Artigo Original

DELAY ON GAIT PATTERNS ON DOWN SYNDROME CHILDREN

ATRASO NO PADRÃO DA MARCHA EM CRIANÇAS COM SÍNDROME DE DOWN

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RESUMO

O objetivo foi comparar as variáveis espaço-temporais do ciclo da marcha em crianças com Síndrome de Down em função da idade. Um estudo longitudinal foi conduzido com 20 crianças, de ambos os sexos, com idade entre 24 e 83 meses. Técnicas convencionais foram usadas nos procedimentos metodológicos para registrar a antropometria e a técnica cinematográfica bidimensional para quantificar as variáveis espaço-temporais das suas marchas em relação às variáveis globais e parciais. Os resultados mostraram diferenças no comportamento das variáveis antropométricas e cinemáticas, comprimento da passada, frequência da passada e tempo do primeiro apoio simples nas crianças com Síndrome de Down entre 24-59 meses e 60-83 meses de idade. O padrão de marcha das crianças ao longo dos anos se estabeleceu pela alteração da frequência do que pelo comprimento da passada para o desenvolvimento da velocidade de marcha. Conclui-se que as modificações do comportamento das variáveis antropométricas e espaço-temporais da marcha de crianças com Síndrome de Down parecem ser pouco evidentes entre 24 e 59 meses de idade.

Palavras-chave: Síndrome de Down. Biomecânica. Postura.

ABSTRACT

The main purpose was to compare the spatiotemporal variables of the gait cycle in children with Down Syndrome as a function of age. A longitudinal study was conducted with 20 children, of both genders, aged between 24 and 83 months. Conventional techniques were used in the methodological procedures to record the children's anthropometry and two-dimensional cinematographic techniques for quantification of the spatiotemporal variables of their gait in relation to the global and partial variables. The results showed differences in the behavior of the anthropometric and kinematic variables, stride time, stride frequency, and time of first simple support in children with Down Syndrome between the age of 24-59 months and 60-83 months. The children's gait pattern over the years was established by the changes in frequency instead of the changes in the stride length for the development of gait speed. In conclusion the Behavior modifications in the anthropometric and spatiotemporal variables of the gait in children with Down Syndrome appear to be barely evident between 24 and 59 months of age.

Keywords: Down Syndrome. Biomechanics. Posture.

Introduction

The understanding and interest in analyzing the gait in special populations has been growing. The study of gait variables allows greater understanding of the mechanisms related to maturational stages[1]. It is understood that the acquisition of the knowledge of its maturational aspect can provide support for the planning of more appropriate motor stimulus, therefore, more grounded pedagogical and/or therapeutic work will be possible to be done. In this respect, the mature human gait contributes to the acquisition of environment independence by the child.

Our study is focused on the maturational aspect of the child's gait with Down Syndrome (DS). DS is characterized as a genetic condition, which causes the bearer to present a series of specific physical and mental characteristics, affecting the neuropsychomotor development, physical growth, and achievement of motor milestones[2]. The gait in children with DS is characterized as "waddling", this term being attributed to increased join laxity and decrease in muscular tonus[3].

Considering the literature so far consulted, we observed that there are no studies that observed the spatiotemporal variables of the gait in children with DS between 2 and 7 years of age throughout their growth. Regarding the study of gait in children with DS, few studies were found in the literature with samples composed of non-sequential age groups, a common feature in studies in this area. Mancini et al.[2] studied 20 children with DS, but aged from 2 to 5 years. Felício et al.[4] studied 6 children with DS, but three aged 3, 4 and 5, and three aged 10, 15, and 20. Kubo and Ulrich[3] studied 12 children aged between 8 and 10 years. Kim; Bang; Kim[5] studied 15 children with an average age of 10.9 years.

In this study, we focus on the analysis of motor aspects in the children with DS, taking into consideration that such aspects are deviant in relation to children with typical motor development. It is known that children with DS learn to walk independently at an average age of 19 months. Yet children with typical motor development walk, on average, at 12 months of age[6].

