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ORIGINAL ARTICLE

# Static balance assessment among children and adolescents with Down syndrome

## Avaliação do equilíbrio estático de crianças e adolescentes com síndrome de Down

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## Abstract

**Objectives:** To evaluate static balance and the influence of visual information among children and adolescents with Down Syndrome (DS) by means of computerized biophotogrammetry. **Methods:** Eleven children and adolescents with DS took part in the study and 14 neurologically normal children and adolescents comprised the control group (both genders). During filming, the subjects remained in the orthostatic position with arms to the side of the body and feet parallel on a flat surface. Both groups were filmed in anterior view (frontal plane) and right lateral view (sagittal plane) with and without the eyes covered. While being filmed with eyes covered, the subjects wore fully blacked-out swimming goggles to eliminate all visual information. The instrument used was computerized biophotogrammetry, which served as an angular reference for verifying body sway in static stance. **Results:** The subjects with DS swayed more (p<0.05) than the control group. When the visual information was eliminated, the anterior-posterior and lateral sway showed significant differences in the balance of the subjects with DS, compared with the subjects of the control group (p<0.01). **Conclusion:** The present study showed that children and adolescents with DS swayed more than the children in the control group with and without visual information and in both the anterior-posterior and lateral planes.

**Key words:** Down Syndrome; assessment; balance; photogrammetry.

## Resumo

**Objetivos:** Avaliar o equilíbrio estático de crianças e adolescentes com Síndrome de Down (SD) pela Biofotogrametria Computadorizada e verificar a influência da visão nesta situação. **Métodos:** Participaram 11 crianças e adolescentes com SD e 14 crianças e adolescentes de ambos os gêneros, neurologicamente normais que compuseram o grupo controle. Durante as filmagens, os participantes se mantiveram na posição ortostática com os braços posicionados ao lado do corpo e com os pés paralelos sobre uma superfície plana. As crianças de ambos os grupos foram filmadas na vista anterior (plano frontal) e na vista de perfil direito (plano sagital) nas condições com visão e sem visão. Nas filmagens na condição de olhos fechados, foram utilizados óculos de natação totalmente vedados, com a finalidade do participante não ter nenhuma informação visual. O instrumento utilizado foi a Biofotogrametria Computadorizada, que serviu como referência angular para verificar as oscilações do corpo em equilíbrio estático. **Resultados:** As crianças e adolescentes com SD oscilaram mais (p<0,05) que as do grupo controle e, quando a informação visual foi manipulada, as oscilações ântero-posterior e latero-lateral mostraram a existência de diferenças significativas no equilíbrio nas crianças e adolescentes com SD quando comparadas com as crianças do grupo controle (p<0,01). **Conclusão:** O presente estudo mostrou que as crianças e adolescentes com SD oscilaram mais que as crianças do grupo controle com e sem a informação visual nos planos ântero-posterior e latero-lateral.

**Palavras-chave:** Síndrome de Down; avaliação; equilíbrio; fotogrametria.

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## Introduction

Down Syndrome (DS) was clinically described for the first time by English physician John Langdon Down in 1866, but it was not until 1959 that French geneticist Jerome Lejeune identified its causes. DS is the most common of all genetic syndromes[1] and it is caused by chromosomal changes, in this case the trisomy of the 21st chromosome pair, resulting in physical and mental changes[1,2]. This syndrome has been studied by several researchers and, with regard to aspects of child development, they have found that children with DS have a delay in motor skill development, indicating that these skills emerge at a different time compared to children with normal development[3-6].

Some aspects have been suggested as causes for the delay in the acquisition of motor skills in DS children. The main causes of these differences include an exacerbated weakness in the joints, muscle weakness, sensory-motor abilities, cerebellar hypoplasia, and hypotonia[6-10]. Dysfunctions in the postural control are often described in DS children and associated with motor coordination difficulties, problems with sensory-motor integration or simply with awkward movements. Movements are considered awkward when the individuals are slow to adapt to a task and to changing conditions in the environment or are less capable of making anticipatory postural adjustments[6,11].

