

Contents lists available at [ScienceDirect](https://www.sciencedirect.com)**Heliyon**journal homepage: www.cell.com/heliyon

Review article

Physical fitness assessment in Goalball: A scoping review of the literatureLuca Petrigna^{a,b}, Valerio Giustino^{a,b}, Daniele Zangla^b, Samantha Aurea^b, Romilda Palma^b, Antonio Palma^{b,c}, Giuseppe Battaglia^{b,c,*}^a PhD Program in Health Promotion and Cognitive Sciences, Department of Psychology, Educational Science and Human Movement, University of Palermo, Via Giovanni Pascoli 6, 90144, Palermo, Italy^b Department of Psychology, Educational Science and Human Movement, University of Palermo, Via Giovanni Pascoli 6, 90144, Palermo, Italy^c Regional Sport School of CONI Sicilia, Italian National Olympic Committee, Italy

ARTICLE INFO

Keywords:

Public health
Quality of life
Disability
Physical activity
Aging and life course
Visually impaired people
Health-related evaluation
Standard operating procedure

ABSTRACT

Background: Goalball is a Paralympic sport for visually impaired athletes. Although it is widely practiced, a great variety of tests are adopted to evaluate athletes' physical fitness. Therefore, the objective was to identify the physical fitness tests adopted in this sport to find the common aspects between them and, eventually, to propose a standard operating procedure.**Methods:** The Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) guidelines were adopted. The studies were extracted from PubMed, Web of Science, and Scopus. A selection process by title, abstract, and full-text, according to the inclusion and exclusion criteria, was performed. The results were discussed with narrative synthesis.**Results:** A total of 7 papers and 222 participants were included. A wide variety of tests were adopted and the Brockport Physical Fitness Test (BPFT) was the only battery included to evaluate general athletes' well-being.**Conclusions:** Although few literature exists on Goalball, the BPFT could be the battery for evaluating Goalball athletes though the test battery should be standardized to the characteristics of this sport.**1. Introduction**

Goalball is a Paralympic sport created in 1946 by Hanz Lorenzen and Sepp Reindle to relieve blind war veterans during their rehabilitation. This sport was included in the Paralympics Games program in 1976 becoming popular worldwide over the years. Visual impaired (VI) Goalball athletes present several peculiar features in physical, psychological, and cognitive spheres. The first important effect of practicing this sport is the reduction of body fat mass and body mass index (BMI) (Caliskan et al., 2011; Karakaya et al., 2009). A second, but not least, aspect is the positive effect of this sport on health-related physical fitness characteristics such as cardiorespiratory endurance, muscular strength, muscular endurance, and flexibility (Caspersen et al., 1985; Colak et al., 2004; Karakaya et al., 2009). Positive effects are also on postural control capacity (Colak et al., 2004; Karakaya et al., 2009), and on auditory reaction speed and hearing duration compared to VI sedentary people (Yildirim et al., 2013). All the positive effects of Goalball are important because young VI people show poor neuro-psycho-motor and perceptual developments (Yildirim et al., 2013), lower cardiovascular and muscular

endurance, poor flexibility and postural control than people with normal vision (Skaggs and Hopper, 1996).

Goalball is a widely practiced sport by in different levels ranging from school and leisure time (Caliskan, 2010; Caliskan et al., 2011; Colak et al., 2004; Furtado et al., 2016; Karakaya et al., 2009) to the national Paralympics level setting (Akinoglu and Kocahan, 2018; Alves et al., 2018; Bednarczuk et al., 2017; Goulart-Siqueira et al., 2019). Regardless of the sporting level, the evaluation of physical performance is fundamental for monitoring both the athletes' health status and the team's preparation for the competition. Lieberman and Mc Hugh (Lieberman and McHugh, 2001), due to the wide variety of tests adopted, have tried to standardize the health-related fitness evaluation in VI children. The authors (Lieberman and McHugh, 2001) proposed to adopt items from the Fitnessgram health-related fitness test, such as the 1-mile walk/run test for cardiovascular endurance assessment, sit-ups and push-ups for muscular strength and endurance, sit and reach test, back extension test, and shoulder stretch test for flexibility. A similar attempt to create a standard procedure to evaluate youth with mental and physical disabilities, and therefore also for VI people, was performed by Winnick and

* Corresponding author.