The primary purpose of this study was to analyze the spatiotemporal variables of the gait cycle in children with DS between 2 and 7 years of age. To do so, we sought to describe the behavior of the anthropometric data from children with DS and the spatiotemporal variables of their gait; to verify the presence of a relationship of these variables with respect to age, and verify the existence of a relationship between the anthropometric and kinematic variables.

Methods

Design

This study was characterized as longitudinal with convenience sampling and consecutive selection[7]. Consecutive selection is related to access to the population with sufficient time to include temporal changes, in this case, developmental aspects related to the gait. The study was approved by the Standing Committee on Ethics in Research involving Humans (CAAE N. 0241.0.093.000-08).

Subjects

Twenty children with DS participated in this study. This group was comprised of children of both genders (14 females and 6 males), aged between 24 and 83 months. Samples were collected in 24 months in five data collections in a specialized school of South Brazil.

After collection of anthropometric and spatiotemporal variables, the data for analysis was groups by age range as follows: 7 children between 24 and 35 months, 8 children between 36 and 47 months, 8 between 48 and 59 months, 7 between 60 and 71 months, and 10 between 72 and 83 months.

Instruments and variables

For anthropometric measures, we used a tape measure, a portable stadiometer and a portable body weight scale. The anthropometric variables measured were: body mass, height, and circumference of the thigh and legs.

For the analysis of the spatiotemporal variables of the gait, we used the two-dimensional, cinematographic technique[8]. The global spatiotemporal variables included: stride length, time, velocity, and frequency. The partial spatiotemporal variables included: length of right and left leg stride, time of the first and second double support, and time of first and second simple support, during the movement cycle.

Procedures

Before the data collection, the researchers obtained from the authorities of the education sector and parents, the authorization for the study and sample selection. The data collection occurred into the school during class time. The measurements were followed by a school teacher. Both thigh and leg measurements were carried out in segments place with greater circumference.

Gait movements were recorded with a digital camera positioned perpendicular to the previously calibrated two-dimensional reference system. Three step cycles were recorded for each child in each collection. The children's gait, at a freely selected speed, was recorded adjacent to the reference system, excluding, thus, possible interference resulting from parallax errors. After filming, the sequences were sampled at 60 Hz (fps). All analysis was performed in relation to the right side of the children's bodies.

From the generated image sequences, the two-dimensional reference system coordinates and the identification, in the video, of the moments of foot contact with the ground, using the Dvideow *software*[9], global and partial spatiotemporal variables were calculated. According to the analysis, the average value of the variables (spatiotemporal variables) was selected for each child, in relation to the three walking cycles.

Statistical Analysis

For statistical analysis of the data, using SPSS - Statistical Package for the Social Sciences, V.20, the following tests were selected: a) the Shapiro-Wilk normality test; b) the non-parametric group comparison tests, Kruskal-Wallis and Mann-Whitney U ($p<0.05$); c) the Anova one factor parametric test, with post hoc Tukey test ($p<0.05$) and the Effect Size/Partial Eta Squared, for comparison between age groups. In application of the Anova one factor test, in case the homogeneity of variables was not assumed, we used the above-indicated non-parametric tests. To diagnose the existence of a correlation between the anthropometric variables, we used the Spearman linear correlation coefficient for non-normal distributions, and Pearson linear correlation for normal distributions.

Results

The values of the anthropometric variables above 60 months of age are significantly higher than those for the other age groups (Table 1). The variables also show an increase in values according to the age of the children with DS. Thus, a correlation coefficient was calculated for analysis of this behavior.

Table 1. Anthropometric data of children with DS by age.

