Balance, Gait Speed, and Functional Strength in Individuals with Spinocerebellar Ataxia and Healthy Controls: a Cross-Sectional Study on Disease Severity

Equilíbrio, Velocidade da Marcha e Força Funcional em Indivíduos com Ataxia Espinocerebelar e Controles Saudáveis: um Estudo Transversal sobre a Gravidade da Doença

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ABSTRACT

Introduction: Despite the importance of assessing functionality in individuals with Spinocerebellar ataxia (SCA), data on performance in these tests are scarce.
Objective: Analyze the performance of these individuals in functional tests and compare them across different levels of dependence and with healthy individuals.
Methods: Thirty-five individuals with SCA and 30 healthy individuals were evaluated using the Five Times Sit to Stand (5TSTS), 10-Meter Walk Test (10MWT), and Functional Reach Test (FRT). Movement patterns during the FRT were analyzed with accelerometry. The Scale for the Assessment and Rating of Ataxia (SARA) determined disease severity. It categorized individuals with SCA into different degrees of dependence on activities of daily living: minimal-moderate (n=11), maximal (n=10), and severe-total dependence (n=12). One-way ANOVA and t-tests were used for analysis.
Results: A main effect of group was found for all variables (p=0.001). Individuals with SCA performed worse on the 5TSTS, FRT, and 10MWT than controls. On the FRT, controls reached greater distances than the maximal and severe-total dependence subgroups (p<0.001), with the minimal-moderate subgroup performing better than the severe-total subgroup (p=0.003). On the 10MWT, the minimal-moderate subgroup outperformed the maximal and severe-total subgroups (p=0.046). FRT accelerometry revealed a main effect of the group on total movement duration (p=0.003), with the maximal dependence subgroup exhibiting longer durations (p=0.033).
Conclusion: Individuals with SCA exhibit impairments in functional strength, dynamic balance, and gait compared to controls. Disease severity influenced FRT and 10MWT performance, but not 5TSTS. Accelerometry suggests possibly compensatory mechanisms and is affected by disease severity. Further research is necessary.

Keywords: Cerebellar Ataxia; Spinocerebellar Ataxias; Postural Balance; Gait Ataxia; Disease Progression.

RESUMO

Introdução: Apesar da importância da avaliação da funcionalidade em indivíduos com ataxia espinocerebelar (SCA), os dados sobre o desempenho nestes testes são escassos.
Objetivo: Analisar o desempenho destes indivíduos em testes funcionais e compará-los dentro de diferentes níveis de dependência e entre indivíduos saudáveis.
Métodos: Trinta e cinco indivíduos com SCA e 30 saudáveis foram avaliados através dos testes Five times sit to stand (5TSTS), 10m walk test (10MWT) e Functional reach test (FRT). Os padrões de movimento durante o FRT foram analisados com acelerometria. A Scale for the Assessment and Rating of Ataxia (SARA) determinou a gravidade da doença. A SARA Classificou os indivíduos com SCA em diferentes graus de dependência nas atividades da vida diária: dependência mínima-moderada (n=11), máxima (n=10) e grave-total (n=12). Para a análise, foram utilizados os testes ANOVA e t.
Resultados: Foi encontrado um efeito principal do grupo para todas as variáveis (p<0,001). Os indivíduos com SCA tiveram um pior desempenho no 5TSTS, no FRT e no 10MWT do que os controles. No FRT, os controles atingiram distâncias maiores do que os subgrupos de dependência máxima e grave-total (p<0,001), sendo que o subgrupo mínimo-moderado teve melhor desempenho do que o subgrupo grave-total (p=0,003). No 10MWT, o subgrupo de dependência mínima-moderada superou os subgrupos de dependência máxima e grave-total (p<0,046). A acelerometria FRT revelou um efeito principal do grupo na duração total do movimento (p=0,003). O subgrupo de dependência máxima apresentou durações mais longas (p<0,033).
Conclusões: Os indivíduos com SCA apresentam deficiências na força funcional, equilíbrio dinâmico e marcha em comparação com os controles. A gravidade da doença influenciou o desempenho no FRT e no 10MWT, mas não no 5TSTS. A acelerometria sugere possíveis mecanismos compensatórios e é afetada pela gravidade da doença.
Futuras pesquisas são necessárias

