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Distance and temporal characteristics of jump gait in children with spastic diplegia

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Abstract

Background and Objective: Cerebral palsy is the leading cause of loco motor disability in children around the world [1]. Four frequently described gait patterns in cerebral palsy are jump gait , crouch gait ,equinus gait and stiff knee gait [2]. Very few studies describe the spatiotemporal parameters of jump gait in children. Studies describing the same in the Asian Indian population are a rarity. Aim of this study was to describe the distance and temporal characteristics of jump gait in children with spastic cerebral palsy.

Method: Clinical and 3 D gait analysis reports of 14 children with spastic diplegia walking with jump gait were compiled and studied.3D gait analysis was done using BTS smart DX 600 motion analysis system. Spatial parameters studied were stride length, step length and step width. Temporal parameters studied were cadence mean velocity, stance time, swing time and stride time. The above parameters were studied using independent t test after grouping them by age, sex and GMFCS (Gross motor functional classification system).

Results & Discussion: Cadence and mean velocity was found to decrease as age advances(mean cadence was 129.77steps/minute and the mean velocity was 66.92 cm / sec). While stance time, swing time and stride time increased as the children grew older. Children with jump gait belonging to the GMFCS I group had better cadence and mean velocity than those belonging to GMFCS II group. Most of the results of our study was similar to that of Chang et al except cadence and step width, which showed higher percentage.

Conclusion: Mean velocity and cadence of children with jump gait of the Indian population showed decrease as age advances. Children with jump gait had wider base of support when compared with other studies.

Keywords: cerebral palsy, spastic diplegia, jump gait, spatiotemporal characteristics, 3 D gait analysis.

Introduction

Cerebral palsy (CP) is defined as "a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, behavior, epilepsy and secondary musculoskeletal problems" according to Rosenbaum[3].

Cerebral palsy is the leading cause of locomotor disability in children around the world [1]. Sutherland and Davids described the classical gait patterns of spastic cerebral palsy. Frequently described gait patterns in spastic cerebral palsy are equinus gait, crouch gait , jump gait , stiff knee gait [2], these gait abnormalities vary from a mild toe walking to severe scissoring with crouch gait , some even needing assistance. The management of spasticity, improving balance and strengthening of weak muscles are necessary for improvement of gait in Cerebral palsy. A well carried out clinical examination gives a good insight into the functioning of the muscle groups and pattern of gait. Objective measurement of the temporal and distance parameters of gait can help us to measure the outcomes of the types of gait and the effectiveness of treatment in a better way. The combination of systematic clinical assessment and measurement from instrumented Gait analysis helps to develop the best treatment plan for a specific child or adult with CP and represents the strongest outcome based approach to address the ambulatory needs of this challenging population [4].

Palisano et al described a simple classification to measure gross motor function, the Gross Motor Functional Classification System (GMFCS). This was stratified into five levels [5].

Level I –walks without restriction, limitations in high level skills. Level II -walks without devices, limitation in walking outdoor. Level III- walks with devices, limitation in walking outdoors. Level IV - limited mobility, powered mobility outdoors. Level V-very limited self-mobility, even with assistive technology.

Gait analysis is the systematic study of animal locomotion, more specifically the study of human motion, using the eye and the brain of observers, augmented by instrumentation for measuring body movements, body mechanics, and the activity of the muscles [6].

Anne et al studied the kinematic and electromyographic characteristics of children with cerebral palsy who exhibited genu recurvatum and concluded that through the use of hip, knee and ankle diagrams, knee phase plane plots and knee angle versus time diagrams, distinctive kinematic patterns emerged for children with cerebral palsy who exhibited genu recurvatum[7]. Thus a generalized treatment modality and orthosis need not necessarily lead to similar outcome in comparison of one child with the next. Further research is necessary to describe the possible outcomes of various patterns of gait in these children for evolving better treatment protocols.

This study attempts to describe the temporal and distance characteristics of jump gait in children with spastic diplegia of the Indian population with the aid of 3 D instrumented gait analysis.

Jump gait is characterized by increased hip and knee flexion followed by slight dorsiflexion at initial contact followed by rapid knee extension and plantar flexion during loading response and mid stance. Mauro Cesar et al studied the frequent gait patterns in Cerebral Palsy and found that 9% of the children exhibited jump gait [8]. To our knowledge only very few studies describe the temporal and distance parameters of jump gait in children with spastic diplegia.

