

Didactic unit based on goalball: Effects on balance and reaction time in schoolchildren without visual impairment

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ABSTRACT

Para-sports as a core component of educational content constitute a key space for motor development and the promotion of inclusive practices within the school context. In this context, adapted sports such as goalball have emerged as pedagogical tools that foster participation and raise awareness of disability; however, scientific evidence regarding the development of motor skills in students without disabilities remains limited. To evaluate the effect of a goalball-based didactic unit on static balance, dynamic balance, and reaction time in secondary school students simulating a visual impairment. A quantitative quasi-experimental study was conducted. The sample consisted of 22 school students (mean age = 16.83 ± 0.54 years) from an educational institution in south-central Chile. The intervention was eight weeks in duration and comprised nine sessions, applied under two conditions: with visual restriction (blindfolded) and without visual restriction. Static balance was assessed using the Flamingo Balance Test, dynamic balance using the Y Balance Test, and reaction time using the Plate Tapping Test. Significant improvements were observed in static balance ($p = .008$; $\eta^2 = .16$), with large effect sizes in both conditions and a greater magnitude of improvement in the blindfolded condition. Dynamic balance showed slight increases, reaching significance only in the non-blindfolded condition, while reaction time did not exhibit significant changes. The goalball-based didactic unit primarily enhances static postural control and proprioceptive stimulation in students without visual impairment, confirming its value as a pedagogical resource in physical education.

Keywords: Physical education, Goalball, Static balance, Dynamic balance, Reaction time, Inclusive education, School students.

Cite this article as:

Valderrama-Piñones, C., Rodríguez, P., Muñoz-Hinrichsen, F., Arroyo-Rojas, F., Luarte-Rocha, C., & Campos-Campos, K. (2026). Didactic unit based on goalball: Effects on balance and reaction time in schoolchildren without visual impairment. *Journal of Human Sport and Exercise*, 21(2), 705-720. <https://doi.org/10.55860/511qt120>



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Submitted for publication February 09, 2026.

Accepted for publication March 11, 2026.

Published March 18, 2026.

[Journal of Human Sport and Exercise](#). ISSN 1988-5202.

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doi: <https://doi.org/10.55860/511qt120>

INTRODUCTION

In Chile, the integration of students with disabilities into the school system is supported by a regulatory framework that promotes access, participation, and educational equity (Law Decree 170, 2009; Law Decree 83, 2015; Law 20,422, 2010; Law, 20,845, 2015). Nevertheless, progressing from integration toward effective inclusion remains a challenge, particularly in the field of physical education (PE), where pedagogical practices must simultaneously address motor, social, and educational objectives (Muñoz-Hinrichsen et al., 2024). In this context, sport is not just seen as a physical or recreational activity, but also as a social phenomenon and a powerful pedagogical tool with significant formative potential. It has the ability to contribute to students' holistic development and foster the creation of educational environments that promote inclusivity as a personal experience (Corrales, 2010; Gamonales & Campos Galán, 2017; Hernández-Beltrán et al., 2024; Noguera, 1995).

Adapted sport has emerged as a key pedagogical strategy within PE, as it allows students to experience conditions of functional diversity (e.g., visual restriction). This strategy can contribute to the development of positive attitudes toward disability, value education, and provide equal opportunities (Abellán, Sáez-Gallego, & Carrión, 2018; Abellán, Sáez-Gallego, & Reina, 2018; Campos-Campos et al., 2023; Hernández-Beltrán et al., 2017). As such, for us, inclusive education involves more than the mere coexistence of students with and without disabilities in the same space (Haegele, 2019). Following Haegele (2019), inclusion entails an intersubjective experience of belonging, acceptance, and appreciation, in which each student constructs meaning within the shared educational environment. Accordingly, the implementation of adapted sports in school contexts has demonstrated benefits in promoting healthy lifestyles and improving participation and peer interaction among students with and without disabilities (Hernández-Beltrán et al., 2017).