Palavra-chave: Ataxia cerebelar, Doença Neurodegenerativa, Ataxia Espinocerebelar

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INTRODUCTION

Spinocerebellar ataxia (SCA) is a family of hereditary ataxias that progressively degenerate the cerebellum and its pathways, leading to postural instability and incoordination, directly impacting functionality[1]. Beyond postural instability, the progressive decline of other body functions, such as strength and tone, associated with limitations in gait activity, can contribute to the high risk of falls seen in this population[2]. These factors contribute to a sedentary lifestyle, physical decline, and social isolation[3]. Additionally, other features such as the severity of ataxia seem to influence the risk of falls[2,3]. Thus, objective assessment of motor functionality is relevant in SCA for monitoring disease progression and evaluating the effectiveness of therapeutic interventions. Quantitative performance measures during functional tests, such as distance, number of steps, and acceleration, can provide accurate information on motor performance, guiding effective and specific therapeutic exercise prescriptions for this condition.

Despite the importance of assessing functionality in these individuals, data on functionality in SCA is still scarce in the literature. This is especially true because SCA is a rare condition[1]. For example, the functional reach test (FRT)[4], the five times sit to stand (5TSTS)[5], and the 10 Meter Walk Test (10MWT)[6] are very well described in conditions recognized to affect balance[7-19]. However, these tests remain unexplored in individuals with SCA. In the present study, the performance of a sample of individuals with SCA in these tests was described and compared with healthy individuals to establish reference values. Additionally, individuals with SCA were categorized into different levels of dependence on activities of daily living (minimum-moderate, maximum, and severe-total dependence), based on SARA cutoff values established by Kim *et al*.[20]. Their study identified significant correlations between SARA scores, gait status, and functional dependency levels, supporting this classification approach as relevant for rehabilitation assessment and interventions. The performance between these categories was then compared. For a more detailed assessment of dynamic postural control and to identify how the progression of the disease influences dynamic stability, this study also used an innovative approach to analyze trunk acceleration during the FRT, seeking to identify specific displacement patterns used by individuals.

Therefore, given the scarcity of data on functional performance in SCA, this study aimed to elucidate the differences in performance on balance, gait, and functional strength tasks, comparing individuals with SCA with healthy controls, as well as investigating how the severity of the disease influences these aspects among the different levels of independence within the SCA group. The choice of this battery of tests allowed for a multidimensional assessment of functional capacity, encompassing dynamic balance, lower limb strength, and walking ability.

MATERIALS AND METHODS

This is an observational cross-sectional study based on the STROBE checklist. The study was approved by the local Ethics Committee (protocol number 70797823.1.0000.5235). In this cross-sectional analysis, initial data from a randomized clinical trial registered at clinicaltrials.org were used.

To participate in the research, individuals with SCA had to meet the following criteria: aged between 18 and 70 years old; a diagnosis of SCA of any type, provided by a neurologist and confirmed by DNA testing; severity of cerebellar ataxia ranging from mild to moderate according to the stages proposed by Klockgether (stages: stage 0 = no gait difficulties; stage 1 = disease onset, defined by the onset of gait difficulties; stage 2 = loss of independent gait; stage 3 = confinement to a wheelchair)[21]; able to walk 2 meters with or without the aid of orthoses; a score of 21 or greater on the Mini-Mental State Examination (MMSE); and no other concomitant neurological diseases. Participants with SCA were excluded if they were illiterate; had a suspected or confirmed pregnancy; had a history of brain surgery; had musculoskeletal or cardiorespiratory disorders that prevented the research from being conducted; or had another neurological disease.