E-mail address: giuseppe.battaglia@unipa.it (G. Battaglia).<https://doi.org/10.1016/j.heliyon.2020.e04407>

Received 4 May 2020; Received in revised form 3 June 2020; Accepted 3 July 2020

2405-8440/© 2020 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Short in 2009, who developed the Brockport Physical Fitness test (BPFT) manual (Winnick and Short, 2009). The test battery consists of four to six test items to evaluate aerobic capacity (1-mile walk/run test), body composition (skinfold thickness of triceps plus calf) and musculoskeletal functioning (curl-up, trunk lift, push-up and shoulder stretch tests). Unfortunately, the tests batteries proposed by the literature (Lieberman and McHugh, 2001; Winnick and Short, 2009) are specific for a general population with disabilities and not for Goalball athletes. Considering the importance to have updated sport-specific guidelines, to the best of our knowledge, there are no test batteries for the Goalball athletes' evaluation. For the reason described above, it was important to review the literature to understand if a standard operating procedure (SOP) guidelines clearly described, has been created for the Goalball athletes' evaluation. Hence, through a review of the literature, the objectives of the present manuscript were: (i) to study the tests adopted to evaluate VI Goalball athletes; (ii) to find the common aspects between the testing procedure; (iii) to propose, eventually, a SOP for the evaluation of Goalball athletes and practitioners.

2. Materials and methods

The present scoping review of literature partially adopted the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) checklist and explanation (Tricco et al., 2018). The manuscript was not previously registered on PROSPERO or published before even if the protocol was written down before the beginning of the work.

2.1. Eligibility criteria

Research articles that met the inclusion and exclusion criteria were selected for review and PICO-S (Population, intervention, comparison, outcomes, and study design) points were followed.

Studies were included if participants were VI Goalball athletes (B1, B2, and B3). All kinds of interventions and comparisons (clinical trials, randomization, observational studies, descriptive studies, and longitudinal) were included if the Goalball was evaluated or adopted to improve participants' physical fitness. The language adopted in the studies was English, regardless of the country of origin.

Studies were excluded if papers were reviews, meta-analyses, abstracts, statements, opinion pieces, citations from scientific conferences, commentaries, editorials, book reviews, books, letters and non-peer reviewed journal articles.

2.2. Information sources

Data were sourced from PubMed, Web of Science and Scopus databases, and the screening was carried out between January, 1st 2000 and March, 4th 2020. Terms of group 1 ("goalball") and group 2 ("physical fitness", "sports physiology", "performance analysis") were combined with the Boolean indicator "AND" or "OR". "Goalball AND (physical fitness OR sports physiology OR performance analysis)" is an example of a string created and adopted during the systematic literature search.

2.3. Data selection and management

Data selection followed a two-step process in which, during the first step, duplicates were deleted through the program EndNote X8 (EndNote version X8; Thompson Reuters, New York, USA), while a manual selection to identify the appropriate manuscript was performed in the second step. The manual selection involved two examiners and it was developed in a three-step process during which the inclusion and exclusion criteria were applied on the title, abstract and full-text. In case of disagreement between the two examiners, a third examiner considered the work and after discussion, it was decided to include or exclude it. This process was presented through a PRISMA flow diagram.

2.4. Data collection and synthesis

A Microsoft Excel spreadsheet (Microsoft Corp; Redmond, Washington, USA) was created to extract the following information: first author and year of publication, sample size and gender, participants' age (range, mean and standard deviation), and tests adopted. The health-related components were categorized into the following seven: (i) muscular strength; (ii) aerobic capacity; (iii) postural control; (iv) range of motion; (v) flexibility; (vi) percentage body fat; (vii) battery adopted. The information were extracted from any part of the study.

All data were summarized using descriptive tables and graphs and analysed through a narrative synthesis.

3. Results

From 71 studies selected after the primary search, a total of 7 papers were included after duplicates removal and eligibility criteria screening (Figure 1).

A total of 222 participants were included, 64 of whom were female and 158 were male. The age ranged between 10 and 42 years. People included were athletes and active or sedentary Goalball practitioners. Visual impairment of the Goalball athletes included ranged from B1 to B3 (Table 1).

