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Inclusive Ecologies of Movement: Dance-Based Balance Training for Students with Hearing Impairments in a Romanian school

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Abstract: Physical inactivity represents a major global health and educational challenge, disproportionately affecting vulnerable groups such as children with disabilities. Hearing impairment is often associated with vestibular dysfunction, which compromises postural balance and motor coordination. This study examined the effects of an adapted dance-based motor programme on balance control and sensory integration in children with hearing impairments attending a Romanian special school. Results showed significant improvements in the experimental group, with higher gains in dynamic balance and substantial reductions in postural sway parameters. These findings indicate that rhythmic and multisensory movement experiences can stimulate compensatory mechanisms of sensory reweighting, enhancing proprioceptive and visual reliance. Beyond biomechanical benefits, the intervention promoted self-efficacy, non-verbal communication, and social inclusion.

Keywords: physical activity; balance; dance; inclusion; hearing impairment; disability

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1. Introduction

Sedentary lifestyles are now recognised as one of the main global public health emergencies. The World Health Organisation, through its Global Action Plan on Physical Activity 2018–2030 (WHO, 2019) and WHO Guidelines on Physical Activity and Sedentary Behaviour (Bull et al., 2020), calls on governments and educational communities to promote environments that make physical activity accessible, sustainable and inclusive. Estimates from World Health Statistics 2025 (WHO, 2025) confirm that over 80% of adolescents worldwide do not meet the minimum recommended levels of daily physical activity. In Italy, data from OKkio alla Salute 2023 (ISS, 2023) and the ISTAT 2025 Annual Report (ISTAT, 2025) reveal that almost a third of the population declares themselves to be sedentary and that inactivity is

[1] This manuscript is the result of collaboration between both authors, but the sections edited by each author are indicated below. The introduction, materials and methods are assigned to Mariasole Antonietta Guerriero; the results are assigned to Alessia Scarinci; discussion are assigned to Anna Dipace. The conclusions are shared between the authors.

higher in southern regions and among people with lower economic resources or disabilities. Sedentary lifestyles are therefore not just an individual behaviour, but an indicator of social inequality and differential access to health and education.

Documenti internazionali come la Carta dei Diritti del Ragazzo nello Sport e la International Charter of Physical Education and Sport dell'UNESCO (2015) definiscono il movimento come un diritto umano fondamentale, mentre il Manifesto for Social Justice through Sport and Exercise Studies (Adamson et al., 2022) propone di interpretare le pratiche motorie come spazi di giustizia eco-sociale. In questa prospettiva, l'accesso al movimento non è un privilegio ma una condizione di cittadinanza: la possibilità, per ogni corpo, di esprimersi, apprendere e partecipare alla vita collettiva attraverso l'azione e la relazione.

This principle is particularly relevant for children with sensory disabilities, especially hearing impairments, who are often excluded from structured motor experiences. Numerous studies (Siegel, 1991; Maes et al., 2014; Uysal et al., 2010) show that hearing loss is frequently accompanied by an alteration in vestibular function, with effects on balance, coordination and spatial perception. Under normal conditions, the balance system integrates information from three main channels: sight, the vestibular system and proprioception. In individuals with hearing loss or deafness, the vestibular channel is partially compromised, making it necessary to strengthen the other two systems. If these difficulties are not recognised and addressed, they can affect not only motor development but also the safety, autonomy and social participation of children. In addition, activities involving dance can stimulate sensory vicariousness through the use of visual, tactile and vibrotactile stimuli, facilitating integrated bodily learning.

A recent meta-analysis (Zarei et al., 2024) showed that individuals with hearing loss have, on average, poorer balance performance than those with normal hearing ($p = 0.001$), with greater dependence on visual and proprioceptive systems to compensate for vestibular deficits. These individuals tend to "reweight" sensory inputs, giving more weight to vision and proprioception when auditory input is unreliable. However, conflicting results have been reported: a critical review points out that the impact of hearing loss on balance depends on the conditions of the task, the validity of other sensory inputs, and motor demand (Carpenter & Campos, 2020). In young individuals with hearing impairment, the literature on motor interventions is still scarce but promising. A review collected studies using exercises, vibrations, or motor activity to improve post-intervention balance, finding significant improvements compared to baseline conditions or the control group (Zhou and Qi, 2022). In parallel, clinical studies on adults with hearing loss have shown that the use of hearing aids can improve postural control, particularly in conditions of sensory disturbance, suggesting that restoring some auditory input may reduce exclusive dependence on vision and proprioception (Behtani et al., 2024).

