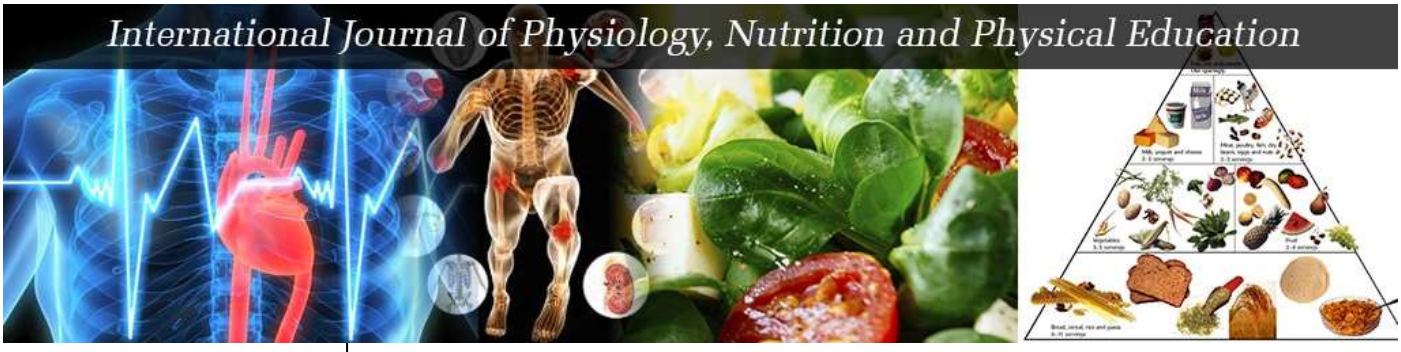

ISSN: 2456-0057
IJPNPE 2021; 6(1): 65-70

www.journalofsports.com
Received: 14-11-2020
Accepted: 30-12-2020

Dr. Syed Anayat Hussain
Director Physical Education, Government Degree College, Ganderbal, Jammu and Kashmir, India

Dr. Surjeet Singh
Assistant Professor, Department of Physical Education, University of Kashmir, Jammu and Kashmir, India

Sarfaraz Hussain Malik
Director Physical Education, Government Degree College, Ganderbal, Jammu and Kashmir, India

Corresponding Author:
Dr. Syed Anayat Hussain
Director Physical Education, Government Degree College, Ganderbal, Jammu and Kashmir, India

Biomechanical analysis of spatio-temporal gait factors in determining gender gait maturation in school children

Dr. Syed Anayat Hussain, Dr. Surjeet Singh and Sarfaraz Hussain Malik

DOI: https://doi.org/10.22271/journalofsport.2021.v6.i1b.2164

Abstract
Background: Spatio-temporal gait analysis includes identification of distance (Spatio) and time (temporal) related events during entire gait cycle for characterizing the gait.
Research question: Although quantitative norms have been developed for various spatial and temporal characteristics of gait but less information is available of childhood, especially during early school years. There is a lack of adequate description of biomechanics in typically developing healthy children. Subsequently, the study was focused on both the genders of human population with ages ranging from 5-8 years, because this is the transition period in relation to the development of steady gait.
Methods: The approach consisted of designing an experimental set up to gather kinematic data of running of school children at optimum gait speeds. A total of numbers of four hundred and two (402) school children were randomly selected for the study. The Spatio-temporal gait parameters were recorded during a complete gait cycle and were analyzed using "Silicon Coach Pro-7"motion analysis software. The statistical analysis was done using SPSSv17.0.
Results: The outcome showed significant difference in Step Length (t = 2.92; p<0.004), Cadence (t = 11.15; p<0.000); Subject Velocity (t = 10.32; p<0.000); Gait Cycle Duration (t = 9.25; p<0.000); Stance Phase Duration (t = 13.43; p<0.000); while as no such significant difference was observed in case of Stride length and Swing Phase Duration.
Significance: The results depicted a statistically significant difference in most of the selected biomechanical parameters between different age groups of both the genders. This indicates that during this period (5-8 years) a child is in a maturing stage of his gait, and it can be concluded that all the interventions regarding the abnormality of gait and in-efficient running if any can be completely rectified during this period, before the mature gait sets in.