3.1. Studies characteristics

The seven health-related components considered are analysed one by one below. A summary and details of each health-related component are provided in Table 2. Body fat percentage was evaluated through the skinfold measurements (Akinoglu and Kocahan, 2018) in seven (one study), five (one study), or two sites (two studies). Upper limbs strength was measured with the handgrip test (two studies) while the lower limb strength was evaluated with vertical jump tests (three studies) and through isometric devices (two studies). Other tests adopted to evaluate muscular strength were the push-up and the curl-up test (two and one study, respectively). The aerobic capacities were evaluated through field and laboratory tests. Among the laboratory tests, the treadmill incremental test to evaluate the maximal VO₂ consumption was adopted in one paper. Among the field tests, authors adopted the 1-mile walk/run test (two studies) and the Yo-Yo IR1 test (one study). The flexibility was evaluated using the sit and reach test (one study), the back-saver sit and reach test (one study), and the trunk lift test (two studies). The mobility was measured by two research groups with the shoulder stretch test for the shoulders, and, moreover, using the evaluation of the range of motion for shoulders, elbows and wrists (one study). The postural control capacity was valued through laboratory tests (two studies) and field tests such as the Flamingo Balance test (one study).

The only physical fitness test battery adopted was the BPFT (two studies).

4. Discussion

The results of the present scoping review show that the evaluation of Goalball athletes does not present a standardized test battery, and a wide variety of tests is proposed highlighting the lack of a SOP. Furthermore, a second important finding is the poor literature on this topic, although the health-related physical fitness assessment should be fundamental in individuals with VI.

Considering the lack of a SOP in the literature, an evaluation of the seven health-related tests found in the included studies was performed. The first point to highlight is the suggestion of the BPFT as the basis of the SOP because this test battery was the only one adopted in Goalball athletes (Furtado et al., 2016; Karakaya et al., 2009). A second important consideration is to decide to include only field tests. Indeed, although laboratory tests have more reliable results, field tests are generally easier, faster, and cheaper to administer (Heyward, 1991). These aspects are

