A KINEMATIC ANALYSIS OF HANDICAPPED AND NONHANDICAPPED HORSEBACK RIDERS

A THESIS

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CHAPTER I

ORIENTATION TO THE STUDY

Introduction

In recent years horseback riding has gained in popularity as a therapeutic tool for the physically handicapped. Case studies of handicapped riders engaged in these programs seem to indicate that gains in muscular strength, balance, and coordination are achieved through horseback riding (Gerster, 1976; Rosenthal, 1975; Saywell, 1975).

To achieve success on horseback, riding instructors stress four major factors in attaining a functionally "sound" or "balanced seat." These factors include (a) close thigh and leg contact with the saddle and horse's body; (b) keeping the body balanced over the center of gravity of the horse; (c) sitting deep in the saddle, with weight down in the heels; and (d) carrying the body weight on the pelvis to ensure flexibility in riding with the movements of the horse. If all four factors are crucial to success on horseback, then people with disabilities involving amputation of various parts of the lower body, or paralysis and/or weakness of the trunk or lower extremities may experience limited success on horseback.

Although the above factors are regarded as important for success on horseback, actual documentation of the body's position and movement in relationship to the movements of the horse is limited. Observation has, for the most part, been the instrument through which body positioning and movement have been analyzed. It was not until the use of motion photography by ReQua (1939) and White (1940) that objective measurement of body position was attempted. These studies focused primarily on ascertaining differences in "riding seats" and substantiating the effect of a new teaching method. No studies to date have been found which actually support the view that successful riders keep their body weight down in the saddle, and move efficiently on the horse during a walk, slow trot, or canter.

Even though motion photography has not been used extensively in the study of horsemanship, studies conducted by researchers studying gait patterns and kinematics of the forelimbs of horses have found it to be a very useful tool (Fredricson, Drevemo, Moen, Dandanell, & Andersson, 1972; Wentink, 1978). Plagenhoef (1971), a researcher involved in the study of human movement, implied that it is one of the best methods for studying human movement.

Since motion photography has proven to be an effective tool in the study of human movement as well as equine movement, it was the intent of the researcher to use this tool in order to describe and compare handicapped and non-handicapped riders. Of special interest to the investigator were: (a) the changes in the position of the rider's head and trunk relative to the movement pattern of the horse; (b) the changes in the position of the center of gravity relative to the stability of the rider and to changes in the head and trunk, and (c) changes in the trunk velocity and acceleration relative to the changes in the position of the trunk. By doing so, the researcher hoped to provide insight into the differences in head, trunk, and center of gravity positions observed between the two handicapped riders and two control riders.

Purpose of the Study

The purpose of the study was to observe, through cinematographic analysis, differences in the position changes of the head, trunk, and center of gravity between the handicapped riders and the control riders, during the movement changes of the horse. In addition, changes in trunk velocity and acceleration relative to changes in the position of the trunk were to be examined. Such an investigation would contribute to the existing void in the literature regarding kinematic analysis of horseback riding, and the movement patterns of the physically handicapped.

Statement of the Problem

The problem selected for study was to examine, through analysis of filmed data, changes in: (a) head position; (b) trunk position; (c) center of gravity position; (d) absolute displacement; (e) absolute velocity; and (f) absolute acceleration of the rider's trunk during the various movement changes of the horse. Subjects for the study were four college students; two had lower extremity disabilities, and two did not. The physically handicapped adults selected for the study consisted of one male with bilateral leg amputations above the knee and one female with surgically released contractures of the internal rotators of the legs. The other two were free of disabilities and served as control riders.

Prior to filming, appropriate saddle selection, as well as a 10 week course in horsemanship, was conducted for the handicapped riders. A western saddle, with its horn and swell construction, was selected for the male handicapped subject because it gave him greater trunk stabilization. An English saddle with its reduction in padding was selected for the female handicapped subject in order to ensure greater saddle contact with the weakened rotators. The control riders were chosen on the basis of the sex and the type of saddle used by the handicapped riders. The male control was proficient in western riding and the female control was proficient in English riding.

Instruction in horsemanship centered around independence in starting and stopping a horse as well as maintaining a "balanced seat" at the walk and trot. Film data were collected on each of the riders during: (a) stop-walk; (b) walk-trot; (c) trot-halt; and (d) walk-halt.

