THE GAIT OF ADOLESCENT MALES WITH AUTISTIC BEHAVIORS: A PILOT STUDY

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by

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ABSTRACT

The manner by which a person walks provides information about the functioning of the nervous system. Information of this type may be useful in the determination of the etiology(s) and management of autism. The primary purpose of this pilot study was to determine whether a difference existed between a group of four adolescent males with autism and a group of three normal male adolescents in 17 parameters of gait studied. A secondary purpose of the inquiry was to test a method of collecting and extracting data on temporal-spacial, linear, angular and qualitative gait parameters through the use of a videotaping/data extraction technique. Markers were placed on specific sites on the subjects' body to enable the measurement of joint angles. The subjects were then videotaped while they walked up and down a walkway for a total of six times. Data was extracted from the videotape for 15 of the parameters studied. A footprint paper technique was used to collect data on two gait parameters. All data was extracted from the videotape by the investigator. In order to assess a sample of the intrarater reliability of the outcome measures, the investigator extracted data for two of the gait parameters studied on two occasions. Results

indicate that the intrarater reliability was excellent for the sample of outcomes measured. Student t-test and chi square analysis revealled no statistically significant differences between the two groups in the 17 gait parameters studied. Clinical significance was found for the knee angle in the initial contact position, alternate arm swing and head position parameters. A Repeated Measures Analysis of Variance (1 factor) analysis showed no significant differences between the two study groups in the symmetry of right and left leg gait parameters. However, the likelihood of detecting a difference should one have existed, is limited due to the small sample size and the limitations and biases operative in study. Therefore, no definitive conclusion can be drawn concerning the differences in the gaits of the groups studied. Modifications to this study are suggested which may enable future research to answer the study question.

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To Paul Stratford my research advisor whose knowledge, accessibility and supportive efforts were for ever present - my sincere respect.

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1.0 INTRODUCTION

1.1 Background

In 1943, Dr. L. Kanner identified a group of children who shared similar distortions in the development of basic psychological functions. The essential diagnostic distortions in the development of children classified as having autism are a lack of responsiveness to other people, gross impairment in communicative skills and bizarre responses to all aspects of the environment (See Appendix 1). These essential characteristics of the disorder develop within the first 30 months of age (APA, 1980).

The wide differences in severity, periodic changes in symptoms, confusing and inconsistent nosology and the lack of overt physical signs make diagnosis a difficult procedure (Ornitz and Ritvo, 1976). A high percentage of individuals with autism have concurrent mental retardation (DeMeyer, et. al. 1981). The disorder is chronic and two thirds of the individuals remain severely handicapped and are unable to lead independent lives (APA, 1980).

The literature identifies the prevalence of the disorder from 2.4 cases per 10,000 (Lotter, 1966; Treffert, 1970; APA, 1980). The prevalence figures

presently available should be considered low as children with autism under the age of four and after the age of six are frequently misdiagnosed (Ornitz and Ritvo, 1976). The etiology of the disorder is unknown but multiple causation is suspected (Coleman and Gillberg, 1985). In future, therefore, it appears that more individuals will receive the diagnosis of Infantile Autism as clinical diagnostic methods and expertise improve. Consequently, it is imperative that research continue in defining the etiology(s) of the disorder and that reliable and valid diagnostic tools and effective therapeutic programs be designed to promote the optimal development and societal functioning of these individuals.

1.2 Rationale for Study

The abnormal motor behaviors frequently exhibited by individuals with autism eg. finger posturing, hand-flapping, rocking, unusual gait are well documented in clinical reports and the academic literature (Ornitz and Ritvo, 1976; Rutter, 1974; Wing, 1966). The literature pertaining to motor proficiency and development is scanty and conflicting (Ando, et al. 1978; DeMeyer, 1976; Ornitz, 1977: Reid and Morin, 1981; Wing, 1966; Wing, 1976a).

Damasio and Maurer (1978) propose a neurological

model for Infantile Autism and describe the abnormal movement patterns associated with individuals with autism in neurologic terminology. In furthering the concepts presented in this model, it is suggested that through astute observation and analysis of movement patterns, it may be possible to indirectly obtain information about the functioning of the nervous system in both the production and learning of motor responses, and the manner by which the individual, processes and uses environmental sensory stimuli to shape movement behaviour. Obtaining such information about the movement of individuals with autism may provide some insight to the etiology(s) of the disorder, as well as relevant information pertaining to the clinical management of the population. Kinesiology is knowledge base which examines the factors that AFFECT and EFFECT human movement (See Figure 1) and thus, is a discipline which can study and provide useful information to the clinician intervening in the care of the individual with autism and their family.

Kinesiological
Framework
for
Gait

Factors that Affect and Effect Human Gait

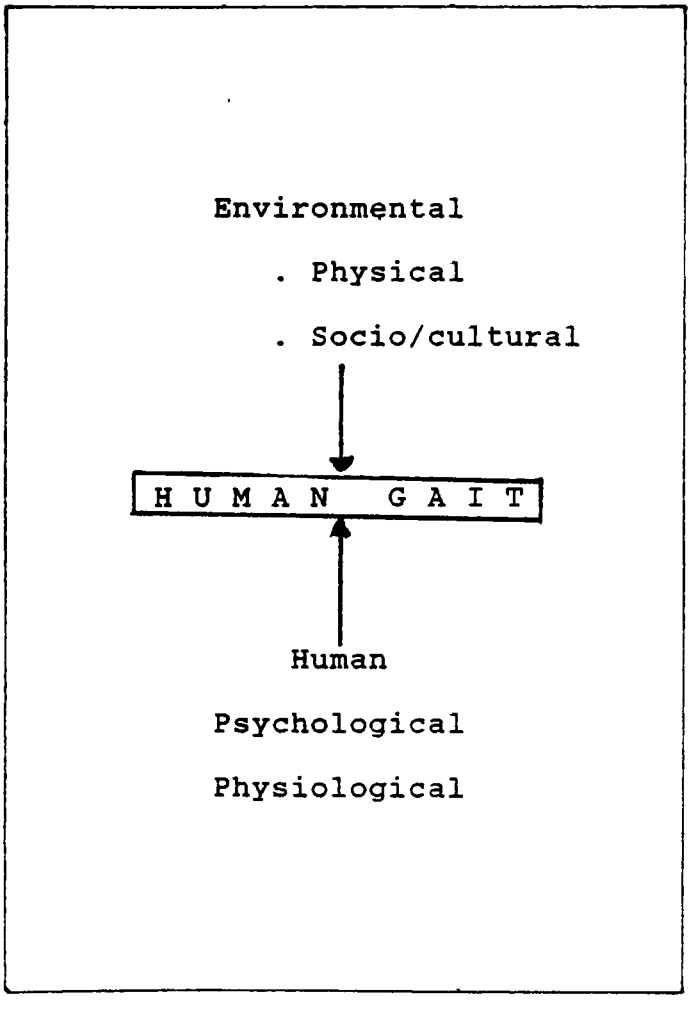


FIGURE 1

1.3 Purpose of the Study

The primary purpose of this pilot study was to answer the following question:

> Is there a difference in several aspects of the way adolescent males with autism walk as compared to a normal group of adolescent males as measured by a videotaping and data extraction technique?

The technique chosen to measure and analyze aspects (parameters) of gait had not been assessed for intrarater reliability. Therefore, a second purpose of this study was to answer the question:

> Does the videotaping data extraction technique used demonstrate adequate intrarater reliability when used with adolescent males with autism and normal adolescent males?

As symmetry of right and left leg gait parameters has been proven to be the most characteristic property of normal gait (Stanic, et. al. 1977), the following sub question was addressed in this study:

> Are there differences in right and left gait parameters in a group of adolescents with autism as compared to a group of normal adolescent males?

1.4 Justification of Movement Pattern Selection

The investigator selected to study several aspects of the way individuals with autism walk because gait is:

a) one of the most frequently elicited movement patterns exhibited by most people.

b) one of the most repeatable and consistent motor patterns in the human movement repertoire (Murray, et. al., 1964).

c) is the signature of nervous system health (Grimm, 1984).

2.0 PRESENT STATE OF KNOWLEDGE

2.1 Overview:

The literature reviewed related to:

1. Gait and individuals with autistic behaviors.
2. Gait development/normative data on children.
3. Methods of gait evaluation.

2.2 Gait of Individuals with Autistic Behaviour:

The literature related to the gait in individuals with autistic behaviors was reviewed in order to determine the nature of the problem and its possible determinants. No studies were found which addressed these issues in adolescents. Only one paper was located which examined the topic in children. Vilensky et. al. (1981) used a filming technique to compare nine gait parameters of 21 children with autism to 15 normal and five children with hyperactive-aggressive behaviour. The research findings revealed that the children with autism differed significantly in five of the parameters studied. This information was then compared to data obtained from other descriptive studies of adult pathological gait. Vilensky concluded that the gait differences between the subjects with autism and the normal subjects resembled the differences between the gaits of

adults with parkinsonism and normal adults. Based on the above similarities, Vilensky emphasized that the results of this study supported the view that autism may be associated with specific dysfunction of the motor system affecting amongst other structures the basal ganglia. Results of this study must be viewed cautiously. Methodological flaws that existed in this reported research (see Table 1) included:

1) lack of a randomized sample selection
2) insufficient description of subjects
3) referral bias was operative
4) observers were not blind
5) hip angle measurement had poor validity
6) insufficient description of technique/procedure
7) no attempt to control for antipsychotic medication which may potentiate motor side effects
8) no temporal description of gait
9) no reported reliability of data extraction procedure
10) no study of right/left leg gait parameters

2.3 Gait Development/Normative Data in Children:

The author was unable to locate any literature describing the gait of normal adolescent individuals. In order to ascertain the appropriateness of using the normative gait data derived from observations of adults, it was necessary to review the literature on normal gait development.