Within this framework, goalball, as an adapted sport, has become established as a sporting modality that promotes participation under equal conditions through the restriction of vision using blindfolds (International Blind of Sports Federation, 2024). Although goalball is specifically designed for individuals with visual impairments, its use as a pedagogical tool in educational contexts, involving students without disabilities, has shown positive effects (Gamonales et al., 2023). For example, at the socio-emotional level, goalball has been shown to enhance cooperation, empathy, respect for diversity, and peer interaction (Gamonales et al., 2023; Laughlin & Happel, 2016). At the motor level, although there is evidence reporting benefits associated with its practice, the available empirical evidence remains limited (Ojeda-Troncoso & Campos-Campos, 2025). Thus, goalball can be positioned as a relevant pedagogical tool for integrated PE –where students with and without disabilities are educated in the same environment– by providing an intervention context that combines social sensitization experiences with motor challenges that remain underexplored empirically, particularly among students without disabilities.

Goalball practice is characterized by high demands on postural control and motor responses to non-verbal stimuli (Santos et al., 2018). Balance, understood as the ability to maintain the centre of gravity within the base of support, depends on the integration of visual, vestibular, and somatosensory systems (Cohen, 2013; Grace-Gaerlan et al., 2012). Diverse studies have shown that visual restriction significantly affects balance, increasing postural sway and reducing stability, both in individuals with visual impairments and in individuals without visual impairments subjected to visual restriction (Zetterlund et al., 2019; Bataller-Cervero et al., 2022). In this context, simulating a visual impairment through goalball practice forces a reorganization of postural control, enhancing the use of proprioception and other sensory channels as compensatory strategies (Bednarczyk et al., 2017).

Alongside balance, reaction time constitutes another key capacity in goalball, as it determines defensive and offensive effectiveness in response to rapid and unpredictable auditory stimuli (Morales & Torres, 2016; Muñoz-Jiménez et al., 2021). The absence of visual information increases reliance on auditory and proprioceptive cues, requiring faster and more precise motor responses (Ince, 2021). In this regard, visual restriction has shown to increase demands on motor control reorganization processes, directly impacting response speed to external stimuli (e.g., sound) (Bataller-Cervero et al., 2022; Gökşen & Ince, 2024). Likewise, adapted sports such as goalball can promote neural plasticity and the use of alternative perceptual channels, consolidating reaction time as a relevant capacity at both sporting and educational levels (Silva et al., 2010).

From a social and educational perspective, the relevance of this study is particularly significant in the Chilean context. National reports demonstrate that 17.01% of the Chilean population presents some type of disability (Encuesta Nacional de la Discapacidad [ENDISC], 2022). Moreover, a substantial proportion of children and adolescents with disabilities attend primary (92.9%) and secondary education (81.2%), respectively, reinforcing the need for inclusive, evidence-based pedagogical practices in integrated educational settings (ENDISC, 2022). However, scientific evidence regarding the effects of goalball, for example, on school-aged populations without visual impairments remains limited, particularly concerning specific motor variables such as balance and reaction time.

While previous studies have incorporated adapted sport into PE classes with a predominantly sensitization-oriented focus and with value-based and participation-related outcomes, their impact on the development of motor skills and abilities has been limited (Abellán, Sáez-Gallego, & Reina, 2018; Campos-Campos et al., 2023; Hernández-Beltrán et al., 2017). Therefore, the present study focuses exclusively on the analysis of motor outcomes. As such, the aim of this study was to evaluate the effect of a goalball-based didactic unit on static balance, dynamic balance, and reaction time in secondary school students simulating visual impairment.

METHODS

Study design

This study followed a quantitative approach using a quasi-experimental design without a control group, with pre- and post-intervention measurements and a descriptive scope.

Participants

Using a non-probabilistic convenience sampling method, 22 secondary school students (female and male) from an educational institution located in south-central Chile participated in this study. The mean age of the participants was 16.83 ± 0.54 years. Participation was voluntary and required both student assent and informed consent from their parents or legal guardians prior to the start of the intervention. In addition, the necessary approvals were obtained from the school management team where data collection took place. This study was approved by the Scientific Ethics Committee of the Universidad Adventista de Chile (Adventist University of Chile) under approval number 2025-002.

Inclusion criteria

The inclusion criteria were: (a) enrolment in the elective PE course entitled “*Promotion of Active and Healthy Lifestyles*” and (b) submission of signed informed consent and assent, as applicable.