Objective

To describe the distance and temporal characteristics of Jump gait in children with spastic diplegia of the Indian population as assessed using 3 D gait analysis.

Materials And Methods

Study design

Descriptive retrospective

Setting

Department of Physical Medicine and Rehabilitation , Government Medical College , Thiruvananthapuram

Duration- Jan 2013 to June 2016

Study population

Children between the ages of 2 years and 18 years attending the CP clinic, clinically diagnosed to have spastic Cerebral Palsy with diplegia and walking with jump gait pattern, who underwent 3 D gait analysis, were included.

Ethical consideration

Data was collected after Institutional Ethical Committee approval and Informed Consent.

Inclusion criteria

1. Children with spastic diplegia having jump gait pattern.
2. Children classified as GMFCS I & GMFCS II.
3. Ambulant children who could walk for 5 meters independently.

Exclusion criteria

1. Children with spastic diplegia having other gait patterns like crouch, ataxia, pure equinus.
2. Children who were classified as GMFCS III , IV& V.
3. Children with on-going seizure disorder or who were medically unstable.
4. Parents & children who were not willing to participate.

Sample size

Using convenient sampling 14 children satisfying the above inclusion criteria were included in the study.

Methodology

Clinical and gait analysis details of spastic diplegic children with jump gait (walking independently with hip flexed, knee flexed and plantar flexed ankles), who underwent 3 D gait analysis was entered in to a performa after informed consent. Data was collected and analyzed over a span of 3 ½ years . All these children were asked to continue their treatment irrespective of their inclusion in the study. They continued on anti spastic medication, exercises, serial casting, play therapy, physiotherapy and occupational therapy as needed. One child had undergone soft tissue surgery for the lower limbs.

Clinical assessment was done for muscle power, tone and range of motion of the lower limbs. Manual goniometer was used to measure joint range of motion. Those children who had more than or equal to 10 degree of fixed flexion deformity of the hip was considered to have hip flexion contracture. Those with less than 80 degree of adductor angle were considered to have adduction deformity. More than 25 degree of popliteal angle was considered to have knee flexion deformity. After clinical assessment, if the child satisfied the inclusion criteria, the child was selected for the study. The 3 D gait analysis data of the child was also recorded in the performa.

3 D gait analysis included anthropometric measurements according to the simple Helen Hayes protocol. Measurement was taken using a standard weighing scale , measuring tape , beam calipers. Measurements included, height, weight, ASIS width, pelvic depth, knee diameter, ankle diameter, leg length, thigh and calf circumference.

After clinical evaluation and anthropometric measurements and calibration of the 3D gait system, reflective markers were attached to the child at 15 points namely one on sacrum, and on both sides – Anterior Superior Iliac Spine, Mid-thigh, femoral condyles, mid-calf, lateral malleolus, heel and 2nd metatarsal head.

Further on 3 D gait acquisition was done by taking a standing session and several walking sessions. The best walking session or sessions was selected for tracking, processing (elaboration) and reporting using the BTS smart DX 600 motion analysis system. This system consisted of four high speed infrared cameras, two video cameras and two force plates embedded on a 5 meter walk way. The protocol used for processing, analyzing and reporting was Simple Helen Hayes protocol.

Analysis

Statistical analysis was performed using SPSS version 16.0 , mean and independent t test was used to determine the difference in spatiotemporal parameters in the above children classified on the basis of age, sex, GMFCS and deformities of hip, knee and ankle.

Results And Observation

Gait analysis reports of 14 children with spastic diplegia, walking with jump gait were studied. There were 9 boys and 5 girls. The mean age of the study population was 8.43 years and the mean weight was 27.11 kg . The mean height of the 14 children was 117.79 cm . 6 of them belonged to GMFCS I and 8 of them belonged to GMFCS II category.

n=14

Table no 1: Age distribution in the study group

Table no 2: Sex distribution in the study group

Table no 3: GMFCS distribution in the study group

The mean value of cadence was 129.77 steps per minute. Cadence was found to decrease with increase in age. The mean velocity of these children with jump gait was 66.92+/-23.4Cm /sec. The speed of walking was found to decrease with advance in age.