TABLE 1

GAIT AND CHILDREN WITH AUTISTIC BEHAVIOURS

STUDY	DESIGN	SUBJECTS	COMPARABILITY
Vilensky, J et al (1981)	descriptive	N = 41 Exp 1 = 21 Control 1 = 15 Control 2 = 5	generally for age (no stated comparisons)

MEASURES Quantitative	Qualitative	INSTRUMENTATION
- hip, knee, ankle angles at touch and toe off - stance phase - swing phase - cycle duration - stride length	- amount of upper limb movement - elbow orientation - position of face at heel strike	- 2 high speed film cameras - manual video analysis

RESULTS	MAJOR WEAKNESSES
Autistic group showed: decreased stride lengths increased stance phases, increased hip flexion at toe-off, reduced knee extension at initial contact, more intelligent children had heel touch ankle angles that more closely resembled those of normal children, the gait of children with autism is similar to that of patients with Parkinson's disease.	many referral biases, no subject matching described, antipsychotic medications not controlled for, poor validity of measure of hip angle, observer not blind, lack of adequate description of methodologies, lack of diagnostic information, not a temporal description, no demonstration of reliability of measurement process.

Beck et. al. (1981) studied the gait of 51 children aged 11 months to 14 years. Data from this study indicated that time, distance measurements and ground reaction force measurements were dependent on the walking speed and age of the child. The same authors found that the increase of height with age was the major factor in the change of time and distance parameters with age. General force reaction measurements were shown to attain adult patterns at an age of five years. Rose-Jacobs (1983) used a footprint paper technique to examine five gait parameters in three and five year old children walking at slow, free and fast speeds. Results indicated that stride length and cadence were significantly different for age and speed, while step length and stride width were significant for only speed. The angle of inclinations of the subjects' feet were not significant for age or speed. Rose-Jacobs concluded that gait patterns of three and five year old children are not fully mature. Sutherland et. al. (1980) in a comprehensive study examining multiparameters of gait concluded that the important parameters determining gait maturity included duration of stance phase, walking velocity, cadence, step length and the ratio of pelvic span to ankle spread. This author stresses that increasing limb length and greater limb stability resulting in the increase in stance phase are important factors in the development of mature gait. Contrary to Rose-Jacobs, Sutherland concluded that a mature gait pattern

based on the above criteria is well established at the age of three years. Foley et. al. (1979) used a TV computer system of data collection and analysis to study 10 kinematic gait parameters in 20 children ranging in age from six to 13 years. Findings from this study suggested that while joint angle ranges of motion were identical to adult values, other parameters such as linear displacements, velocities and accelerations were almost consistently larger for children. This author concluded that there are some differences between adult and child gait.

In summary, the research findings were not consistent or conclusive in the limited review of the literature on gait development/characteristics of children (see Table 2). The differences in the findings could be attributed to a variety of sources including:

1) lack of randomized sample selection
2) small sample sizes in some cases
3) use of different methods of analyzing gait
4) differences in types and number of parameters measured
5) number of walks analyzed
6) scant reporting of reliability data

TABLE 2

DESCRIPTIVE STUDIES EXAMINING THE DEVELOPMENT OF NORMAL GAIT

Legend

V = velocity
C = cadence
SP = stance phase
SWP = swing phase
CD = cycle duration
PP = pace period
SPL = step length
SL = stride length
SPW = step width
SW = stride width
HKA = hip, knee, ankle angles
PO = pelvic obliquity
FGRF = foot ground reaction forced
RLES = rotations of lower extremity joints/-segments
A = acceleration
SPNR = sample procedure not reported
NRS = not a randomized sample

Study	Sample N	Age Range	Described Criteria for Normal	Reproducible	Gait Parameters
Beck et. al. (1981)	51 SPNR	11 months to 14 years	yes	yes	V, C, SL, SP, SWP, CD & FGRF
Rose-Jacobs (1983)	31 NRS	3 & 5 year olds	yes	yes	SL, SPL, AOF, C, SW; Correlated Gait Factors & Motor Dev.
Sutherland et. al. (1980)	186 SPNR	1 - 7 years	no	yes	HKA, SPL, V, SP, C, PT
Foley et. al. (1979)	20 SPNR	6 - 13 years	yes	yes	PP, SL, V, A, HKA

Study	Temporality	Techniques & Methods	Findings
Beck et. al 1981	yes	20 traverses of 10 M walkway at 3 speeds; photocells; foot switches; force plate; joint markers	- time/distance & GRF measurements were dependent on walking speed and age - increase in height with age was major factor in determining changes in distance & time with age - after 5 years, an adult pattern of ground reaction force emerged
Rose-Jacobs (1983)	no	footprint paper technique; 3 walking speeds; McCarthy Scales of Motor Development	- SL,C were significantly different for speed & age - SPL & SW sig. different for speed - motor ability correl. only with SL & C - gait patterns in 3 & 5 year olds are not fully mature
Sutherland et. al. (1980)	no	- 4 16mm movie cameras; Graf-Pensonic digatizer; motion analyzer; computer analysis system; plotter; electromyograms; joint markers; force plate; at least 3 down walkway	- five most NB determinants of gait maturity are SP, V, C, SPL & ratio of pelvic span to ankle spread - mature gait pattern as determined by the above is established at an age of 3 years
Foley et. al (1979)	no	TV videosystem; joint markers; TV computer analysis	- standard dev. > for children than adults - HKA joint angles almost identical for child & adult - large vert. displacement of markers, velocities & accelerations with lower force levels are found with children - SL as % of body weight is NB assess. guideline

Based on the reviewed information it is not possible to ascertain that adolescent gait reflects adult gait in absolute terms. The evidence does indicate that if gait patterns are not the same between these populations, and that many similarities would be shared at least when full adult height is reached.

2.4 Methods of Gait Evaluation

The final component of this literature review examined articles and studies describing methods and characteristics of gait analysis.

DeBruin et. al. (1981) studied the attempts of six orthopedic residents who observationally scored the gaits of children with cerebral palsy as none, mild or severe. The authors attributed the problems in the visual assessment to the variability in between rater concordance. It was found that observational gait analysis more closely correlated with results from gait laboratory instrumentation methods than did physical examinations or questionnaires describing daily living activities. Krebes et. al. (1985) compared findings of an observational gait analysis tool with 3 expert observers with videotaped kinematic data on 15 children who had lower limb disability. Rating occurred over two sessions spaced one month apart. Identical ratings

between and within raters occurred in two-thirds of the observations, and another 29% of the observations differed by one point. Between-rater intraclass correlation coefficient was .73; within-rater Pearson product-moment correlation averaged .68. It was concluded that an observation method of gait analysis appears to be a convenient, but only moderately reliable technique.

In consideration of the limitations of using an observational tool to measure parameters of gait, and the lack of gross motor impairment in the individuals with autism, it was concluded that a quantitative method of gait analysis was required to test this study question.

Numerous strategies have been employed to quantitatively measure human gait (Smidt, 1974; Stanic et. al. 1977; Burnett and Johnson, 1971). Burnett and Johnson (1971) compared the measurement of hip and knee angles directly from film frames and from electrogoniometrical derived data. Electrogoniometry appeared to be the most accurate method. Burnett et. al. also compared step and stride length measures from two methods including a footprint paper technique and film frame measurement. Stride measurements were significantly comparable for the two methods as determined by percentage of error and correlation coefficient. Step measurements were similar in

both cases, although accuracy was somewhat less when measuring the film frames. Winter (1982) demonstrated conclusive analytical evidence that high speed movie cameras and optoelectric systems are not necessary for higher-level biomechanical gait analysis. Winter concluded that standard 16mm cine camera (24 frames per second) or television cameras (30 frames per second) can be used rather than expensive higher speed systems to measure gait kinematics. Stanic et. al. (1977) contrasts and compares nine kinematic measuring systems (see Table 3). In respect to limitations in the choice of gait parameter, Stanic states

> "...limitation in the choice of gait parameters is established by the choice of the measuring system. The more the gait parameters that have to be measured, the more complex will be the measuring system, the more encumbered will be the subject and the more time consuming will be the analysis of the measured data".

This article also reports that the minimum number of kinematic variables necessary for quantitative gait evaluation is represented by step length, step duration and stance phase normalized with stride duration. Stanic also states that it has been proven that the symmetry of right and left gait parameters is the most characteristic property of normal gait.

TABLE 3 - A

COMPARISON OF DIFFERENT KINEMATIC MEASURING SYSTEMS

	Properties			
Gait Measure-ments	Output Parameters	Gait Encum-brance	Price	On-Line Computer Analysis
Stroboscopic photography	coordinates of measured points in space	low	low	no
Movie camera	coordinates of measured points in space	low	high	no
TV picture analysis	coordinates of measured points in space	low	high	yes
TV signal analysis	relative motion of coordinates	low	high	yes
Chronocyclo-graphical measurement	coordinates of measured points in space	low	medium	yes
Polarised light goniometer	relative angles	medium	medium	yes
'Selspot' system	coordinates of measured points in space	medium	high	yes
Parallelo-gram gonio-meters	relative angles	high	low	yes
Exoskeleton goniometers	relative angles	medium	low	yes

adapted from Stanic et. al. 1977.

TABLE 3 - B

COMPARISON OF DIFFERENT KINEMATIC MEASURING SYSTEMS

	Properties		
Gait Measure-ments	# of Steps Measured	Simultan. Right & Left Leg Measurement	Accuracy
Stroboscopic photography	low	no	medium
Movie camera	low	yes	medium
TV picture analysis	low	no	medium
TV signal analysis	low	no	low
Chronocyclo-graphical measurement	low	no	low
Polarised light goniometer	low	no	medium
'Selspot' system	medium	no	medium
Parallelo-gram gonio-meters	high	yes	low
Exoskeleton goniometers	high	yes	medium

In the design of the present study, an attempt has been made to measure gait as reliably as possible given the needs of the population studied and the limited time and resources of the project.