Exclusion criteria

The exclusion criteria were: (a) failure to complete all assessments during the pre- and post-test phases and (b) medical leave or health-related justifications that prevented full physical participation in the implemented activities

Instruments

Static balance

Static balance was assessed using the Flamingo Balance Test, whose validity and test–retest reliability were demonstrated by Tsigilis et al. (2002), reporting an intraclass correlation coefficient (ICC) of .73. The test was performed barefoot, with the participant standing on one foot on a non-slip beam measuring 50 cm in length, 4 cm in height, and 3 cm in width (Ünal et al., 2024), while the free leg was flexed at the knee and held with the hand on the same side. Timing began once the initial position was released and was stopped each time the participant lost balance. If the participant lost balance 15 times within the first 30 seconds, the test was terminated and assigned a score of 31 (Grosej et al., 2019). The test outcome corresponded to the number of attempts rather than the number of errors; therefore, a lower score indicated better static balance performance.

Dynamic balance

Dynamic balance was assessed using the Y Balance Test (YBT). During testing, participants stood barefoot in a single-leg stance on a central platform connected to three pipes oriented in the anterior, posteromedial, and posterolateral directions. Using the free limb, participants pushed a reach indicator that slid along the pipe. The trial was discarded and repeated if: (1) the stance foot was lifted from the platform or crossed the marked line, (2) the participant kicked, pushed, or stepped on the reach indicator, (3) the reaching limb touched the ground, or (4) balance was lost before returning to an upright position (Alkhatami, 2023).

For each direction, one practice trial was performed followed by three valid trials. The greatest reach distance (in centimetres) recorded in each direction was used for analysis. A composite score was calculated and expressed as a percentage of limb length using the formula:

$$[(\text{Anterior} + \text{Posteromedial} + \text{Posterolateral}) / (3 * \text{Limb length}) * 100].$$

Limb length was measured in centimetres from the anterior superior iliac spine to the most distal portion of the medial malleolus (Foldager et al., 2023; Plisky et al., 2021).

Reaction time

Reaction time was assessed using the plate tapping test (Ince, 2021). Participants were positioned in front of a table equipped with a board containing two circular metal plates (20 cm in diameter) separated by 80 cm between their centres. The non-dominant hand was placed on a rectangular plate (30 × 20 cm) located in the centre of the board. Participants were instructed to perform 25 consecutive taps with the dominant hand on the circular plates as quickly as possible. Timing stopped when a total of 50 taps had been completed (Council of Europe, 1983). A shorter completion time indicated better reaction time performance. The procedure was repeated twice, and the best recorded time was used for analysis.

Intervention

The intervention followed a self-developed protocol lasting 8 weeks, distributed across nine sessions of 60 to 90 minutes each (Table 1). It was implemented within the elective PE course “*Promotion of Active and*

Healthy Lifestyles”, addressing learning objectives numbers 1, 2, and 5 established by the Chilean Ministry of Education (Ministerio de Educación, 2019).

The activity design was based on guidelines from the *Goalball Manual* (Gómez & Tosim, 2016) and the *Paralympic Sport Initiation Manual: Goalball* (Aparecido de Oliveira & Pereira da Silva, 2022), which were adapted to the school context of the study. Sessions included individual, paired, and group-based tasks, predominantly using blindfolds to simulate visual impairment, thereby promoting static and dynamic balance as well as reaction speed. This approach aligned with the pedagogical model proposed by the Chilean Ministry of Education, which emphasizes the development of motor skills and adaptation to diverse contexts within PE classes. Additionally, medicine ball throws, locomotor tasks, and authentic goalball game situations were incorporated.

Table 1. Intervention program.

Session	Objective	Activities	Use of blindfolds	Duration
1	<ul style="list-style-type: none"> To become familiar with the Paralympic sport of Goalball. To strengthen motor and sensory coordination. 	<ul style="list-style-type: none"> Presentation on the history of the sport, its objectives, equipment, defensive and offensive fundamentals, and rules, supported by audiovisual materials. Discussion on the differences between Paralympic sport and adapted sport. Familiarization with the equipment used in Paralympic Goalball. Practical demonstration of basic rules. 	<ul style="list-style-type: none"> No No No No 	90 minutes
2	<ul style="list-style-type: none"> To develop strength and accuracy in throwing. To apply basic game rules in practical situations. 	<ul style="list-style-type: none"> Specific warm-up: guided jogging and joint mobility exercises. Throwing and reaction speed stations: chest passes, overhead throws, and hip rotation throws. Target throwing using different techniques. Defensive movement drills. Application in real game situations. 	<ul style="list-style-type: none"> Yes No No Yes Yes 	90 minutes
3	<ul style="list-style-type: none"> To improve reaction speed to auditory stimuli. To refine defensive movements in game-like conditions. 	<ul style="list-style-type: none"> Specific warm-up: guided jogging and joint mobility exercises. Auditory reaction exercises: rapid throws with immediate defensive response; tracking the ball after rebounds or directional changes. Defensive circuit: lateral movements and zone blocking. Fast passing in pairs with changes of direction. Mini-games (1 vs. 1) emphasizing reaction speed in both defence and offense. 	<ul style="list-style-type: none"> Yes Yes Yes Yes Yes 	90 minutes
4	<ul style="list-style-type: none"> To enhance strength and speed in Goalball throwing. To improve coordination and application in real game situations. 	<ul style="list-style-type: none"> Specific warm-up: guided jogging and joint mobility exercises. Throws using a medicine ball. Throwing and receiving drills in lines (two groups). Guided coordination circuit. Game-like situations. 	<ul style="list-style-type: none"> Yes Yes Yes Yes Yes 	90 minutes

