



Effects of eight weeks of canoeing on the dynamic body balance of children and adolescents with Down Syndrome

Efeitos de oito semanas de canoagem no equilíbrio corporal dinâmico de crianças e adolescentes com Síndrome de Down

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ABSTRACT

The objective herein was to analyse the effects of eight weeks of canoe training on the dynamic body balance of children and adolescents with Down syndrome. Seven subjects, four boys and three girls (10.8 ± 2 years), participated in this study, attending eight weeks of canoe training (two weekly sessions). The Four Square Step Test was used to measure dynamic body balance; this test involves completing a course with obstacles as quickly as possible. The Wilcoxon test was used to compare the values of dynamic body balance obtained in the pre- and post-tests. To compare the values between the boys and girls, the Mann-Whitney test was used, and the size of the effect of the intervention was calculated using the Cohen scale. It was concluded that eight weeks of canoeing was sufficient to produce positive effects on the dynamic body balance of children and adolescents with Down syndrome.

Keywords: Canoeing. Down syndrome. Dynamic body balance.

RESUMO

O objetivo dessa pesquisa foi analisar os efeitos de oito semanas de treinamento de canoagem no equilíbrio corporal dinâmico de crianças e adolescentes com síndrome de Down. Sete sujeitos, sendo 4 meninos e 3 meninas ($10,8 \pm 2$ anos) participaram da pesquisa durante oito semanas de canoagem, com duas sessões semanais. Para mensurar o equilíbrio corporal dinâmico adotou-se o *Four Square Step Test* (FSST) que compreende em completar um percurso com obstáculos o mais rápido possível. O teste de *Wilcoxon* foi utilizado para comparar os valores de equilíbrio corporal dinâmico obtidos no pré e pós. Para comparar os valores entre meninos e meninas, foi utilizado o teste de *Mann-Whitney*, sendo o tamanho do efeito da intervenção calculada pela escala de Cohen. Pode se afirmar que oito semanas de aulas de canoagem são suficientes para produzir efeitos positivos no equilíbrio corporal dinâmico de crianças e adolescentes com síndrome de Down.

Palavras-chave: Canoagem. Equilíbrio corporal dinâmico. Síndrome de Down.

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INTRODUCTION

Down syndrome (DS) is a genetic condition caused by the trisomy (presence of three copies of genetic material) of human chromosome 21 (HSA21)¹. Brazil has an estimated prevalence of approximately one case of DS in every 800 live births².

The presence of this extra genetic material produces several characteristics, such as excess body weight, hypotonia, ligament laxity, changes in the central nervous system, and changes in physical growth that influence body balance³.

Body balance is a skill that requires the active participation of the sensorimotor system to maintain, achieve, and restore the adjustment of the forces acting on the body in any adopted posture⁴. Body balance is considered as an important motor competence for the performance of most functional skills, assisting in the recovery of unexpected balance disorders, during locomotion or even while performing a motor task that requires reaching the limits of body stability⁵.

According to Guzman-Muñoz et al.⁶, body balance is the basis for the development of motor skills in people with DS. However, children with DS demonstrate less motor proficiency in body balance tasks when compared to their non-disabled peers⁷.

Canoeing is presented as one of the tools to promote the improvement of body balance in this population as it can be practiced under the same conditions by both disabled and non-disabled people⁸. It is a modality that requires balance adjustments in the sitting position. It also involves high metabolic demands and challenges related to the specific sensorimotor system of postural control, due to the movements of the upper body, the kayak, the paddle in the water, the upper limbs, and the paddle in the air⁹.

Chung¹⁰ investigated the postural responses of canoeists without disabilities. The results showed that body balance presented a positive relationship with the time of canoeing. Grigorenko et al.⁸ investigated the effects of canoe training on the static balance of people with spinal cord injuries. The results showed that the subjects consolidated postural control strategies after the completion of the canoe training period.

However, no studies have been found to address this relationship in people with DS. In addition, most investigations use the quantitative assessment of the centre of pressure (COP) to analyse static body balance in people with DS¹¹, demonstrating that these members have higher values of displacement and frequency of postural oscillation^{12,13}.

The COP protocol, however, requires high-cost equipment, is highly technical, and is restricted to laboratory application due to the difficulty of portability¹⁴. In addition, static balance does not necessarily represent the postural control that is required on a daily basis¹⁵.