3.0 HYPOTHESES

3.1 Null and Alternate Hypotheses:

Ho (1-17)

THERE WILL BE NO SIGNIFICANT DIFFERENCES BETWEEN THE ADOLESCENT MALES WITH AUTISM AS COMPARED TO THE CONTROL SUBJECTS IN THE FOLLOWING GAIT PARAMETERS:

1) step length
2) stride length
3) step width
4) cadence
5) cycle duration
6) swing phase
7) stance phase
8) walking velocity
9) hip angle at initial contact
10) knee angle at initial contact
11) ankle angle at initial contact
12) hip angle at loss of contact
13) knee angle at loss of contact
14) ankle angle at loss of contact
15) foot angle of inclination
16) head position
17) alternate arm movement

Ha (1-17)

THERE WILL BE SIGNIFICANT DIFFERENCES BETWEEN THE ADOLESCENT MALES WITH AUTISM AS COMPARED TO THE CONTROL SUBJECTS IN THE 17 GAIT PARAMETERS LISTED ABOVE.

3.2 Operational Definitions

3.2.1 **Adolescent:** Pubertal and postpubertal individuals between the ages of 12.5 years and 19.0 years of age.

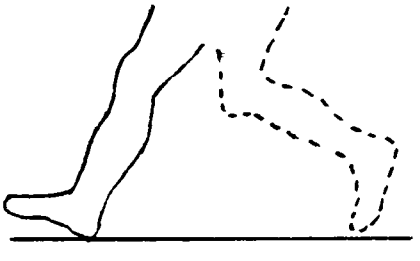
3.2.2 **Walking:** The foot of the support extremity remains in contact with floor until the opposite foot has made floor contact.

3.2.3 **Free Walking Speed:** A normal relaxed walking speed relative to the individual subject.

3.2.4 **Gait:** The manner by which an individual bipedally moves through space at a free walking speed.

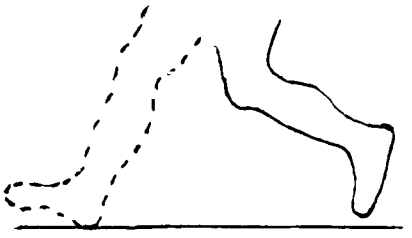
Position Definition:

3.2.5 **Initial Contact (Heel Touch):**
The earliest moment that the experimenter could visually detect that the sole of the subject's shoe had made floor contact.



3.2.6 Loss of Contact (Toe Off):

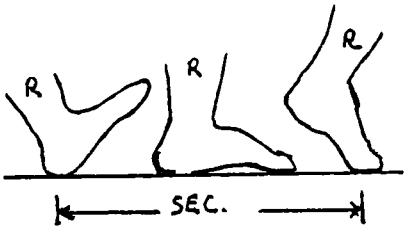
The earliest moment that the experimenter could visually detect that the subject's shoe sole had lost floor contact.



Temporal Parameters:

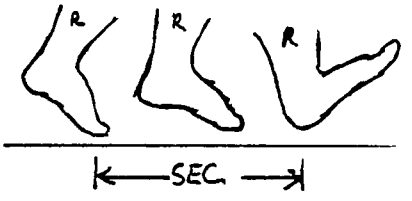
3.2.7 Stance Phase:

The period of time (sec) between initial contact and loss of contact (weight bearing) of the same foot.



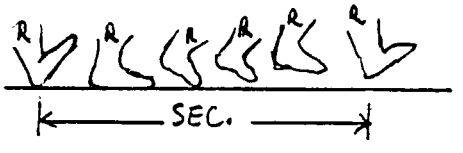
3.2.8 Swing Phase:

Period of time (sec) between loss of contact and just prior to initial contact of the same foot (non weight bearing).



3.2.9 Cycle Duration:

The total period of time (sec) involved in the stance plus swing phase.



3.2.10 Walking Velocity:

The average walking speed of the subject (cm/sec).

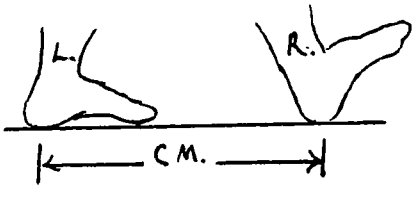
3.2.11 Cadence:

The number of steps taken per minute.

Linear Parameters:

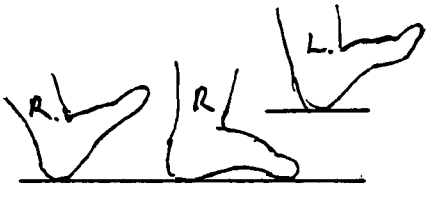
3.2.12 Step Length:

The distance between successive contact points of opposite feet (cm).



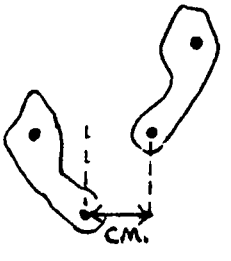
3.2.13 Stride Length:

The distance (cm) between 2 successive initial heel contacts of the same foot.



3.2.14 Step Width:

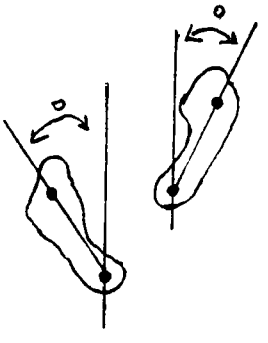
The horizontal length (cm) between two heels of alternate foot touches.



Angular Parameters:

3.2.15 Foot Angle of Inclination:

The deviation of the foot from the vertical (degrees).



Qualitative Gait Parameters:

3.2.16 **Normal head position:**

Head in a relaxed neutral position in at least half of the subject's walking trials.

3.2.17 **Normal alternate arm swing:**

Rhythmical, relaxed, symmetrical alternate arm swing in at least half of the subject's walking trials.

4.0 METHODOLOGY

4.1 The Research Setting

Samples of the subjects' gaits were videotaped at The Geneva Centre for Autism, Communication and Language Disorders (TGC) in Toronto, Ontario. TGC provides community based service to children with autism and their families.

4.2 The Study Sample

The population studied was comprised of adolescent males who were attending a summer programme designed for adolescents with autism. These subjects were selected for study because they were familiar with the physical environment of the filming site and were attending TGC regularly throughout the summer months. The sample population is further described in Tables 4a and b.

TABLE 4a

DESCRIPTION OF SUBJECT SAMPLE

Subject	Age (yr.)	Walking Age (mo)	Weight (kg)	Height (cm)	FLL (cm)	Hand Dominance
With Autism						
1	15.6	20	62	182	95	right
2	14.3	18	76.5	170.5	89	left
3	17.6	13	73	179	96	right
4	12.7	18	64	179	97	left
Normal Subjects						
1	13.9	10	57	171.5	88	right
2	18.6	10	79	179	92	right
3	14.6	10	58	168.5	88.5	right

TABLE 4b

MOST RECENT DIAGNOSTIC INFORMATION ON SUBJECTS WITH AUTISM

Diagnosis on Subjects 1 - 4	Year	Location of Diagnosis	Diagnosing Professional
Subject #1 - Information not available			
Communication disorder with autistic features	1983	Toronto	Psychiatrist
Psychosis in early childhood	1974	Toronto	Psychiatrist
Brain Dysfunction General Mild Developmental Delay Communication Disorder Autistic Features	1978	Toronto	Psychiatrist

4.2.1 Eligibility Criteria

4.2.1.1 Group with autism:

1) Considered by a Registered Clinical Psychologist to exhibit behaviour consistent with the American Psychiatric Association's (APA, 1980) definition of Pervasive Developmental Delay.

2) Considered appropriate by a Registered Clinical Psychologist to attend a summer program designed for adolescents with autism.

3) 12.5 - 19.0 years of age

4) Resided within Metropolitan Toronto or the City of Mississauga with natural or adoptive parent(s).

4) Were receiving or awaiting TGC services.

5) Parental consent to participate in the research study.

6) The subject's consent to participate in the study if considered appropriate by the Manager of Clinical Services of TGC (a Registered Clinical Psychologist).

4.2.1.2 **Control Subjects:**

1) Were attending a regular school programme and studying at an expected and age appropriate academic level.

2) 12 - 19 years of age.

3) Resided within Metropolitan Toronto or the City of Mississauga with natural or adoptive parent(s).

4.2.2 Exclusion Criteria

4.2.2.1 **Experimental and Control Subjects**

1) Had no longstanding history of and were not taking medications that may have induced motor side effects.

2) Had no history of visual, auditory, orthopaedic, seizure disorder or other pathology that may have significantly influenced gait development or execution.