Figure no 1: Line diagram showing cadence variation as age advances

Figure no 2: Line diagram showing variation of mean velocity with age

The stance and swing time was also observed to increase with increase in age. The mean stance time was 0.59+/-.23 secs on the right and 0.57+/- 0.21 secs on the left. The mean swing time was 0.42 +/- 0.098(Right) and 0.46+/- 0.14 secs (Left). Stride time mean values were 1.02+/- 0.32 secs on the right and 1.01+/- 0.3 secs on the left. Stride time was also found to increase with age.

Distance parameters assessed revealed the following. Mean stride length was 79.57+/- 14 cm on the right and 79.92+/- 11 cm on the left. The mean step width was 17.3 cm and the mean step length were 36.5+/- 8cm on the right and 35.21+/- 8 cm on the left. The distance parameters initially increased up to the age of 12 and thereafter it decreased.

Figure no 3: Variation of Step length values on right side with age

Figure no 4: Variation of Step length values on left side with age

Figure no 5: Variation of Step width with age

Studies by Thevenon et al mention that the pediatric gait changes pattern to adult around 7 years of age [9]. So in our study we classified the children into two groups those above or equal to 7 years of age and those less than 7 years.

Independent t test was done to compare the spatiotemporal parameters in children under the age of 7 and those above 7 years.

Children with age more than 7 years had decreased cadence, mean velocity and step width than children with age less than 7 years, children with age more than 7 years had increased stance time, swing time, stride time, step length and stride length when compared with children below 7 years of age. Statistical significance was present only for cadence , stance time ,swing time and stride time.

Table no 4: Relationship between age and spatiotemporal parameters

Independent t test conducted on the data of boys and girls revealed the following. Girls had decreased cadence and mean velocity when compared to boys. Stance time , swing time, stride time , step length , stride length and step width values were more for girls than boys.

Table no 5: Gender and spatiotemporal parameters

Independent t test compared the GMFCS I group and GMFCS II group revealed that GMFCS I group had better cadence , mean velocity and stride length than GMFCS II group, and decreased stance time, swing time and stride time than GMFCS group II. Of the above, the changes in the temporal parameters showed statistical significance.

Table no 6: GMFCS and spatiotemporal parameters

Table no 7: Presence of hip adduction deformity in the study group

An independent – sample t- Test was conducted to compare the spatiotemporal parameters in children with hip adduction deformity (adductor angle < or = 80 degree) and those with adductor angle >80 degree. Those with decreased adductor angle had decreased cadence, mean velocity, step length and stride length, and stance, swing and stride time values increased in children with tighter adductors. p-values were not statistically significant.

Table no 8: Hip adduction deformity and spatiotemporal parameters

Table no 9 :Presence of knee flexion deformity in the study group

Table no 10: Gastronemius tightness pattern in the study group

Table no 11: Presence of Hip flexion deformity in the study group

An independent – sample t- Test was conducted to compare the spatiotemporal parameters in those with hip flexion deformity >10 degree and those with hip flexion deformity < 10 degree. Those with hip flexion deformity had decreased cadence, mean velocity, stride length and increased stance time, swing time, stride time, step length and step width when compared to those without the deformity. But none of the them had significant p-value.

Table no 12: Hip flexion deformity right and spatiotemporal parameters

An independent – sample t- Test was conducted to compare the spatiotemporal parameters in children with knee flexion deformity (popliteal angle >25 degree) and those without knee flexion deformity (popliteal angle < 25 degree) . Each limb was assessed separately. Those with increased popliteal angle (> 25 degree) had decreased cadence, mean velocity and increased stance and swing time and stride time when compared to those with popliteal angle (< 25 degree). p-values of cadence, velocity, stance time of both sides and swing time of right side were statistically significant for children with knee deformity on the left.

Table no 13: Knee flexion deformity on right side and spatiotemporal parameters

Table no 14: Knee flexion deformity on left side and spatiotemporal parameters

An independent – sample t- Test was conducted to compare the spatiotemporal parameters in children with spastic equinus and those with dynamic equinus. Those with decreased stretchability of Gastrosoleus ie R2-R1 less than 5 degrees had increased cadence, mean velocity and step width. Whereas stance time, swing time, stride time, step length and stride length values decreased. p-values of this table were not statistically significant.