The following items were evaluated in order to describe the observed differences and similarities in the position and displacement of the head, trunk, and center of gravity among the horseback riders:

1. The initial position of the head, trunk, and center of gravity as viewed from the side.

2. The initial displacement of the head, trunk, and center of gravity as viewed from the side.

3. The frontal displacement pattern of the head, trunk, and center of gravity as viewed from the side.

4. The initial position of the head, trunk and center of gravity as viewed from the front.

5. The initial displacement of the head, trunk, and center of gravity as viewed from the front.

6. The sagittal displacement pattern of the head, trunk, and center of gravity as viewed from the front.

7. The absolute trunk displacement measured from the side view.

8. The absolute trunk velocity as calculated from the side view.

9. The absolute trunk acceleration as calculated from the side view.

Definitions and/or Explanations of Terms

To contribute to a clear understanding of the problem, the following definitions and/or explanations of terms were established for use through the study.

Physically handicapped. Those children and adults who have difficulty in performing physical movements as a result of structural abnormalities or traumatized conditions of their physical body (Telford & Sawry, 1972).

Nonhandicapped. Those children and adults who do not possess structural or functional abnormalities of their physical body, which prevent them from performing normal physical movement.

Gait. The locomotor pattern of the horse, either natural or acquired, which is characterized by a distinctive rhythmic movement of the hooves and legs (Ensminger, 1969).

Walk. The locomotor movement of the horse which involves four definite beats. Hoof contact is made first by the right hind hoof, followed by the right fore hoof, left hind hoof, and left fore hoof. The walk is the most stable and relaxed movement of the horse (Prince & Collier, 1974).

Slow trot. The locomotor pattern of the horse which involves two definite beats. It is a diagonal pattern in which the right front hoof and left hind hoof leave from and land on the ground together alternately with the left front hoof and right hind hoof. The slow trot involves a brief period of suspension when no contact with the ground is made (Ensminger, 1969).

Center of gravity. The point at which the mass of the body is centered. This is the point about which a body or object would be balanced perfectly (Northrip, Logan, & McKinney, 1974).

Mass. The physical volume or bulk of a solid body. It is the measure of the body's resistance to acceleration (American Heritage Dictionary of the English Language, 1969).

Absolute displacement. The distance a body segment has moved relative to a fixed point on the earth (Plagenhoef, 1971).

Absolute velocity. The rate of change of a position in a given direction relative to a fixed point on the earth (Plagenhoef, 1971).

Absolute acceleration. The rate of change in the velocity of a given object, relative to a fixed position on the earth (Plagenhoef, 1971).

Sagittal displacement. The distance a body segment has moved in the vertical right-left plane of the body (Wells & Luttgens, 1976).

Frontal displacement. The distance a body segment is moved in the forward-backward plane of the body (Wells & Luttgens, 1976).

Kinematics. The study of motion without reference to the forces causing motion (Northrip, Logan, & McKinney, 1974).

Estimated Stability Range. The angular range within which the center of gravity should remain to maintain the stability of the body. This range was devised by dropping perpendiculars to the outer most points of the base of support (knees and buttocks for the side view, the right and left side of the pelvic girdle for the front view), and measuring angulation from the pivot point of the trunk (symphysis pubis).

Delimitations of the Study

The study was subject to the following delimitations:

1. Two handicapped college students, one male and one female, with trunk or lower leg involvement.

2. Two nonhandicapped college students, one male and one female, proficient in horseback riding.

3. Complete independence of the handicapped riders to maneuver their horses through the designated movement patterns, after a 10 week training session.

4. The validity, reliability, and objectivity of the equipment utilized.

CHAPTER II

REVIEW OF RELATED LITERATURE

A thorough search of the literature produced consistent descriptions of the "balanced seat," placement of the saddle in relationship to the center of gravity of the horse, and the body position of the rider during movement changes of the horse. Changes in the center of gravity of the rider, as they relate to the observed changes in the body position of the rider, have not been researched. The effect of a physical handicap, specifically trunk and/or lower extremity involvement, upon the relationship of center of gravity of a rider to maintenance of a "balanced seat" has also not been examined.

The following review of literature will include what equitation authorities consider a "balanced seat," positioning and construction of the saddle and body position of the "balanced seat" rider relative to movement changes of the horse. "Balanced seat" riding for the physically handicapped, as well as all the available research on body position of the rider, will also be examined.

The Balanced Seat

The "balanced seat" is defined as the riding position which utilizes the least amount of muscular effort for both the rider and the horse. The rider moves with the horse by keeping the body's center of gravity over the center of gravity of the horse (Ensminger, 1969).