To maintain balance in any posture, the human body must receive information about its position in space and about the environment. The body receives this information through the neural system, which integrates the sensory information to access the position and the movement of the body in space, and the musculoskeletal system, which generates forces to control the position of the body, known as postural control system[12,13]. Postural control has two behavioral aims: orientation and postural balance. Postural orientation is the positioning and alignment of body segments in relation to one another and in relation to the environment. Postural balance is the state of equilibrium between all the forces that act on the body to maintain the desired position and orientation[14]. To ensure that the postural control system achieves both behavioral objectives, namely orientation and postural balance, two elements are necessary: perception (the integration of the sensory information to analyze the position and the movement of the body in space) and action (the capacity to produce forces to control the body's positioning systems). Thus, postural control requires a continuous interaction between the musculoskeletal and the neural systems[13,15].

Among the instruments used to assess balance is computerized biophotogrammetry, which applies the photogrammetric principle to photographic images obtained from body movements. Photointerpretation principles are then applied to these images, generating a new tool for the study of kinematics[16-18]. Thus, computerized photogrammetry is a resource that can be used in assessments for functional physical diagnosis in several areas, having been used in many studies which demonstrated its validity[16,19-21]. Therefore, the objectives of this study were to evaluate the static balance of children and adolescents with Down Syndrome by means of computerized photogrammetry and to determine the influence of sight on static balance.

## Methods

This was a case-control study approved by the Research Ethics Committee of Centro Universitário Hermínio Ometto (UNIARARAS), under the protocol number 236/2007. Twenty-five children and adolescents aged 7 to 14 years took part in the study. Eleven had DS and constituted the studied group (SG), and the remaining 14 were neurologically normal and composed the control group (CG). Both groups were homogeneous in gender, weight, height, and age. The subjects were recruited from a special education institution and from regular schools. A parent or guardian signed the consent form.

Inclusion criteria were DS children and adolescents aged 7 to 14 years and diagnosed by a karyotype test. The criteria for exclusion were DS children and adolescents with a diagnosis of autism or other diagnosed neurological dysfunctions, children and adolescents without the syndrome who had been diagnosed with neurological dysfunctions, and those who could not remain in the orthostatic position during filming.

The data collection for the assessment of the static balance occurred on the premises of the child's educational institution as the methodology allowed the researchers to set up the equipment in different locations. Each subject had their body mass and height measured on a digital scale (Welmy digital) duly inspected by INMETRO (National Institute of Metrology, Normalization, and Industrial Quality). An adhesive marker measuring 19mm in diameter was then placed on the glabella for anterior view evaluation and on the euryon for the sagittal view evaluation.

During filming, each subject was advised to assume a relaxed posture, with arms as stable as possible to the side of the body and feet parallel on a flat surface, previously marked for the plantar support. A plumb line was placed in the background to serve as a reference for the angle analysis. The children from both groups (SG and CG) were filmed in the anterior view (frontal plane) and the right lateral view (sagittal plane). During filming with eyes open, the subject was asked to fix their gaze at a target on the front wall, at eye level. The target was a round piece of yellow paper. During filming with eyes covered, the subjects wore totally blacked-out goggles to eliminate all visual information. Three subjects were excluded from the studied group (SG) because they did not remain in the orthostatic position and thus could not be filmed. The children were positioned so that the previously marked anthropometric points were aligned with the plumb line both in the anterior-posterior view (glabellar area) and in the right lateral view (euryon) and, to form the angle, a straight line was drawn to the vertex, which was perpendicular to the plumb line to determine the point of intersection.

The assessment rooms where the footage was taken had artificial lighting and a working area of approximately $18m^2$. Isolated rooms were chosen to minimize sound interference during data collection. A digital video recorder (Sony DSC-H2 digital 6.0 mega pixels) was placed on a leveled tripod fitted with plumb-bob, at a distance of 2.70m and 1.00m above the ground. The camera remained in this position throughout filming. The time of exposure to the camera was 30 seconds for each posture: anterior view and right lateral view, with and without the eyes covered. Computerized biophotogrammetry was used to quantify angles and verify body sway in static balance, followed by the application of Romberg's test. In order to obtain the moment of greatest anterior-posterior (sagittal) sway with and without the eyes covered, the images were analyzed frame by frame with the aid of the software *Windows Movie Maker*. At the moment of greatest sway in each plane, the image was selected and analyzed by computerized biophotogrammetry using the software *Corel Draw* and then calculated in degrees, as shown in Figure 1.

## Data analysis

To analyze the effect of sight, we proposed the calculation of the difference between each child's number of sways with and without eyes covered.


A. Sway angles (°) in the frontal (right-left) plane measured with Corel Draw; B. Sway angles (°) in the sagittal (anterior-posterior) plane measured with Corel Draw.

