Test battery to assess physical fitness in university students with visual impairment

Batería de pruebas para evaluar la condición física en estudiantes universitarios con discapacidad visual

http://doi.org/10.17981/cultedusoc.15.1.2024.4693

Received: December 26, 2022. Accepted: July 24, 2023. Published: May 31, 2024.

Eduardo Elles-Cuadro
Universidad del Atlántico. Barranquilla (Colombia)
eelles@mail.uniatlantico.edu.co

Odelaidis-Vaneza Marimon-Mendoza
Universidad del Atlántico. Barranquilla (Colombia)
ovmarimon@mail.uniatlantico.edu.co

Lina-Johanna Álvarez-Toro
Universidad del Atlántico. Barranquilla (Colombia)
linaalvarez@mail.uniatlantico.edu.co

Fabián-Andrés Contreras-Jáuregui
Universidad del Atlántico. Barranquilla (Colombia)
fabiancontreras@mail.uniatlantico.edu.co

To cite this article:
Elles-Cudaro, E., Marimon-Mendoza, O.-V., Álvarez-Toro, L.-J. & Contreras-Jáuregui, F.-A. (2024). Test battery to assess physical fitness in university students with visual impairment. *Cultura, Educación y Sociedad*, 15(1), e03394693. DOI: http://dx.doi.org/10.17981/cultedusoc.15.1.2024.4693

Abstract

Introduction: Certain adjustments must be made to physical tests for groups with particular characteristics. **Objective:** To propose a battery of tests designed and validated to evaluate physical fitness in university students with visual impairment. **Methodology:** Mixed approach, triangulation-concurrent design. The participants were six experts, using the double-blind method, and 12 students. A literature review was carried out by means of a selection of abstracts, and expert opinions were received by means of a checklist and a SWOT matrix. **Results:** Twelve field tests were adapted with the aim of evaluating certain manifestations of conditional physical capacities. The battery obtained scores of 90.2% in the objectivity index, 89% in reliability, 85.5% in validity and 89.7% in protocol-adaptation. The experts considered that the tests were adequately structured and designed according to the objectives of each test and the battery, and that the tests selected were practical and consistent with the characteristics of the target population. They suggested explaining better the protocol-adaptation component, especially for the speed and endurance tests. A pilot application of the battery was carried out. **Conclusion:** Positive and close quantitative indexes were obtained for all the battery assessment criteria, and the experts' rating was homogeneous in most cases. The experts highlighted several positive aspects of the initial design of the battery; based on their suggestions, certain protocol-adaptation adjustments were made to improve the final design. The piloting allowed establishing specifications to regulate the participation of a sighted guide to guide visually-impaired students in the speed and endurance tests.

Keywords: Instrument validation; test battery; physical fitness; visual impairment; university students; expert opinion

Resumen

Introducción: Existen grupos con características particulares que requieren adaptaciones para la aplicación de pruebas físicas. **Objetivo:** Proponer una batería de pruebas diseñada y validada para evaluar la condición física en estudiantes universitarios con discapacidad visual. **Metodología**: Enfoque mixto, diseño de triangulación-concurrente. Participaron 6 expertos, con método doble ciego, y 12 estudiantes. Se realizó revisión documental mediante un fichero de síntesis, y juicio de expertos mediante una lista de cotejo y una matriz FODA. **Resultados:** Se adaptaron 12 pruebas de campo, orientadas a evaluar algunas manifestaciones de las capacidades físicas condicionales. La batería obtuvo 90.2% en el índice de objetividad, 89% en confiabilidad, 85.5% en validez y 89.7% en protocolo-adaptación. Los expertos consideraron adecuada estructuración y concepción de acuerdo al objetivo de cada prueba y la batería; practicidad y coherencia entre las pruebas seleccionadas y las características de la población objeto; sugirieron explicar mejor el componente de protocolo-adaptación, especialmente en las pruebas de velocidad y resistencia. Se realizó un pilotaje de aplicación de la batería. **Conclusiones:** Se presentaron índices cuantitativos positivos y próximos en todos los criterios para evaluar la batería, la calificación de los expertos fue homogénea en la mayoría de los casos. Los expertos expresaron varios aspectos positivos del diseño inicial de la batería; atendiendo sus sugerencias debieron realizarse algunos ajustes de protocolo-adaptación que permitieron mejorar el diseño final. El pilotaje permitió establecer especificaciones para regular la participación de un guía vidente que oriente a los estudiantes con ceguera en las pruebas de velocidad y resistencia.

Palabras clave: Validación de instrumento; batería de pruebas; condición física; discapacidad visual; estudiantes universitarios; juicio de expertos

Introduction

A physical fitness assessment is an important diagnostic process for all people, from a functional, health and pedagogical perspective, particularly in the area of Physical Education. However, the physical fitness tests must be adapted to population groups with particular characteristics. A physical fitness assessment helps determine whether bodily functions are in good condition, and is an indicator that is directly associated with health conditions (Blanco-Luengo et al., 2020). Similarly, "when the intention is to lead people towards a healthy level of physical fitness, it is necessary to perform an assessment" (Farinola et al., 2020, p. 3). In a university context, this procedure enables addressing the health possibilities and requirements for student training (Contreras and Elles, 2022).