The Four Square Step Test (FSST) presents itself as an alternative to assess dynamic body balance as it requires little space, equipment, and time, in addition to its ease of application and administration. The protocol involves assessing the ability of a subject to overcome obstacles positioned on the ground by rapidly changing direction (front, back, and side)¹⁶.

Verma et al.¹⁴ analysed the FSST reliability to measure static body balance in people with DS. The results showed the values of the intraclass correlation coefficient (ICC) of test-retest reliability and between ICC evaluators $_{(1,1)} = 0.70$ (0.64 - 0.90) and $_{(2,1)} = 0.78$ (0.62 - 0.9), respectively.

The objective of the present study was to analyse the effects of eight weeks of canoe training on the dynamic body balance of children and adolescents with DS using the FSST.

METHODOLOGY

TYPE OF STUDY

The present investigation adopted a quasi-experimental design, which is characterised by having a convenience sample and pre- and post-evaluation¹⁷ periods.

SAMPLE

Initially, specialised and regular educational institutions in the cities of Petrolina (Pernambuco) and Juazeiro (Bahia) were contacted to recruit par-

ticipants. After the disclosure, 16 children and adolescents with DS showed interest in participating in the study. Of these, eight managed to complete the pre-test period evaluations, with one withdrawing after the first day of intervention. Consequently, seven subjects ($n = 4$ boys and 3 girls; 10.8 ± 2 years) participated in the study until the end.

The Ethics Committee of the Federal University of Vale do São Francisco approved the research. The participants and their family members were provided with both verbal and written information before signing the terms of consent. Their consent was obtained before the start of the study. A minimum frequency of 75% in canoeing classes was adopted as a permanence criterion.

BODY BALANCE

To measure dynamic body balance, the FSST was used, which requires a subject to perform a balance task that involves completing an obstacle course (with obstacles on the ground) by changing direction as quickly as possible¹⁴.

For the application of the test, four 90 cm beams with flat bases were arranged to form the shape of a cross, creating four squares, numbered from 1 to 4. The subjects were instructed to move from square 1 to 4, clockwise, in such a way that both feet made contact with the ground in each area. Soon after, the subjects were instructed to retake the test in a counter-clockwise direction¹⁶ (Figure 1). Two attempts were granted, and the best time was recorded. Videos demonstrating the implementation of the FSST are available on YouTube (<https://www.youtube.com/watch?v=doaPhh3KJHM>).

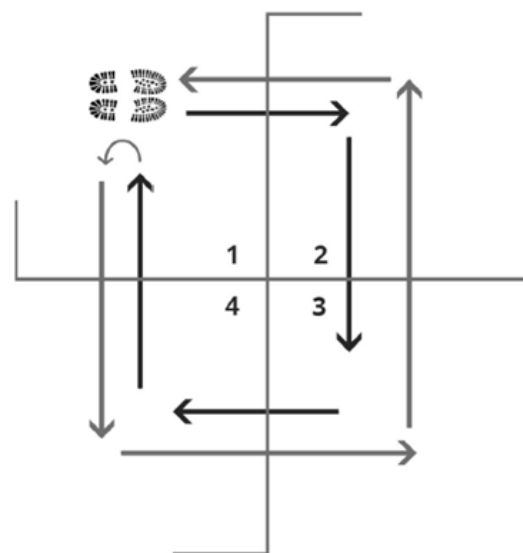


Figure 1. FSST demonstration: the test starts in square 1 with frontal movement towards square 2, lateral movement towards 3, back towards 4 and laterally towards 1. Subsequently, the subject must move around in the opposite direction—1, 4, 3, 2, 1—to complete the attempt.

Source: Moore & Barker¹⁶

INTERVENTION

Canoeing classes were held in a semi-Olympic pool, located in the sports complex of the Federal University of Vale do São Francisco, Petrolina (PE). The intervention period was eight weeks with a frequency of two times a week for 40 minutes each session. The protocol involved the following activities: adaptation to the liquid environment and canoeing material, initiation to canoeing, recreational games, and technical deepening (Chart 1). For all activities, tourism kayaks (*Sit on Top*, Brudden®) and life jackets approved by the Brazilian Navy were used.

Considering that children and adolescents with DS show greater motivation and performance in activities that offer rewards¹⁸, at the end of each session, participants were allowed to paddle and/or swim freely for five minutes after completing the activities.