5	<ul style="list-style-type: none"> To improve strength and postural control for Goalball throwing. To improve balance and spatial orientation during movement. 	<ul style="list-style-type: none"> Specific warm-up: guided jogging and joint mobility exercises. Workstations: medicine ball throws against a wall; balance exercises on a BOSU with auditory instructions combined with guided straight-line running; rapid blocking following auditory signals (auditory stimulation and reaction). Small-sided games (1 vs. 1 and 2 vs. 2) emphasizing balance maintenance and control during offensive and defensive actions. 	Yes	60 minutes
6	<ul style="list-style-type: none"> To improve coordination and orientation through auditory stimuli. To enhance balance and teamwork in adapted activities. 	<ul style="list-style-type: none"> Specific warm-up: guided jogging and joint mobility exercises. Group game: collecting materials guided by auditory cues within a set time. Balance station: obstacle course on a BOSU with guidance, performed in teams (the fastest team wins). Line movements: forward movement, turn, and return following auditory guidance. Applied final game: paired reaction speed dynamics using auditory stimuli and movement. 	Yes	60 minutes
7	<ul style="list-style-type: none"> To strengthen accuracy and power in Goalball throws. To improve reaction speed and blocking in real game situations. 	<ul style="list-style-type: none"> Joint mobility exercises. Frontal throws using medicine balls. Throws performed from a BOSU (balance and body control training). Reaction to auditory stimuli, rapid movements, and blocking drills. Game-like situation (3 vs. 3). 	Yes	90 minutes
8	<ul style="list-style-type: none"> To promote cooperation and spatial orientation through auditory stimuli. To apply passing techniques and gameplay in reduced Goalball situations. 	<ul style="list-style-type: none"> Specific warm-up: guided jogging and joint mobility exercises. Cooperative sound maze: obstacle course with one guide, transporting the group from one side to the other. Goalball passing drills: zig-zag dynamics with back-and-forth movement; the group completing the task in the shortest time wins. Small-sided game applying passes, blocks, and auditory orientation. 	Yes	60 minutes
9	<ul style="list-style-type: none"> To integrate the skills learned into real Goalball situations. To promote reflection on learning, inclusion, and teamwork. 	<ul style="list-style-type: none"> Cooperative warm-up: activation game in pairs (with and without auditory stimuli). Integrative circuit of stations: precision throwing to targets; auditory reaction with movement and blocking; dynamic balance in an obstacle course. Goalball match. Group discussion reflecting on learning outcomes achieved during the intervention. 	Yes	60 minutes

Procedures

First, the educational institution was visited to present the voluntary intervention plan to students enrolled in the elective course “*Promotion of Active and Healthy Lifestyles.*” All participants received assent and informed

consent forms, which were required to be signed by both the students and their parents or legal guardians. Once the signed consent and assent forms were obtained, baseline data collection (pre-test) was conducted.

Assessments were carried out in the school gymnasium during regular class hours, under the supervision of the principal investigator and with PE teacher support. Each student was assessed under two experimental conditions: a non-blindfolded condition (without blindfold; WOB), representing normal visual input, and a blindfolded condition (with blindfold; WB), simulating visual impairment. All assessments were conducted following the standardized protocols established for each test. After completion of the assessments, an 8-week intervention was implemented (Table 1). At the end of the intervention, physical assessments (post-test) were repeated in the school gymnasium. For the analysis of results, only students who completed both the pre-test and post-test were included.