Universidad del Atlántico is a government higher education institution located in the Caribbean Region in northern Colombia. Its student population includes 34 students with visual impairment as of April 2022, of whom 18 participated in a diagnostic survey (volunteers). It was found that seven (7) reported that they had little or no options to engage in physical activity in their environment, and ten (10) reported that the options available are not accessible or difficult to access. Based on the International Physical Activity Questionnaire (IPAQ-short version), it was found that eleven (11) of the 18 students reported a low level of physical activity, four (4) reported a moderate level and three (3) a vigorous level. Eight (8) of them spent 240 minutes a day or more sitting (adding continuous periods of more than 10 minutes).

Twelve (12) of the 18 students accepted to have their anthropometric measurements taken in order to find Indirect Measures of Adiposity –IIA–, finding that according to the Body Mass Index –BMI–, one (1) had low weight, eight (8) had normal weight, two (2) were overweight, and one (1) was obese. In terms of the Waist-to-Hip Ratio (WHR), nine (9) were normal and three (3) were at risk of cardiovascular disease. Physical fitness practice and levels are associated with the IIA indicators, which are deemed necessary for an acceptable physical fitness level (Enríquez-Del Castillo et al., 2021): In the case of some of these students, the results are a matter of concern.

A research group at the institution intended to carry out a study based on a proposal for an intervention for healthy physical activity for these students; however, they did not have an instrument that was designed and validated specifically to assess their physical fitness. The absence of protocols and procedures to assess physical fitness adapted for people with visual impairment represents a limitation for the design and implementation of programs that adequately prescribe activities and exercises for this population (Alcaraz-Rodríguez et al., 2022; Qasim et al., 2021).

Based on a review of the institutional archives of Universidad del Atlántico, it was found that several studies have been carried out to assess the physical fitness of students, but none of them focused specifically on students with visual impairment. In view of the above, the purpose of this article is to propose a test battery designed and validated to assess the physical fitness in university students with visual impairment. To achieve this objective, a study was carried out with a mixed approach and a triangulation-concurrent design, with the participation of six (6) experts, using the double-blind method, and twelve (12) university students with visual impairment, using the techniques of literature review and expert opinion and using a selection of abstracts, a checklist and a SWOT matrix as instruments.

Literature review

Lifestyle and physical fitness

A lifestyle associated with physical activity is one of the factors that has a strong influence on a person's physical fitness. In many countries, the low levels of physical activity have become a concern for many governments, and the prevalence of sedentary lifestyles has even come to be considered a global public health issue that concerns several international organizations in the health area (Alcaraz-Rodríguez et al., 2022; Kljajevic´ et al., 2022). Specifically in connection with people with visual impairment, many studies carried out in different parts of the world agree that the level of physical activity in this population is considerably lower (Alcaraz et al., 2019; Alcaraz-Rodríguez et al., 2022; Cai et al., 2021; Haegele, Kirk et al., 2018; Inoue et al., 2018; Ong et al., 2018; Qasim et al., 2021; Salazar, 2018; Smith et al., 2019; Yessick & Haegele, 2019), and that they face barriers in this regard that are greater than those experienced by people in general (Matoso & Portela, 2020; Richardson et al., 2023), especially in terms of environmental-type barriers (Ascondo et al., 2023).

This phenomenon also occurs in the educational context, as a result of which students with visual impairment are often excluded from activities and programs that involve physical activity (Alcaraz-Rodríguez et al., 2022; Haegele & Zhu, 2017; Haegele et al., 2017; Wilhelmsen et al., 2019). The negative consequences of low levels of physical activity cause deficiencies in physical fitness in the student population. For example, "an aspect that has raised concern about the levels of physical fitness for students' health has been a progressive increase in overweight and obesity among young people over the last two decades" (Blanco-Luengo et al., 2020, p. 552). Specifically, in the university context, the non-existence of time slots allocated to rest is one of the variables that most strongly influences the acquisition of habits that are harmful for well-being (Flores et al., 2023), in addition to the academic workloads that represent a barrier for students to engage in physical exercise (Vásquez-Gómez et al., 2018).

One of the most common external negative factors that influences the performance of physical activity in the student population is the lack of time, due to the academic schedules and the obligations of social and family life (Alcaraz-Rodríguez et al., 2022).

Background of the assessment of physical fitness in people with visual impairment

Some studies were found involving the application of physical fitness tests to students (Sánchez & Gonzáles, 2020), and young adults with visual impairment (Godoy-Cumillaf et al., 2022; Gómez and Ortiz, 2014; Oliveira et al., 2020; Moreno and Cuastumal, 2016); however, none of them offers any standards for the classification of the results, but instead focus on statistical descriptions. Several authors have pointed out that there are very few studies that assess the physical fitness of people with visual impairment, and those that have been made are mainly related to nutritional, anthropometric and motricity aspects (Alarcón et al., 2021; Betancourt et al., 2020; Salazar, 2018; Sánchez & Gonzáles, 2020; Valdés et al., 2014).