Participants were interviewed regarding eligibility criteria and sociodemographic data (sex, height, age, weight, year of disease onset, type of SCA, presence of comorbidities, use of walking aids, and current level of physical activity). Those who met the eligibility criteria and agreed to participate signed a free and informed consent form. Initially, 39 individuals with SCA of any subtype were recruited for convenience. Of these, 4 did not agree to participate (N = 35). Among the 35 participants who agreed to participate, 33 had SCA3 and only two participants had other types of SCA (SCA2 and SCA7). Since SCA3 is the most common subtype in Brazil and worldwide, participants with SCA2 and SCA7 were excluded from the analysis to uniform the sample (N = 33)[1].

The sample of individuals with SCA was characterized using the Scale for the Assessment and Rating of Ataxia (SARA), a clinical scale that evaluates disease severity[22]. It consists of eight items that assess gait, posture, sitting, speech disorders, and limb coordination tasks. Currently, it is the most widely used scale in clinical research and follow-up studies[23]. The level of independence in activities of daily living (ADL) has been correlated with the SARA score, indicating that patients with higher SARA scores exhibit greater dependence on ADL [20].

After the group of participants with SCA was formed, 30 healthy participants, matched in sex and age with the SCA group, were recruited. They would be excluded if they had musculoskeletal, neurological, or cardiorespiratory disorders that prevented the research from being conducted.

All participants were assessed using three tests related to the domains of postural control (5TSTS, FRT, and 10MWT). The 5TSTS was used to assess the functional strength of the lower limbs, which involves the participant moving from a sitting position, with arms crossed over the chest and without resting their back on the back of the chair, to standing up and sitting down five times as quickly as possible. The test result is measured in seconds, using a timer triggered by the examiner's command, and paused after the fifth repetition, as soon as the participant's buttock touches the chair[5, 24].

The FRT assesses dynamic stability by measuring the maximum distance an individual can reach forward while standing in a fixed position. In this test, the participant was instructed to stand next to a wall, without touching it, with the arm extended and shoulder flexed at 90º, bringing the hand forward as far as possible without moving the feet[4]. The difference between the start position of the third finger and its end position was the reach distance, measured in centimeters. Two repetitions were allowed, and the result was the average of the two measurements. In addition to the reach distance, the acceleration of the participant's trunk was also recorded using a three-dimensional signal captured with MATLAB software (The MathWorks Inc., USA) installed on a smartphone with an attached accelerometer.

Gait speed and walking cadence were assessed using the 10MWT, where the participant is instructed to walk 12 meters as quickly as possible, with the first and last meters of the route being the acceleration and deceleration zones, respectively[6]. The time and number of strides were recorded from the moment the participant's foot touched or crossed the final line of the acceleration zone, and the recording ended when they crossed the initial line of the deceleration zone. Speed was calculated by dividing the distance by the time taken, in meters per second. In this study, the number of steps was also recorded. The test was performed at least once and at most three times, depending on the participant's condition, with the use of assistive devices allowed. Additionally, for safety reasons, extra assistance from a researcher was offered if needed, and all this information was documented in the test report.

Signal acquisition and analysis

The body movement was recorded during the FRT using signals from 3D accelerometers built into the Android smartphone (iPhone 13, designed by Apple in California, USA, assembled in Brazil), positioned in the lumbar region of the participants, at the height of L5-S1, secured with an anchoring strap at the waist (Fig. 1A). Accelerations in the X (lateral), Y (vertical), and Z (anteroposterior) axes were acquired using the MATLAB Mobile App (MathWorks, USA) at a sampling rate of 100 Hz. The data were sent to a cloud account and subsequently processed using Python version 3.11.5. The Z-axis (anteroposterior) signal was selected for analysis, processed with a 2 Hz low-pass filter (2nd order Butterworth), and used to identify the points where the displacement began, the maximum point, and the point of return to the initial position. From these points, two phases were defined: phase 1, from the starting point to the maximum point; and phase 2, from the maximum point to the return to the starting position (Fig. 1B and 1C). The variables computed included the time spent in phases 1 and 2, the total duration of the movement, and the percentage time of the total duration of phases 1 and 2.