Table no 15: Gastrosoleus tightness on right side and spatiotemporal parameters

Table no 16: Gastrosoleus tightness on left side and spatiotemporal parameters

DISCUSSION

The objective of the study was to describe the distance and temporal characteristics of jump gait in children with spastic diplegia. The temporal parameters studied were cadence, mean velocity, stance time, swing time and stride time. Cadence and mean velocity was found to decrease with advancing age. Whereas stance time, swing time and stride time increased with age.

The distance parameters studied were step length, stride length and step width. All these decreased as age increased in these children with spasticity. Chang ,Ju Kim et al studied the spatiotemporal parameters of children with spastic diplegia (n=8) and compared it with normal children (n=8). Chang found that walking velocity , cadence , stride length and step width of the children with spastic diplegia were 60%, 77%,73%and 160 % respectively when compared with normal children [10]. When the spatiotemporal parameters of the jump gait of children with spastic diplegia in this study was compared with those of the group of normal children studied by Chang et al , the walking velocity, cadence , stride length and step width were 62%, 108 %, 69% and 234% respectively.

Most of the results of our study were similar to that of Chang et al , except for cadence and step width , both of which showed a higher percentage in the present study group. Cadence was higher among our study group probably due to inclusion of younger children. Step width was higher when compared to the cohort of children with spastic diplegia studied by Chang et al.

Thevenon et al collected normative data of spatiotemporal parameters from a cohort of French children aged between 6 and 12. According to this study the mean velocity , step length , stride length increased with age and cadence, step time, swing time , stance time, single limb stance time, double support time remained static after the age of 7 [9].

In our study of children with jump gait, cadence, mean velocity, step length & stride length decreased with age and stance time, swing time and stride time increased as age advanced. The age related decrease in cadence and mean velocity and increase in stance time, swing time and stride time were found to be statistically significant. Hence when compared with normal children, children with jump gait had decreased mean velocity and cadence which correlates with the increase in stance time, swing time and stride time.

In the present study boys and girls showed almost same parameters of gait except that the cadence and mean velocity was less for girls.

Domaglaska et al studied the relationship between clinical measurements and gait analysis data in children with cerebral palsy and concluded that gait pathology does not depend on the contractures of hip and knee flexors and that clinical evaluation and gait patterns need to be considered as independent factors [12]. In the present study children with hip flexion deformity had decreased cadence and mean velocity when compared to children without hip flexion deformity , but none of the parameters had significant p value. However those children with increased popliteal angle showed decreased cadence and mean velocity (p value < 0.05). Those with poorly stretchable Gastrosoleus muscle had increased cadence (p value < 0.05). Thus unlike Domaglaska et al study the present study shows some significant relation between gait parameters and deformities.

Limitations of the study

Small sample size of n= 14. Indian normative data is not yet available for comparison. Other types of spastic diplegic gait also need to be studied for a more comprehensive comparison.

Conclusions

1. Our study concluded that increase in stance time, swing time and stride time manifested as decrease in cadence and mean velocity as age advanced in children with spastic diplegia, walking with jump gait.
2. Children with jump gait had wider base of support when compared with normal children of other studies.
3. Boys and girls did not show a statistically significant change in the spatiotemporal parameters of gait, though the raw data showed that girls were a bit more slower.

Conflict of Interest

None

Other interest

This original article is part of the unpublished Thesis of the first author Laxmi Mohan

Source of funding

Nil

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Tables

Table no 1: Age distribution in the study group

Age in years	Number of children (%)
2-4	2 (14%)
5-6	5 (36%)
7-12	3 (21%)
13-18	4 (29%)
TOTAL	14 (100%)

Table no 2: Sex distribution in the study group

Sex	Number of children (%)
Male	9 (64%)
Female	5 (36)%
Total	14 (100%)

Table no 3: GMFCS distribution in the study group

GMFCS	Number of children (%)
I	6 (43%)
II	8 (57%)
Total	14 (100%)