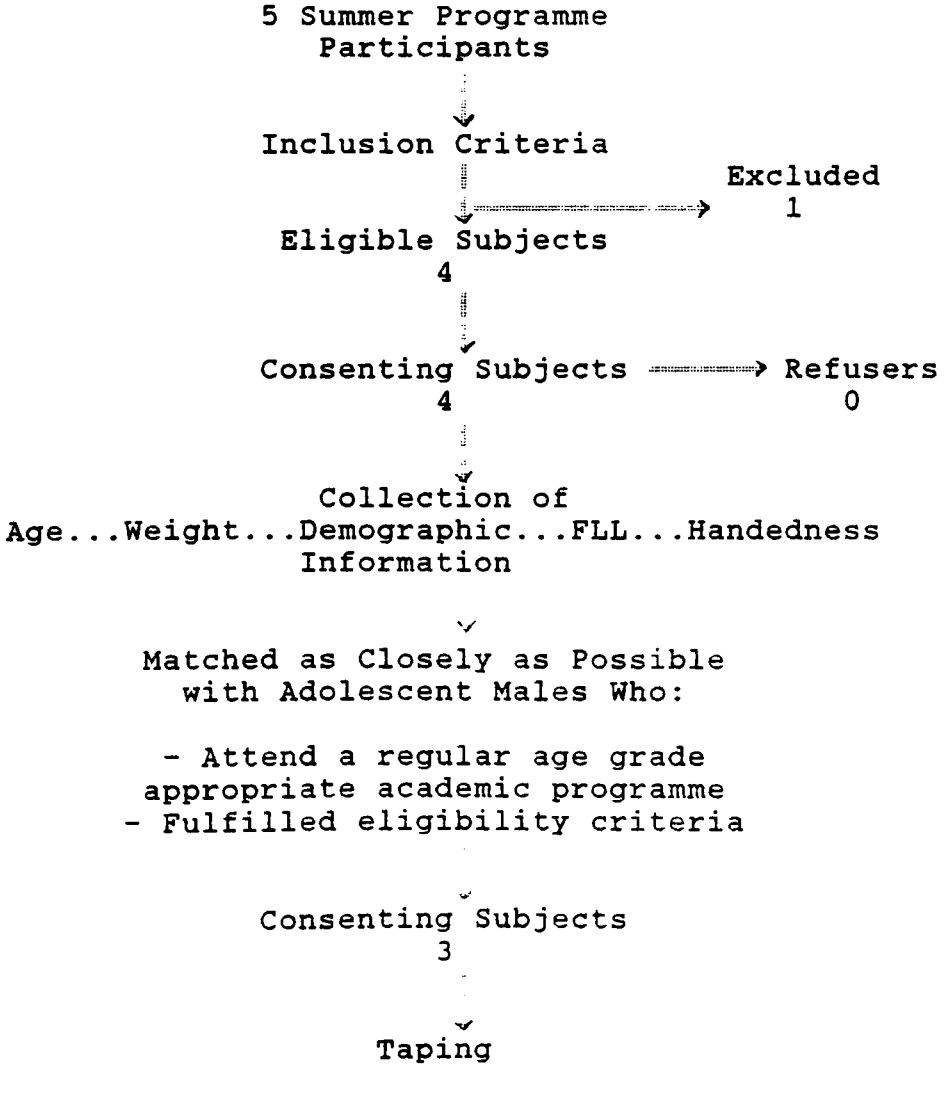
3) Had no uncorrected visual or auditory impairment.

4.2.3 Sample Selection

The Executive Director of TGC was approached by the investigator and supported the research proposal. The Sample Selection Procedure is depicted in Figure 2.

FIGURE 2

SUBJECT SAMPLE SELECTION



The Manager of Clinical Services of TGC screened all of the subjects in respect to the inclusion/exclusion criteria and then contacted the families of the individuals who fulfilled the study criteria. The study was briefly described to the prospective subject's family and the Manager of Clinical Services determined if the parents were receptive to having their son included in the study. All of the parents who expressed an interest in having their child participate were sent a letter/consent form (Appendix 2) which explained the purposes and procedures involved in the research. The researcher contacted the interested parties by phone and answered any questions they might have had concerning the study. Following subject participation consent, the researcher interviewed one parent of each subject and outlined study information.

4.3 Sample Size

The sample size for this pilot study was derived following the analysis of the data as no normative description of adolescent male gait was found in the literature. An estimated N per group was calculated for each gait parameter studied using the formula:

$$N = 2\left[\frac{(Z\alpha - Z\beta)S}{CSD}\right]^2$$

N = number per group
S = standard deviation (pooled)
CSD = clinically sig. difference

Colton, 1974, p. 145

The largest N requirement amongst all parameters estimated was selected as the required sample size.

The investigator was willing to risk rejecting the null hypotheses when it was true one in twenty times. Therefore, an alpha (α) level of 0.05 (two-tailed) was chosen. $Z\alpha$ for a two-tailed test is 1.96. Beta (β) was set at 0.20 which meant that if a difference existed between the groups, there would be an 80% probability that it would be detected. $Z\beta$ for a one-tailed test is 0.83. Determination of the clinically significant difference between the means of the two groups and the standard deviation in this population were based on the data scores and clinical judgement as no population specific data was found in the literature.

On this basis, it was estimated that 28 subjects would be required to minimize both type one and type two errors. The sample size of this pilot study was seven.

4.4 Study Design:

Two independent descriptive designs were used to address the research question. Neither group studied was randomly selected due to the low prevalence and accessibility to individuals with autism, and, the time limitations in recruiting normal adolescent males. The lack of random selection of subjects in this study meant that it was not possible to equalize known and unknown confounders. The investigator was the only person involved in the collection and extraction of the data from the videotapes and therefore, was not blind to the group assignment of the subjects. It is unlikely that a blind observer status could be achieved in this type of study as any observer may have been able to identify the mannerisms and movement behaviours of individuals with autism.

The purpose of this study was to describe the gaits of individuals with autism as compared to a group of similar aged adolescents, to test the feasibility of using a specific technique to analyze specific parameters of gait in a community environment and to compare the findings of this study to those of another author who used a similar research design and techniques. It was not the purpose of this study to assign causation ie) autism

causes an individual's gait to be different nor to describe these individuals' gaits over time.

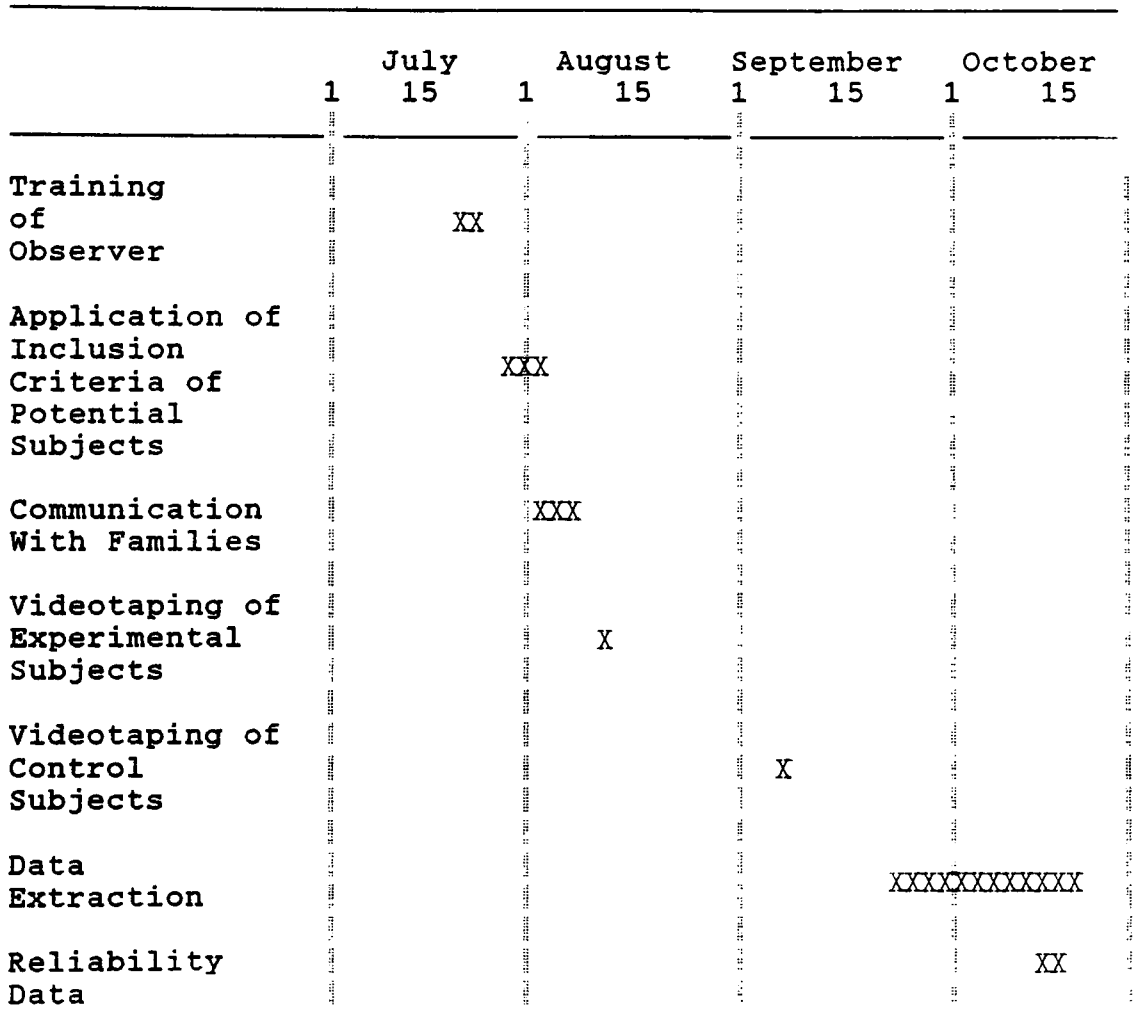
Based on the scope of this study, the infantile state of the topic knowledge and the time and resource limitations of this project, the selection of a descriptive design producing low methodological rigour, class four evidence is justified.

4.5 Data Collection Schedule:

The data collection procedure used in the study is depicted in Figure 3. The investigator was trained in camera operation in mid July 1986. In late July, three children who were participating in a summer programme directed by the Ontario Association for Autistic Children were videotaped according to research protocol. This videotaping procedure was considered investigator training and the data obtained form the videotapes was not used in the analysis. The subjects with autism were videotaped in mid August and the control subject in early September 1986. The data was extracted from the videotape during late September and October.

FIGURE 3

DATA COLLECTION PROCEDURE



4.6 INSTRUMENTATION

4.6.1 Demographic Data (pretaping)

A subject information form was used to collect relevant demographic and behavioral information on each subject (Appendix 3). Parental reported data collected included: date of birth, height, weight, age at which subject walked, hand dominance, medication history, diagnostic information, visual, auditory and/or orthopaedic history, parental gait characteristics, school setting, special services received at home or school, parental opinions concerning the subject's reaction to the test situation, behavioral information and useful behavioral management techniques. The above information was collected from the parent during the phone interview. This interview was approximately one half hour in duration.