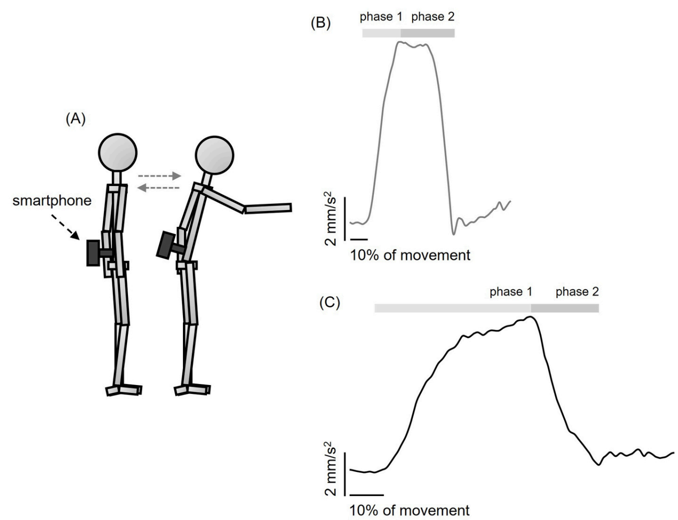

Figure 1. Illustration of the acquisition (A) and processing of the signal from the smartphone's built-in accelerometer during the FRT. The anteroposterior axis signals of representative participants from the control group (B, female, 66 years old) and an individual with SCA3 (C, male, 37 years old) are shown, indicating the respective phases of movement (1 and 2).

Statistical analysis

As most of the data vectors (70%) showed a normal distribution (Shapiro-Wilk test), a parametric approach was adopted. To manage absent data and outliers (ranging from 1.6% to 16% of each variable's data), K-Nearest Neighbors (KNN) imputation procedures were used. KNN imputation was chosen due to its ability to preserve the underlying data structure by estimating missing values based on the similarity between observations. This method identifies the most comparable data points (neighbors) and uses their values to impute missing entries, operating under the assumption that closely related samples exhibit similar patterns[25]. Compared to simpler methods (e.g., mean or median imputation), KNN reduces bias by accounting for multivariate relationships, making it particularly suitable for datasets with complex interdependencies.

For comparison between groups, individuals with SCA (N = 33) were subdivided into three groups based on their SARA scores, which relate to the level of dependence in performing ADL: the group with minimal - moderate dependence, with scores less than or equal to 10.0 (N = 11); the group with maximum dependence, with scores between 10.0 and 12.3 (N = 1); and the group with severe-total dependence, with scores greater than 12.3 (N = 12)[23]. The analysis of the movement pattern during the FRT, using data from an accelerometer positioned in the participants' lumbar region, was performed with a subgroup of 22 controls and 26 individuals with SCA. For between-group comparisons, a one-way ANOVA was conducted, followed by Tukey's post-hoc test in the event of a significant main effect. Eta squared (η^2) was used as a measure of effect size. The statistical threshold was set at 5%. All analyses were carried out in the Python 3.11.7 environment, using the pingouin 0.5.4 and fancyimpute 0.7.0 packages.

RESULTS

The features of the participants are shown in Table 1. No significant differences were found in sex distribution or age. However, the control group was taller and heavier, resulting in a higher BMI compared to the patient group. Nevertheless, as no significant correlation was found between BMI and any of the functional assessments performed (Pearson's r ranged from -0.153 to 0.204, with all P-values above 0.115), this issue was not further considered.

Table 1: Sample characteristics

Variables	Control (N=30)	Individuals with SCA (N=33)	P-Value*
Sex (F/M)	18/12 (60.0/40.0%)	23/10 (70/30%)	0.588
Age (years)	45 (24-69)	45 (23-70)	0.473
Weight (kg)	84 (48-130)	66 (49-115)	0.002
Height (cm)	172 (153-188)	163 (152-179)	0.021
BMI (kg/m2)	27.8 (18.7-41.3)	25.5 (17.5-36.3)	0.018
Time since diagnosis (years)	NA	7 (1-20)	
MEMS (score)	NA	26 (19-30)	

Data are expressed as median (min.-max.) or absolute frequency (% of total).
*Independent t test or chi-squared test, for continuous and categorical variables, respectively.