Table no 4 : Relationship between age and spatiotemporal parameters

PARAMETER	AGE < 7 n=7	AGE > = 7 n=7	p-value
Cadence(steps/min)	155.85+/-36.19	103.70+/-25.74	0.009
Mean velocity(cm/s)	74.14+/-24.5	59.71+/-22.2	0.272
Stance time(R)(s)	0.44+/-0.11	0.74+/-0.23	0.009
Stance time (L)(s)	0.44+/-0.10	0.70+/-0.21	0.013
Swing time (R)(s)	0.37+/-0.06	0.48+/-0.09	0.016
Swing time (L)(s)	0.36+/-0.06	0.57+/-0.12	0.002

Stride time (R)(s)	0.81+/-0.17	1.23+/-0.31	0.009
Stride time (L)(s)	0.80+/-0.16	1.21+/-0.31	0.01
Step length (R)(m)	0.33+/-0.08	0.39+/-0.07	0.13
Step length (L)(m)	0.31+/-0.05	0.39+/-0.08	0.07
Stride length(R)(m)	0.75+/-0.13	0.84+/-0.16	0.29
Stride length(L)(m)	0.74+/-0.13	0.85+/-0.14	0.16
Step width(m)	0.19+/-0.03	0.16+/-0.05	0.33

Table no 5: Gender and spatiotemporal parameters

PARAMETERS	MALE n=8	FEMALE n=6	p-value
Cadence(steps/min)	142+/-42.78	106+/-24.90	0.11
Velocity (cm/s)	70.67+/-25.12	60.20+/-21.86	0.45
Stance time(s) (R)	0.53+/-0.23	0.71+/0.22	0.17
Stance time (s)(L)	0.51+/-0.20	0.69+/-0.18	0.14
Swing time(s) (R)	0.40+/-0.10	0.48+/-0.07	0.12
Swing time(s) (L)	0.45+/-0.16	0.49+/-0.10	0.65
Stride time(s) (R)	0.93+/-0.32	1.20+/-0.29	0.15
Stride time (s) (L)	0.92+/-0.32	1.17+/-0.28	0.16
Step length(m) (R)	0.36+/-0.10	0.37+/-0.03	0.78
Step length (m) (L)	0.36+/-0.10	0.34+/-0.02	0.64
Stride length(m)(R)	0.80+/-0.18	0.80+/-0.08	0.98
Stride length(m) (L)	0.80+/-0.17	0.80+/-0.08	0.90
Step width	0.16+/-0.04	0.19+/-0.48	0.33

Table no 6: GMFCS and spatiotemporal parameters

PARAMETERS	GMFCS I n=6	GMFCS II n=8	p-value
Cadence(steps/min)	164+/-33.42	104.06+/-22.12	0.02
Velocity (cm/s)	80.83+/-25.20	56.50+/-17.35	0.05
Stance time(s) R	0.42+/-0.10	0.73+/-0.21	0.006
Stance time (s) L	0.41+/-0.08	0.70+/-0.19	0.004
Swing time (s) R	0.35+/-0.05	0.49+/-0.07	0.003
Swing time (s) L	0.35+/-0.06	0.55+/-0.04	0.004
Stride time (s) R	0.76+/-0.14	1.22+/-0.29	0.004
Stride time (s) L	0.75+/-0.14	1.20+/-0.28	0.004
Step length (m) R	0.36+/-0.12	0.36+/-0.04	0.993
Step length (m) L	0.34+/-0.07	0.36+/-0.09	0.73

Stride length (m) R	0.83+/- 0.20	0.77+/- 0.09	0.47
Stride length (m) L	0.82+/- 0.19	0.79+/- 0.10	0.70
Step width (m)	0.17+/- 0.03	0.17+/- 0.05	0.809

Table no 7: Presence of hip adduction deformity in the study group

Hip adduction deformity	Number of children (%)
Present (<or=80)	7 (50%)
Absent (>80)	7 (50%)
Total	14 (100%)

