

# Effects of Goalball on Balance: A Systematic Review

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**Abstract:** Goalball has been highlighted as a reference disabled sport from educational levels to its participation in the Paralympic Games, where the effects of this sport on balance and its relevance have been investigated. The aim of the systematic review was to systematically review those studies that evaluated the effects of goalball on balance in goalball athletes. A systematic review of PubMed and FECYT (Web of Sciences, CCC, DIIDW, KJD, MEDLINE, RSCI, and SCIELO) was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The articles were included if they met the following inclusion criteria: (i) participants were goalball players; (ii) athletes playing goalball; (iii) outcomes were related to balance; and, (iv) original articles without language restriction. From the 85 studies initially identified, 7 were fully reviewed, and their outcome measures were extracted and analyzed. In conclusion, the levels of balance seem to be closely related to the success of competitions, leading coaches to consider its development during training sessions. In this sense, the general practice of goalball may be sufficient at children's levels, while the practice of 2 days or 5 h per week seems to be an adequate reference. However, athletes with partial levels of visual loss should not be subjected to continuous blinding during training sessions because it could lead to an accelerated reduction in balance levels.

**Keywords:** paralympic; motor control; physical activity; disabled; balance



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## 1. Introduction

Goalball, practiced by visually impaired athletes, has been established as a reference sport at different levels ranging from school and leisure [1] to international and Paralympic [2–4] levels; thus, goalball is the best-known team sport among visually impaired people [5]. This sport faces two teams of three players for 20 min on an 18 × 9 m court divided into six areas, easily recognizable to the touch by their relief, and which facilitate the location of the players. In this Paralympic sport, the detection of the ball requires a developed auditory sense to detect the sound of the bells that are inside [6]. What is specific about this sport is that it requires a developed sense, and spatial orientation is also necessary for good physical condition [7]. All these components will allow the detection of the ball before it is introduced into one of the 9-m-long goals, and the subsequent throw to try to score a goal [8].

Visually impaired athletes can be sedentary and engage in lower physical activity, having lower physical conditioning than their sighted peers [9]. However, the practice of this sport leads visually impaired goalball athletes to present different peculiar features in physical, psychological, and cognitive spheres [1]. In this sense, Petrigna et al. [1] defined the main features in three levels: (i) a reduction in body fat mass and increment in body mass index [10], (ii) health-related physical fitness and conditioning characteristics,

and (iii) positive effects on postural control capacity and on auditory reaction speed and hearing duration compared with people than practice other sports. However, since visual and auditory abilities are considered the most crucial sensory information in the process of maintaining postural control [11], and considering goalball athletes have the vision overridden by the masks necessary for the practice of goalball [12], balance seems to be a limitation to practice goalball rather than a positive effect, highlighting in one of the main concerns for goalball community [13].

The physiological rationale belongs to the stimuli that a player receives through the vestibular, auditory, and muscular systems [14]. Any deterioration in visual perception and hearing ability will affect the maintenance of balance as a result of the damaged vestibular system and the deterioration of the connections between the neural structures in the higher centers [13]. In this sense, Karakoc [15] states that the most important problem in congenitally blind people is the functional insufficiency of the balance centers due to the inability to visually perceive an external stimulus. Therefore, even if the vestibular system, proprioceptors, and antigravity muscles are fully efficient, the absence of visual perceptions will have a detrimental effect on both standing static balance or dynamic balance [15]. Therefore, it seems that balance will represent the main difficulty for goalball practitioners.

So, despite some authors ratifying the limitation that visual impairment supposes in goalball practice, other scientific researchers encourage visually impaired people to practice goalball to improve balance. The main reason may be the mandatory nature of maintaining adequate control of body posture despite a series of destabilizing factors [2]. In this scenario, different authors have tried to investigate the real effects of goalball on balance and its relevance for visually impaired goalball athletes [2,16].

To date, despite the interest of different authors in the development of scientific articles with goalball athletes, a single review has been published on the development of physical fitness (i.e., aerobic capacity, body composition and the functioning of the shoulder extensors [1]. However, and to the knowledge of the authors, there are no systematic reviews that have analyzed the effects and relevance of goalball practice in balance. Therefore, the objective was to systematically review those studies that evaluated balance in goalball athletes. This review can be very useful for coaches and physical trainers of this sport.