Age Group (months)	Mass (kg)	Height (cm)	Thigh circumference (cm)	Leg circumference (cm)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
24-35 (n=7)	11.50 (1.19)[a, b, c]	81.71 (5.16)[a, b, c]	25.50 (1.68)[a, b, c]	19.43 (1.06)[a, b, c]
36-47 (n=8)	12.13 (1.87)[d, e, f]	91.29 (14.87)[d, e, f]	27.13 (2.09)[d, f]	20.13 (1.63)[d, e, f]
48-59 (n=8)	14.59 (2.07)[g, h]	106.94 (17.40)[h]	28.66 (1.67)[g]	21.38 (0.91)[g, h]
60-71 (n=7)	17.14 (1.68)	112.54 (11.14)	31.07 (1.32)	22.49 (0.84)
72-83 (n=10)	19.65 (3.16)	124.35 (16.64)	31.24 (3.57)	23.50 (2.02)

Note: Kruskal-Wallis and Mann-Whitney U (p<0,05) tests. Indices: a = statistical difference between age 24-35 and 48-59, b = statistical difference between age 24-35 and 60-71, c = statistical difference between age 24-35 and 72-83, d = statistical difference between age 36-47 and 48-59, e = statistical difference between age 36-47 and 60-71, f = statistical difference between age 36-47 and 72 -83, g = statistical difference between age 48-59 and 60-71, h = statistical difference between age 48-59 and 72-83.
Source: Own source.

Analysis of the relationship between the anthropometric variables and the children's age revealed significant correlations for mass (r=0.86; p<0,001), height (r=0.76; p<0,001), thigh circumference (r=0.75; p<0,001), and leg circumference (r=0.79; p<0,001).

Additional analysis revealed that the anthropometric variables (height, thigh circumference, leg circumference) appear strongly correlated with the mass variable: height (r=0.79; p<0,001); thigh circumference (r=0.76; p<0,001); leg circumference (r=0.89; p<0,001).

Statistically significant differences were observed in stride time and frequency (Table 2). These differences occur between the 24-35-month age group and the 60-71 and 72-83 month groups, demonstrating that between the 24-35 months and 48-59 months' groups, the gait variables were not changed.

Table 2. Global spatiotemporal variables of the gait cycle in children with DS.

Age Group (months)	Stride length (m)	Stride time (s)	Gait speed (m/s)	Stride frequency (Steps/s)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
24-35 (n=7)	0.43 (0.12)	0.73 (0.12)[a]	0.63 (0.22)	2.81 (0.44) [a, b]
36-47 (n=8)	0.50 (0.10)	0.82 (0.17)	0.67 (0.25)	2.54 (0.50)
48-59 (n=8)	0.51 (0.08)	0.81 (0.14)	0.66 (0.18)	2.54 (0.46)
60-71 (n=7)	0.51 (0.15)	1.00 (0.20)	0.57 (0.22)	2.08 (0.40)
72-83 (n=10)	0.60 (0.18)	0.96 (0.19)	0.67 (0.29)	2.14 (0.38)

Note: Anova one factor test with post hoc Tukey (p<0.05). Indices: a = statistical difference between age 24-35 and 60-71, b = statistical difference between age 24-35 and 72-83. Effect Size/Partial Eta Squared: Stride time (0.29); Stride frequency (0.30).
Source: Own source.

The variables presented a correlation with age group equal to: stride time (r=0.54; p<0,001) and stride frequency (r=-0.54; p<0,001). In relation to the partial spatial variables, right stride length (m) and left stride length (m) were found, respectively, in the following averages (standard deviations) for each age group: 24-35 (n = 7), 0.20 (0.06) e 0.23 (0.07); 36-47 (n = 8), 0.24 (0.05) e 0.26 (0.05) ;48-59 (n = 8), 0.24 (0.06) e 0.27 (0.04); 60-71 (n = 7), 0.23 (0.09) e 0.28 (0.07); 72-83 (n = 10), 0.30 (1.00) e 0.30 (0.08). Is was not observed statistically significant differences between the right and left stride length variables.

The values for the partial temporal variables of the gait cycle in children with DS, differentiated by age group (Table 3). Regarding partial temporal variables, we observed that the differences were statistically significant only in the first phase of simple support, which is characterized by the weight reception phase. It can also be noted that the time variable of the first simple support over 72 months of age is significantly higher than those for the first three age groups, which includes from 24 to 59 months.