Table no 8: Hip adduction deformity and spatiotemporal parameters

PARAMETERS	ADD > 80^0 n=10	ADD < =80^0 n=4	p-value
Cadence(steps/min)	141.740+/- 47.70	123.133+/- 37.31	0.43
Velocity (cm/s)	72.80+/- 37.81	63.67+/- 12.86	0.51
Stance time(s) R	0.5400+/- 0.29	0.6267+/- 0.20	0.53
Stance time (s) L	0.5260+/- 0.25	0.6011+/- 0.19	0.54
Swing time (s) R	0.4140+/- 0.08	0.4367+/- 0.10	0.69
Swing time (s) L	0.4260+/- 0.12	0.4911+/- 0.15	0.43
Stride time (s) R	0.9560+/- 0.39	1.06+/-0.3	0.57
Stride time (s) L	0.9420+/- 0.38	1.04+/- 0.29	0.58
Step length (m) R	0.4200+/- 0.09	0.33+/- 0.06	0.052
Step length (m) L	0.3520+/- 0.07	0.35+/- 0.08	0.99
Stride length (m) R	0.8780+/- 0.17	0.75+/- 0.11	0.12
Stride length (m) L	0.8740+/- 0.16	0.75+/- 0.11	0.14
Step width(m)	0.1720+/- 0.04	0.17+/- 0.04	0.92

Table no 9: Presence of knee flexion deformity in the study group

Knee flexion deformity (Popliteal angle)	Number of children (%)
Present (Pop > 25 degree)	6 (43%)
Absent (Pop < 25 degree)	8 (57%)
Total	14 (100%)

Table no 10: Gastronemius tightness pattern in the study group

Gastronemius tightness (R2-R1)	Number of children (%)
Static (< or =5)	2 (14%)
Dynamic (> 5)	12 (86%)
Total	14 (100%)

Table no 11: Presence of Hip flexion deformity in the study group

Hip flexion deformity	Number of children (%)
Present (>10 degree)	2 (14%)
Absent (< or =10 degree)	12 (86%)
Total	14 (100%)

Table no 12: Hip flexion deformity (HFD) right and spatiotemporal parameters

PARAMETERS	HFD<10 R n=12	HFD>=10 R n=2	p-value
Cadence(steps/min)	134.933+/-40.40	98.850+/-34.1533	0.26
Velocity(cm/s)	69.42+/-22.02	52.00+/-38.18	0.35
Stance time(s) R	0.5600+/-0.21	0.8100+/-0.32	0.17
Stance time (s) L	0.5433+/-0.19	0.7600+/-0.26	0.18
Swing time (s) R	0.4192+/-0.09	0.4850+/-0.10	0.39
Swing time (s) L	0.4592+/-0.14	0.5200+/-0.16	0.59
Stride time (s) R	0.9775+/-0.30	1.3100+/-0.43	0.19
Stride time (s) L	0.9633+/-0.29	1.2800+/-0.43	0.20
Step length (m) R	0.3600+/-0.08	0.3850+/-0.04	0.70
Step length (m) L	0.3558+/-0.08	0.3300+/-0.02	0.69
Stride length (m) R	0.8025+/-0.15	0.7550+/-0.0	0.69
Stride length (m) L	0.8033+/-0.15	0.7750+/-0.02	0.80
Step width(m)	0.1675+/-0.04	0.2100+/-0.04	0.23

Table no 13: Knee flexion deformity on right side and spatiotemporal parameters

PARAMETERS	Pop<25^0 R n=10	Pop>=25^0 R n=4	p-value
Cadence(steps/min)	138.760+/-42.04	107.325+/-29.58	0.20
Velocity (cm/s)	71.00+/-26.39	56.75+/-12.42	0.32
Stance time(s) R	0.5490+/-0.21	0.7125+/-0.26	0.25
Stance time (s) L	0.5240+/-0.18	0.7000+/-0.23	0.16
Swing time (s) R	0.4040+/-0.09	0.4900+/-0.09	0.13
Swing time (s) L	0.4580+/-0.15	0.4925+/-0.11	0.69
Stride time (s) R	0.9550+/-0.30	1.2000+/-0.35	0.21
Stride time (s) L	0.9360+/-0.29	1.1900+/-0.34	0.19
Step length (m) R	0.3610+/-0.09	0.3700+/-0.04	0.86
Step length (m) L	0.3560+/-0.08	0.3425+/-0.08	0.79
Stride length (m) R	0.8100+/-0.16	0.7600+/-0.08	0.58
Stride length (m) L	0.8150+/-0.15	0.7600+/-0.09	0.53
Step width(m)	0.1640+/-0.04	0.1975+/-0.05	0.22