## 2. Materials and Methods

A systematic review was performed following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [17] and guidelines for performing systematic reviews in sport sciences [18]. The procedure realized for data identification, selection, and extraction is presented in Figure 1.

### 2.1. Data Sources

A systematic electronic search was computed from PubMed ( $n = 18$ ) and Web of Science ( $n = 61$ ) on 1 March 2021. The authors were not blinded to journal names or manuscript authors. The search strategy combined terms covering the topics of the population (Goalball) and outcomes (balance). These terms were separated using AND.

### 2.2. Data Collection

One of the authors downloaded the primary data from the articles (title, authors, date, and database) to an Excel spreadsheet (Microsoft Excel 2016, Microsoft, Santa Rosa, CA, USA) and removed the duplicate records. Then, two authors screened the search results independently against inclusion/exclusion criteria (Table 1). The references that could not be eliminated by title or abstract were retrieved and independently evaluated for inclusion. The authors were not masked to the title or authors of the publications. Any disagreements on the final inclusion-exclusion status were resolved through discussion in both the screening and excluding phases, and the final decision was an agreement between authors. Abstract and conference papers from annual meetings were not included due to

the lack of information needed to systematize. The additional information provided by the authors was considered during the screening process. The lack of other forthcoming details led to the article being excluded. Documents from all languages were included but were excluded if a translation could not be carried out.

**Table 1.** Eligibility criteria.

	Inclusion Criteria	Exclusion Criteria
Population	Goalball players from any age group, competitive level or sex.	Sports other than Goalball.
Exposure	Articles where athletes play goalball.	Articles where the athletes do not play goalball.
Comparator	-	-
Outcome	Articles where the balance was assessed.	Article where the balance was not assessed.
Other	Only original studies (not restricted to any language).	Other article types (e.g., reviews, letters to editors, trial registrations, proposals for protocols, editorials, book chapters and conference abstracts).

### 2.3. Data Selection

The following information was extracted from the included original articles: (i) sample; (ii) athletes' level; (iii) assessment method; (iv) intervention; (v) comparison sample; (vi) results; and (vii) conclusions.

### 2.4. Methodological Assessment

The methodological assessment process was performed by two authors (JRC and MRG) using an adapted version of the STROBE assessment criteria [19], looking at studies eligible for inclusion. Each article was assessed based on 10 specific criteria (see Table 2). Any disagreement was discussed and solved by consensus decision. Each item was evaluated using numerical characterization (1 = completed; and 2 = non-completed). As suggested by O'Reilly et al. [19], each study rating was qualitatively interpreted by the following law: the study has a risk of bias or low quality with lower punctuation than 7 points, while those studies with greater punctuations are considered a low risk of bias or high quality.

## 3. Results

A total of 85 articles were initially retrieved from the mentioned databases. After duplicated removal, a total of 83 articles were analyzed, contemplating exclusion and inclusion criteria. Finally, the full text of 16 studies was read and due to a lack of vital information, 9 studies were not considered. Therefore, 7 articles were included in this review (Figure 1).