For example, very little work has been done in this area to identify sports talent through physical diagnoses among students with special educational needs due to disabilities, in particular involving students with visual impairment, and there are insufficient studies related to the pedagogical skills a coach must have to select sport talents based on the use of physical diagnoses (Betancourt et al., 2020).

Salazar (2018) made a narrative review on the assessment of physical fitness and physical activity levels in blind people. One of the most significant findings suggested by the author is to use tests with sub-maximum demands, such as the "*cycle ergometer effort test*" for the cardio/pulmonary endurance component, because people with visual impairment often tend to have a predominantly sedentary lifestyle, which produces substantial difficulties or deficiencies in speed and strength. For this last aspect, she suggests the "*hand dynamometer*" test; and to assess flexibility she recommends any variant of the "*sit and reach*" test, because of its simplicity and practicality, and she mentions that it is common to find muscular retractions in this population due to postural disorders.

Methodology

Study type

Based on the contributions of Hernández-Sampieri and Mendoza (2018), this study is considered of the mixed type, because it involves a combination of both qualitative and quantitative techniques and instruments for data collection and analysis. It used a triangulation-concurrent design, whose main benefit is enabling the cross-validation of quantitative and qualitative data, in order to confirm or corroborate them with each other. Its particular characteristic is that during its application, both types of data are collected, assessed and compared simultaneously.

Unit of study

Six (6) experts participated in the validation of the instrument, four (4) of whom were international and two (2) local. The pilot test was carried out with twelve (12) students of Universidad del Atlántico, eight (8) with low vision levels and four (4) with blindness; seven (7) men and five (5) women; of ages between 18 and 27 years old. The characterization of visual impairment (causes, consequences, criteria and methods to determine and classify blindness depending on the level and effects of impairment) was performed mainly following the guidelines of the World Health Organization (WHO, 2023), supplemented by the contributions of Arias-Uribe et al. (2018).

Criteria for the selection of experts and the inclusion of students

The experts had to have undergraduate and graduate degrees and at least one (1) scientific publication and three (3) academic participations; experience in physical activity; experience in visual impairment and research experience.[1] The students had to have some type of visual impairment (low vision or blindness), validated by a clinical diagnosis, and had to authorize their participation by assigning rights and signing an informed consent. Students who did not authorize their participation or that had any risk factors related to physical activity were excluded.[2]

Techniques, instruments and phases of the study

The battery was designed based on a literature review using a selection of abstracts, and the validation of the battery's contents was performed based on expert opinions using the double-blind method by means of a checklist and a SWOT matrix (adapted). On the checklist, the experts were to assign a score to each test and the overall battery between 0 and 3 for each of the defined criteria, based on their opinion on whether the defined items fulfilled or failed to fulfill each of the stated criteria (Annex A).

Instrument validation

Several studies have used the expert opinion technique to assess the quality of physical tests (Agudelo, 2019; Beltrán, 2019; Blanco-Luengo et al., 2020; Gómez-Carmona et al., 2020; González et al., 2021; Lincango & Chávez, 2022; Ortiz et al., 2020). This study used this technique, taking into consideration that Ortiz et al. (2020) mention that "the use of this method is useful to assess the appropriateness of the test battery, as it enables perfecting the test results before applying them" (p. 460). The contributions of Blanco-Luengo et al. (2020) were taken into consideration regarding the phases for the validation of an instrument through expert opinions, as well as those by Gómez-Carmona et al. (2020) regarding the selection criteria that must be met by the experts to assess the test battery.

Regarding the quality criteria of a physical fitness test in quantitative terms, Martínez (2017) considers that the main three indicators are: objectivity (independence from any possible external influences), reliability (that it does not fail over a given time period) and validity (consistent relationship with the variable to be measured). Cardona (2018) and Cardona and Buitrago (2019) believe that these three criteria have the same level of importance, and suggest that the test protocol should be assessed as a new test; these authors also suggest that a checklist is an appropriate instrument for the quantitative component for the assessment of physical tests.

[1] Publications (articles, books and chapters) and participations (presentations, conferences and workshops in academic events) related to physical activity and visual impairment. For experience, a minimum of 10 years in each field.

[2] According to the Physical Activity Readiness Questionnaire (PAR-Q).

Regarding the qualitative component, Gómez-Carmona et al. (2020) suggest that this component complements the quantitative component, and enables performing a fuller assessment. In their study they assessed this component through a matrix of negative aspects, which was taken into consideration as methodological reference to adapt the SWOT matrix. Similarly, Camacho (2022) points out that the SWOT matrix has often been used for planning and assessment of health-related programs and in sports research. In his study, Beltrán (2019) made field observations and carried a field diary to monitor application of the test battery designed for his study. In another study, González et al. (2021) performed a literature review to design their battery.