4.6.2 Camera Equipment

Sagittal View:

A stationary Panasonic VHS WV 3240 video camera mounted on a tripod was used to video the subjects from a sagittal perspective.

Frontal View:

A Panasonic AG-100 hand-held video camera was used to tape the subjects from the end of the walkway (see Figure 4).

4.6.3 Recorder and Monitor:

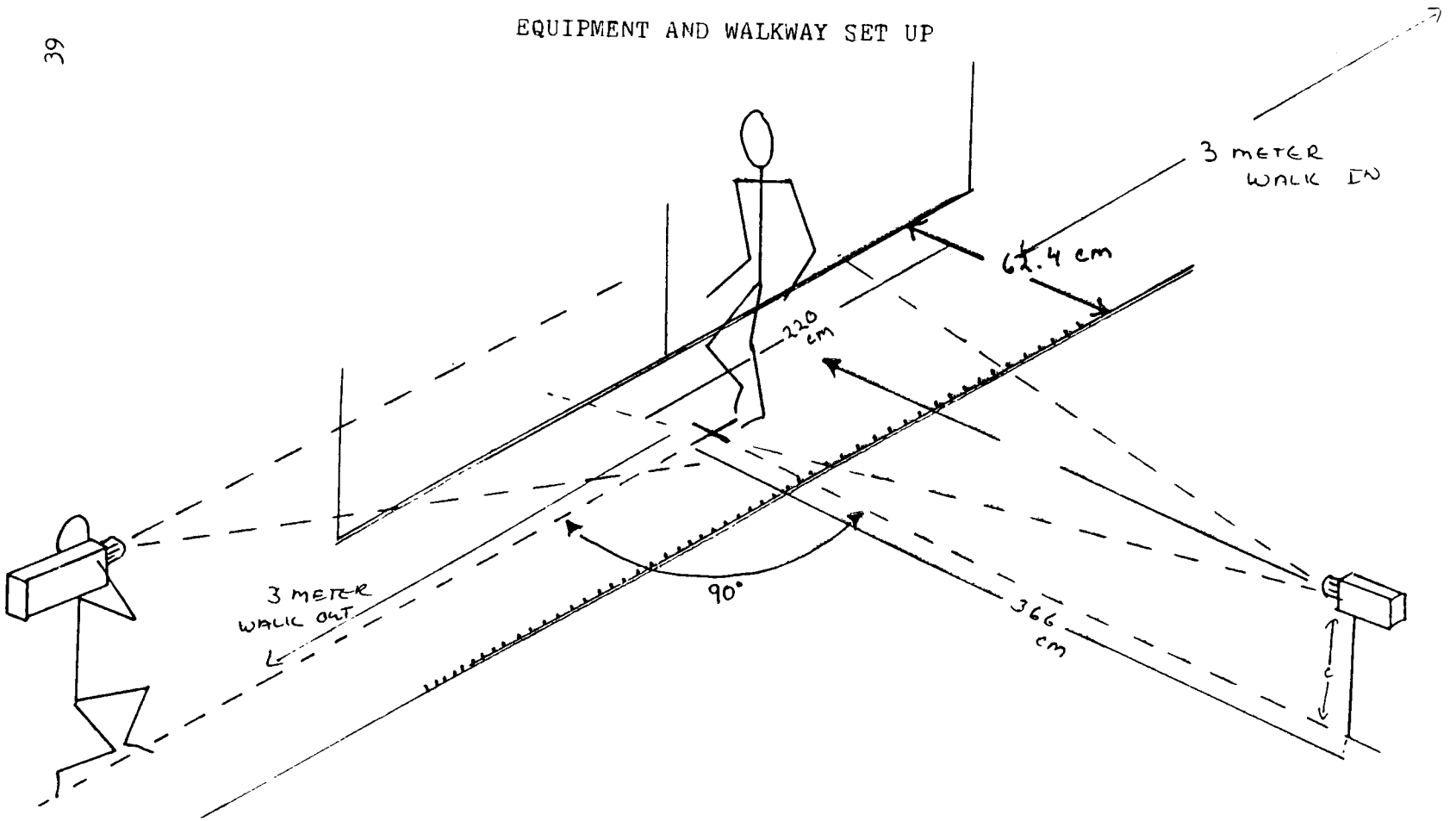
A Mitsubishi AVRD55 four headed VCR was used to project the videotapes onto a variable scanning video monitor for data extraction.

4.6.4 Joint Measurement:

Joint angles were measured by a protractor from stick figures, according to the guidelines published by the American Academy of Orthopaedic Surgeons (1965) (see Figure 5). The stick figures were generated via placing an acetate on top of a freeze frame of the subject in an initial contact or loss of contact position. The observer made marks on the acetate corresponding to the positions of the anatomical landmark markers on the subjects. These marks were superimposed on the acetate while the observer viewed the marker on the monitor at eye level. The marker dots were then joined and the angles were measured.

FIGURE 4

EQUIPMENT AND WALKWAY SET UP



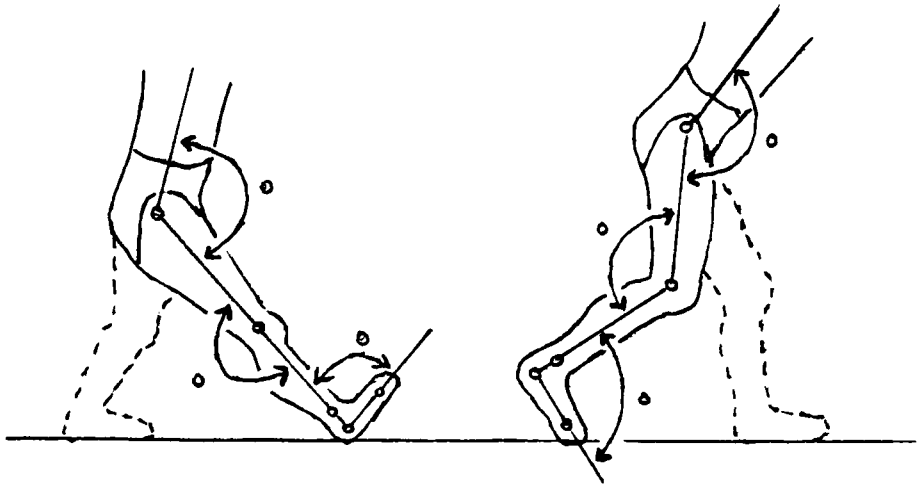


FIGURE 5 - ANGLE MEASUREMENT REFERENCE POINTS AT LOSS OF CONTACT AND INITIAL CONTACT

4.6.5 Height:

Was measured in cm with a standard metric measuring tape.

4.6.6 Functional Leg Length (FLL):

Was the distance (cm) measured from the greater trochanter to the floor of each subjects hand dominant body side (see Figure 6). A standard metric measuring tape was used.

4.6.7 Weight:

Was measured (kg) via a portable bathroom scale for all subjects. Two measures of weight were taken to assure reliability of the scales.

4.6.8 **Time:**

Time resolution to 1/1000th of a second was imaged onto the videotape via an optional feature mechanism of the camera.

4.6.9 **Linear Measurement:**

Linear measurement was calculated from a grid of taped lines spaced 5 cm. apart along the walkway (see Figure 4).

4.6.10 **Walkway:**

The surface of the walkway was comprised of a hardwood floor covered with indoor-outdoor carpeting without an under padding. The borders of the walkway were outlined with masking tape and measured .64 M wide and 8.2 M long. The background of the walkway was comprised of black bristol board. Three meters at each end of the walkway served as walk-in and walk-out areas. The purpose of these areas were to allow the subject to attain and maintain a normal speed while passing through the videotaped portion of the walkway. The sagittal camera was focussed in the centre of the walkway and stood at 90 degrees and 3.6 meters from the central point of the walkway (see Figure 4).

4.7 Video Taping Preparation

4.7.1 Subjects with Autism:

The subjects with autism were prepared for the procedure in a manner considered appropriate by the investigator and the TGC staff who had worked with the adolescents throughout the summer. The day prior to the taping all subjects were briefed regarding the procedure and the clothes that they would have to wear for the taping.

4.7.2 Control Subjects:

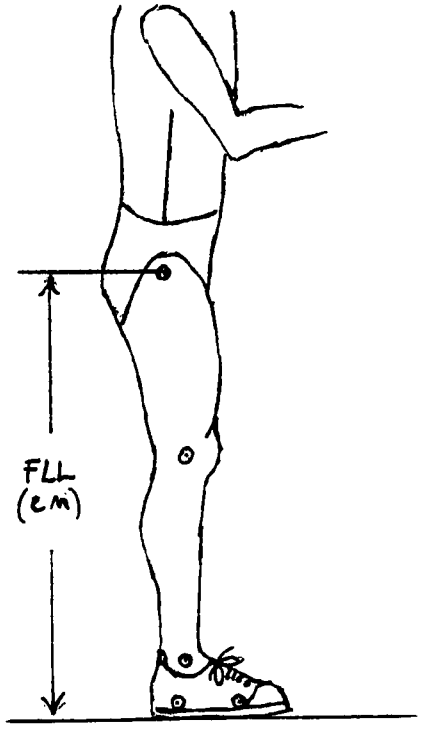
In addition to the explanation provided to the control subjects prior to obtaining their informed consent, all of the subjects were briefed on the procedure the day prior to the videotaping.

4.7.3 Procedure

1. Before videotaping all subjects were weighed and measured for height and FLL. The experimenter placed .5 inch circular white stickers with a black dot in the centre on the estimated joint centers of the subject's hip, knee and ankle joints. The joint centres were estimated by palpating specific anatomical landmarks (see Figure 6). Stickers were also placed at the base of the subject's fifth

FIGURE 6

MARKER PLACEMENT FOR JOINT ANGLE DETERMINATION



Trunk: Estimated midline of sagittal trunk from iliac crest.

Hip: Estimate of centre of joint via palpation of the greater trochanter.