Chart 1. Description of activities performed during the intervention

Period	Content	Equipment
Initial (1 week)	Adaptation to the liquid medium Adaptation to canoeing materials Paddling movements with hands Paddling movements on land (Figure 1)	Life jacket, floats, kayak, and paddle
Intermediate (2–4 weeks)	Paddling movements with hands Paddling movements on land Paddling movements in the liquid medium Recreational games involving the modality	Life jacket, floats, kayak, paddle, balls, buoys, and bladders
Final (4–8 weeks)	Paddling movements in the liquid medium Recreational games involving the modality	Life jacket, floats, kayak, paddle, balls, buoys, and bladders

Source: Research data

STATISTICAL ANALYSIS

For statistical analysis, initially, the Shapiro–Wilk normality test was used. After confirming the non-parametric data distribution, the Wilcoxon test was used to compare the values of dynamic body balance obtained in the period before and after the intervention program lasting eight weeks. To compare the values between the boys and girls, the Mann–Whitney test was used. The effect size of the intervention was calculated using the Cohen scale (1977)¹⁹ and was classified as small ($0.2 < 0.5$), moderate ($0.5 < 0.8$), and large (≥ 0.8).

RESULTS

This study is the first investigation to use the FSST as an instrument to measure the effects of an intervention protocol on the dynamic body balance of children and adolescents with DS. For this, seven participants with DS: four boys with an average age of 11.75 ± 2 years and three girls with an average age of 9.67 ± 1.5 years were recruited.

Table 1 shows the descriptive values (central tendency and dispersion), the size of the effect, and the level of significance now before and after the intervention. It was noted that there was a statistically significant decrease ($p < 0.01$) and great effect ($f^2 = 0.84$) in the scores achieved in the FSST on comparing the pre-test (13.5 ± 3.2) and post-test (11.1 ± 2.45), showing an improvement in the dynamic body balance of the subjects evaluated after the intervention period.

Table 1. Comparison of the effects of the intervention program on FSST values in the study sample

	Pre-test			Post-test			Pre vs Post DM	f ²	p
	Min	Max	Mean and SD	Min	Max	Mean and SD			
FSST	9.54	19.37	13.5 ± 3.2	8.97	15.85	11.1 ± 2.45	- 2.4	0.84	0.01

Source: Research data

Min = minimum; Max = maximum; SD = standard deviation; DM = Difference between the means; f² = effect size; p = statistical significance

Figure 2 shows the results categorised by gender. It was observed that the intervention period reduced the time to perform the FSST in the group of boys ($\eta^2 = 0.49$; $f^2 = 0.49$) and girls ($\eta^2 = 0.78$; $f^2 = 2.78$), showing an improvement in the dynamic body

balance of the subjects. In addition, although the size of the intervention effect was greater in girls, boys showed better performance in the motor task.

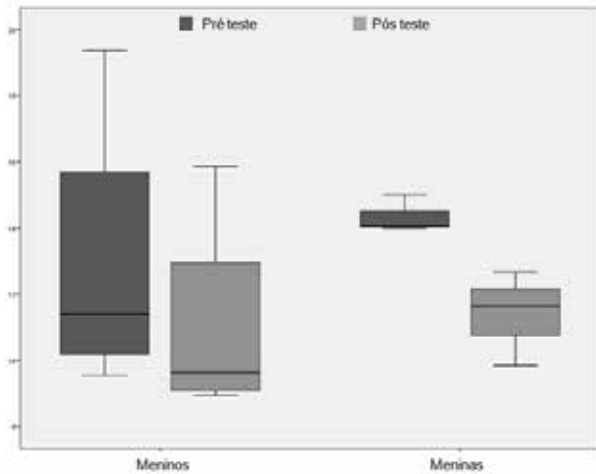


Figure 2. Comparison of the values reached by the boys and girls in the FSST in the pre and post-test moments.

Source: Research data

DISCUSSION

A lack of body balance negatively influences the development of children and adolescents as adequate body balance (ability to anticipate, prevent, and recover from instability generated internally or externally) is essential for the development of gross motor skills²⁰, the performance of daily life activities, and participation in sports²¹. A lack of body balance, therefore, increases the chances of people with DS to present a sedentary lifestyle and low physical fitness²².

Body balance disorders in people with DS manifest in different ways and are characterized by the need for a wide support base, the tendency to fall frequently, the demonstration of difficulties in daily activities, and the limited ability to articulate movements during walking²³. In this regard, the aim of this research was to analyse the effects of a canoeing intervention protocol on the dynamic body balance of children and adolescents with DS through the use of the FSST.