Keywords: *Gait* analysis, spatio-temporal, motion analysis, gait cycle, stance phase

Introduction
Locomotion (walking and Running) is one of the most common in human movements. The motion of the body is a complicated process involving the coordination of neuromuscular and skeletal systems in order to have a smooth and efficient locomotion [1]. It is one of the most complex tasks that we learn, but once learned it becomes subconscious and automatic. The main purpose of walking/running is to transfer or move the body efficiently and comfortably across the ground [2]. Walking and running is one of the basic activities seen in children helping them to develop their bones, nerves and muscles [3]. Since the function and independence of a child depends upon the treatment of any abnormality in walking or running, it is of prime importance to timely assess any type of disorder if observed in walking or running with accuracy and objectivity [4]. "*Gait"* is the term used to describe the characteristics of body motion [5]. It varies between the individuals and also varies from step to step within an individual. Gait consists of coordinated complex and cyclic movements of body parts through a dynamic interaction of the internal and external forces [6]. The systematic study of human bipedal locomotion which is carried out both by visual observation and usage of various instruments is termed as gait analysis [7].
The development of running ability of children at different ages is being researched by various sports and teaching institutions and has become a paramount topic in current scenario.

At younger age children exhibit different gait patterns because their muscles, power, physical coordination and body balance are in developing stage. With the assistance of video analysis, the childrens' gait is analyzed from biomechanical aspect. The deviations if any in gait patterns from the normal one is recognized and the causes are traced out. Then improvement suggestions are proposed to promote healthy development of children. The development of human neuromuscular system starts right from the infancy. At an age of approximately 6-months an infant becomes able to sit, at 9-months to crawl, at the age of 1 year he learns to walk with support, at the age 15-months he learns to walk without support and at the age of 18-months he learns to run, after that a steady gait pattern begins to establish. At the age of 3 years, a more mature gait sets in and a balance in walking is visually apparent [8]. However, development in neuromuscular coordination and locomotor function continues well beyond this age [9]. Some investigators are of the opinion that this development process terminates by the age of 5 years [10] or earlier. It has also been reported that at the age of 10 to 11 years or more, the gait pattern of children approaches to that of an adult, after that only slight changes may occur and the anthropometrical factors become dominant [11]. It is therefore of interest to define gait variations among different age groups especially 5-8 years which is a transition period in the development of gait in children and a little quantitative research has been conducted in this dimension. Therefore, our study was aimed to analyze the Spatio-temporal gait factors of both the genders thereby characterizing their gait maturation.

Method

Participants

Four hundred two (402) normal school going children (with no record of neurological, orthopedic or developmental problems) including both the genders and categorized into three different age groups; 5-6 years, 6-7 years, 7-8 years, participated in the study. The subjects were randomly selected from different schools of different districts of Kashmir Division of Jammu & Kashmir (UT). The mean and standard deviation (SD) of body height (cms) and body weight (kgs) of different age groups of both the genders are shown in tabular form (Table 1 & 2).

Table 1: Subject demographics by age group of school children, boys (n = 201)

S. No.	Group	No. of Subjects	Age (Years)		Weight (Kgs)		Height (Cms)	
		(n)	Mean	SD	Mean	SD	Mean	SD
1	5-6 years	67	5.37	0.24	21.53	3.01	122.61	6.19
2	6-7 years	67	6.25	0.13	24.80	4.40	129.14	7.81
3	7-8 years	67	7.35	0.19	27.22	5.20	133.53	7.09

Table 2: Subject demographics by age group of school children, girls (n = 201)

S. No.	Group	No. of Subjects	Age (Years)		Weight (Kgs)		Height (Cms)	
		(n)	Mean	SD	Mean	SD	Mean	SD
1	5-6 years	67	5.28	0.19	20.85	3.26	119.83	7.20
2	6-7 years	67	6.30	0.21	22.76	3.39	127.00	6.43
3	7-8 years	67	7.32	0.18	27.20	4.16	134.89	4.20

Procedure

Spatio-temporal gait data was obtained using a Legaria SF10 Cannon Camcorder which was positioned perpendicular to sagittal plane on the left side of the subject at a distance of 8.5 meters from the mid of the calibrated running line/axis. The subjects ran on the provided calibrated running line/axis for about 10 meters at optimum speeds. The subjects were given three trials and the best one was taken under consideration for analysis. The parameters assessed were, step length (mts), stride length (mts), cadence (steps/mint.), subject velocity (mtr/sec) gait cycle duration (sec.), stance phase duration (sec) and swing phase duration (sec).