Table no 14: Knee flexion deformity on left side and spatiotemporal parameters

PARAMETERS	Pop<25^0 L n=10	Pop>=25^0 L n=4	p-value
Cadence(steps/min)	145.056+/-37.73	102.28+/-31.94	0.054
Velocity (cm/s)	79.11+/-19.52	45.00+/-11.4	0.004
Stance time(s) R	0.4967+/-0.14	0.774+/-0.27	0.028

Stance time (s) L	0.4789+/-0.11	0.74+/-0.23	0.014
Swing time (s) R	0.3867+/-0.07	0.50+/-0.08	0.022
Swing time (s) L	0.4367+/-0.15	0.52+/-0.116	0.289
Stride time (s) R	0.8833+/-0.20	0.88+/-0.20	0.22
Stride time (s) L	0.8700+/-0.19	0.87+/-0.19	0.22
Step length (m) R	0.3433+/-0.09	0.34+/-0.09	0.232
Step length (m) L	0.3589+/-0.08	0.35+/-0.08	0.692
Stride length (m) R	0.8044+/-0.16	0.80+/-0.16	0.779
Stride length (m) L	0.8022+/-0.15	0.80+/-0.15	0.922
Step width(m)	0.1611+/-0.03	0.19+/-0.06	0.175

Table no 15: Gastrosoleus tightness on right side and spatiotemporal parameters

PARAMETERS	R2-R1>5^0 right n=12	R2-R1<=5^0 right n=2	p-value
Cadence(steps/min)	122.808+/-37.04	171.600+/-46.66	0.11
Velocity (cm/s)	65.08+/-25.24	78.00+/-4.24	0.49
Stance time(s) R	0.6275+/-0.23	.4050+/-0.09	0.23
Stance time (s) L	0.6008+/-0.21	.4150+/-0.09	0.26
Swing time (s) R	0.4458+/-0.08	.3250+/-0.10	0.10
Swing time (s) L	0.4925+/-0.13	.3200+/-0.09	0.11
Stride time (s) R	1.0742+/-0.32	.7300+/-0.19	0.17
Stride time (s) L	1.0558+/-0.31	.7250+?-0.20	0.18
Step length (m) R	0.3692+/-0.08	.3300+/-0.05	0.55
Step length (m) L	0.3525+/-0.08	.3500+/-0.014	0.97
Stride length (m) R	0.7992+/-0.15	.7750+/-0.04	0.84
Stride length (m) L	0.8067+/-0.15	.7550+/-0.06	0.65
Step width(m)	0.1717+/-0.04	.1850+/-0.007	0.71

Table no 16: Gastrosoleus tightness on left side and spatiotemporal parameters

PARAMETERS	R1-R2 >5^0 left n=13	R1-R2 <=5^0 left n=1	p-value
Cadence(steps/min)	124.023+/-35.74	204	0.05
Velocity (cm/s)	65.85+/-24.32	81	0.55
Stance time(s) R	0.6154+/0.23	0.34	0.27
Stance time (s) L	0.5915+/-0.26	0.35	0.28
Swing time (s) R	0.4423+/-0.08	0.25	0.05
Swing time (s) L	0.4846+/-0.13	0.25	0.11

Stride time (s) R	1.0585+/- 0.31	0.59	0.17
Stride time (s) L	1.0415+/- 0.30	0.58	0.17
Step length (m) R	0.3692+/- 0.08	0.29	0.37
Step length (m) L	0.3531+/- 0.08	0.34	0.88
Stride length (m) R	0.8000+/- 0.15	0.74	0.71
Stride length (m) L	0.8062+/- 0.14	0.71	0.53
Step width(m)	0.1723+/- 0.04	0.19	0.72