Results processing and analysis

For the quantitative data, quality indicators were defined independently for each criterion of the test battery by means of a proportionality ratio (stated as a percentage) between the scores obtained for each criterion and the maximum score possible for each criterion.[3] The degree of agreement between the experts was determined by means of analysis of variance, using the SPSS statistical package, according to the ALPHA significance. It should be highlighted that Nogueira et al. (2022) also used this program to correlate the values in the validation of the physical fitness tests. The qualitative data were treated with a CAME matrix. The observations from the pilot study were recorded in a field diary.

Results

Initial design of the battery

A literature review was carried out between May and June 2022, based on which twelve (12) field tests were selected to assess certain manifestations of conditional physical capacities. Most of them were taken from the specialized book by Martínez (2017), except the Cafra test, which was taken from the scientific article by Bahamonde et al. (2019) and the Incremental Shuttle walking test, taken from the scientific articles of Itaki et al. (2018) and Clague-Baker et al. (2019). The tests were adapted taking into consideration the guidelines of several authors for the assessment of physical fitness in people with visual impairment (Nikic, 2017; Salazar, 2018; Sánchez & González, 2020), such as: the nearest approximation between evaluators and those being evaluated; assign greater priority to verbal over visual explanations; support for audio information with proprioception; replacement of visual-based materials for sound and tactile based materials inasmuch as possible.

It should be highlighted that this instrument was developed based exclusively on the selection of the tests proposed by previous studies, to adapt them and group them into a test battery; in no case are any new tests proposed. A summary sheet was used to record

[3] The study involved six (6) experts, and each could assign a maximum score of 3 to each criterion, i.e., a total maximum score of 18 for each criterion.

the bio-motor capacity of the manifestation assessed by each test, the test name, the component for scoring and the instrumentation aids required for each test. The initial design of the battery is summarized in Table 1:

Table 1. *Test battery to assess physical fitness.*

N	C	Manifestation	Test name	Score component	Instrument or aid
1	Strength	Maximum hand grip strength.	Hand dynamometer.	Recorded value (both hands).	Dynamometer.
2		Upper body strength-endurance.	Elbow extensions in 1 minute.	Repetitions performed.	Chronometer.
3		Middle body strength-endurance.	Squats in 1 minute.	Repetitions performed.	Chronometer.
4		Lower body strength-endurance.	Sit-ups in 1 minute.	Repetitions performed.	Chronometer.
5		Upper-middle body explosive strength.	Medicine ball throw.	Launch distance.	Metric tape.
6		Lower body explosive strength.	Vertical jump with feet together.	Jump height.	Metric ruler.
7	Flexibility	Active flexibility in the lumbar, hamstring and gluteal area.	Sit and reach test.	Distance reached.	Wells drawer.
8		Active flexibility in the lateral trunk area.	Lateral trunk flexion.	Distance reached (both sides).	Metric tape.
9	Speed	General travel speed.	20 m sprint test.	Time required.	Chronometer.
10		Cyclical travel speed.	10 × 5 shuttle run test.	Time required.	Chronometer.
11	Endurance	Cardiorespiratory capacity.	Cafra test.	Heart rate.	Pulsometer Sound strap.
12		Aerobic endurance and cardiovascular performance.	Incremental shuttle walking test.	Times traveled, heart rate.	Pulsometer Sound strap.

Note: *N* = Test number; *C* = Fitness component. Score units: test 1 in kilos; tests 2, 3, 4 and 12 (times traveled) in units; tests 5, 6, 7 and 8 in centimeters; tests 9 and 10 in seconds; Tests 11 and 12 in pulsations/minute.
Source: Prepared by the authors.

Assessment of the initial design of the battery – quantitative component

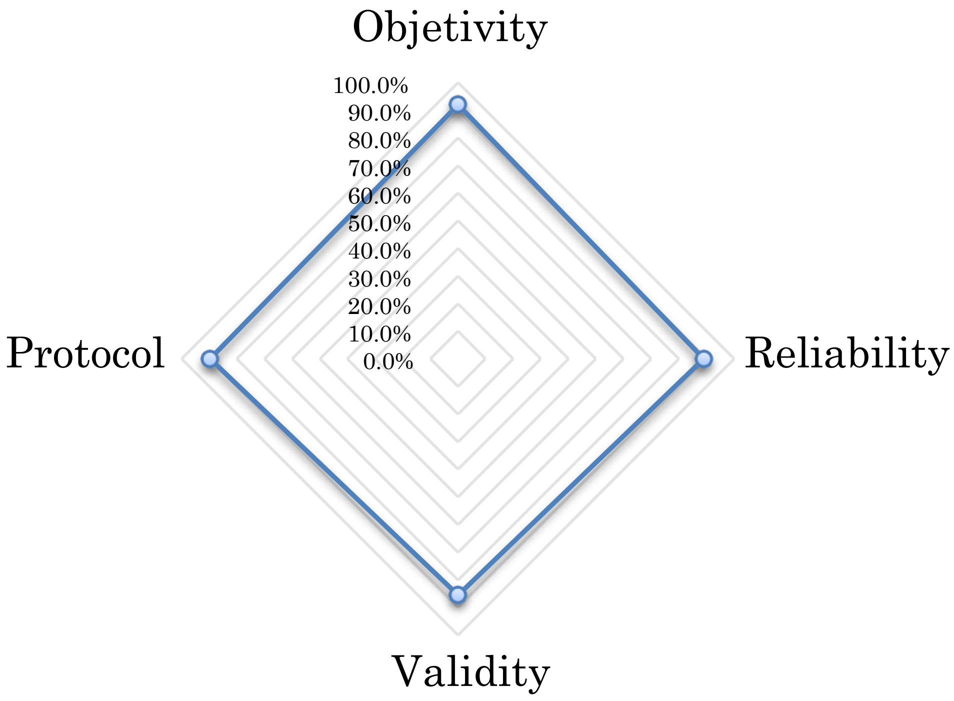
Between July and August 2022, the experts filled out the battery assessment forms. Table 2 and Figure 1 display the battery's quality indicators for each defined criterion, based on the quantitative scores assigned to the different tests and the overall battery:

TABLE 2. *Quantitative results of the test battery assessment.*

Tests	Objectivity		Reliability		Validity		Protocol	
	P	%	P	%	P	%	P	%
Hand dynamometer	17.0	94.4	17.0	94.4	16.0	88.9	17.0	94.4
Elbow extensions in 1 minute	18.0	100.0	16.0	88.9	14.0	77.8	17.0	94.4
Squats in 1 minute	17.0	94.4	17.0	94.4	17.0	94.4	17.0	94.4
Sit-ups in 1 minute	18.0	100.0	18.0	100.0	18.0	100.0	18.0	100.0
Medicine ball throw	17.0	94.4	16.0	88.9	17.0	94.4	17.0	94.4
Vertical jump with feet together	15.0	83.3	16.0	88.9	12.0	66.7	15.0	83.3
Sit and reach test	16.0	88.9	16.0	88.9	15.0	83.3	16.0	88.9
Lateral trunk flexion	16.0	88.9	16.0	88.9	15.0	83.3	16.0	88.9
20 m sprint test	15.0	83.3	15.0	83.3	15.0	83.3	15.0	83.3
5 × 10 shuttle run test	15.0	83.3	15.0	83.3	15.0	83.3	15.0	83.3
Cafra test	15.0	83.3	15.0	83.3	15.0	83.3	15.0	83.3
Incremental shuttle walking test	16.0	88.9	16.0	88.9	15.0	83.3	16.0	88.9
Overall battery	16.0	88.9	16.0	88.9	16.0	88.9	16.0	88.9

Note: *P* = Score obtained; %: quality indicators.
Source: Prepared by the authors.

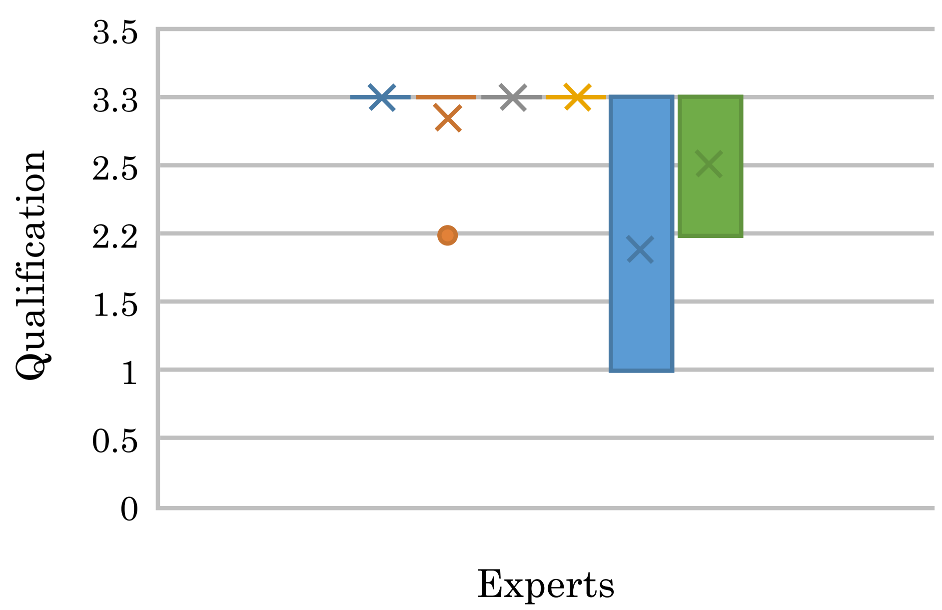
FIGURE 1. *Quantitative results of the test battery assessment.*



Note: After calculating the average of each criterion, the corners of the blue perimeter were marked, which indicate the quality index for each criterion. The entire area within the blue perimeter reflects the overall quality of the instrument according to the assessment.
Source: Prepared by the authors.