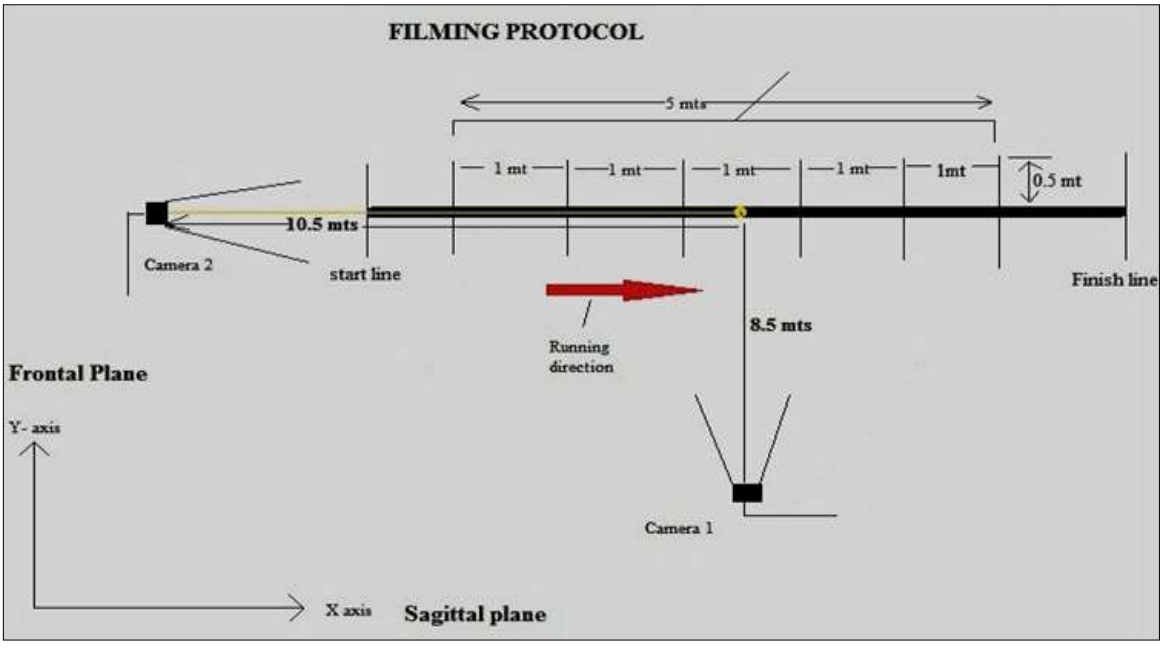

Fig 1: Filming experimental set-up

Criterion measure

Spatial parameters

These parameters are related to distances or space and were determined during each gait cycle from the initial heel strike to toe-off. Silicon Coach Pro-7 (Motion Analysis Software) enabled the researcher to measure distances by converting pixels on screen to a real life distances. Before measuring, a scale was set using the measurement that was included on the day of filming.

Step length

Step Length is measured from the heel center of one limb to the heel center of the opposite limb.

Stride length

Stride length is the distance between the two subsequent contacts of the same foot. It is measured from the heel contact of one limb to the next heel contact of the same limb. Stride length is measured along the line of progression.

Temporal parameters

These are time dependent measurements and are measured in the following way:

Cadence

It is measured as the number of steps per unit time, usually expressed as steps/minute as an individual walks or runs. In present study, the time duration of five steps taken by subject was recorded (1.640 sec) and accordingly the number of steps in one minute or sixty seconds was calculated.

Subject velocity

Velocity is the rate of change of position with respect to some frame of reference. It is calculated as the displacement over time. In figure 3.20, the subject's centre of gravity was taken as a stationary point, its displacement was measured, and time recorded as subject moved from one point to other.

Gait cycle duration

It is the time period lapsed between the successive heel contacts of the same foot. It encompasses in it the two phases durations; stance phase duration and swing phase duration. It is measured in seconds.

Stance phase duration

It is the period of time in gait cycle during which the foot remains in contact with the ground, measured in seconds.

Swing phase duration

It is the period of time in gait cycle during which the foot is off the ground and swinging forward, measured in seconds.