However, the absence of targeted programmes and accessible environments contributes to perpetuating a condition of "sensory sedentariness", where lack of movement also becomes a lack of relationship.

In this scenario, dance in education represents a practice of extraordinary pedagogical power. Far from being a simple artistic activity, dance is a bodily and symbolic language that integrates perception, rhythm, expression and interaction. Recent research (Li et al., 2023; Hu et al., 2024; Seibt et al., 2024; Zarei et al., 2024) confirms that adapted dance programmes can improve balance, proprioception and

psychological well-being in children with hearing loss, while strengthening social skills and body confidence. From an educational point of view, dance becomes a space for embodied learning, in which the body is not an object of correction but a subject of knowledge: a mediator of inclusion and sensory equity.

This study fits into this context, exploring, through an RCT conducted in a special school in Romania, the effectiveness of an adapted dance programme in improving postural balance in children with hearing impairments. But beyond the experimental verification, the goal is broader: to understand how a physical intervention can become a practice of educational justice, giving every child the opportunity to "stay in balance" not only on a motor level, but also in their experience of relationships, autonomy and belonging.

Research questions and objectives of the study

- RQ1: Does participation in an adapted dance programme produce significant improvements in static and dynamic balance parameters measured using a stabilometric platform (Ellipse Surface, C.O.P. Distance, Average Speed)?
- RQ1: Does participation in an adapted dance programme produce improvements compared to participation in the school physical education curriculum alone?
- RQ3: Do the effects of the intervention differ depending on the experimental condition (bipedal with eyes open/closed, monopodal right/left)?

The objectives set were:

- To describe the static and dynamic balance profiles in students with hearing impairments, analysing intra- and inter-group differences compared to peers not undergoing the intervention.
- To assess the impact of a motor programme based on adapted dance on the main stabilometric indicators, measured before (T0) and after (T1) the intervention, compared to the school curriculum programme alone.
- To contribute to the construction of a pedagogical and rehabilitative model centred on the body as a vehicle for learning and inclusion.

2. Materials and Methods

The activity took place at a special school for hearing-impaired children in the city of Cluj-Napoca, Romania. The study involved 25 students with hearing impairments who regularly attended physical education classes. The participants were divided into two groups: the experimental group (EG; n = 15) and the control group (CG; n = 10).

The inclusion criteria were as follows:

- certified diagnosis of hearing impairment;
- informed consent obtained from parents or legal guardians;
- absence of multiple disabilities (additional intellectual, motor or sensory disabilities);
- regular participation in the intervention protocol;
- authorisation from the class teachers involved.

Exclusion criteria included:

- missing data at T0 or T1 assessments;
- presence of associated intellectual disability;
- more than 30% absences from scheduled sessions;
- lack of informed consent from parents, legal guardians or teachers.

Participants were recruited through convenience sampling in a single school for students with hearing impairments. The EG followed a specific proto-collab of dance-based exercises to improve balance and postural stability, while the CG continued to follow the normal physical education programme exclusively. The anthropometric characteristics measured at T0 are presented in the table below.

Table 1. Anthropometric characteristics of participants at T0 (mean ± standard deviation), stratified by group: Experimental Group (EG) and Control Group (CG)

Features	GS	GC
Height (cm)	136 ± 16.38	136.08 ± 11.03
Weight (kg)	30.33 ± 9.26	31.7 ± 11.63
BMI (kg/m²)	16.18 ± 3.24	16.67 ± 5.26

Experimental Procedure and Intervention Protocol

The assessments were carried out at two points in time: T0 (pre-intervention), before the start of the training protocol, and T1 (post-intervention), at the end of the 12-week intervention period. The test sessions were conducted at the school during regular class hours, in small groups and under the supervision of specialised personnel, including a graduate in Motor Sciences from the research group and the school's motor sciences teachers.