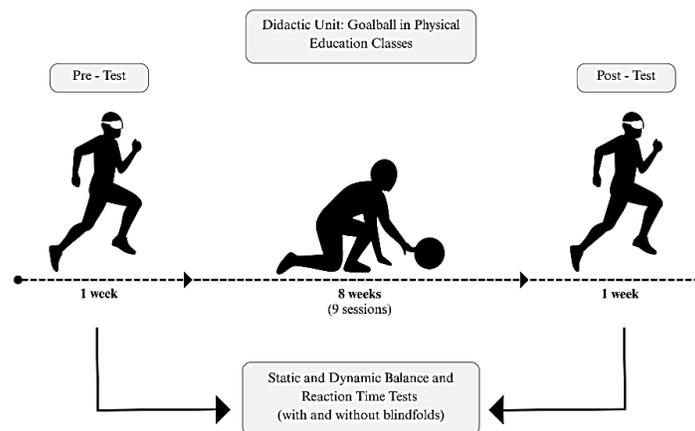


Figure 1. Intervention overview.

Statistical analysis

Sample size was estimated a priori using G*Power version 3.1.9.7, assuming a large effect size ($f = 0.40$), based on previous evidence reporting moderate to large effects (Bednarczuk et al., 2019; Zetterlund et al., 2019). The analysis considered a significance level of $\alpha = .05$, a desired statistical power of 0.80, two measurements, and a moderate correlation between repeated measures ($r = 0.50$), with a sphericity correction of $\epsilon = 1$. Under these assumptions, the minimum required sample size was 15 participants. In this context, the final sample of 22 students was considered adequate and sufficient to meet the study objectives.

Descriptive data were presented using means and standard deviations for static balance (n), dynamic balance (%), and reaction time (s), given that the data showed a normal distribution according to the Shapiro–Wilk test.

Subsequently, to compare outcomes, a repeated-measures ANOVA with two within-subject factors (time: pre vs. post; condition: with blindfold vs. without blindfold) was applied to evaluate main effects and interactions between the study variables. When the time \times condition interaction was significant, post hoc comparisons with Bonferroni corrections were conducted to identify differences between assessment moments (pre vs. post) and between conditions (with and without blindfold).

The effect size of the interaction was estimated using partial eta squared (η^2), interpreted as small (.01), medium (.06), and large (.14) (Pallant, 2011). For multiple comparisons, effect size was calculated using

Cohen's d , with the following qualitative thresholds: trivial ($<.20$), small ($.21 - .49$), moderate ($.50 - .79$), and large ($>.80$) (Cohen, 1992).

As a complementary analysis, the individual relative delta was calculated for each variable and condition. For variables in which an increase in post-intervention scores represented improved performance (e.g., dynamic balance), the relative delta was calculated using the equation: $[(\text{Post value} - \text{Pre value}) / \text{Pre value}] * 100$. Conversely, for variables in which a decrease in post-intervention scores indicated improved performance (static balance and reaction time), the relative delta was calculated using the equation: $[(\text{Pre value} - \text{Post value}) / \text{Pre value}] * 100$. Based on these values, the absolute change by condition and the difference between conditions ($\Delta\text{WB} - \Delta\text{WOB}$) were estimated, along with their 95% confidence intervals, which were displayed using a forest plot. Positive values indicated greater improvement in the WB (with blindfold) condition, whereas negative values reflected a relative advantage of the WOB (without blind fold) condition.

Statistical analyses were performed using RStudio V 4.5.0. Statistical significance was set at $p < .05$.

RESULTS

The results of the repeated-measures ANOVA for static balance, dynamic balance, and reaction time under the WB and WOB conditions, comparing pre- and post-intervention time points, are presented in Table 2.

Regarding the time \times condition interaction, a significant effect was observed only for static balance ($F_{(1,42)} = 7.80, p = .008, \eta^2 = .157, \text{large effect}$). In contrast, no significant interactions were found for dynamic balance ($F_{(1,42)} = 0.00, p = .973, \eta^2 = .000$) or reaction time ($F_{(1,42)} = 0.01, p = .920, \eta^2 = .000$).