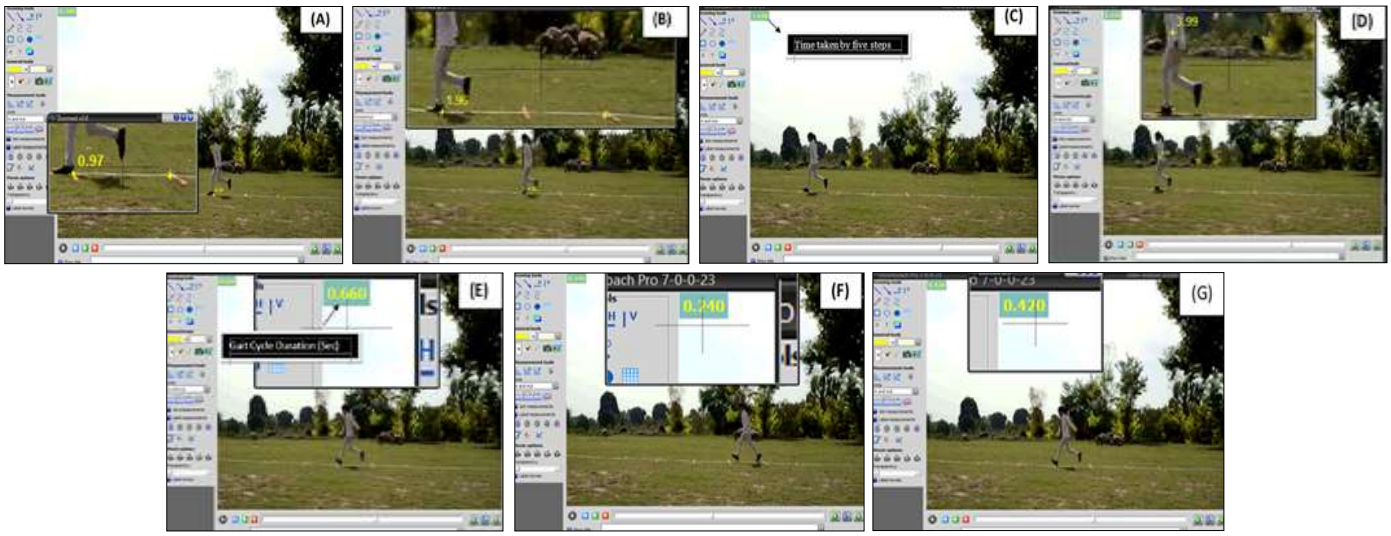

Fig 2: Measurement of spatio-temporal parameters using silicon coach pro-7 (Motion analysis software). (A) Step length (B) Stride length (C) Cadence (D) Subject velocity (E) Gait cycle duration (F) Stance phase duration (G) Swing phase duration

Data Reduction

After obtaining the required video data, the recorded videos were carefully viewed and the best performance clips were extracted and Special Identification Code (SIC) was given to each subject for recognition. A big complex data was reduced based on identified criterion measures set by the researcher. The selected video clips with specific SIC number were slashed into frames as per the phases of running gait; Stance Phase (Initial Contact, Mid Stance, and Toe-Off) and Swing Phase (Initial Swing and Terminal Swing). As no markers were attached to the subject, the selected anatomical landmarks on subject's body in slashed frames were manually digitized when playing Silicon Coach Pro-7 motion analysis software. This helped in quantifying the identified kinematic parameters.

Selection of frames for analysis

The selection of frames for analysis of running gait, because of its cyclic nature, was divided into two basic phases, both having their sub phases: Stance Phase (Initial Contact/Heel Strike, Mid Stance, Toe-off) and Swing Phase (Initial Swing, Mid Swing, and Terminal Swing) as shown in figure - 3.