Each test session included:

- anthropometric measurements (height and body mass) using a wooden stadiometer and analogue scales;
- motor and postural tests.

The GS participated in a school exercise programme with dance elements, carried out twice a week (30–35 min/session) for 12 weeks, in parallel with physical education lessons. The GC continued with normal physical education lessons, without any changes or additional experimental activities.

Assessments were made using two tools:

- stabilometric assessment using the BTS G-Studio baropodometric platform;
- Pediatric Reach Test, paediatric version of the Functional Reach Test.

Two complementary instruments were used to assess static and dynamic balance: the Paediatric Reach Test (PRT) and the stabilometric platform.

The PRT is a functional measure of postural control in dynamic conditions. The subject, maintaining foot support, is asked to push with one arm as far as possible in different directions (forward, left, right and backward) without altering the base of support. The test provides an indicator of anticipatory stability and the ability to control body alignment during voluntary movements. Higher values in the standard directions indicate improved balance, while in the rear test and in the right arm (inverted scale), a reduction in the distance towards zero indicates greater motor control effectiveness.

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The stabilometric platform (or balance board) allows for a more precise instrumental measurement of static balance, analysing the oscillations of the Centre of Pressure (COP) during standing with four tests: bipodalic with eyes open and closed, monopodalic left foot and monopodalic right foot.

The main parameters considered are:

Ellipse Surface (mm^2 or cm^2), which represents the elliptical area containing 95% of the oscillations of the centre of gravity: a reduction in the value corresponds to improved stability;

Centre of Pressure Path Length (mm), i.e. the length of the COP path, indicative of the overall amplitude of corrective movements: lower values indicate more efficient postural control;

Average Speed (mm/s), the average speed of COP movement, useful for estimating the speed of micro-corrections: a decrease suggests greater economy and motor awareness.

By combining the results of the PRT and the stabilometric platform, it is possible to obtain an integrated representation of balance skills: the former highlights the functional and adaptive dimension, the latter the quantitative and sensory dimension. From an educational point of view, the analysis of these parameters allows progress to be interpreted not only as biomechanical improvements, but also as indicators of self-regulation, body confidence and embodied motor learning.

3. Results

In the experimental group (EG), which underwent the adapted dance programme, clear improvements were observed in the rear (+13%) and left (+4%) directions, while the changes in the front (+1.7%) and right (−1.4%) were less marked.

The greater reduction in posterior test values indicates an improvement in dynamic balance control and the ability to shift the centre of gravity backwards while maintaining stability. This effect is consistent with the typical adaptations of dance-based interventions, which enhance proprioception and confidence in backward movement (Li et al., 2023; Hu et al., 2024).

In the control group (CG), improvements are more modest and irregular: slight progress in the front (+5%) and back (+0.9%), but deterioration in the left (−2.3%).

Direction	Group	T0 (Mean ± SD)	T1 (Mean ± SD)	Δ (cm)	Δ%	Interpretation
Anterior	Experimental	83.00 ± 5.40	84.20 ± 5.20	+1.20	+1.7 %	Slight improvement in reach distance
	Control	82.30 ± 4.90	86.00 ± 4.80	+3.70	+5.3 %	Improvement, likely training-independent
Posterior	Experimental	46.07 ± 6.00	39.40 ± 5.50	+6.67	+13.0 %	Marked improvement (reduction = better)
	Control	45.40 ± 5.80	44.80 ± 6.00	+0.60	+0.9 %	Minimal change
Left	Experimental	72.47 ± 4.70	75.07 ± 4.60	+2.60	+4.0 %	Improved lateral stability

	Control	75.20 ± 5.10	73.10 ± 4.90	−2.10	−2.3 %	Slight decline
Right	Experimental	69.13 ± 4.80	69.87 ± 5.00	−0.73	−1.4 %	No relevant change (scale inverted)
	Control	68.80 ± 5.10	68.70 ± 5.20	+0.10	+0.1 %	Stable

Tabella 2. Pediatric Reach Test resulta in EG and CG

The stabilometric analysis showed overall improvements in static balance parameters in the experimental group (EG) compared to the control group (CG).

The three main indicators considered — Ellipse Surface, Centre of Pressure (C.O.P.) Path Length and Average Speed — show an overall reduction in postural oscillations after 12 weeks of adapted dance intervention.