When the results for each criterion are averaged, the battery obtained 90.2% for the *objectivity index*, 89% for *reliability*, 85.5% for *validity* and 89.7% for *protocol-adaptation*. The most favorable results were obtained by the *objectivity* criterion, whereas *validity* obtained the least favorable results, with a small difference of 4.7% between them. The *reliability* and *protocol-adaptation* results were very close to those for *objectivity*. The results for the strength tests (except the vertical jump and the elbow extensions in 1 minute tests, specifically for the criterion of validity) were more favorable than the results for the other tests. The results for the speed and endurance tests (especially the Cafra test) had less favorable results (Figure 2).

Figure 2. *Results of the level of agreement between the experts.*



Note: The blue bar represents expert E, and the green bar represents expert F.
Source: Prepared by the authors.

The level of agreement between the experts was very similar for the four (4) assessment criteria, which was significantly positive in most cases. However, expert E had significant differences with his peers regarding the vertical jump tests and the other tests that do not assess manifestations of strength, assigning them lower scores. Expert F had minor differences with his peers, assigning slightly lower scores (specifically for the elbow extensions, 20 meter sprint and the 10 × 5 shuttle run tests).

Assessment of the initial battery design – qualitative component

In general, the experts considered that each test and the battery were adequately structured and conceived according to the objectives, and that the selected tests were practical and consistent with the characteristics of the target population. Three (3) experts stated that the adaptation criteria were of great value and reflect the differences compared to those applied to people with normal vision. Four (4) of the experts stated that the methodological description of the adaptation of the tests was insufficient, and suggested that they should be improved and justified through illustrations, particularly for the speed and endurance tests. Two (2) of the experts suggested adding coordination tests involving its various manifestations, while the remaining four (4) indicated that the battery does not necessarily need to include coordination and balance tests if the instrument is focused on conditional physical capacity.

Focusing on the specific tests, one (1) expert suggested that the weight of the balls for the throw test should not be set by gender (5k for men and 3k for women), but by the possibilities of each test subject, with a preference for lower weight balls. Four (4) of the experts suggested clearly explaining the duties of the sighted guide for the task of providing orientation for the speed and endurance tests. Also, two (2) experts suggested taking into consideration that people with visual impairment, especially blind people, are not used to running long distances. Two (2) of the experts suggested taking into consideration that the sit-up, vertical jump and waist bend tests could destabilize the subjects' postural adjustment and give rise to safety concerns, given that visual information is one of the underlying inputs for body balance.

Final design of the battery

In September 2022 adjustments were made based on the reviewers' suggestions. Overall, more detailed and grounded descriptions and illustrations were provided for the protocol-adaptation for each test. For the speed and endurance tests, rules were set for the participation of the sighted guide to ensure reaching the maximum without favoring nor hindering the subjects' performance. For the ball throw test, a weight of 3k was proposed for men and 1k for women for cases in which the subjects face difficulties in handling heavier balls. For the sit-up, vertical jump and lateral trunk flexion tests, subjects are allowed a base for support (determined by the position of their feet) that is slightly larger than authorized in the protocol for sighted people, with the aim of achieving greater stability, and mattresses were placed around the subject to prevent injuries in the case of falling.

Pilot run of the battery

The pilot was carried out between October 3 and 13, 2022, with twelve (12) students who met the inclusion criteria, tested in four (4) groups of three (3) students each. The evaluators were two (2) members of the Physical Education and Sciences Applied to Sports Research Group (GREDFICAD, by its acronym in Spanish) (one young professional researcher and a young undergraduate-level researcher). The tests were applied in two (2) sessions (the strength and flexibility tests were taken the first day, and the speed and endurance tests were taken on the next day), each with duration of approximately 40 minutes (including 10 minutes for warm-up and 4 minutes to return to calm). The time for recovery after completing each test (or each attempt) was between 30 seconds and 3 minutes. As a general rule, the subjects were not allowed to rest during the test; if they did, it was considered the end of an attempt. The following are the most significant notes taken from the field diary:

- Blind students required more time to understand the tests than low-vision students, and it is quicker to lead them to the required position for each test that waiting for them to find the position based on the information provided.
- Most subjects were able to complete the battery; two (2) were not able to perform the sit-ups; one (1) was not able to perform the elbow extensions, and one (1) was unable to perform the Cafra test. Several of them said that the latter test is very demanding because it is not progressive, and that it requires previous rehearsal to enable the subjects to adapt to the pace of the walk.
- It is essential that the subjects perform recognition of the area where the test is to be taken (and that the evaluators complement it with oral descriptions as required), especially in the case of blind people and their guides, who must first take a rehearsal test to coordinate their movements and the communications dynamics.
- The guide must strictly follow the protocol in order to prevent his/her participation from creating any bias in the measurement of the subject's performance.
- It is recommended to take the tests during the daytime, in clear spaces, without excess lighting and low levels of people traffic.
- For signage of the tests, people with low vision require large signs in bright colors, and for blind students the large signs should be replaced by floor markings that can be seen by the guide.