Studies have shown that motor interventions have a positive relationship with body balance^{24,25}. The results of the present investigation demonstrate that canoeing can be used as a motor intervention tool to promote gains in the dynamic body balance of children and adolescents with DS. These findings corroborate with the literature. Studies that used canoe-

ing as an intervention proposal to promote the body balance of several populations have demonstrated the positive effects of the practice of this sport in the postural control of its practitioners^{9,24,26,27}.

The values obtained in the present study in the pre-test period (13.5 ± 3.2 s) were higher than those observed in studies that evaluated children with typical development, 9.1 ± 2.6 s \sim 8.3 ± 2.4 s^{28,29}. Verification of the values after the canoeing lessons revealed that the intervention had a positive effect on the values obtained by FSST in this study (11.1 ± 2.45 ; $f^2 = 0.84$), which were higher than those of the children and adolescents with typical development.

According to Malak et al.³⁰, children with DS experience difficulties with body balance due to changes in the cerebellum (reduced size and volume). In addition, hypotonia, persistence of primary reflexes, slower volitional reactions, inadequate muscle co-contraction, and dysfunctions in the sensory integration system cause children and adolescents with DS to present more disharmonious and unstable body movements than their non-disabled peers³¹.

In the study by Bandog et al.³², the researchers used the FSST to assess the body balance of 14 children and adolescents (five boys and nine girls) with DS aged 8.7 ± 1.9 years, reporting mean values of 21.7 ± 5.1 s. These values are similar to those reported by Verma et al.¹⁴, who identified values of approximately 13 to 26 s (19.35 ± 3.93 s). In the present study, the sample reached final scores of approximately 9 to 16 s (11.1 ± 2.4 s).

The positive effects of the intervention on the dynamic body balance of subjects may have occurred because balance in a sitting position is one of the requirements for canoeing, which provides sensory-motor stimuli related to balance in virtually all movements caused by surface instability⁹. During canoeing, the seated balance is unstable and undergoes continuous disturbances due to the movements of the kayak, paddle in the water, upper limbs, and paddle in the air, thereby requiring adjustments from the practitioner to maintain balance with quick adaptations and readaptations, effective measures related to internal and external stimuli (sensory, motor, and cognitive information)³³.

In the study by Barros et al.³⁴, the researchers analysed the effects of eight weeks of canoe training on the global motor skills of children and adolescents with DS. The results from the study showed that the subjects increased their scores in all motor skill tasks after the intervention period; when the dynamic balance was analysed, statistically significant increases were observed ($\eta^2 = + .4$; $p < 0.04$; $d = 0.6$).

When a child experiences a type of sensory stimulus that is challenging for his or her central nervous system and successfully responds to that stimulus, then an adaptive response occurs, reducing body sway, provided that this sensory source provides useful information for the task³⁵. Stimulation experienced through canoeing, on an unstable surface, offers several sensory stimuli that can contribute to the modulation of responses necessary to maintain body balance. Studies that used interventions with physical exercises on unstable surfaces reported improvements in the postural control of subjects^{8,9,36}.

Muscle weakness is another factor that also compromises the body balance of people with DS³⁷. Canoeing is a sport that exerts high muscular demands on the torso and limbs (upper and lower limbs)³⁸. In this regard, activities involving muscular strength during the intervention period may be positively correlated with an improvement in body balance, as observed in the subjects of this study.

Some of the limitations of the present investigation are the use of a limited number of subjects and the absence of a control group. The small number of available studies that address dynamic balance and canoeing in this population makes it difficult to expand the discussion on the object studied. In order to better explore the benefits of canoeing on the dynamic body balance of children and adolescents with DS, further investigations with a larger sample size, the presence of a control group, and different types of motor interventions are required.

CONCLUSION

In conclusion, the proposed program of canoeing classes, for a period of 8 weeks, was found to

promote an improvement in the dynamic body balance of the children and adolescents who participated in this study.

Thus, it is recommended that activities on unstable surfaces be performed by people with DS for better motor development. Canoeing proves to be a good methodology as it is a sport that requires, at all times, motor, physical, and sensory characteristics related to body balance.

In addition, the FSST proved to be a simple, low-cost, and potentially sensitive method for measuring the dynamic body balance of the sample group.

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