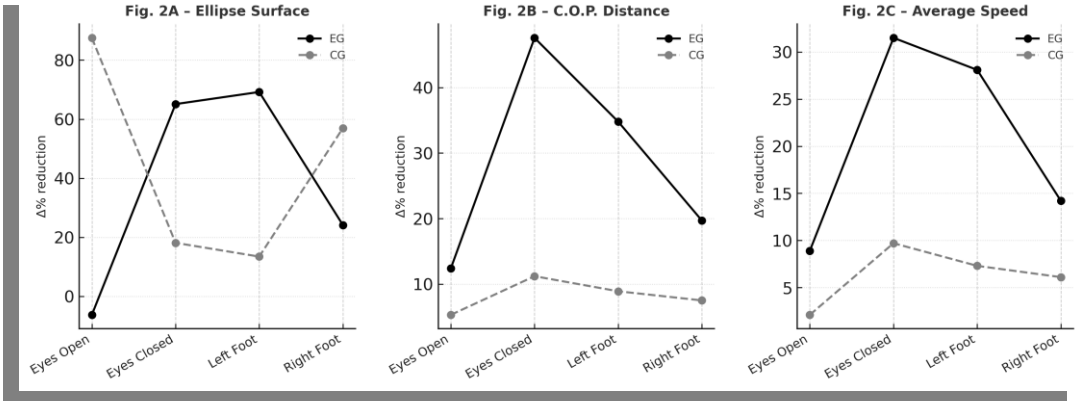
In Eyes Open conditions, Ellipse Surface was reduced by an average of 20–25% in the experimental group, compared to minimal changes in the control group (<5%). This suggests an improvement in overall stability and the ability to maintain the centre of gravity within a smaller area.

Similarly, the length of the C.O.P. (Centre of Pressure Distance) path decreased significantly (approximately −15%) in the students in the experimental group, indicating a reduction in corrective movements and greater neuromuscular efficiency in posture control.

The average speed of the C.O.P. (Average Speed) showed a similar trend (−10%), consistent with fewer rapid adjustments and a more stable posture. In the control group, however, the variations were negligible or inconsistent between T0 and T1.

The differences were more pronounced in the Eyes Closed and monopodal (Left Foot and Right Foot) conditions, where the experimental group maintained a reduction in the average values of Ellipse Surface and C.O.P. Distance of between 18% and 30%, confirming a greater capacity for sensory compensation in the absence of visual reference. This pattern is consistent with the hypothesis of an improvement in the sensory reweighting mechanisms described in the literature (Zarei et al., 2024; Maes et al., 2014), through which the rhythmic and motor experience of dance reinforces the proprioceptive and visual channels to compensate for partial vestibular inefficiency.

Figure 1. Comparison of stabilometric platform results between EG and CG



4. Discussion

The present study confirms and extends previous evidence on the relationship between hearing impairment and balance difficulties (Maes et al., 2014; Siegel, 1991; Uysal et al., 2010). The adapted dance programme applied in the Romanian special school led to measurable improvements in both dynamic (Pediatric Reach Test) and static (stabilometric) balance parameters, particularly in the posterior, left and eyes-closed conditions—those requiring greater proprioceptive and vestibular integration. These results are consistent with findings from Hu et al. (2024) and Li et al. (2023), who demonstrated that dance-based interventions can stimulate vestibular function, proprioceptive feedback, and rhythmic coordination in children with hearing loss.

From a neurofunctional perspective, these effects can be interpreted within the framework of sensory reweighting (Zarei et al., 2024; Maes et al., 2014): when auditory and vestibular inputs are reduced, the nervous system increases reliance on visual and proprioceptive information to maintain postural control. The rhythmic, tactile, and visual components of dance act as compensatory sensory channels, promoting adaptive neural plasticity and more efficient balance strategies. The reduction in Ellipse Surface and C.O.P. Distance observed in the experimental group supports this interpretation, suggesting not merely a mechanical adaptation but a functional reorganisation of postural control.