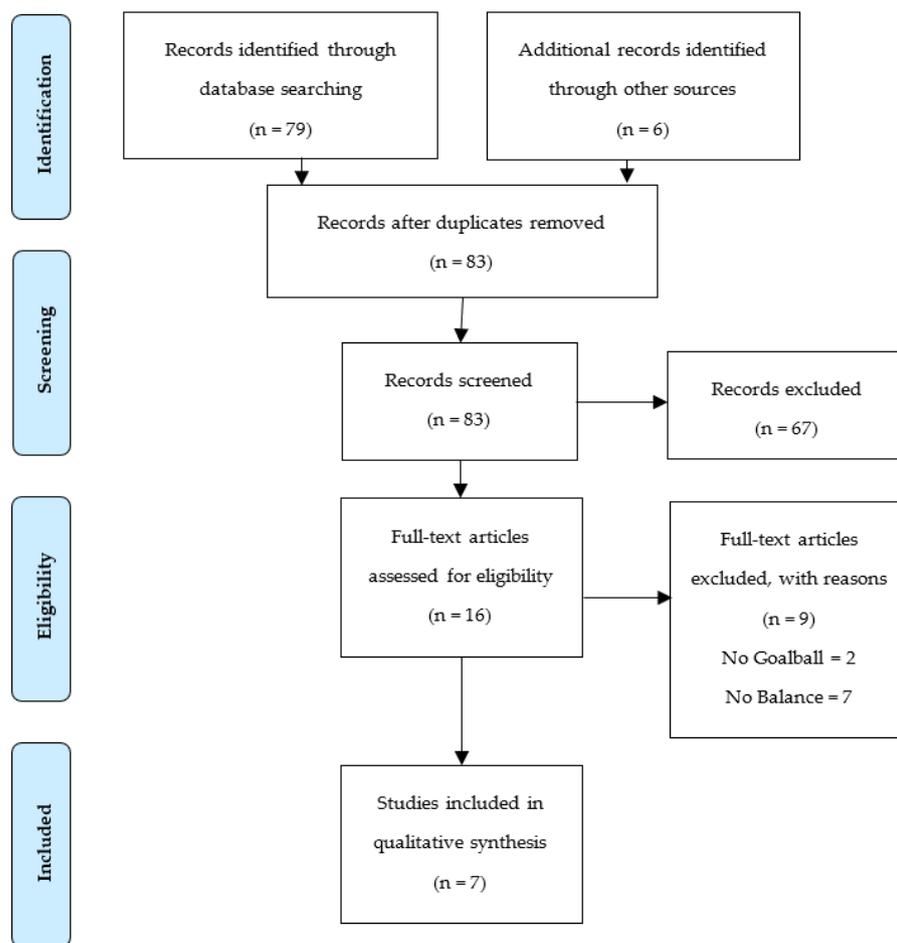


Figure 1. PRISMA flow diagram.

### 3.1. Methodological Quality

The overall methodological quality of the studies can be found in Table 2.

Table 2. Methodological assessment of the included studies.

Reference	1	2	3	4	5	6	7	8	9	10	Quality
Akinoglu and Kocahan [17]	1	0	1	1	1	1	1	0	1	1	High
Aras et al. [20]	1	0	1	1	1	1	1	0	1	1	High
Aydoğ et al. I [21]	1	0	1	1	1	1	1	0	0	0	Low
Bednarczuk, Wiszomirska et al. [7]	1	0	1	1	1	1	1	0	0	1	Low
Bednarczuk, Molik et al. [2]	1	0	1	1	1	1	1	0	0	1	Low
Kornev et al. [22]	1	0	1	1	1	1	1	0	1	0	Low
Santos et al. [23]	1	1	1	1	1	1	1	0	1	1	High

Note: provide in the abstract an informative and balanced summary of what was carried out and what was found (item 1); state-specific objectives, including any prespecified hypotheses (item 2); Give the eligibility criteria, and the sources and methods of selection of participants (item 3); for each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group (item 4); explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why (item 5); give characteristics of study participants (item 6); summarize key results with reference to study objectives (item 7); discuss limitations of the study, considering sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias (item 8); give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (item 9); give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based (item 10).

### 3.2. Study Characteristics

Characteristics of studies are summarized in Table 3.