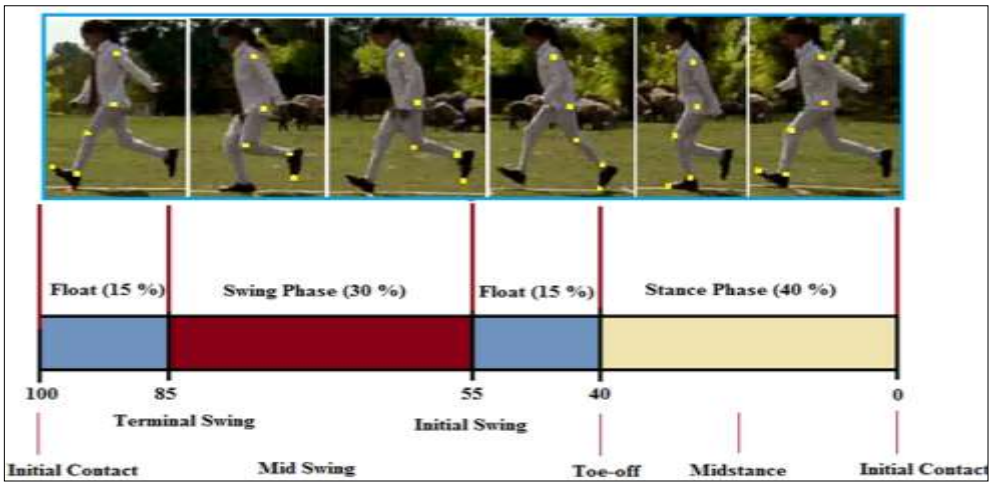

Fig 3: Phases of gait cycle for analysis

Motion analysis software

To analyze the clipped or slashed video recording of the running gait of school children, software; Xilisoft Video Converter Ultimate 6.0 and Silicon Coach Pro-7 were used. These motion analysis software provide to identify and quantify the angles, velocity, displacement, time, and number of frames of the selected biomechanical parameters of the study.

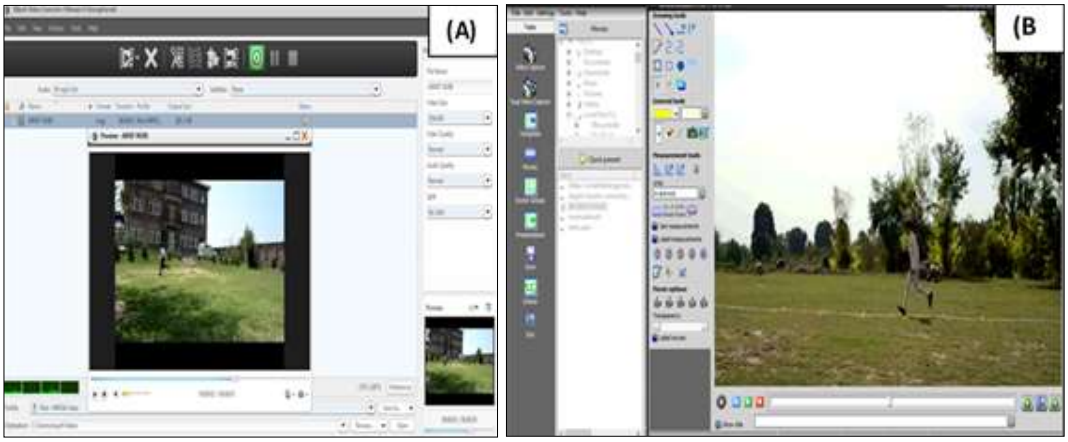

Fig 4: Motion analysis software (A) Xilisoft video converter ultimate 6.0 software (Opening window) (B) Silicon coach pro-7 motion analysis software (Opening window)

Results

Independent T-test was performed to find out the significant mean difference between selected biomechanical variables of two gender groups (Boys and Girls). According to table 3, there was a significant difference in Step Length (t = 2.92; p<0.004), Cadence (t = 11.15; p<0.000); Subject Velocity (t = 10.32; p<0.000); Gait Cycle Duration (t = 9.25; p<0.000); Stance Phase Duration (t = 13.43; p<0.000); between the two genders. Female school children had lower step length, cadence and subject velocity than their counterparts; but their gait cycle duration and stance phase duration was higher. No significant difference was observed in Stride Length (t = 1.90; p>0.057) and Swing Phase Duration (t = 1.64; p>1.01) between the two genders.