Discussion

Discussion of the battery design

There are very few research studies with proposals for the assessment of physical fitness in people with visual impairment (Betancourt et al., 2020; Sánchez & Gonzáles, 2020). Some of the selected tests have been applied to people with visual impairment in previous studies, such as elbow extensions, sit-ups, and sit and reach (Gómez and Ortiz, 2014; Karakoc, 2016; Sánchez & González, 2020; Valdés et al., 2014); sit and reach (Kurtoglu et al., 2022); medicine ball throw (Moreno and Cuastumal, 2016); lateral trunk flexion (Surakka & Kivelä, 2011); Cafra test (Valdés et al., 2014); hand dynamometer manual and vertical jump (Karakoc, 2016; Kurtoglu et al., 2022).

In some studies, the Brockport battery has been applied to this population, which is consistent with the battery designed in this study in terms of the following tests: sit and reach, elbow extensions and sit-ups; it differs from this study in the 1-mile run instead of the Cafra test or the incremental shuttle walking test (Haegele, Zhu et al., 2018; Piva da Cunha et al., 2016; Qasim et al., 2021). Some authors prefer the horizontal jump rather than the vertical jump (Gómez and Ortiz, 2014; Sánchez & González, 2020; Valdés et al.,

2014) and the 20 m run test to assess endurance (Godoy-Cumellaf et al., 2022; Oliveira et al., 2020). Kurtoglu et al. (2022) used the throw test rather than the 10 × 5 shuttle run test to assess cyclical speed.

Salazar (2018) suggests using sub-maximum demand tests, such as the "*effort test on cycle ergometer*" for the cardio-pulmonary endurance component, because people with visual impairment tend to have a predominantly sedentary lifestyle, which gives rise to noticeable difficulties or deficiencies in speed and strength. For the latter capacity it is suggested to use the "*hand dynamometer*" test; to assess flexibility it is recommended to use any variant of the "*sit and reach*" test because of its simplicity and practicality. In agreement with this author, Invernizzi et al. (2020) mention that:

> When the administration of maximum tests is inadequate, due to possible undesirable effects on motivation, possibly leading to interrupting the exercise or inappropriate measurements and assessments, alternative physical fitness tests are required (p. 2).

Discussion on the procedure to validate the physical test battery

Regarding the techniques used to assess physical tests, Cardona (2018) and Cardona and Buitrago (2019) used a literature review rather than expert opinion, even though other authors selected the test-retest technique (Jung et al., 2019; Invernizzi et al., 2020; Lillo et al., 2020), but none of them discredits the use of expert opinion, which according to González et al. (2021) was the one he applied in his study to supplement the test-retest technique. Regarding the instruments, a Likert-type scale has been used in several studies to quantitatively assess the quality of the physical fitness and physical activity tests, rather than a checklist (Agudelo, 2019; Blanco-Luengo et al., 2020; Gómez-Carmona et al., 2020; Lincango & Chávez, 2022; Ortiz et al., 2020; Piñeiro-Cossio et al., 2023); however, other authors used a grid (Beltrán, 2019; González et al., 2021).

Regarding the quality criteria for the quantitative component of physical fitness tests, Invernizzi et al. (2020) and Gómez-Carmona et al. (2020) consider that the most relevant criteria are reliability and validity; while Ortiz et al. (2020) consider that objectivity and reliability are the most relevant; and Beltrán (2019) adds additional criteria to those mentioned above, such as relevance, economy and usefulness. Instead, Lincango and Chávez (2022) focus on a single criterion, relevance, even though to determine it, they took into consideration aspects related to the aforementioned criteria, also with an emphasis on practicality and adaptability. These studies did not include the protocol as a criterion, and they do not mention aspects related to the adaptability of the tests and battery to visual impairment.

Of the reviewed studies, only the one by Gómez-Carmona et al. (2020) included a significant qualitative component in the assessment, by using a matrix of tests and considerations for the matrix (usually negative) by the consulted experts, and the subsequent corrective actions adopted by the authors. In his instrument, Beltrán (2019) only added a small section where experts could add short suggestions.

For this study, it was considered of interest to also assess a qualitative component; however, a SWOT matrix was selected to separate positive from negative considerations, in order for the experts to also visualize the strengths and opportunities of the physical fitness tests selected to make up the battery. The trend in the aforementioned studies was to assess the tests independently, with an analytic approach (each test separately); in this study we perform the same exercise, supplemented by an assessment of the battery as a whole, with a synthesis approach (the overall battery).

Conclusions

There are not enough physical tests designed for and applied to populations with visual impairment, even though many of the tests designed for people without disabilities can be adapted. The physical test battery designed to assess the physical fitness of university students with visual impairment was validated in both quantitative and qualitative terms: the quantitative indexes were positive and close to each other in all the criteria for the battery assessment, and the ratings assigned by the experts were homogeneous in most cases. The experts commented on several positive aspects of the initial battery design, taking into consideration the characteristics of the target population it was designed for; however, certain adjustments were made related to protocol-adaptation that enabled enhancing the final design.