Functional performance assessment

There was a main effect of group for all measured variables: 5TSTS, F=25.051, P<0.001, η^2=0.560; FRT, F=18.990, P<0.001, η^2=0.491; 10MWT duration, F=25.513, P<0.001, η^2=0.565; 10MWT number of steps, F=22.112, P<0.001, η^2=0.529. The group results are shown in Figure 2.

The control group completed the 5TSTS test in less time than all SCA groups (post hoc P<0.001; Fig. 2A), while no significant differences were found among the SCA groups (P>0.112). Regarding the FRT, the control group achieved significantly greater distances than the maximal and severe-total groups (P<0.001; Fig. 2B), while the minimal-moderate group performed better than the severe-total group (P=0.003). In the 10MWT, the control group exhibited shorter times and fewer steps to complete the task than all SCA groups (P<0.040; Fig. 2C, D). Additionally, the minimal-moderate ADL dependence group showed shorter times and fewer steps than the maximal and severe-total groups (P<0.046).

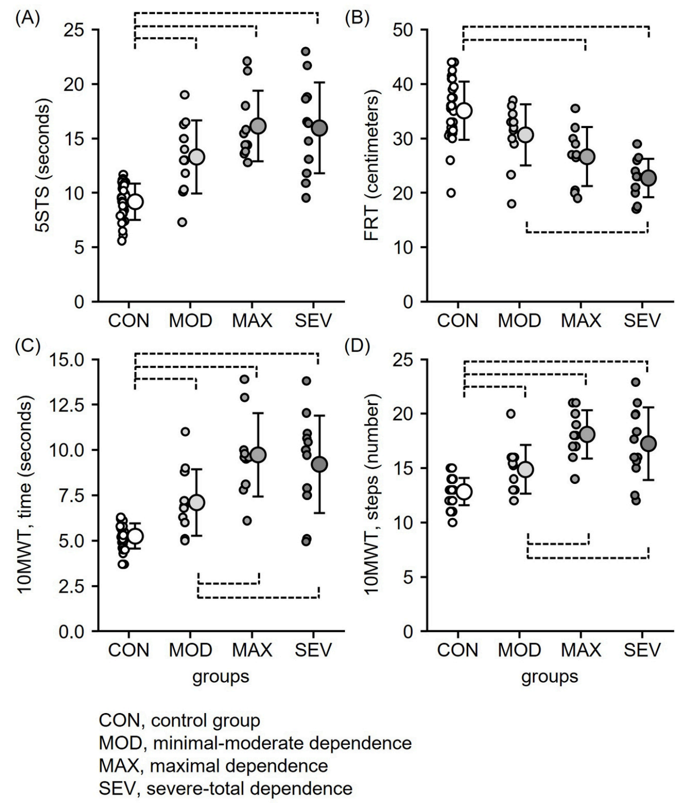

Figure 2. Comparison between the control and the groups of individuals with SCA, with different levels of dependence indicated by the SARA score (see text for details). For each group, data are presented as mean ±SD (circles on the right) and individual values (smaller circles on the left). Dashed lines indicate significant differences (Tukey post-test).

FRT movement analysis

These results are shown in Figure 3. As in the previous analysis, there was a significant between-group difference in the distance achieved in the FRT (P<0.001, η^2=0.487), with individuals with SCA achieving shorter distances. There was a main effect of group on the total duration of FRT movement (F=5.281, P=0.003, η^2=0.265; Fig. 3A), but no significant effect for the duration of phase 1 or phase 2, either in seconds or as a percentage of the total (P>0.148; Fig. 3). Specifically, the maximal group showed a longer total FRT movement duration than the control (P<0.001), minimal-moderate (P=0.020), and severe-total groups (P=0.033).