Table 3. Partial temporal variables of the gait cycle in children with DS.

Age Group (months)	First Time Double Support (s)	Time of Second Double Support (s)	Time of First Simple Support (s)	Time of Second Simple Support (s)
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
24-35 (n=7)	0.11 (0.03)	0.10 (0.04)	0.27 (0.03)[a]	0.26 (0.04)
36-47 (n = 8)	0.13 (0.07)	0.12 (0.06)	0.28 (0.03)[b]	0.29 (0.04)
48-59 (n = 8)	0.15 (0.11)	0.10 (0.04)	0.28 (0.04)[c]	0.28 (0.04)
60-71 (n = 7)	0.17 (0.06)	0.16 (0.05)	0.33 (0.09)	0.34 (0.10)
72-83 (n = 10)	0.16 (0.07)	0.10 (0.03)	0.36 (0.06)	0.34 (0.09)

Note: The ANOVA one factor test, with post hoc Tukey test (p<0.05) → Time of Second Double Support and Time of First Simple Support. Kruskal-Wallis (p<0.05) test → Time of First Double Support and Time of Second Simple Support. Indices: a = statistical difference between age 24-35 and 72-83, b = statistical difference between age 36-47 and 72-83, c = statistical difference between age 48-59 and 72-83. Effect Size/Partial Eta Squared: Time of First Simple Support (0.36).
Source: Own source.

Figure 1 presents the behaviors of the average variable values: time of first simple support (T1SS); time of the second simple support (T2SS); length of left step (LLS); length of right step (LRS); time of first double support (T1DS); time of second double support (T2DS), as a function of age. A slight accentuation (growth) in the partial variables (spatial and temporal) as a function of age was also evident.
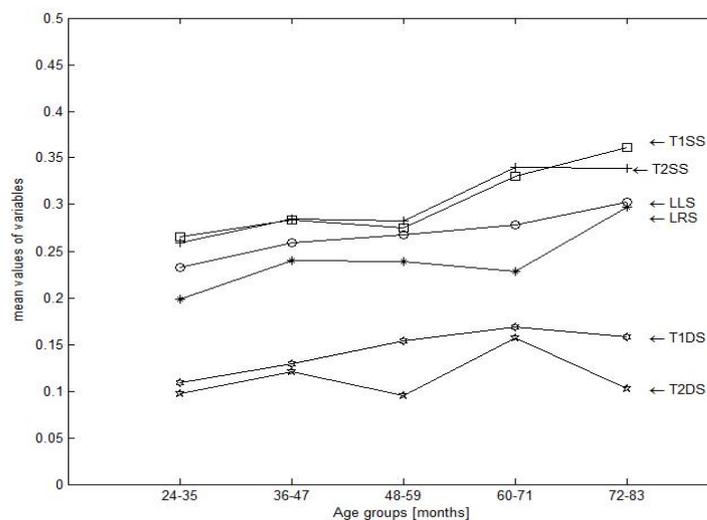
Figure 1. Behavior of partial variables according to age group (T1SS – Time of first simple support; T2SS – Time of the second simple support; LLS – Length of left step; LRS – Length of right step; T1DS – Time of first double support; T2DS – Time of second double support).
Source: Own source.

Moderate and significant correlations with age group were presented with the first simple support time (r=0.57; p<0,001) and the second simple support time (r=0.45; p= 0,004). Significant correlations between the spatiotemporal gait variables and anthropometric variables were also observed in this study. The stride time presented a significant correlation with mass (r=0.59; p<0,001), with height (r=0.59; p<0,001), with thigh circumference (r=0.41; p=0,009), and with leg circumference (r=0.66; p<0,001).