**Figure 1.** Sway angles (°) in the frontal (right-left) plane measured with Corel Draw.

Difference = Without eyes covered - With eyes covered

With this kind of subtraction, negative values indicated a greater sway in the "eyes covered" condition, and positive values indicated greater sway "without eyes covered". To quantify the degrees of anterior-posterior sway, we calculated the sum of the anterior and posterior sway deviations, and to quantify the degrees of lateral sway we calculated the sum of the sways to the left and to the right.

## Statistical analysis

The paired *t* test was used to verify the effect of sight on sway in the frontal and sagittal planes in the SG and CG. To evaluate the normality of the sample, the Shapiro-Wilk test was applied. To compare the means of the groups, we used the analysis of variance (ANOVA) for each of the defined experimental conditions: frontal sway without eyes covered, frontal sway with eyes covered, sagittal sway without eyes covered, and sagittal sway with eyes covered. Turkey's test was then applied to compare the means. The level of significance adopted for all the statistical analyses was $p<0.05$.

# Results

The paired *t* test was used to verify the effect of sight on sway in the frontal and sagittal planes. With regard to frontal sway, the SG had greater sway with eyes covered ($p<0.05$). Nevertheless, the CG had no significant difference, as shown in Table 1. In the sagittal plane, there was no significant difference as the *p* value was greater than 0.05, as shown in Table 2.

The results of the ANOVA test revealed that the SG children had a greater sway in the frontal plane without eyes covered ($p<0.05$) compared to those of the CG. Similarly, in the frontal sway with eyes covered, the SG had a significance level of $p<0.01$ compared to the CG, as illustrated in Figure 2. In the sagittal plane with and without eyes covered, the SG had greater mean sway ($p<0.01$) compared to the CG. The means can be observed in Figure 3.

# Discussion

The understanding and quantification of human body movements have attracted great interest in various fields of knowledge. The search for efficient and precise evaluation methods has been a constant concern when planning and programming effective interventions. Computerized biophotogrammetry is not only a reliable method but also highly precise, and it also allows image storage in a file for comparisons and measurements whenever necessary[16-18]. For static balance evaluation, the instrument was easily applied[16,19-21].

Overall, some changes were observed in the sway of children with DS in the anterior-posterior and lateral directions, both with and without eyes covered. For some authors[22-24], the fact that children with DS sway more can be explained by the difficulty in capturing the sensory information which determines the position of the body in space and the speed at which the body is moving. This seems to happen particularly when the information from one of the sensory systems is removed or manipulated, further increasing the body sway in individuals with DS[11,24].

The dynamic postural control system attributes a weight or value of importance to each type of sensory information. This sensory information basically relies on the context of the postural task to generate more precise information concerning the position of the body segments and the body's center of mass in space[25]. Thus, depending on the task, a particular type of sensory information may prevail over the others; however, in a different context, this preponderance may be altered or even inverted[25]. Based on this perspective, children with DS are less efficient in selecting and using sensory information according to the context in which the task is being executed.

The results of the present study show that, during the tests in which no visual information was available, the evaluated groups had a greater sway than when the visual information was preserved. In fact, both anterior-posterior and lateral sway was more significant with eyes covered than without eyes covered. Studies have detected an increase in body sway when the sensory information is removed or manipulated[26,27]. This difference may be due to the context in which the task is executed. Maintaining an erect posture in a context where there is no interference with sensory information is apparently simpler and requires less adaptation from the postural control system. However, when visual information is removed or manipulated, the context becomes more complex and requires a more active participation from this system[28,29].

**Table 1.** Sway values in the frontal plane.

| Group | Difference mean | Standard deviation | P value |
|---|---|---|---|
| CG | -2.5714 | 4.8787 | 0.070257 ns |
| SG | -13.5455 | 14.2784 | 0.010397 * |

* Significance level (p<0.05); ns (non-significant).

**Table 2.** Sway in the sagittal plane.

| Group | Difference mean | Standard deviation | P value |
|---|---|---|---|
| CG | -1.71429 | 7.83904 | 0.42796 ns |
| SG | -1.27273 | 7.77291 | 0.59898 ns |

ns (non-significant).