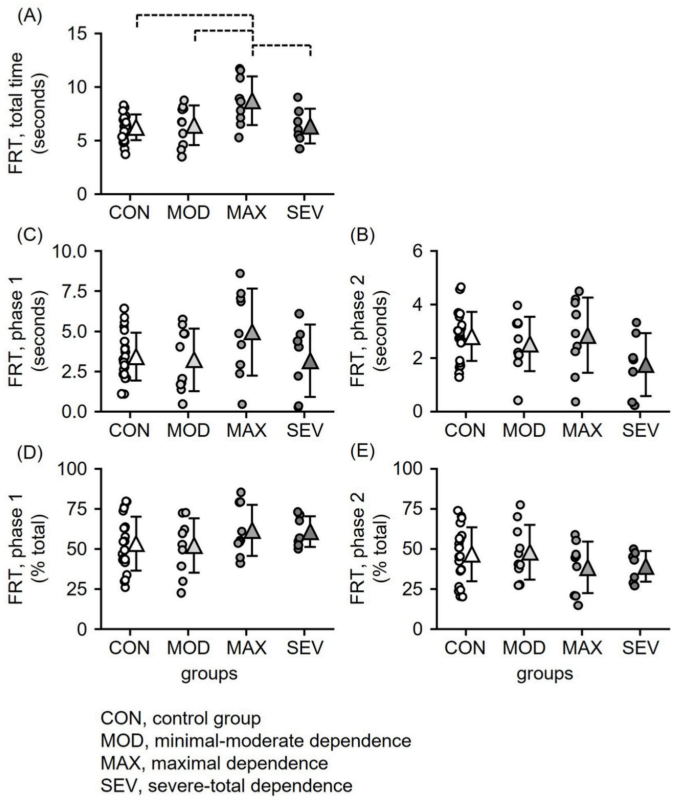

Figure 3. Comparison between the control and individuals with SCA groups, with different levels of dependence indicated by the SARA score (see text for details). For each group, data are presented as mean ±SD (triangles on the right) and individual values (smaller circles on the left). Dashed lines indicate significant differences (Tukey post-test). FRT, functional reaching test.

DISCUSSION

This study aimed to elucidate the differences in balance, gait, and functional strength tasks between healthy controls and individuals with SCA. Additionally, it aimed to compare these aspects across different levels of independence within the SCA group. The present findings showed that the healthy group performed better on all the variables studied. The subgroup of individuals with ataxia classified as minimal-moderate dependent on ADL did not show a significant difference in FRT performance compared to the healthy group. The subgroup with minimal-moderate dependence also obtained better results in FRT compared to the subgroup with severe-total dependence, but there was no significant difference within the subgroup with maximum dependence. In the analysis of movement during the FRT, the only variable that presented differences was the total duration of the movement, with the subgroup with maximum dependence exhibiting a greater total duration compared to the other subgroups of individuals with SCA and the control group. Regarding the 10MWT, the subgroup with minimal-moderate dependence showed a difference in both time and the number of steps compared to the subgroups with maximum dependence and severe-total dependence. For the 5TSTS outcome, no significant differences were found between the patient subgroups.

SCA is a progressive degenerative disease, and its balance impairments are well documented in the literature[1,26]. Therefore, worse performance of these individuals was expected when compared to healthy individuals. However, the results of healthy individuals in the FRT did not differ from those of the minimal-moderate dependence ADL subgroup. This suggests that there may be less impairment of dynamic stability in the early stages of SCA, or that the test was not sensitive enough to detect the differences. This lack of difference could also be attributed to the characteristics of FRT execution. It is performed with an anterior displacement, in which the knees must remain fixed in extension. One study suggested that locking the knees is a common postural control strategy in individuals with SCA to reduce the number of degrees of freedom needed to control the movement[27]. Locking the knees can reduce the need for fine postural adjustments during reaching, masking minor balance difficulties present in the early stages of SCA, as the task primarily assesses anterior reach while minimizing the need for lateral or posterior postural adjustments.