**Table 3.** Characteristics of individual studies.

Reference	Sample (n)	Assessment Tool	Assessment Test	Comparisons	Results	Conclusions	
Akinoglu and Kocahan [16]	20	Paralympic athletes	Human Body Equilibrium 360	Maintain a static position on two legs for 50 s. One leg balance for 30 s.	Goalball players with visual disability vs. athletes with hearing impairment.	No overall, significant differences found. However, in one leg balance test shown fewer balance level than athletes with hearing impairment.	The imbalance and balance of muscle strength in people with disabilities will be an important issue in goalball training programs.
Aras et al. [20]	13	National athletes	Biodex Balance System SD (Biodex Medical Systems, Shirley, New York).	Global balance test (OSI) (3 bouts × 20 s with 10 s recovery). Fall hazard test (2 bouts × 30 s with 10 s recovery).	Blind goalball athletes and judo athletes with and without visual impairment.	Athletes without disabilities perform better for balance and risk of falling. However, all the parameters of balance and risk of falling showed a deterioration in athletes without disabilities. No significant changes in any of the static or dynamic balance parameters were found in goalball players.	Balance training with eyes closed may affect performance in team sports.
Aydoğ et al. [21]	20	University athletes	Balance system SD Biodex (Biodex, Inc., Shirley, New York),	Bilateral stance at level 8 using balance system for 20 s.	Blind Goalball Athletes with Sighted People and Sedentary Blind People.	Stability of goalball players was better than sedentary blind in mediolateral balance.	Dynamic postural stability was shown to be affected by vision. Blind people who play goalball 1–2 days a week were found to have greater mediolateral stability than sedentary sighted people
Bednarczuk, Wiszomirska et al. [7]	37	National athletes	Stabliographic platform AMTI AccuSway Force platform (ACS Model)	Standing with both legs with eyes open and closed. Standing with one leg with eyes open and closed.	Goalball athletes with visually impaired shooters.	Static balance of visually impaired athletes differs significantly in single leg stance.	In the tests carried out with both feet, it did not differentiate the athletes in terms of the sport they practiced. Goalball players demonstrated higher levels of balance in the one-leg test with eyes closed
Bednarczuk, Molik et al. [2]	65	Paralympic athletes	AMTI AccuSway Stabilographic platform (ACS Model).	Standing with one leg with eyes closed for 10 s. Standing with one leg with eyes open for 10 s.	Goalball athletes were divided into groups considering level, disability experience, training experience, and training loads.	Higher level of static balance athletes who reached the final rounds.	The study revealed the importance of static balance in achieving excellence in goalball.
Kornev et al. [22]	22	Young athletes	Electrometry Electronic micrometer	Romberg test	Control group (no sport participants) vs. experimental group (Goalball young players).	Children who did not train goalball perform worse on the Romberg test than those who do train goalball at least one day a week. Girls who do not play goalball, on average, score lower (2 s difference from girls who regularly practice goalball).	The study wants to contribute, with the results obtained in the Romberg test (static balance), to the inclusion of goalball in the physical education class to strengthen and increase the development of physical qualities, as well as teach vital motor skills for children and school-age girls.
Santos et al. [23]	12	Regional and national athletes	Force platform (AccuSway PLUS, AMTI, EE.UU)	Standing with feet together on the medial line of the body, arms relaxed at the side of the body and with the head in a neutral position (3 bouts × 35 s with 2 min rest).	Goalball players vs. futsal and judo players.	The main finding of this study is that athletes with total vision loss had better semi-static bipedal postural balance capacity than athletes with partial vision loss.	Goalball athletes oscillate less and have lower travel speed than judokas. These differences may be related to the specificities and requirements of each sport, such as the obligation to wear eye masks in goalball, which can produce chronic differentiated adaptations of the systems related to maintaining balance.

#### 4. Discussion

The objective of the present article was to systematically review those studies that evaluated balance in goalball athletes. The main findings were: (i) the levels of balance seem to be closely related to the success of the competitions; (ii) the general practice of goalball may be sufficient for the development of balance at educational levels, while the practice of 2 days or 5 h per week seems to be a suitable reference; and, (iii) athletes with partial levels of visual loss should not be subjected to continuous blinding that can lead to an accelerated loss of their balance levels.

Goalball is a sport practiced by athletes with visual disabilities [1]. Since it has been shown that the absence of visual perception influence both standing static balance and dynamic balance [15], goalball athletes are subjected to training in this crucial capacity to achieve optimal performance [21]. Therefore, the objective of the review was to analyze the studies that have assessed balance in goalball.

As a result of the present review, it has been found that the development of this capacity assumes crucial importance from athletes from the young level [22] to the national level [7,20,23] and even Paralympic [2,16], including intermediate levels such as regional and/or university [21,23]. The summary of these articles may highlight the importance of balance in goalball athletes, leading coaches to establish certain training strategies to develop this quality.