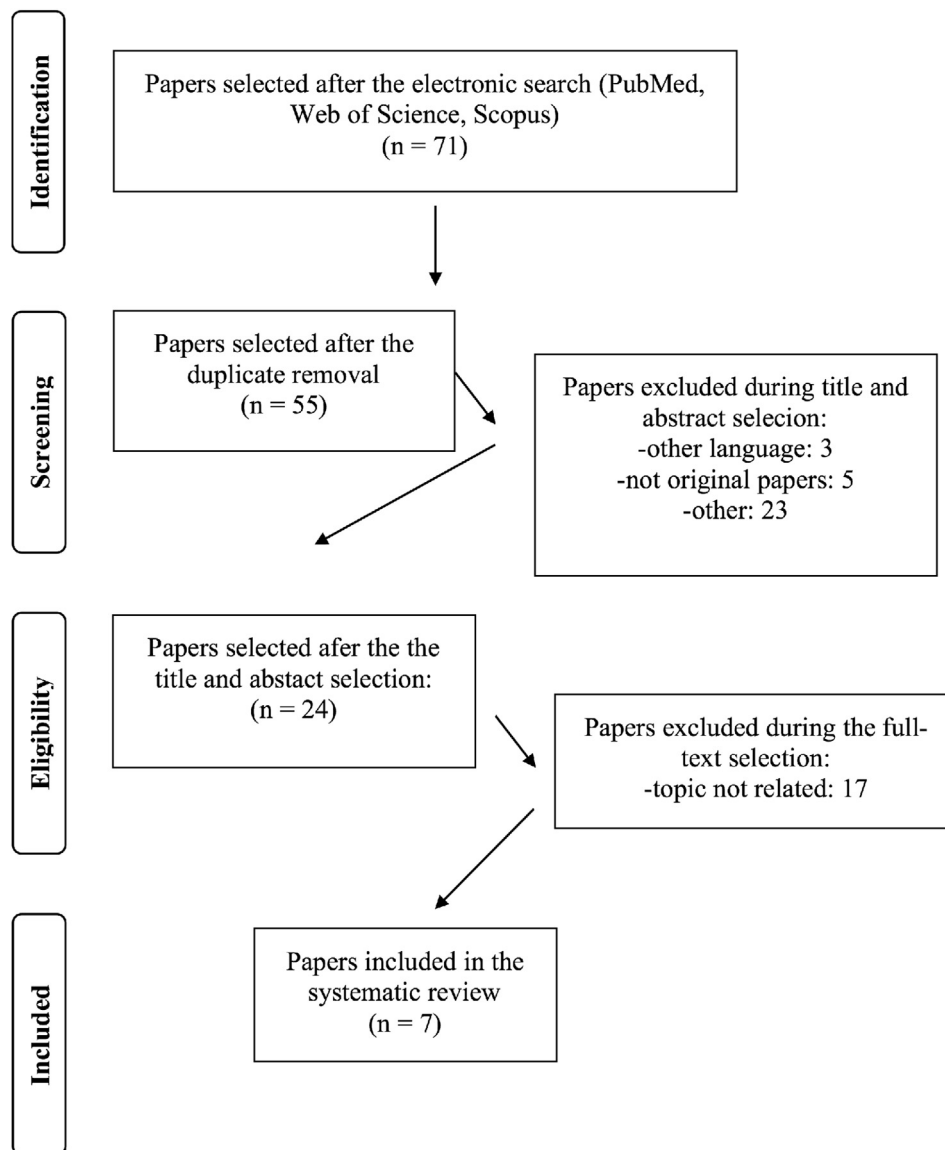


Figure 1. Flow diagram.

Table 1. General information of the studies examined.

Author and year	Sample (female) [male]	Sample kind VI level	Age (SD) and range	Test adopted
Akinoglu and Kocahan (2018)	20 (9) [11]	Elite B1–B3	23.25 (4.05) 17–29	isokinetic measurements; balance platform
Alves et al., (2018)	[7]	Elite B1–B3	20–34	incremental test on a treadmill
Bednarczuk et al., (2017)	65 (23) [42]	Elite B1–B3	28.22 (6.14)	stabilometric platform
Colak et al., (2004)	[51]	School setting B1–B3	15.2 (0.7)	goniometric measures; handgrip strength; vertical jump; sit and reach test; Flamingo Balance
Furtado et al., (2016)	40 (20) [20]	School B1–B3	17.3 (1.6) 13–19	2 sites ST; BPFT
Goulart-Siqueira et al., (2019)	11 (4) [7]	Elite B1–B3	25.3 (6.2)	7 sites ST; vertical jump; handgrip; Yo yo IR1
Karakaya et al., (2009)	28 (8) [20]	School	13.2 (1.4) 10–16	-2 sites ST; BPFT

BPFT: Brockport Physical Fitness Test; SD: standard deviation VI: visual impairment; ST: skinfold thickness.

Table 2. Information regarding the test adopted.

Health-related component	Test adopted	N of time
Muscular strength evaluation	Isokinetic measurement: Akinoglu and Kocahan (2018); Colak et al., (2004)	2
	Handgrip evaluation: Colak et al., (2004); Goulart-Siqueira et al., (2019)	2
	Vertical jump: Colak et al., (2004); Goulart-Siqueira et al., (2019); Karakaya et al., (2009)	3
	Curl-ups: Furtado et al., (2016); Karakaya et al., (2009)	2
	Push-ups: Furtado et al., (2016); Karakaya et al., (2009)	2
Aerobic evaluation	Incremental test on a treadmill: Alves et al., (2018)	1
	One mile run/walk test: Furtado et al., (2016); Karakaya et al., (2009)	2
	Yo-yo IR1: Goulart-Siqueira et al., (2019)	1
Postural balance control	Laboratory evaluation Akinoglu and Kocahan (2018); Bednarczuk et al., (2017)	2
	Field evaluation Flamingo Balance Test Colak et al., 2004	1
Range of motion	Standard goniometric measures Colak et al., (2004)	1
Flexibility	Sit and reach test Colak et al., (2004)	1
	Back-saver sit and reach test Furtado et al., (2016)	1
	Shoulder-stretch test Furtado et al., (2016); Karakaya et al., (2009)	2
	Trunk lift test Furtado et al., (2016); Karakaya et al., (2009)	2
Percentage body fat	2 site skinfold thickness Furtado et al., (2016); Karakaya et al., (2009)	2
	7 sites skinfold thickness Goulart-Siqueira et al., (2019)	1
BPFT	Furtado et al., (2016); Karakaya et al., (2009)	2

BPFT: Brockport Physical Fitness test.

fundamental especially for fitness components evaluation in population-based studies and in school settings (Artero et al., 2011).