Accelerometry analysis revealed no significant difference between phases 1 and 2 of the FRT. However, the maximum dependence subgroup exhibited a longer total test duration compared to both the control group and the other SCA subgroups. The severe-total dependence subgroup reached significantly shorter distances than the minimal-moderate subgroup, likely contributing to their shorter total test duration. While the maximum dependence subgroup did not differ significantly in reach distance from the minimal-moderate and severe-total dependence subgroups, they demonstrated a longer movement duration. This may suggest that the severe-total dependence subgroup (higher SARA scores) experiences greater impairment in dynamic stability and balance, potentially hindering their ability to reach greater distances, unlike the maximum dependence subgroup (intermediate SARA scores). An alternative explanation is that the maximum dependence subgroup may have prioritized accuracy over speed, resulting in longer movement times. These findings indicate that individuals with intermediate disease severity may still have some capacity to compensate for balance and dynamic stability deficits, although further investigation is necessary.

While the total movement duration was the only significant accelerometry metric in the current study, additional measures such as trunk sway variability could provide more detailed insights into the movement patterns of individuals with SCA. The lack of significance for other accelerometry variables, such as the duration of the individual phases of the FRT, might be attributed to the limited sensitivity of the accelerometer to detect finer nuances in movement, especially in individuals with more severe levels of impairment. Furthermore, the current analysis focused on the primary movement phase during the FRT, which may not fully capture the complexity of the dynamic stability and coordination impairments seen in individuals with SCA. Future studies could refine the methodology by incorporating more sensitive accelerometry measures, increasing the frequency of data collection, or exploring other dynamic variables, such as trunk sway amplitude or frequency, which could provide a more comprehensive understanding of postural control and mobility in these patients. Additionally, the inclusion of a larger and more diverse sample could help identify subtle differences in movement performance across varying degrees of ataxia severity.

In the present study, the minimal to moderate dependence ADL subgroup spent less time and used fewer steps to perform the 10MWT than both the maximum and severe-total dependence subgroups. This suggests that disease severity may compromise gait speed and cadence. These findings are consistent with a recent study that evaluated the gait characteristics of individuals with SCA using a portable gait detection device. Several gait parameters of individuals with SCA showed significant differences compared to the control group, including speed and stride length. Furthermore, that study highlighted that higher SARA scores are predictors of lower gait speed[28]. Despite this, in the current study, there were no significant differences regarding time and number of steps between the subgroups with maximum and severe-total dependence. However, the use of assistive devices for walking was allowed, which may have influenced the step count and gait speed, and while we did not stratify the data by this factor, we recommend that future studies consider such stratification to better assess its impact on gait performance. Other factors, such as variations in disease phenotype or individual compensatory strategies, may have also contributed to this result.

In this study, individuals with SCA demonstrated poor performance compared to healthy controls in the 5TSTS, indicating compromised lower limb functional strength. However, no significant differences were found across different levels of functional dependence. This suggests that while lower limb functional strength is reduced in individuals with SCA compared to healthy individuals, it may not decline significantly with disease progression, at least as measured by this test. In contrast, dynamic stability (FRT) and gait performance (10MWT) were progressively compromised with increasing disease severity, as evidenced by the poorer performance of individuals with higher SARA scores. To our knowledge, no previous studies have specifically investigated lower limb functional strength in individuals with SCA using the 5TSTS, which limits direct comparisons with the present data.

Patients with SCA may present difficulties ranging from variations in performing complex tasks, such as walking, to simply maintaining an upright posture[29]. The deficit in balance and postural control in patients with SCA arises mainly from cerebellar degeneration[30]. It is also affected by extra-cerebellar characteristics, such as visual disturbances, movement restrictions in specific muscles, and changes in tone, among others[3]. These changes influence components related to biomechanics, movement strategies, and dynamic controls responsible for postural control during static and dynamic tasks[31]. The variety of types, manifestations, clinical signs and symptoms, and progression of the disease provides great heterogeneity among individuals with SCA[1,32]. The current study sought to remedy this heterogeneity by matching the group with SCA with healthy individuals by sex and age group, and by subdividing the group of individuals with SCA according to the level of dependence based on the SARA score.