In younger age groups, Kornev et al. [22] divided 42 visually impaired children (28 boys and 14 girls) aged from 12 to 15 years (mean  $13.5 \pm 0.9$  years) into two groups: regular goalball practice and no participation in this modality. The Romberg test was used to assess athletes' balance levels. The results showed significant differences between the boys/girls who practice goalball at least one session a week, and the boys who do not engage in this sport. Kornev et al. [22] suggested that these differences are due to the fact that children who practice goalball feel safer and more comfortable during the test than participants that are not enrolled in this sport.

At the regional level, Aygog et al. [21] enrolled a sample of 20 university athletes, while Santos et al., [23] took into account regional athletes. In the first article, Aygog et al. [21] focused on dynamic postural stability in blind athletes using the Biodex stability system (Biodex, Inc., Shirley, NY, USA). The participants were blind athletes, sighted subjects (with eyes open and closed) and sedentary blind persons. The results showed that athletes who practiced goalball at least 1-2 days a week obtained a greater development of mediolateral stability than sedentary sighted people [21]. On the other hand, Santos et al. [23] evaluated stability with a force platform (AccuSway PLUS, AMTI, Waltham Street, Watertown, MA, USA) by subjecting 12 regional participants to a test with their feet together in the medial line of the body for 35 s in 3 bouts with a 2 min rest between bouts. The results showed that goalball athletes can assume differentiated chronic adaptations with respect to subjects who practice other sports such as judo or futsal. In addition, it has been shown that athletes with total vision loss have a greater capacity for semi-static bipedal postural balance than athletes with partial losses [23]. The main reason may be due to goalball athletes assume the obligation to blindfold, which can lead them to develop balance more quickly.

The athletes at the national level who participated in the aforementioned studies developed by Santos et al. [23] shared results with previous studies which considered athletes from regional levels. In this line, Aras et al. [20] supported these results after finding that the visual system plays a crucial role in balance, showing how athletes with visual disabilities have a vestibular system and more advanced proprioceptive senses for the maintenance of this ability, although it details that blindfolding athletes without visual impairment can lead to impaired balance when the eyes are closed. Finally, Bednarczuk et al. [7] subjected 37 national players to a test on a stabilographic platform (AMTI AccuSway force platform, ACS Model) in which athletes had to stand on both feet (test 1) and on one foot (test 2) with eyes open and closed. The results showed that, although with test 1 there were no differences with other athletes of other modalities, the goalball players demonstrated higher levels of balance in test 2 with their eyes closed. All these

results carried out at the regional and national levels suggest that the practice of goalball is a stimulant for the development of balance in athletes with total visual loss, although caution should be exercised with subjecting athletes with partial losses to continue training with the mask.

Finally, the evidence that visual loss induces lower levels of balance seems conclusive even with Paralympic athletes [16]. In this study, Akinoğlu and Kocahan [16] compared bipodal and unipodal balance in athletes with visual (goalball) versus athletes with hearing impairment. The results were supported by the aforementioned ideas that the single-leg balance test was lower in athletes with visual loss. Therefore, a set of these studies suggest that the determination of the imbalance and balance of muscular strength in people with disabilities will be crucial in training program design [16]. In this sense, Bednarczuk, Wiszomirska et al. [7] showed that athletes who trained more than 5 h a week showed a better balance compared with those who practiced less than 5 h a week.

In brief, levels of balance seem to be closely related to success in sports such as goalball, at least, in professional athletes. It is supported by Bednarczuk, Molik et al. [2] who analyzed the balance of Paralympic goalball athletes and related them to the final ranking of a tournament (London Olympics 2012), finding higher levels of this ability in those athletes who participated in the final rounds of the championship. At an educational level, the practice of goalball may be enough to develop this capacity, while at a regional level, the consideration of 2 days or 5 h per week seems to be an adequate reference. However, athletes with partial levels of visual loss should not be subjected to continuous blinding which can lead to an accelerated loss of balance levels. All these findings should be considered with caution due to the small number of articles published to date.

## 5. Conclusions

Balance is a fundamental competence in goalball athletes, which makes its development essential in training programs. As a result of this review, it can be concluded that blindness caused by the use of masks promotes the development of balance. However, goalball athletes without complete vision loss may suffer loss of balance after continuous training with the use of the mask. However, most studies are focused on evaluating the balance of goalball athletes, however, future studies could consider the influence of certain exercises as a complement to regular training to accelerate the development of this ability.

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