Knee: Estimated centre of joint via palpation (Joint line between lateral epicondyle and tibial tubercle).

Ankle: Estimated centre of joint via palpation of the lateral malleoli.

Forefoot: Fifth Metatarsophalangial joint crease.

Heel: At calcaneus, at the same height as the forefoot marker.

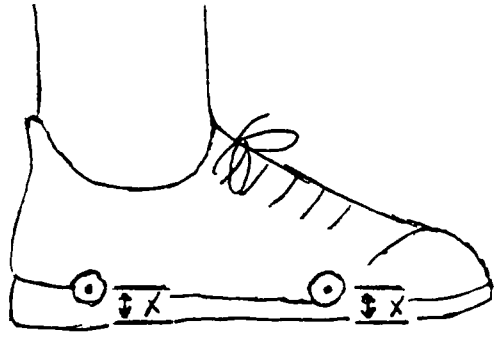


FIGURE 7: MARKER PLACEMENT OF THE FIFTH METATARSOPHALANGEAL JOINT AND HEEL

metatarsophalengeal joint crease, and at the midpoint of the heels of the subjects shoes, the same distance from the floor as the fifth metatarsophalangeal markers (see Figure 7). A piece of white surgical tape was placed on the estimated midline of the sagittal trunk rosterally from the iliac crest, (see Figure 6).

2. Each subject was then instructed to walk normally up and down the centre of the walkway a total of six times. Some of the subjects with autism were given trial walks over the walkway for preparation purposes. The practice walks occurred or did not occur according to the recommendations of TGC staff. The control subjects were given the option of taking practice trial walks.

3. During the videotaping of the walks, the subjects were verbally cued to walk straight down the walkway if they started to deviate from the track. No subject was cued to walk via the experimenter or any other person walking beside them during the videotaping.

4. On the completion of the subject's sixth videotaped walk the subjects were requested to sit on a chair which was positioned at the end of the walkway.

5. A five meter piece of butcher paper (waxed side down) was extended over the track surface and secured by taping the ends to the floor.

6. The subjects were then verbally prepared for the next part of the procedure.

7. On both soles of the subject's shoes the experimenter placed 2 cm pads of Dr. Scholl's mole skin to the most extreme tip of the toe and centre back of the heel. The pads were then inked.

8. The subject was then requested to walk the full length of the paper.

4.8 Treatment of Videotape

To obtain as clear and steady an image as possible to measure joint angles in the initial contact and loss of contact positions, the videotape was treated by:

1) bumping to one half inch copy tape.
2) jogging the freeze frames of the subject images in both positions for 15 seconds.

This process resulted in an actual taping of the freeze frame and hence avoided the necessity of relying on the use of the VCR to freeze the image.

4.9 Reliability of Data Extraction

A reliability study was conducted as part of this inquiry to determine the extent to which components of the described data extraction technique was reliable.

4.9.1 Design:

A repeated measures of variance with two factors was used to examine the reliability of hip and knee data.

4.9.2 Rationale of Parameter Selection for Reliability Analysis:

The time restrictions and scope of this study made it necessary to limit the data reliability analysis to two parameters. The investigator selected to test the reliability of the knee and hip joints at the moment of initial contact. These two parameters were chosen because:

1) The joint angle data was determined through a three step technique (monitor --→ acetate→ measurement) where as the linear parameters were measured directly from the monitor. It was deduced that there would be more potential for error in the

three step as opposed to two step data extraction process.

2) The most clearly visible joint centre markers on the videotape were the hip, knee and ankle (lateral Malleoli) points. The investigator inferred that the knee angle measurement would be the most reliable joint measure. Conversely, the hip joint angle was not easily readable as the estimated midline marker of the sagittal trunk was frequently obliterated by the subject's arm movement. The investigator was frequently forced to estimate this trunk line. It was therefore projected that the hip angle would be the most unreliable measurement.

3) The initial contact position was selected for reliability analysis as the raw data suggested that there may have been a difference between the control and experimental groups on knee angle measurement in this position.

4.9.3 Method:

1) Two subjects from both the experimental and control groups were randomly selected.

2) The investigator extracted the hip and knee measurements at the initial contact position for a second time two weeks from the initial data extraction process.

4.10 Ethical Considerations

Approval to conduct this study was obtained from the Executive Director of Clinical Services of TGC.

Parents were required to sign a letter of explanation and consent. This letter briefly outlined the purpose, methods and data collection employed in the study (see Appendix 2). Parents were informed both verbally and in the letter that there were no known harmful effects that resulted from the experimental methods. It was also explained to all involved parties that they could withdraw from the study at any time. Only children for whom written consent was obtained were included in the study.

Confidentially was maintained by assigning a code to each subject and using this code throughout the data analysis. TGC staff were present during all of the videotaping. The experimenter asked the permission of the subjects to touch their bodies in order that the joint centers could be palpated and marked.

The experimental methodology was designed to be as minimally intrusive and anxiety producing for the subjects and their families as possible.

4.11 Efforts to Minimize Bias

The control subjects were comprised of individuals who were in a general sense matched for age. Information concerning special services received by the subjects, details concerning subject school placement and recreational activities, medical information and physical traits were collected in order to assess sampling contamination. An attempt to study the reliability involved in the experimental method was made.

The investigator is aware that many biases may have been operative in this study. These will be discussed in detail in a later section of this report entitled Study Limitations.

4.12 Data Analysis

Table 5 outlines the statistical analysis used in this study.

TABLE 5

METHODS OF DATA ANALYSIS

Statistical Analysis	Variables/Data Sets
Chi Square	Demographic Data - Hand dominance Qualitative Gait Parameters - Alternate Arm Swing - Head Position
Student T-Test	Demographic Data - Height, weight, age, walking age, FLL Continuous Quantitative Gait Parameter Data - step length, stride length, step width, stance phase, swing phase, cycle duration, cadence, velocity, hip-knee-ankle angles, foot angle, foot angle of inclination.
Repeated measures Analysis of Variance With 1 Grouping Factor	Symmetry of the Right and Left Sides of Body - in step length, stance phase, swing phase and hip-knee ankle joint angles.
Repeated Measures of Variance with Two Analysis	Reliability of Hip and Knee Angle - at initial contact Factor

5.0 RESULTS

5.1 Comparability of Groups

The Student t-test and chi-square analysis carried out on the demographic information collected on all subjects indicated that no significant differences existed between the groups at the time of videotaping in respect to age, weight, height, functional leg length and hand dominance (see Table 6). Although the differences between groups on Hand Dominance was not statistically significant, it was felt to be clinically significant. Fifty percent of the subjects with autism were right handed as compared to one hundred percent of the normal subjects. This finding is consistent with the literature which states that there is a higher incidence of left handedness in mentally defective and neurologically disordered children (Kolb and Whishaw, 1980).

There was a significant difference between groups in the reported age at which subjects began to walk. All of the normal subjects were reported to have walked at 10 months of age whereas the mean reported walking age of the individuals with autism was 17.25 months (with a range of 13-20 months).

TABLE 6

COMPARABILITY OF GROUPS

COMPARISON OF AGE, AGE OF WALKING, HEIGHT WEIGHT, AND FUNCTIONAL LEG LENGTH

Variable	Control X	Control SD	Experimental X	Experimental SD	DF	t Value	p Value
Age (yr)	15.69	2.52	15.02	2.08	5	0.390	NS
Age of Walking (mon)	10	0	17.25	2.99	5	4.10	$p < .05$
Height (cm)	173	5.41	177.6	4.96	5	1.18	NS
Weight (kg)	64.67	12.42	70.13	5.66	5	0.794	NS
Func. Leg Length (cm)	89.5	2.18	94.25	3.60	5	2.0	NS

Comparison of Hand Dominance

% Right Hand Dominant Control	Experimental	x Value	DF	p Value
100%	50%	4.1	5	NS

5.2 Calculations of Missing Data

In several instances, complete set of data for all parameters measured were not obtainable. When a complete set of data was not present the mean of the available data was calculated and was then identified as the missing data point.

One subject with autism completed only five of the six required walks. Data recorded for this individual was not included in the Analysis for Right/Left body symmetry.

5.3 Intrarater Reliability

Rater reliability was assessed by applying a Repeated Measures of Variance (two factor) to hip and knee angle data at initial contact which had been extracted from the videotape on two separate occasions. The analysis demonstrated that a very small amount of the percent of variance in the data analyzed was due to the observer and walks within subjects for hip (3.17%) and knee (0.59%) angle measurement (see Table 7). These values indicate that the rater reliability of the above measure was quite high. Reliability of other gait parameters was not ascertained due to time limitations of the study.

TABLE 7

REPEATED MEASURES OF VARIANCE WITH TWO WITHIN FACTORS

Source	DF	SS	MS	Variance	% of total Variance
Knee Joint					
Among Subjects	3	1686.2	562.1	44.27	72.76
Within Subjects	44	662.5	15.1		
Observer	1	10.5	10.5	0.36	0.59
Ob x Sub	3	5.3	1.8	0.03	0.0
Walks	5	153.67	30.72	0.01	0.0
W x Sub	15	460.47	30.70	14.53	23.88
Ob x Walks	5	7.9	1.6	0.0	0.0
Sub x Ob x W	15	24.66	1.64	1.64	2.69
Hip Joint					
Among Subjects	3	111.6	307.5	28.89	62.8
Within Subjects	44	733.4	16.7		
Observer	1	1.9	1.9	0.0	0.0
Ob x Sub	3	19.6	6.5	0.09	0.1
Walks	5	226.05	45.21	1.46	3.17
W x Sub	15	349.72	23.31	8.69	18.8
Ob x Walks	5	48.0	9.6	0.92	2.00
Sub x Ob x W	15	89.13	5.94	5.94	12.9

5.4 Hypothesis Testing

5.4.1 Null Hypotheses

Ho - There will be no significant differences between the adolescent males with autism as compared to the control subjects in 17 gait parameters studied.