These adjustments were applied in the pilot run, and enabled establishing specifications to regulate the participation of a sighted guide to provide orientation to blind students for the speed and endurance tests. The guides' participation, rehearsal testing, audio information, proprioception, the adequate selection and previous recognition of the spaces and implementation play a key role in the application of physical tests for people with visual impairment, which enable enhancing confidence and safety for the test subjects. It is recommended to apply it in populations with similar characteristics in order to obtain results that may serve as comparative reference for the developments of specific benchmarks for this population.

Financing

Colombian Ministry of Science, Technology and Innovation, and National Financing Fund for Science, Technology and Innovation (Francisco José de Caldas Fund), through invitations for proposals from Young Researchers and Innovation in the framework of the 2021 economic reactivation; Universidad del Atlántico, through the office of the Vice-rector of Research, Extension and Social Outreach.

Statement of conflicts of interest

The authors declare that the submitted study does not represent any conflict of interest between them, with the magazine, the publisher or the financing entities.

Ethical considerations

This study was carried out in abidance of the scientific, technical and administrative standards for health research set out in Resolution No. 8430 of the Ministry of Health and Protection of Colombia (1993), with special attention to regulations for research studies in which people with disabilities participate. The study was approved by the Research Ethics Committee of Universidad del Atlántico.

Special acknowledgements

- To the Ministry of Science, Technology and Innovation, and Universidad del Atlántico, for financing and institutional support for the project.
- To the Physical Education and Sciences Applied to Sports Research Group for academic and intellectual support.
- To the Program for the Inclusion of Diverse Populations of Universidad del Atlántico (DiverSer), its coordinator Oris María Mercado Maldonado, and the students with visual impairment who participated in the project, for their dedication and commitment.
- To the experts who contributed to the assessment of the designed instrument for their contributions and enhancements.
- To Professor Alberto Ricardo Albis Arrieta for his support for the logistics and storage of the research instruments and devices.
- To Professor José Herrera Acosta for his advisory and support in the statistical analysis of the quantitative data.

Author's contribution

Eduardo Elles-Cuadro: Conceptualization, data curation, formal analysis, fund raising, research, visualization and writing.
Odelaidis-Vaneza Marimon-Mendoza: Conceptualization, fund raising, research and visualization.
Lina-Johanna Álvarez-Toro: Fund raising, methodology, project management and supervision.
Fabián-Andrés Contreras-Jáuregui: Fund raising, research, resources and validation.

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Author information

Eduardo Elles-Cuadro: Professional in Physical Education, Recreation and Sports. Master's in Inclusive and Intercultural Education. Member of the Physical Education and Sciences Applied to Sports Research Group –GREDFICAD–. Young Researcher at Universidad del Atlántico (Colombia), supported by the Ministry of Science. ORCID: https://orcid.org/0000-0002-4393-8774

Odelaidis-Vaneza Marimon-Mendoza: Professional in Physical Education, Recreation and Sports. Member of the Physical Education and Sciences Applied to Sports Research Group –GREDFICAD–. Young Researcher at Universidad del Atlántico (Colombia), supported by the Ministry of Science. ORCID: https://orcid.org/0000-0002-4325-918

Lina-Johanna Álvarez-Toro: Physical Therapist. Master's in Child Development. Member of the Physical Education and Sciences Applied to Sports Research Group –GREDFICAD–. Research Professor at Universidad del Atlántico (Colombia). ORCID: https://orcid.org/0000-0002-1151-5478

Fabián-Andrés Contreras-Jáuregui: Physical Therapist. Specialist in Sports Training; Doctor in Physical Education Sciences. Member of the Physical Education and Sciences Applied to Sports Research Group –GREDFICAD–. Research Professor at Universidad del Atlántico (Colombia). ORCID: https://orcid.org/0000-0003-0721-6309

Annexes

Annex A. *Quantitative scoring criteria for the test battery quantitative assessment.*

Criterion	Item description	IS	Max
Objectivity	Degree of independence from possible external influences.	1	3
	It is performed according to a method that can be subsequently reproduced in the same manner.	1	
	Assessment and interpretation in numeric terms according to a standardized scale.	1	
Reliability	It can be used without failure for a given time period (does not involve significant risk of failure).	1	3
	The test results would be consistent if applied twice to the same group.	1	
	The materials, techniques and times established for each test are appropriate.	1	
Validity	It measures what it is intended to measure (consistent relationship between the test and the variable to be measured).	1	3
	It can be used by anyone with expertise in the application of physical fitness tests, and in any controlled situation.	1	
	The results would be consistent with the results obtained from other tests (that measure the same variable) when applied to the same group.	1	
Protocol-adaptation	Clear description of the test, of the assessed person's actions (taking into consideration the visual disability), and by the evaluator.	1	3
	Visual impairment does not limit test performance (adapted) nor the use or materials.	1	
	Visual impairment does not represent a disadvantage in terms of the form of measurement, scoring and penalization.	1	

Note: *IS* = Score for each criterion item; Max = Maximum score for each criterion.
Source: Prepared based on Martínez (2017) and Cardona and Buitrago (2019).