With respect to between-condition effects, a significant main effect of condition was identified for static balance ($F_{(1,42)} = 49.29, p < .001, \eta^2 = .540, \text{large effect}$), indicating overall differences between the WB and WOB conditions across both measurement time points. No significant between-condition differences were observed for dynamic balance ($F_{(1,42)} = 1.77, p = .191$). For reaction time, a significant main effect of condition was found ($F_{(1,42)} = 4.39, p = .042, \eta^2 = .095, \text{medium effect}$); however, given the absence of a time effect and a significant interaction, this result reflects a general difference between conditions rather than an intervention-related effect.

Table 2. Repeated-measures ANOVA results.

Variable	Effect	F _(df)	p - Value	η^2 partial
Static balance (n)	Condition	$F_{(1,42)} = 49.29$	$<.001$	.540
	Time	$F_{(1,42)} = 182.55$	$<.001$	.813
	Interaction	$F_{(1,42)} = 7.80$	.008	.157
Dynamic balance (%)	Condition	$F_{(1,42)} = 1.77$	.191	.040
	Time	$F_{(1,42)} = 15.53$	$<.001$	.270
	Interaction	$F_{(1,42)} = .00$	.973	.000
Reaction time (s)	Condition	$F_{(1,42)} = 4.39$	.042	.095
	Time	$F_{(1,42)} = .07$	.790	.002
	Interaction	$F_{(1,42)} = .01$	.920	.000

Regarding within-condition effects, intervention analyses revealed a significant improvement in static balance for both the WB condition ($p < .001, d = 2.34, \text{large effect}$) and the WOB condition ($p < .001, d = 1.53, \text{large effect}$). For dynamic balance, a significant improvement was observed only in the WOB condition ($p = .045, d = 0.31, \text{small effect}$). Finally, no significant improvements were observed in reaction time.

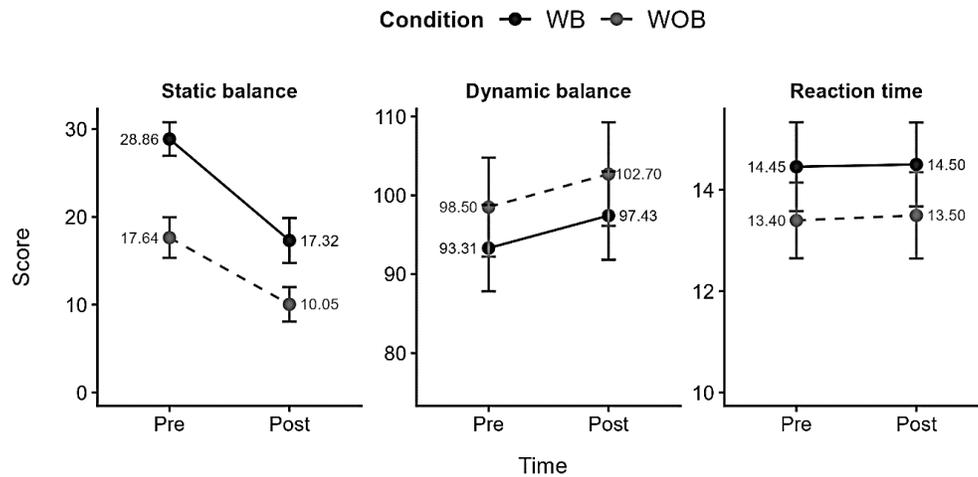


Figure 2. Changes in motor performance following the intervention under conditions with and without visual restriction.

Figure 3 illustrates the between-condition differences (WB - WOB) in absolute change for the analysed variables. For static balance, the point estimate and its 95% confidence interval were entirely located to the right of the null value, indicating a significantly greater improvement in the WB condition compared with WOB. For reaction time, the estimate was close to the null value and the confidence interval crossed zero, indicating no differences between conditions. For dynamic balance, high variability was observed in the estimate, with a wide confidence interval that included the null value, precluding the identification of a clear advantage of one condition over the other.

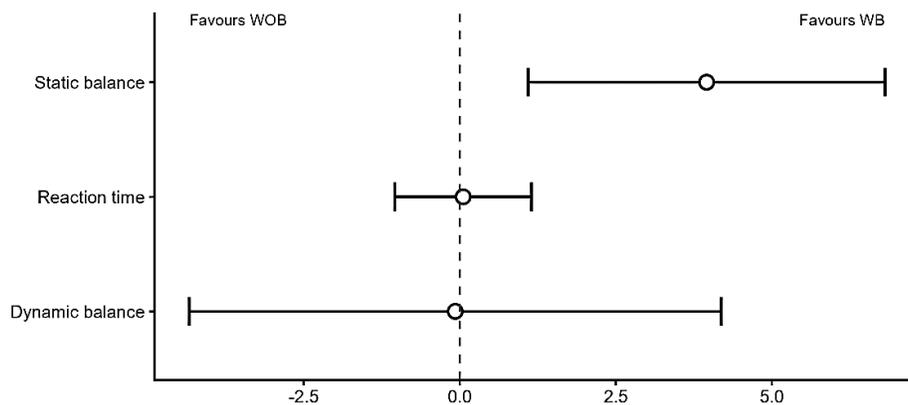


Figure 3. Between-condition difference in absolute change (WB - WOB).