5.4.2 Analysis

5.4.2.1 Qualitative Parameters of Gait

A chi-square analysis demonstrated no statistically significant differences between the groups studied in alternate arm movement and head position. It was determined that there was clinically significant differences between the groups in these parameters (see Table 8).

5.4.2.2 Quantitative Gait Parameters

Student T-tests were used to determine whether differences existed between the two groups studied. No statistically significant differences were found (see Figure 8). The investigator determined that clinically significant differences existed between the two groups in

respect to subject knee angle in the initial contact position (see Table 9).

TABLE 8

COMPARISON BETWEEN GROUPS: QUALITATIVE FEATURES

Parameter	% within normal Control	Exper.	DF	X Value	P	clin. signif.
Alternate arm movement	100	25	5	3.94	NS	yes
Head position	100	0	5	7.00	NS	yes

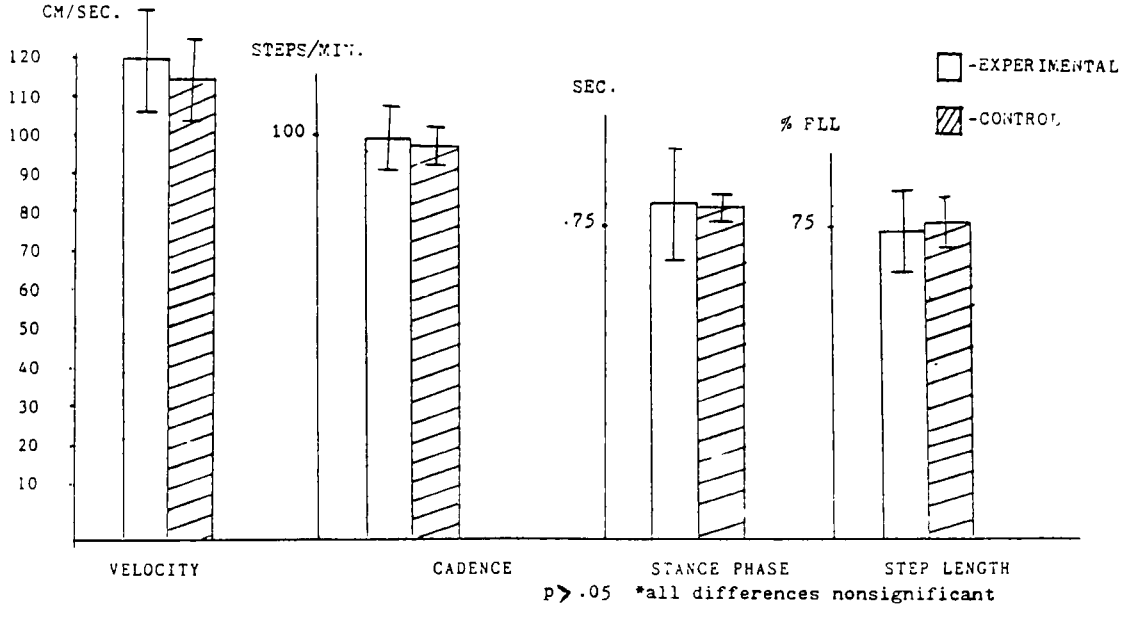
TABLE 9

COMPARISON BETWEEN GROUPS - JOINT ANGLES

Angle (o)	Control X	Control SD	Experimental X	Experimental SD	DF	T&P Value		Clinical Signif.
Initial Contact (Heel Touch)								
Hip	153.81	5.26	155.61	11.23	5	.314	NS	No
Knee	-1.56	3.94	5.93	5.68	5	1.57	NS	Yes
Ankle	92.81	5.63	93.36	5.55	5	.221	NS	No
Loss of Contact (Toe-off)								
Hip	175.69	5.38	177.65	3.69	5	.8397	NS	No
Knee	61.41	5.76	62.68	5.37	5	.351	NS	No
Ankle	101.91	6.62	102.37	6.57	5	.231	NS	No

FIGURE 8

MEANS AND STANDARD DEVIATIONS OF FOUR GAIT PARAMETERS DESCRIBED AS BEING DETERMINANTS OF GAIT MATURITY (SUTHERLAND, ET. AL., 1984)



5.5 Symmetry in Right/Left Leg Gait Parameters

A repeated measures analysis of variance with one grouping factor was used to determine if there were differences in the symmetry of the right/left leg gait parameters between the normal adolescent subjects and the subjects with autism. There was no statistically significant differences between the subject groups (see Table 10).

TABLE 10

COMPARISON OF RIGHT/LEFT LEG GAIT PARAMETERS

Parameter	SS	df	MS	F	P.	Significance
Step length	24.99	1	24.99	1.18	.327	NS
Stance Phase	0.0002	1	0.0002	0.12	0.743	NS
Swing Phase	0.0000	1	0.0000	0.00	0.988	NS
Hip- Initial Contact	5.160	1	5.160	0.02	0.890	NS
Knee - Initial Contact	73.60	1	73.60	5.70	0.063	NS
Ankle - Initial Contact	6.36	1	6.356	0.26	0.634	NS
Hip - Loss of Contact	0.3403	1	0.3403	0.01	0.913	NS
Knee - Loss of Contact	25.00	1	25.00	1.44	0.297	NS
Ankle - Loss of Contact	148.84	1	148.84	3.74	0.125	NS

6.0 DISCUSSION

6.1 Summary of Results

The primary purpose of this study was to describe and hence state any differences that occurred between a groups of adolescent males with autism and a group of normal adolescent males in respect to the 17 gait parameters studied. No statistically significant differences between the subject groups were demonstrated . The investigator considered that clinical significance occurred in subject knee angle in the initial contact position. The two qualitative gait parameters were also considered to be clinically significant as both abnormal alternate arm swing and head position contributed overtly to 'unusual' appearance of the gait of subjects with autism. The lack of statistical significance in all parameters did not permit the rejection of the null hypothesis.

A second major purpose of this study was to determine if the videotape data extraction technique employed to study the 17 gait parameters demonstrated intrarater reliability and was a feasible method of collecting gait analysis information in the clinical setting. Results indicated that this method demonstrated excellent reliability for the two parameters selected for analysis.

The strengths, weaknesses and proposed changes for future use of this technique are outlined in Table 12.

Although the videotape data extraction method demonstrated reliability in collected information about gait in the clinical setting, it was not suitable for such use without modification (see Table 12).

A subquestion concerning the comparability of the symmetry of right/left leg parameters between groups was also addressed in this study. No statistically significant differences between groups were found. The investigator noted that upon inspection of the data on two individual subjects with autism, that these subjects appeared to have more asymmetry in right/left leg gait parameters than did other experimental or control subjects.

This study was unable to replicate the statistically significant findings of Vilensky et. al. (1981). (see Table 11) The findings of this study found a clinically significant difference in knee flexion in the initial contact position similar to Vilensky. The non-agreement in statistically significant difference between the two studies may be a result of sample size, sample selection,

study population, gait measurement technique and data extraction techniques.

TABLE 11

COMPARISON OF STUDY DATA WITH EXISTING LITERATURE

Gait Parameter	Vilensky et al (Subjects with Autism as compared to Control Subjects)	Bond (Similarity to Vilensky)
Cycle Duration	Slightly increased	no
Stride Length	Reduced	no
% Stance Phase	Increase	possibly
Hip Angle at Loss of Contact	Reduced	no
Knee Angle at Loss of Contact	Similar	yes
Ankle Angle at Loss of Contact	More Dorsi-flexion	no
Hip Angle at Initial Contact	Similar	yes
Knee Angle at Initial Contact	Increased	yes
Ankle Angle at Initial Contact	More Dorsi-flexion	no

TABLE 12
STRENGTHS, WEAKNESSES AND RECOMMENDED MODIFICATIONS
OF THE VIDEOTAPE-DATA EXTRACTION TECHNIQUE

Strengths
(as compared to a gait laboratory)

- less expensive in technology cost
- equipment easy to operate and videotaping can be done in the clinical setting.
- individuals with autism less anxious in a familiar environment, and hence, more reliable and normal gait pattern data may be collected

Weaknesses
(as compared to a gait laboratory)

- very time consuming to extract data
- less accuracy in data extraction as compared to a TV computer analysis system
- not possible to measure all parameters of gait

Recommendations for Modification in the Procedure

1. It is recommended that future studies attempt to use the facilities of a gait laboratory to collect data. It would be of paramount importance to provide the subjects with a criteria based desensitization programme which would included the placing of the markers on the body and running trial walks in the gait laboratory.

2. If recommendation #1 is not possible it is suggested that the following modifications be made to the technique used in this study:

   Equipment:
   1) use of betacam, recam or one inch tape as an alternative to videotape. (Note: Videotape is less expensive than the formats listed above, however, it produces significantly less quality images following a copy down or editing process.)

   2) Use of a TV computer system for data extraction.

   3) A camera which has the capacity to function optimally in given lighting conditions.

4) the automatic camera time display which is projected onto the taped image should be positioned near the top of the field of vision as to not interfere with the joint marker reading.

5) A monitor with a flat screen would permit optimal data extraction. (Watt, N., 1986)

Set-up:
1) Ambient lighting conditions (less shiny background).

2) Increased length of walk-in/out areas.

3) Marking of the five cm demarcations over the surface as opposed to only the edge of the walkway.

4) Black centres of joint markers should be larger. If the subjects wear white running shoes, black markers with white centres should be used to improve observability.

5) For normative data comparison purposes it would be better if the subjects walked with bare feet. It would be important to ensure that the children had been desensitized to the track surface and did not display tactile defensive artifacts in their walking.

6) Two observers should agree on joint marker positioning.

7) Walkway surface should be non-carpeted.

8) Use of alternative methods of measuring foot angle of inclination and step width.

6.2 Limitations of the Study

Several biases and limitations were operative in this study and must be considered prior to considering the implications of the results.