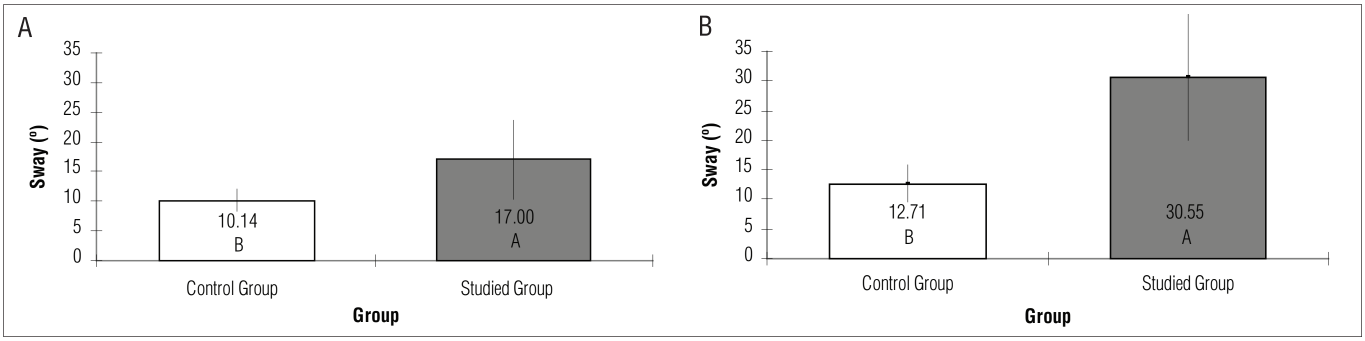


**Figure 2.** Frontal sway values for SG and CG without eyes covered (A) and for SG and CG with eyes covered (B).

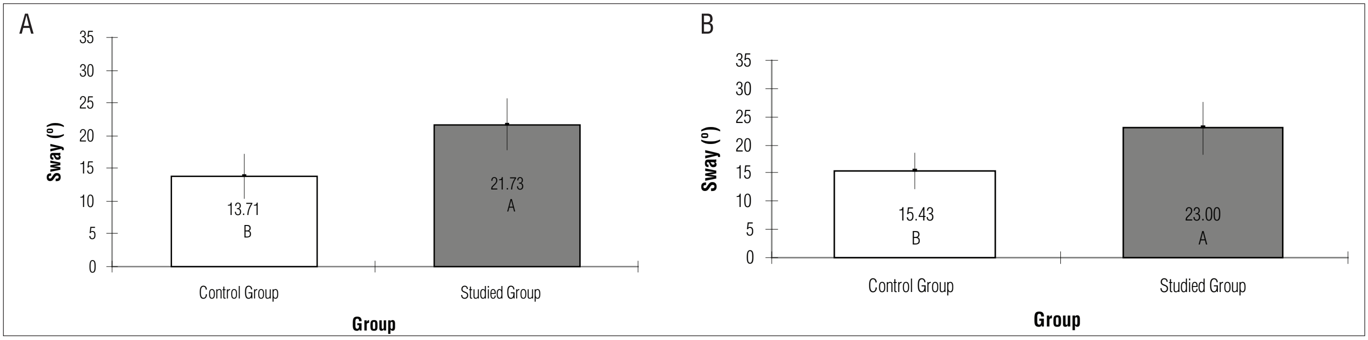


**Figure 3.** Sagittal sway values for SG and CG without eyes covered (A) and for SG and CG with eyes covered (B).

Another result concerned the sagittal plane, in which there was no significant difference in sway between the groups. Oliveira and Barreto[30] evaluated individuals with acquired visual impairment and individuals with normal sight on a force platform. The authors observed that the visually-impaired individuals had significantly greater lateral sway; nevertheless, in the anterior-posterior direction, they found no significant difference between the groups[30].

A second point to be discussed regarding the differences in the static balance of DS children and normal children is the possible delay in motor development in children with DS. Studies have suggested developmental changes such as sensory-motor abilities, muscle fatigue, exacerbated joint fatigue, hypotonia and cerebellar hypoplasia[6-10].

Kokubun et al.[23] compared balance with unilateral support in DS children to that of children with other kinds of mental impairment. The authors observed that the frequencies of sway waves were higher in children with DS, suggesting that higher frequencies of sway wave may be related to muscle hypotonia.

## Conclusion

Computerized biophotogrammetry was efficient in the assessment of balance in DS individuals, establishing itself as an important tool for the evaluation procedures in physical therapy practice. The group composed of DS children and adolescents (SG) and assessed by means of this instrument had a greater sway in static balance when compared to the CG. Likewise, when visual information was removed, the SG had greater anterior-posterior and lateral sway compared to the CG. However, other studies on balance in this population are needed to carry on this investigation given the limited number of subjects who took part in this study.

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