Study limitations

One of the limitations of the present study was the relatively small number of participants in the three subgroups related to functional dependence, reflecting the inherent rarity and heterogeneity of SCA. These factors make large-scale recruitment particularly challenging and may have influenced the statistical power of the subgroup analyses. Regarding the tests, the use of orthoses during the 10MWT may have contributed to equalizing some results between groups with greater disease severity. Another limitation was the sample being composed of participants with different types of SCA. Regarding the control group, a limitation was the pairing only by sex and age, considering that body mass composition could also influence participant performance in the proposed tests. Concerning the tests used, the application of orthoses during the 10MWT may have contributed to masking some results. As previously mentioned, only the control group exhibited a significant difference in time compared to the subgroup with severe-total dependence for ADL. Notably, subgroups with lower SARA scores demonstrated a similar (or even slightly worse) number of steps and time compared to the subgroup with severe-total dependence. This unexpected finding may have been influenced by the frequent use of orthoses in this group.

Another potential limitation of this study is the discrepancy in BMI between the control and SCA groups. Although BMI was not significantly correlated with the functional assessments performed in this study, body composition could still influence mobility and may introduce confounding effects. Body composition, particularly muscle mass and fat distribution, plays a crucial role in mobility and functional performance. For instance, higher muscle mass may enhance mobility and stability, while increased body fat can impair these functions (Janssen et al., 2002). The control group was matched for sex and age, but not for body composition, which could have influenced the observed outcomes, particularly in tasks involving dynamic balance and strength. This discrepancy in BMI may therefore have impacted the interpretation of the results, and future studies should consider controlling for body composition factors, such as fat percentage and lean mass, to isolate more accurately the effect of SCA on mobility.

The present results demonstrated that dynamic stability is relatively preserved in the early stages of SCA, but there is a tendency for it to decrease with disease progression. Furthermore, gait deficits are present in the early phase of symptoms. The study showed that disease severity and greater dependence on ADL did not reflect lower functional strength of the lower limbs in individuals with SCA and may indicate that the impairment of postural control in patients with SCA is not necessarily influenced by strength. Therefore, more studies like these are needed to understand the influence of clinical profile and disease progression on the functional independence of individuals with SCA.

The results of this study have important implications for clinical practice, particularly in the context of assessing and managing individuals with SCA. The functional assessments used in this study, such as the 5TSTS, FRT, and 10MWT, could be easily integrated into routine clinical monitoring to evaluate disease progression and the effectiveness of rehabilitation interventions. By routinely incorporating these assessments, clinicians could more effectively track the functional status of individuals with SCA, identify early changes in functional abilities, and tailor rehabilitation plans to address specific deficits. Furthermore, these tests are relatively simple to administer and do not require specialized equipment, making them feasible for use in a wide range of clinical settings.

This study investigated the impact of SCA severity on balance, gait, and functional strength. The results showed that individuals with SCA had impaired lower limb strength (5TSTS), gait (10MWT), and dynamic stability (FRT) compared to healthy controls. Disease severity influenced performance on the FRT and 10MWT, but not the 5TSTS, suggesting that the latter distinguishes individuals with SCA from controls, but does not discriminate severity within the SCA group. Analysis of trunk acceleration during the FRT revealed differences in movement duration between the groups, indicating that movement execution is affected by disease severity, possibly due to compensatory strategies. These findings highlight the complex interaction of multiple factors in the impairment of postural control in SCA and reinforce the need for future studies that investigate the longitudinal progression of the disease, use other strength measures, and expand the analysis of movement during functional tests, to better understand the influence of clinical profile and disease progression on functional independence in SCA.

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