6.2.1 Sampling Bias

The subjects with autism were obtained through the Geneva Centre for Autism, Communication and Language Disorders. This agency provides community based services to the individuals with autism and their families. This agency's mandate is relatively specific in respect to the type of client it services. Families that apply for such assistance and those accepted for service may differ from those who do not seek services or who are refused service. The subjects who comprised the control group were individuals who lived in the same neighborhood as the investigator. It is possible that these subjects are not representative of individuals from other neighborhoods. It is also possible that these subjects were less anxious throughout the videotaping procedure as they were known to the investigator.

The subjects with autism may not have been representative or homogeneous in respect to the severity

and nature of their disorder. Attempts were made to match the subjects with autism to normal adolescent males in respect to age, height and weight, however, this was not possible due to the time constraints of the project. The lack of a randomized sample and a less than adequate subject matching procedure resulted in the possibility that numerous confounding variables were active in this study eg. maturational levels, somatotype, race, socio-economic background, intelligence, habitual and extracurricular physical activity levels.

Therefore, many biases including centripetal, popularity, referral, volunteer, diagnostic and uncontrolled confounding variables may have been operative in this study. Extreme caution must be exercised in generalizing the findings to any other population.

6.2.2 Sample Size Bias

Due to the small sample size, the chance of a type two error having occurred is high.

6.2.3 Expectation Bias

The investigator was aware of the diagnostic status of the subjects who comprised both the control and

experimental groups. The investigator was also the only individual extracting data from the videotapes and hence was not blind. Therefore, an expectation bias was operative in this study.

6.2.4 Instrumentation Limitations and Biases

(1) **Mechanical Equipment:**

All mechanical equipment used in this study was subject to malfunction which could potentially effect any stage of the data collection/extraction process.

(2) **Monitor Voltage Drop Effect:**

Data was extracted from the videotapes at consistently specific hours of the day. This was an attempt to minimize the effect that regular daily voltage drops have on monitor images ie) when people return home after work a voltage drop occurs which may slightly change the size of the monitor display. This set data extraction schedule, however, did not ensure that this phenomenon did not occur at other than expected times.

(3) **Marker Placement for Joint Angle Measurement:**

All markers placed on the subject's body were placed via palpation or visual estimation of particular body

landmarks or parameters. This method of marker placement is subject to error especially when subcutaneous tissue is thick, bony prominences are not well-developed or the individual's musculature prohibits accurate detection. Visual estimation is always subject to error.

(4) **Length of Walk-In and Out:**

It is possible that the length of the walk-in and out portions of the walkway were insufficient in length to allow the subject to attain and maintain a consistent and free walking speed while being filmed. This may have resulted in contamination of the data.

(5) **Validity and Reliability of Gait Parameter Data:**

Only two gait parameters were analyzed for reliability. It cannot be assumed that the rest of the parameters examined demonstrated such reliability. The ankle joint angle in all positions measured may have lacked both reliability and validity as the time display on the film frequently obscured the joint markers. The freeze frame capacity of the equipment nor the treatment of the video tape produced a clear image of ankle markers for measurement purposes. In several cases, subjects did not navigate in an absolutely straight line and

hence a pure sagittal view of the walk may not have been videotaped. The factors listed above in addition to possible error in marker placement may have resulted in the extraction of less valid and reliable data.

The foot print paper technique used to measure the foot angle of inclination and step width was not suitable for the collection of data in the population studied. The sound of walking on the paper disrupted the subjects with autism. The length of paper was not sufficient to permit the subjects to attain a free walking speed and the inked pads on the subjects' feet stuck to the paper pulling it slightly from the floor.

(6) **Procedural Instructions Given to Subjects:**

The instructions provided to the subjects concerning the videotaping procedure were not consistent among subjects. The individuals with autism required more cues than did the normal subjects to continue walking in a straight path down the walkway. Some subjects were given practice trial walks whereas others were not. It is difficult to ascertain whether or not making instructional protocol consistent among subjects would have resulted in better quality data.

(7) **Difference in Group Taping Times:**

The experimental and control groups were taped several weeks apart. Although efforts were made to make the taping area as similar as possible to the initial taping situation, it is possible that differences in the set-up or environment existed.

6.2.5 Limitations of Design

The study design used to address the research question does not permit any inferences to be made concerning the temporality of the subjects' gaits. It is not possible to ascertain any causal statements concerning gait parameter differences demonstrated between subject groups.

6.3 Implications for Clinical Practice and Future Research

Results of this study conclude that the intrarater reliability of the two gait parameters studied was excellent. While this finding was demonstrated for two parameters, it cannot be assumed that such high reliability can be generalized to the other parameters examined in this inquiry. The importance of the above finding is of relevance to the clinician or researcher who has limited accesses to resources. It would be greatly

more time efficient to extract videotape data via a TV computer system which are commonly in use in gait laboratories (Foley, et. al., 1979; Stanic, et. al., 1977; Winter, 1982).

One of the purposes of a pilot study is to test a proposed methodology to answer a research question. The strengths, weaknesses and suggested modifications of the videotape data extraction technique are outlined on Table 12. The limitations of the study design, time and resources available make it difficult to conclude whether a difference exists in the examined gait parameters between the two study groups. Due to the high chance of a type two error in this study, a definitive conclusion cannot be made. The study, therefore, should be repeated with the following modifications:

1) proper sample size

2) a randomized selection of experimental subjects

3) better matched control subjects

(the above 3 conditions are met from selection from a broader base)

4) use of a study design that would permit:

   (i) study of subjects ranging in age from the age of walking to adulthood with repeated observations over time

(ii) the use of a third control group whose subjects' have a communication disorder other than autism in order that a causal inference could be made

5) to observe a more diagnostically sound population of individuals with autism

6) improved set-up of walkway and modifications of taping procedure as outlined in Table 12

7) an increase in the number of trial and filmed walks per subject

The direct clinical implications of this study are minimal. However, the observations of the individual's movement while in motion or in a stationary position are not. Information concerning dynamic and stationary body movement and control, symmetry of body function and the individual's use of visual cues (ie. head position) can prove valuable in the clinical arena. The teaching or remediation of functional independence skills can be more efficiently addressed if the professional is able to interpret an individual's movement. This is an invaluable skill in the servicing of a population with autism as communication with these clients is impaired.

In considering the severity of the disorder and the strong position of the government to maintain the disabled individual in the community, it is of great importance that the effectiveness of programmes for individuals with autism be improved. The effectiveness of such programmes

implication for both the individuals with autism and their caregivers. It is for these reasons that it would be advantageous for agencies serving the needs of individuals with autism and their families to include a professional with a movement framework on their assessment and treatment teams. Traditionally, this has not been the case.

It may be possible to use gait analysis to assist in solving the mystery surrounding the etiology(s) of autism. By comparing the gait patterns of patients with specific known central nervous system pathology with the gaits of individuals with autism, it may be possible that some degree of etiological prediction could be made. Research including the combined use of PET and CAT scan findings on experimental subjects could be used to explore the potential of gait analysis for this purpose.

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APPENDIX 1

DSM III

Diagnostic Criteria

For Infantile Autism

a) onset before 30 months of age

b) pervasive lack of responsiveness to other people

c) gross deficits in language and language development

d) if speech is present, peculiar speech patterns such as immediate and delayed echolalia, metaphorical language, pronominal reversal.

Prevalence:	2-4 per 10,000
Sex Ratio:	3 times more common in males
Etiology:	unknown

APPENDIX 2

204 St. George Street
Toronto, Ontario
M5R 2N5
July 21, 1986

Dear Parents:

My name is Sally Bond and I am a graduate student in Health Sciences at McMaster University. In collaboration with The Geneva Centre, I am presently conducting a study on the walking style of children with autism. The purpose of this letter is to request that you consider the possibility of having your child participate in this research.

Study participation would involve the following:

(1) The researcher would visit your home or contact you by phone (your choice) to fully describe the purpose and procedures of the study.

(2) Specific information including your child's date of birth, sex, medication history, diagnostic information, age at which he/she started walking (approximately), school setting, special services provided at school or in another environment, a brief description of parental walking style (i.e. anything notable), hand and foot preference, favorite physical activities and hobbies, height and weight.

(3) Your child will be videotaped while walking across a floor wearing a bathing suit, running shoes and small white adhesive stickers (nonpainful visual marker) placed on his/her ankle, knee and hip joints, as well as on the soles of both shoes. The stickers will be easily removed at the end of a taping session.

Geneva Centre staff will be assisting the researcher in carrying out the videotaping procedure. It is important to know that there are no known harmful effects from this study technique. All records (i.e. information and data) will be

confidential, and if any results are published, your child and family will not be identified in any way. It is important to understand that you may refuse to participate or withdraw your child from the study at any time.

The results of this study will be made available to all participating families and, the researcher will provide feedback on each individual child's walking patterns upon the family's request.

If you will consent to having your child take part in this study, please sign and date the bottom of this letter and return it to the Geneva Centre Summer Programme with your son. If after discussing the study with the researcher you no longer wish to have your child participate, this letter of consent will be destroyed.

Thank you for considering this matter.

Sincerely,

Sally L. Bond, B.Sc., R.A.K.

I give my/our consent for _____
child's name
to participate in this study.

_____ _____
parental/guardian name date

Please list phone number _____

APPENDIX 3

Subject Information Sheet

Name: _____ Clinical Diagnosis_____

_____ _____

D.O.B.: _____ _____

Medication History:_____ School Setting:_____

_____ _____

_____ _____

Orthopaedic History:_____ Special Services Received:____

_____ _____

Parental Orthopaedic Height:_____

History/Gait Char.:_____ Weight:_____

_____ F.L.L.:_____

Physical Activities Child H. D.:_____

Participates in:_____

_____

Parental opinion concerning child's probable reaction to taping situation.

Reinforcer used.

NOTES: Behavioral handling techniques.