Riding balance is maintained primarily through the shifting of the upper body over its fixed base of support (the thighs, knees, shanks, and ankles) in accordance with the extension and flexion of the horse's body. The degree of forward inclination in the upper body is dependent upon the speed and gait of the horse (Collier & Prince, 1974; Ensminger, 1969).

The "balanced seat" developed differently in English and western riding. The English version of the "balanced seat" is a modification of the forward seat introduced by Federico Caprilli in 1900 (Wilding & Savitt, 1973). The forward seat, under Caprilli, was developed to ensure maximum freedom of movement for the horse. Maximum freedom is maintained by keeping the rider's center of gravity over the natural center of gravity of the horse. Body position at the standstill is slightly forward of the vertical, or just behind the elbows of the horse (Miller, 1975; Wilding & Savitt, 1973). Body position at the canter, gallop, or jump is also forward and is relative to the speed and head position of the horse (British Horse Society, 1972). Stirrups are shortened and the seat raised out of the saddle to accomplish the forward position (Wilding & Savitt, 1973).

Unrestrained forward movement of the horse's head was originally stressed, causing the rider to be placed further and further forward on the horse's neck. Opinions changed, and stress was placed on shifting the horse's weight backward, to develop the horse's hindquarters and leg muscles for better balance and propulsion. The shift of the horse's weight backward resulted in a corresponding change in the rider's position. The rider's position became more erect. Stirrups were lengthened and the seat of the rider pushed down into the saddle to maintain the erect position over the horse's center of gravity (Collier & Prince, 1974).

The western version of the "balanced seat" evolved out of the daily work on the range. To remain seated astride a fast and agile horse during the cutting of cattle, the cowhand had to develop a firm deep seat. Stirrups were lengthened and carried forward of the cinch strap, to aid in thrusting the rider's weight down into the saddle (Mohan & Mohan, 1963).

Positioning and Construction of the Saddle

Saddle placement and construction are vital factors in keeping the rider balanced over the center of gravity of the horse (Prince & Collier, 1973). Placement of the deepest part of the saddle's seat over the center of gravity of the horse allows the rider to experience only a minimal amount of the horse's movement (Miller, 1975; Prince & Collier, 1973).

Saddles which are too long for either the horse or the rider will place the rider behind the center of gravity of the horse. The horse will be hindered in his movement by an unbalanced weight. The rider will be hindered in his or her ability to maintain the "balanced seat" by the increased amount of movement experienced and the fatiguing stress placed on the thigh and lower leg. Saddles which are too short place the rider forward of the deepest and most comfortable portion of the saddle (Prince & Collier, 1974; Stoneridge, 1968).

Placement of the saddle over the center of gravity of the horse is dependent upon the attachment points of the rigging (Miller, 1975). Rigging attachments on basic English saddles are perpendicular to the pommel. This places the deepest part of the saddle and the rider some 6 to 14 in. behind the elbow of the horse and over the center of gravity of the horse. Rigging attachments on the forward saddle are placed to the rear of the pommel, causing the rider's body to be forward of the center of gravity of the horse (Mohan & Mohan, 1963; Wilding & Savitt, 1973).

Rigging attachments on western saddles vary considerably. Texas roping saddles use rim fire or fully rigged attachments, which hang perpendicular to the horn of the saddle. Saddles with rim fire attachments place the horn over the center of gravity of the horse, thus helping the horse absorb the jerk of a roped steer. Placement of the rider using a saddle with a rim fire rigging, is behind the center of gravity of the horse (Miller, 1975).

Center fire riggings were used by dally ropers in California and the Pacific Northwest. Center fire rigging attachments hang perpendicular to the center of the saddle, placing the weight of the rider over the center of gravity of the horse. Center fire rigging allows the horse to carry the weight of the rider more efficiently, but jerks from roped steers are difficult for the horse to absorb (Miller, 1975).

A compromise between the rim fire and the center fire rigged saddles evolved in the early 1900's in the form of the 3/4 rig. The 2/4 rigged attachments are placed halfway between the center fire and rim fire positions. The 3/4 rigged saddle places the rider over the center of gravity of the horse, yet can also be used for roping. It has virtually replaced the center fire rigging and is preferred by horse breakers and cutting and reined horse riders. It is the only rigging allowed for rodeo saddle bronc riders, and is used extensively in equitation and pleasure riding (Miller, 1975).

Other rigging positions are used, but not extensively. There are 5/8 and 7/8 rigged saddles available, but they are not used as much as the 3/4 rigged position (Miller, 1975).