Discussion

One of the primary objectives of the analysis of gait in special populations is to contribute to the understanding of prospecting of the movement pattern according to maturational process. In this study, we develop a descriptive analysis of the gait in children with DS, seeking to diagnose behaviors and relationships between anthropometric and kinematic data according to age group. This procedure is recommended by the literature as the method to generate reliable parameters in the monitoring of human development[10].

This analysis has a strong significance when we look at the idea that for children, walking is a milestone in the achievement of freedom to explore his environment and develop other necessary abilities to their motor emancipation. It must be considered that when the impairment in mobility restricts the individual's ability to move, this limits the development of their activities in daily life and could generate incapacities[11].

In this sense, the information on the motor behavior of gait throughout their lives allows parent, therapists and educators to engage in a more grounded monitoring of childhood development. According to Sutherland[12] the locomotion is a sensitive measurement of neuromuscular development or impairment.

Regarding the anthropometric data (Table 1), we observed that there is an increasing pattern for mass, height, thigh and leg circumference, as a function of age. In these terms, we noted that weight appeared more strongly related to leg circumference than with height or thigh circumference. This seems to demonstrate that, in the calf area, children with DS, even for an indirect analysis, present an increase in muscular surface area according to weight gains. This feature is important because a positive relationship between muscle strength and activity, as hypotonic characteristics of people with DS, can influence the achievement of motor milestones that may limit their physical activity[13]. This first characteristic pointed out in our study, reinforces the idea that these anthropometric measurements can be easily implemented in offices and laboratories.

Regarding the kinematic and spatiotemporal gait data, an age gap where no statistically significant differences occurred was evident. A period of behavioral stabilization between 24 to 59 months was apparent in the behavior of the variables, stride time and frequency. We also observed that there was no modification in the behavior of the variables, stride length and gait speed, as a function of age.

Quite similar behavior was observed for the partial gait variables, in which only the time of the first simple support showed differences between age groups. During the development of the stride, after initial contact, body support occurs through the simple support phase. There is evidence that children with DS are less stable when walking[14]. It is likely that in our data this instability was revealed in the behavior described for the variable for time of first simple support. We observed that at younger ages, the time spent in simple support is less than that for higher age groups (72-83 months). As simple support requires greater body balance compared to double support, it was observed that in the development of velocity, children with DS prioritized the frequency of the step, so that they quickly moved to the next stage of the gait cycle.

Upon analysis of the correlation between the kinematic and anthropometric variables, we determined that the time variable had its greatest correlation value with the leg circumference variable. This also demonstrates that with an increase in calf circumference, there was also an increase in stride time. This behavior probably demonstrates that the child after 5 years of age begins another stage in musculoskeletal development, which enables demonstration of a differentiated motor pattern. This characteristic corresponds with the age of initiation in the process of language learning and expansion of social relationships[2].

The difference presented indicates a period of stabilization in the behavior of the anthropometric variables, stride time and frequency, in children with DS between 2 to 5 years of age. The children's gait pattern over the years was established by the frequency changes in stride length for development of gait speed. Evidence of differentiated gait patterns begin to appear after 5 years, with acquisition of more developed musculoskeletal structure.

This period of apparent delay seems to present a paradox in the process of child development with DS. Is there no way to contribute to the process of motor skill acquisition in children with DS? Or does the apparent latency indicate that is necessary to maintain muscle strengthening work, especially in the lower limbs, and exercises that promote balance postures to create motor stabilization plans? These questions need to be answered, but inoperability cannot be characteristic of the follow-up process. This behavior revealed the existence of an adaptation process in children with DS until a gait pattern was found, which appears to occur after 5 to 6 years of age.

Conclusion

The children's gait pattern over the years was established by the frequency changes in stride length for development of gait speed. The difference presented indicates a period of stabilization in the behavior of the anthropometric variables, stride time and frequency, in children with DS between 2 to 5 years of age. Evidence of differentiated gait patterns begin to appear after 5 years, with acquisition of more developed musculoskeletal structure. This behavior revealed the existence of an adaptation process in children with DS until a gait pattern was found, which appears to occur after 5 to 6 years of age.

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