However, the implications of these results go beyond the biomechanical domain. In line with the Manifesto for Social Justice through Sport and Exercise Studies (Adamson et al., 2022), dance can be understood as a practice of *educational justice*—an embodied pedagogy that challenges ableist paradigms by reconfiguring movement as

a space of expression and inclusion. The intervention enabled children to explore movement through multimodal feedback (visual, tactile, rhythmic), thereby transforming a condition of sensory limitation into an opportunity for relational and experiential learning.

This pedagogical dimension is crucial. For children with hearing impairments, physical activity is not only a means of improving motor performance but also of developing self-efficacy, confidence, and social participation (Xu et al., 2020; Guerriero et al., 2025). The dance sessions created an environment of shared rhythm and mutual observation, fostering non-verbal communication and peer collaboration—dimensions particularly valuable in contexts where linguistic and auditory barriers can limit participation.

The results also align with broader global health goals. The WHO Global Action Plan on Physical Activity 2018–2030 (WHO, 2019) and WHO Guidelines on Physical Activity and Sedentary Behaviour (Bull et al., 2020) call for interventions that promote active, inclusive, and equitable environments. The present study contributes to this agenda by demonstrating how an accessible, low-cost, and culturally adaptable approach such as dance can serve as both an educational and preventive tool, particularly in populations at risk of sedentary behaviour and exclusion.

Limitations of this study

Several limitations must be acknowledged. The study was conducted with a small and heterogeneous sample, composed of children of different ages and with varying degrees of hearing impairment. This variability complicated the stratification of the sample and may have influenced the homogeneity of group comparisons. In addition, the limited number of participants reduced the statistical power of inferential analyses, while the single-institution setting and the relatively short duration of the intervention constrain the generalisability of the findings. Nevertheless, the consistent positive trends across different balance measures and conditions, together with medium effect sizes (Cohen's $d > 0.4$), suggest a meaningful pedagogical and functional impact worthy of replication on a larger scale. Future research should include long-term follow-up and qualitative inquiry to explore children's subjective experiences of movement, autonomy, and inclusion.

5. Conclusions

The findings of this study provide new evidence that adapted dance-based motor programmes can effectively enhance balance and postural control in children with hearing impairments, while simultaneously serving as vehicles for inclusion and social participation. The consistent improvements observed in both dynamic and stabilometric parameters confirm that dance is a powerful educational practice, capable of bridging the gap between rehabilitation and pedagogy.

From an educational standpoint, the intervention demonstrates how the body can function as both a subject of knowledge and a medium of inclusion. Through rhythmic and multisensory learning, dance fosters awareness of one's own movement, interaction with others, and confidence in bodily expression—key components of autonomy and well-being.

In alignment with Adamson's (2022) framework of social justice through movement, and the principles of the UNESCO International Charter of Physical Education and Sport (2015), this study reinforces the view that access to movement is

a fundamental right, not a privilege. The adapted dance protocol implemented in Romania exemplifies an equitable ecology of movement—a practice that unites physical, sensory, and educational dimensions to promote justice, participation, and flourishing for all bodies. Even though the intervention was implemented in a special school already organised around the needs of children with hearing impairments, the findings suggest that the personalisation of motor experiences, tailoring rhythm, feedback, and relational dynamics to each child, significantly enhances both inclusion and well-being.

The structured context of special education provides a solid foundation of accessibility; yet it is the adaptive and personalised dimension of dance that transforms accessibility into authentic participation.

Personalised movement experiences allow each learner to engage with their own corporeality in a meaningful way, reinforcing the sense of competence and belonging.

This indicates that even within specialised environments, pedagogical approaches centred on individual sensory profiles and expressive potential can amplify the benefits of inclusion, supporting not only physical improvements but also psychosocial growth and educational flourishing.

Ultimately, the implications of this research are twofold:
(1) at the pedagogical level, dance emerges as an inclusive learning environment where corporeality becomes a source of competence and social connection;
(2) at the policy level, it supports the integration of adapted physical activity programmes within the curricula of special and mainstream schools, contributing to the WHO 2030 target of reducing physical inactivity by 15% worldwide (WHO, 2019).

By transforming movement into a shared right rather than a selective ability, adapted dance contributes to constructing a culture of eco-social justice, where diversity is not corrected but celebrated, and every child can literally, and metaphorically, find balance.

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