Table 3: Results of selected spatio-temporal variables of running gait

Variable	Group	N	Mean	Std. deviation	df	t	*p*
Step Length (mtr)	Boys	201	1.067	0.101	400	2.926*	0.004
	Girls	201	1.036	0.113			
Stride Length (mtr)	Boys	201	2.148	0.267	400	1.907	0.057
	Girls	201	2.101	0.224			
Cadence (steps/min)	Boys	201	226.524	15.073	400	11.152*	0.000
	Girls	201	209.880	14.850			
Subject Velocity (mtr/sec)	Boys	201	4.107	0.368	400	10.325*	0.000
	Girls	201	3.740	0.344			
Gait Cycle Duration (sec)	Boys	201	0.493	0.033	400	9.25*	0.000
	Girls	201	0.531	0.049			
Stance Phase Duration (sec)	Boys	201	0.172	0.021	400	13.43*	0.000
	Girls	201	0.206	0.029			
Swing Phase Duration (sec)	Boys	201	0.321	0.029	400	1.644	1.01
	Girls	201	0.326	0.035			

*Significance level at 0.05, Tab $t_{0.05}$ (400) = 1.960

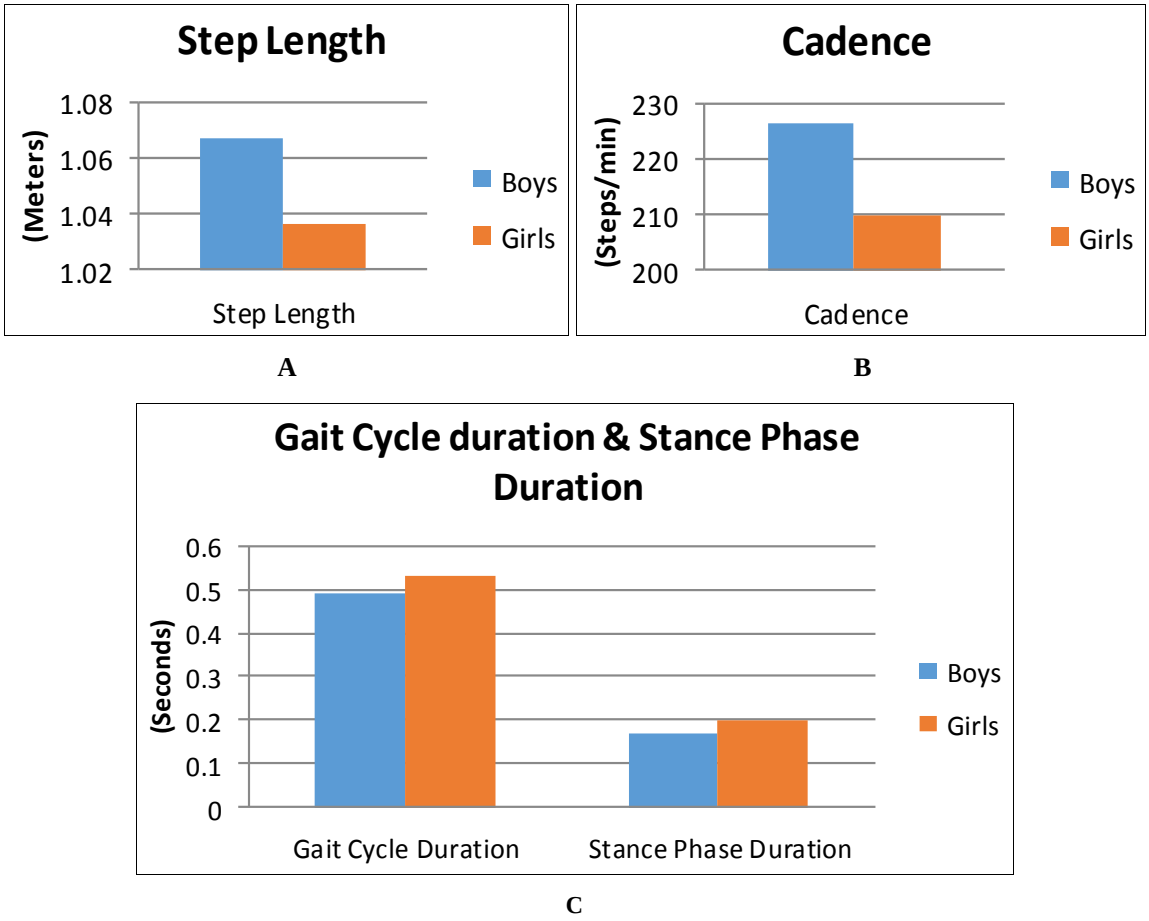

Fig 5: Graphical representation of spatio-temporal parameters having significant difference between boys and girls (A) Step length (B) Cadence, and (C) Gait cycle and Stance phase duration

