoms such as dizziness, sensation of instability, syncope, presyncope, an algorithm called TiTrATE was developed, whose main objective is to categorize vertigo depending on its origin in central and peripheral depending on the moment of onset, triggers, duration of vertigo, and associated symptoms [5, 9].

The set of symptoms related to disorders of the balance system are common in the general population. However, there are few studies that quantify the frequency of onset of the various vestibular disorders that are present in specialized otoneurology units. In the new millennium, the use of websites and web applications is the trend, because they allow rapid communication with the user, generating information of any interest, in different areas: educational, recreational, and in the workplace [11]. In this study, a mobile application prototype was created that digitized the TiTrATE algorithm for use by resident doctors of otorhinolaryngology at the Hospital Universitario de Caracas, to categorize vertigo quickly, effectively, and in real-time, reducing the disproportionate indication of imaging studies for patients, the use of resources, and the accurate referral to services such as internal medicine, cardiology, neurology, and neurosurgery.

Kim, B. J. et al. applied ML algorithms on simple clinical information such as demographics and medical histories, obtained at early stages or emergency centers, can perform a differential diagnosis for vertigo disorders. Such algorithms, once optimized, could assist non-expert physicians treating vertigo in the frontline. The app should enable differentiation between acute emergencies such as strokes ("central vertigo") and vestibular disorders ("peripheral vertigo") using and recognizing or analyzing the accompanying symptom "nystagmus". [14], that can be demonstrated in our work.

A total of 30 patients were evaluated, with an average age of 56.6 years, a mode of 60 years, having a minimum age of 28 years and a maximum age of 74 years, similar to the result obtained in the study "Epidemiology of vestibular disorders in the otoneurology clinic" by the Spanish Otorhinolaryngological Act, where the average age was 53 ± 17 years. [11]

The predominant sex that attended the emergency consultation whose reason for consultation was vertigo, was the male sex in 63.3%, different from the study mentioned above by the Spanish Otorhinolaryngological Act, where the most frequent sex of patients with vertigo was female [9]. In another study by E. C Martin and cols refer the most patients was female, like this and A variety of neuro-otological symptoms and different disease profiles were demonstrated

between patients and subgroups of patients with different vestibular disorders [12].

The measurement of the calculation time of the TiTrATE algorithm was carried out manually, obtaining an average of 1.7 minutes compared to the time obtained using the TiTrATE app based on the digitized TiTrATE algorithm, where the final average time was 3.71 seconds, thus determining that there is a statistically significant difference with a 95% confidence interval. It is important to highlight that there is no current bibliography where a mobile application of the TiTrATE algorithm is developed, nor literature where the calculation time of the algorithm application is compared manually and digitally.

Taking into account the results achieved, it can be affirmed that the application is optimal and reliable if it is desired to reduce the diagnosis time.

5. Conclusions

The creation of an innovative, efficient mobile application prototype based on a progressive web application, called TiTrATE app, was achieved, where the TiTrATE algorithm was digitized to categorize vertigo in patients with that reason for consultation, who attended the emergency room of the Otorhinolaryngology service of the Hospital Universitario de Caracas. When comparing the calculation time of the application of the TiTrATE algorithm manually and the calculation of the application of the digitized TiTrATE algorithm using the TiTrATE app, it was concluded that the mobile application is faster and more effective with a statistically significant difference. Achieving in this way the categorization of the patient with vertigo, accurately and quickly.

The mobile application makes variations in the online forms according to the actions of the browser or user, obtaining dynamic personalization depending on the responses of the users, it does not require advanced or specific technical knowledge to use it. Finally, mobile applications are an objective tool that gives resident doctors of otorhinolaryngology the opportunity to diagnose and make clinical decisions in a practical way and gives them confidence to refer the patient to the correct specialty, and to indicate the studies that are necessary.

Abbreviations

TiTrATE Triage, Timing, Triggers, Targeted Examination, Testing

Conflicts of Interest

There are no conflicts of interest.

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