DISCUSSION

The aim of this study was to evaluate the effect of a goalball-based didactic unit on static balance, dynamic balance, and reaction time in secondary school students simulating visual impairment. The main finding was that a goalball-based instructional unit significantly improved static balance and produced modest gains in dynamic balance in students without visual impairment, with a differential effect favouring the blindfolded condition (WB) observed exclusively for static balance.

Effective inclusion in PE requires strategies that level opportunities for participation while challenging the perceptual–motor capacities of all students. In this regard, goalball emerges as a particularly valuable pedagogical tool. According to Lieberman et al. (2019), adapted sport can be implemented as a strategy that engages all students in equivalent motor demands, facilitating the development of physical capacities through shared participation, regardless of disability status. The findings of the present study support this premise by demonstrating that participation in adapted sports increases the demand on compensatory systems, resulting in improvements in both static and dynamic balance.

The significant time \times condition interaction observed for static balance ($\eta^2 = .157$) suggests that systematic Goalball practice under visual restriction enhances postural control mechanisms, likely through increased reliance on proprioceptive and vestibular information. This finding is consistent with previous studies describing postural adaptations associated with visual deprivation during static balance tasks (Akinoğlu & Kocahan, 2018; Gökşen & İnce, 2024).

In line with these sensory reweighting mechanisms, the complementary forest plot analysis showed a point estimate shifted toward positive values in the between-condition contrast, indicating a greater magnitude of pre–post improvement in the WB condition. Although the confidence interval was wide (reflecting interindividual variability and limited precision) the direction of the effect was consistent with the hypothesis that visual restriction through adapted sport practice increases somatosensory and vestibular demands during postural control (Akinoğlu & Kocahan, 2018; Zetterlund et al., 2019). For example, research conducted with athletes with visual impairment has shown that individuals with low vision (B3) perform lower on balance tests with eyes closed than blind athletes (B1), suggesting that residual vision may interfere with the sensory integration required for postural control (Gökşen & İnce, 2024).

Accordingly, the findings in this study are coherent with prior evidence indicating that the complete absence of visual information may foster more efficient somatosensory and vestibular compensatory strategies than those observed in individuals with partial visual impairment. In this context, Juodzbalienė and Muckus (2006) reported that totally blind adolescents exhibited postural control comparable to that of sighted individuals with eyes open, and superior to that of individuals with residual vision. This suggests that residual vision may interfere with the sensory integration required for static balance. Therefore, compensatory strategies may emerge from the specific motor demands inherent to sport practice (Bednarczuk et al., 2019).

One of the most critical contributions of these findings is the insight they provide into visual restriction in individuals with low vision. As noted by Quevedo et al. (2014), knowledge of functional classifications and the impact of residual vision is essential for teachers. The observation that students with partial vision may display less efficient postural control than their blind peers highlights the pedagogical relevance of blindfold use in PE classes. This tool not only equalizes performance conditions but also, as described by Brian & Haegele (2014), allows students without disabilities to “*experience the barriers that students with visual impairments must overcome to participate in activities*” (p. 44), fostering cognitive empathy grounded in the sensory reality of others.

With respect to dynamic balance, the observed changes were moderate. Although dynamic balance has been shown to be influenced by visual status—where individuals without visual impairment typically outperform blind athletes—, it has also been reported that blind athletes who practice goalball once or twice per week demonstrate better dynamic balance than sedentary blind individuals (Aydoğ et al., 2006). In the present study, although no significant global differences were found ($p = .973$), a significant improvement was observed in the WOB condition following the intervention ($p = .045$; $d = 0.31$, *moderate effect*),

suggesting a positive trend that may depend on longer and more specific training exposure (Bednarczuk et al., 2019).