Discussion

The results revealed that the male school children were having significant increase in mean step length, cadence and subject velocity with an advancement of age from 5-6 years old to 6-7 years old and to 7-8 years old. The apparent increase in step length with the advancement of age, as observed is attributed to; enhanced coordination, equilibrium and movement control of maturing children and to the natural adaptation of their lower extremities [12]. Another factor that contributed to significant increase in mean step-length according to [13] is the gait speed. Additionally, it was observed during data collection that male tend to run faster compared to female counterparts and same was tabulated in figure 5 of our results hence the gait cycle duration and stance phase duration in males is shorter than females. Same observation of increased step was recorded by [14] concluding that with increase in age, the gait in male children is influenced by a set of neurological and musculo-skeletal adaptations that may evolve in terms of spatial and temporal patterns such as step length. Hence, from our results it can be suggested that there is a greater gait maturation of male children than female ones during the same age period (5 to 8 years).

Conclusion

In present study, gender related differences in selected spatio-temporal gait parameters have been presented. Because of the underdevelopment of leg muscles and body coordination, there exists a transition phase between immature and mature gait of children. The results depicted a statistically significant difference in most of the selected biomechanical parameters between different age groups (5-6 years, 6-7 years, & 7-8 years) of both the genders. This indicates that during this period (5-8 years) a child is in a maturing stage of his gait, and it can be concluded that all the interventions regarding the abnormality of gait and in-efficient running if any can be completely rectified during this period, before the mature gait sets in. Further, in relation to gender difference, it can be concluded that both the genders of the same age show a different approach in relation to growth and development of their body.

Declaration of conflict interest

There were no conflicts of interest with other authors or institution for this study.

Acknowledgements

The researcher acknowledges all the children who participated in the study, their parents and all educational institutions who provided with the all facilities and assistance required. No financial support was granted from any of the organization.

References

1. Kyriazis V. Temporal gait analysis of children aged 9-10 years. Journal of Orthopedic Traumatol 2012;3:31-34.
2. Winter DA. Energy generation and absorption at the ankle and knee during fast, natural and slow cadences. Clinical Orthopedics and Related Research 1983;175:147-154.
3. Wang XZ. Ji, Kinematic analysis of running for children of 3 to 6 years old. International Conference on

Electronics, Information & Communication Engineering Lecture Notes in Information Technology 2012;11:174-150.
4. Kyriazis V, Rigas C. Temporal gait analysis of hip oesteoarthritic patients operated with cementless hip replacement. Clinical biomechanics (Bristol, Avon) 2002;17(4):318-21.
5. Baharuddin MY, MSM, Salim Hashim A. Biomechanics analysis on running. Proceedings of International Conference on Application and Design in Mechanical Engineering (ICADME), MALAYSIA 2009.
6. Sacco IC, Amadio AC. A study of biomechanical parameters in gait analysis & sensitive cronaxie of diabetic neuropathic patients. Clinical Biomechanics 2000;15:196-202.
7. Benson M, Fixens J, Macinel M, Parsch K. Children's orthopedics and fractures. Springer-Verleg London Limited 2010.
8. Sheridan MDS. The developmental progress of infants and young children. Ministry of health report No. 102. London 1960.
9. Peris S, Klemms A, Muller K. Gait analysis by measuring ground reaction forces in children: changes to an adaptive gait pattern between the ages of one and five years. Developmental Medicine & Child Neurology 1997;39:228-233.
10. Statham Lois MP. Murray, Early walking patterns of normal children. Clinical Orthopedics and Related Research 1971;79:8-24.
11. Sutherland DH, Olshen R, Cooper L, Woo SL. The development of mature gait. The journal of Bone & Joint Surgery 1980;62:336-353.
12. Wheelwright EF, Minns RA, Law HT, Elton RA. Temporal and spatial parameters of gait in children, I: Normal control data. Developmental medicine and child neurology 1993;35(2):102-13.
13. Jacobs R. Development of gait at slow, free and fast speeds in 3-and 5-year–old children. Journal of American Physical Therapy 1983;62:1251-1259.
14. Hernandez AM, Reyes GR, Uriostegui IQ, Carrera LN, Sanpablo AIP. Temporal and spatial parameters analysis in non-pathological Mexican children. Gait & Posture 2010;32:78-81.