Regarding the tests included in the BPFT, a point by point discussion is provided. Indeed, although skinfold thickness measurement with seven different sites (Goulart-Siqueira et al., 2019) or five (Caliskan et al., 2011) gives more reliable values, this evaluation requires time to be obtained, reducing the test feasibility. For this reason, the two-points skinfold thickness (calf and triceps) adopted by two authors (Furtado et al., 2016; Karakaya et al., 2009) is a faster and feasible solution to obtain information regarding the participants' body fat status. To measure flexibility, the sit and reach test (Colak et al., 2004) is proposed because it presents validity for the hamstring extensibility assessment (Mayorga-Vega et al., 2014). For aerobic and anaerobic capacities, considering the difficulties in the locomotor tasks where changes of direction are required, the 1-mile walk/run test (Furtado et al., 2016; Karakaya et al., 2009) is suggested compared to the Yo-Yo intermittent test where a change of direction is required making this last test not easy to administer to VI people. Muscular strength and endurance were evaluated through different tests (see Table 2). Consequently, a limited number of tests have been decided to include in the SOP based on the feasibility and specificity in the evaluation of Goalball athletes. The tests that could be used for muscular strength evaluation are the curl-up, push-up, trunk lift, or the medicine ball throw, because all of these tests are easy to administer and require no instruments. Although the handgrip test is a valid and reliable test for assessing muscle strength (Artero et al., 2011, 2012), it is not of interest to the characteristics of Goalball athletes. Consequently, in order to reduce the number of tests proposed, it was not included. In a similar way, although the vertical jump tests are widely adopted to evaluate lower limbs muscle strength (Petrigna et al., 2019), they were not included in the SOP. The evaluation of postural control capacity, especially in the health-related contest, is fundamental because of the loss of the visual field is associated with a greater fear of falling (Ramulu et al., 2012). Consequently, the Flamingo balance test (Colak et al., 2004), the only field test to evaluate postural control adopted by the authors, is suggested to be included in the Goalball athletes' evaluation.

Based on the analysis of the tests adopted to evaluate the health-related components in Goalball athletes, a SOP is suggested considering the most adopted and most pertinent test for this population. This include the BPFT as test battery composed by the sit and reach test and shoulder stretch for flexibility; 1-mile walk/run test for aerobic capacity;

curl-up and push-up for muscular strength and endurance; and the two-point skinfold thickness for body fat. Furthermore, as concern the postural control evaluation, the Flamingo balance test could be used.

4.1. Strengths, limits and future studies

The strength of the present study was to highlight how poor the literature on Goalball is. Optimistically, based on these results, researchers will develop these information to improve the health of individuals with VI.

The study has some limitations that need mentioning. First, we could not compare the results of the various studies included in the analysis because the researches employed different measurements and data collection protocols. A second limitation was the sample that was too different. Indeed, it was composed of school-children, adolescents, adults, and, as concern the sport level, participants were both active people and national athletes.

Because of the presence of few articles in the literature and based on the benefits of Goalball in VI people, future studies should increasingly investigate the contribution of this sport on physical, psychological, and social benefits in these athletes.

5. Conclusion

In conclusion, the present manuscript highlights how relatively little research has been systematically conducted to investigate this area and how different are the tests proposed to evaluate Goalball athletes and practitioners. We suggest that the BPFT with standardized tests could be adopted as SOP in Goalball.

Declarations

Author contribution statement

All authors listed have significantly contributed to the development and the writing of this article.

Funding statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Competing interest statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