Although improvement was observed only in the WOB condition, this variation may be explained by the technical demands of the Y Balance Test, which requires highly specific dynamic stability and a greater transfer of acquired skills to elicit significant changes (Plisky et al., 2021; Plisky et al., 2009). Additionally, psychological factors such as fear of falling may limit movement amplitude and confidence during reaching tasks (Erden & Güner, 2018). Consequently, these results should be interpreted in light of the limited duration of the intervention and the absence of a control group, both of which may have constrained the magnitude of observed changes in dynamic balance.

Regarding reaction time, the findings of the present study were more moderate than those reported by Ince (2021), which may be attributed to factors such as the characteristics of the sample, age range, training intensity, and number of sessions. The literature indicates that age influences responsiveness to training stimuli, with younger participants being more susceptible to improvement (Hardwick et al., 2022). Moreover, longer training programs with higher session frequency are associated with greater improvements in reaction time (Balkó et al., 2017), and training specificity and experience are key determinants of these adaptations (Luo et al., 2025). Overall, these findings extend the evidence supporting the use of adapted sport in PE by demonstrating that systematic practice under visual restriction can induce measurable postural adaptations in students without visual impairment, thus extending beyond its traditionally sensitization-focused role.

In summary, the goalball-based didactic unit demonstrated a positive impact primarily on static balance, confirming that participation in this adapted sport stimulates proprioception and strengthens postural control in school-aged students without visual impairment. This finding aligns with previous research highlighting the importance of non-visual stimuli in postural stability (Akinoğlu & Kocahan, 2018; Zetterlund et al., 2019). Although changes in dynamic balance and reaction time were smaller, these results suggest that longer or more targeted programs may further enhance these capacities (Bednarczuk et al., 2019; Ince, 2021; Plisky et al., 2021). Taken together, the present study provides evidence of the pedagogical value of goalball, not only for its motor benefits but also for its inclusive potential to promote body awareness and sensitivity toward diversity within school contexts.

Limitations

This study has several limitations that should be acknowledged. First, differences in the physical spaces where pre- and post-test assessments were conducted may have influenced student performance due to uncontrolled environmental factors. For example, sessions were conducted while sharing the gymnasium with another group, resulting in a constant level of background noise that may have affected the silence required for goalball play and for activities relying on auditory stimuli. Second, the duration of the intervention (8 weeks, 9 sessions) represents another limitation, as longer and more frequent exposure may be necessary to support familiarization and conscious gameplay. Additionally, the absence of a control group limits causal inference regarding the intervention effects.

Future research

Future studies are encouraged to increase sample size, implement longer interventions with higher inter-session frequency, and include a control group to enable more robust comparisons. Furthermore, it would be valuable to explore the impact of this didactic approach in relation to other adapted sports in order to determine the comparative effectiveness of different modalities for developing motor, physical, and cognitive skills in students without visual impairments.

CONCLUSION

The aim of this study was to evaluate the effect of a goalball-based didactic unit on static balance, dynamic balance, and reaction time in secondary school students simulating a visual impairment. In relation to this, it can be concluded that the intervention produced significant improvements in static balance, with large effect sizes in both conditions, but with a greater positive trend in the WB condition. Dynamic balance showed small increases, reaching statistical significance only in the WOB condition, whereas reaction time did not exhibit significant changes. Therefore, the Goalball-based didactic unit appears to be an effective pedagogical strategy for strengthening static postural control and proprioceptive stimulation, even in students without visual impairment, confirming its potential as a valuable instructional resource within PE classes.

AUTHOR CONTRIBUTIONS

CVP: project administration, conceptualization, methodology, data collection, writing-original draft, software, investigation. PR: infrastructure resource management, supervision, investigation. FMH: conceptualization, writing-review, validation. FAR: conceptualization, writing-review, visualization. CLR: methodology, visualization, investigation. KCC: investigation, software, formal analysis, methodology, writing-original draft, editing, supervision.

SUPPORTING AGENCIES

No funding agencies were reported by the authors.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

AI STATEMENT

Artificial intelligence software was used exclusively for translation and language editing purposes in order to improve the English expression and readability of the text. The scientific content of the manuscript (including the study design, data collection, analysis, interpretation of results, and academic writing) was entirely developed by the authors. No artificial intelligence tools were used to generate the research content, results, or conclusions presented in the manuscript. The authors assume full responsibility for the originality, integrity, and accuracy of the work submitted.

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