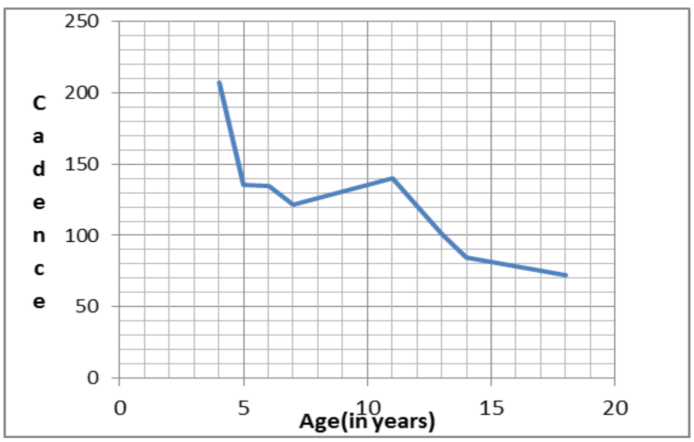

Figure no 1: Line diagram showing cadence variation as age advances

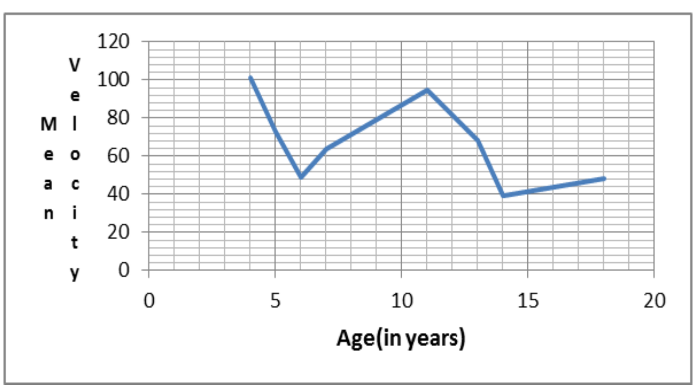

Figure no 2 : Line diagram showing variation of mean velocity with age

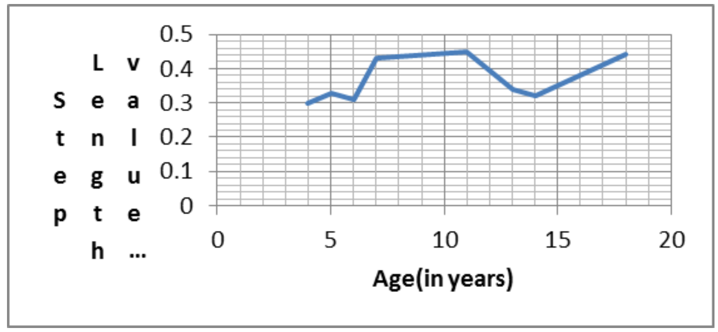

Figure no 3: Variation of Step length values on right side with age

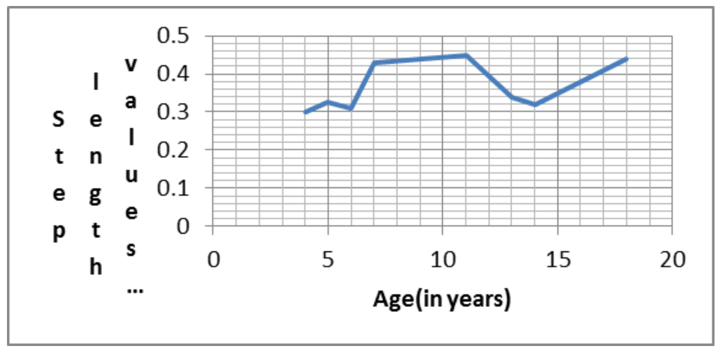

Figure no 4 : Variation of Step length values on left side with age

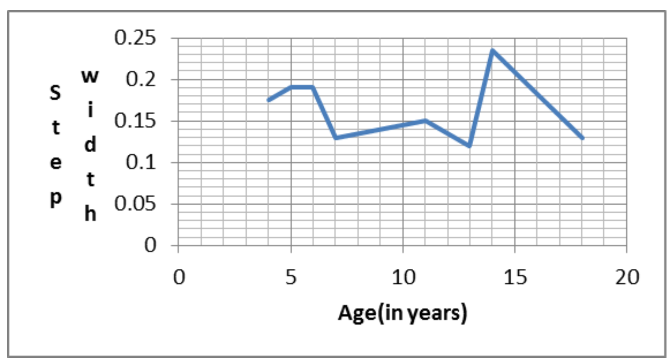

Figure no 5: Variation of Step width with age

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