References

- Akinoğlu, B., Kocahan, T., 2018. Comparison of muscular strength and balance in athletes with visual impairment and hearing impairment. *J. Exerc. Rehabil.* 14 (5), 765–770.
- Alves, I.D.S., Kalva-Filho, C.A., Aquino, R., Travitzki, L., Tosim, A., Papoti, M., Morato, M.P., 2018. Relationships between aerobic and anaerobic parameters with game technical performance in elite goalball athletes. *Front. Physiol.* 9, 1636.
- Artero, E.G., Espana-Romero, V., Castro-Pinero, J., Ortega, F.B., Suni, J., Castillo-Garzon, M.J., Ruiz, J.R., 2011. Reliability of field-based fitness tests in youth. *Int. J. Sports Med.* 32 (3), 159–169.
- Artero, E.G., Espana-Romero, V., Castro-Pinero, J., Ruiz, J., Jimenez-Pavon, D., Aparicio, V., Ortega, F.B., 2012. Criterion-related validity of field-based muscular fitness tests in youth. *J. Sports Med. Phys. Fit.* 52 (3), 263–272.
- Bednarczuk, G., Molik, B., Morgulec-Adamowicz, N., Kosmol, A., Wiszomirska, I., Rutkowska, I., Perkowski, K., 2017. Static balance of visually impaired paralympic goalball players. *Int. J. Sports Sci. Coach.* 12 (5), 611–617.
- Caliskan, E., 2010. The effects of long term goalball sport on reaction times in blind children by sex and handedness. *Neurol. Psychiatr. Brain Res.* 16 (3–4), 97–100.
- Caliskan, E., Pehlivan, A., Erzeybek, M.S., Kayapinar, F.C., Agopyan, A., Yuksel, S., Dane, S., 2011. Body mass index and percent body fat in goalball and movement education in male and female children with severe visual impairment. *Neurol. Psychiatr. Brain Res.* 17 (2), 39–41.
- Caspersen, C.J., Powell, K.E., Christenson, G.M., 1985. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Publ. Health Rep.* 100 (2), 126–131.
- Colak, T., Bamac, B., Aydin, M., Meric, B., Ozbek, A., 2004. Physical fitness levels of blind and visually impaired goalball team players. *Isokinet. Exerc. Sci.* 12 (4), 247–252.
- Furtado, O., Morato, M.P., Potenza, M., Gutierrez, G.L., 2016. Health-related physical fitness among young goalball players with visual impairments. *J. Vis. Impair. Blind. (JVIB)* 110 (4), 257–267.
- Goulart-Siqueira, G., Benitez-Flores, S., Ferreira, A.R.P., Zagatto, A.M., Foster, C., Boulosa, D., 2019. Relationships between different field test performance measures in elite goalball players. *Sports* 7 (1).
- Heyward, V.H., 1991. *Advanced Fitness Assessment and Exercise Prescription*, 3e edition. Human Kinetics Books, pp. 1–50. 2.
- Karakaya, I.C., Aki, E., Ergun, N., 2009. Physical fitness of visually impaired adolescent goalball players. *Percept. Mot. Skills* 108 (1), 129–136.
- Lieberman, L.J., McHugh, B.E., 2001. Health-related fitness of children with visual impairments and blindness. *J. Vis. Impair. Blind.* 95, 272–286.
- Mayorga-Vega, D., Merino-Marban, R., Viciano, J., 2014. Criterion-related validity of sit-and-reach tests for estimating hamstring and lumbar extensibility: a meta-analysis. *J. Sports Sci. Med.* 13 (1), 1–14.
- Petrigna, L., Karsten, B., Marcolin, G., Paoli, A., D'Antona, G., Palma, A., Bianco, A., 2019. A review of countermovement and squat jump testing methods in the context of public health examination in adolescence: reliability and feasibility of current testing procedures. *Front. Physiol.* 10, 1384.
- Ramulu, P.Y., van Landingham, S.W., Massof, R.W., Chan, E.S., Ferrucci, L., Friedman, D.S., 2012. Fear of falling and visual field loss from glaucoma. *Ophthalmology* 119 (7), 1352–1358.
- Skaggs, S., Hopper, C., 1996. Individuals with visual impairments: a review of psychomotor behavior. *Adapt. Phys. Act. Q.* 13 (1), 16–26.
- Tricco, A.C., Lillie, E., Zarin, W., O'Brien, K.K., Colquhoun, H., Levac, D., Straus, S.E., 2018. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. *Ann. Intern. Med.* 169 (7), 467–473.
- Winnick, J.P., Short, F.X., 2009. *The Brockport Physical Fitness Test Manual: A Health-Related Test for Youth with Physical and Mental Disabilities*. Human Kinetics, Champaign, IL.
- Yildirim, S., Yuksel, R., Doganay, S., Gul, M., Bingol, F., Dane, S., 2013. The benefits of regular physical activity on hearing in visually impaired adolescents. *Eur. J. Basic Med. Sci.* 3, 17–21.