Stirrup position also aids in placing the rider's weight over the center of gravity of the horse. On a basic English saddle, the stirrups hang over the cinch and the horse's center of gravity. This position enables the rider to maintain his or her riding position more easily over the center of gravity of the horse.

On a 3/4 rigged western saddle, the stirrups hang over the cinch and consequently over the center of gravity of the horse. On a full rigged or rim fire saddle, the stirrups hang behind the cinch and likewise behind the horse's center of gravity. This makes it difficult, if not impossible, for the rider's weight to be over the horse's center of gravity. Bronc riders, as well as jockeys, hang the stirrups slightly in front of the center of gravity giving the rider the best leg position for riding the horse and the least interference with the horse (Miller, 1975).

Body Position of the Rider Relative to Movement Changes of the Horse

Authorities claim that the horse's center of gravity is displaced (forward, backward, or to the side) as speed of travel, degree of extension or flexion of the body and the lateral movement of the horse changes (British Horse

Society, 1972; Prince & Collier, 1974; Weikel, 1971). The horseback rider remains in equilibrium with the horse by shifting the upper trunk and, consequently, the center of gravity forward, backward or to the side with the movement of the horse (Mohan & Mohan, 1963; Prince & Collier, 1974; Weikel, 1971). Freedom to move the upper body with the horse is achieved by keeping the legs and feet virtually stationary in the "basic seat" position from the hip joint down, and maintaining a deep firm seat in the saddle (Miller, 1975).

The legs are kept in the "basic seat" position by maintaining light contact with the horse from the lower calf of the leg up through the thigh, and keeping the weight down in the heels. A deep firm seat is achieved by relaxing the muscles in the buttocks, sitting on the strongest and deepest part of the horse's back and supporting body weight on the pelvic bones (Prince & Collier, 1974; Weikel, 1971; Wilding & Savitt, 1973). Flexibility in the upper trunk is achieved by keeping the back relaxed and slightly hollow with the shoulders in line with the hips and balanced over the feet (Prince & Collier, 1974; Weikel, 1971).

Movement from the stop to the walk involves a slight forward inclination of the upper trunk for cueing and initial movement. At the walk, the trunk will resume its original vertical position and will move slightly in rhythm with the natural movements of the horse (British Horse Society, 1972).

Movement from the walk to the sitting trot involves a slight forward inclination of the upper trunk for cueing and initial movement change so the rider is "with" the horse (Weikel, 1971). At the slow trot, the upper trunk will be brought back to a position slightly behind the vertical. The weight will still be on the pelvic bones to avoid being bounced out of the seat from the upward thrust of the horse's movement (Wilding & Savitt, 1973).

Movement from the slow trot to the faster posting trot involves movement of the upper trunk from behind the vertical to slightly in front of the vertical for cueing the initial change in the pace of the movement. The faster pace of the horse throws the rider's body forward and upward. The rider leans forward raising himself out of the seat by straightening and bending his knees in order to remain balanced over the horse's center of gravity (Weikel, 1971; Wilding & Savitt, 1973).

Movement from the sitting trot into the canter or lope involves a lateral transfer of weight to the right or left for cueing of initial movement. Back muscles are relaxed allowing the rider to sit deep in the saddle. The upper body is vertical during a collected canter or slightly forward if the canter is more extended. The majority of the work is done by the pelvis as it moves back and forth with the motion of the horse (Prince & Collier, 1974; Wilding & Savitt, 1973).

Movement from an established gait to a stop involves inclination of the upper trunk and body weight backward to the original vertical position of the "balanced seat." A progressive slowdown from a faster gait to a slower gait is recommended for pleasure riders (Prince & Collier, 1974).

Slight differences in English and western riding exist. The English style of riding involves a little more forward inclination of the upper trunk than in the western style. More weight is placed on the upper thighs than is placed in the seat. English riders have a stiffer back position than western riders; that is, more concave than convex (Weikel, 1971). The English riders ride with shorter stirrups. This pushes the lower leg forward of the vertical position assumed by the western rider (Miller, 1975). Differences between the two styles of riding do exist, but both styles of riding adhere to the basic principles and positioning of the "balanced seat" (Prince & Collier, 1974).

Balanced Seat Riding for the Physically Handicapped

The "balanced seat" is the recommended style of riding for the physically handicapped (Davis, 1967). Authorities claim that students who lack strength and coordination in their legs can still ride a "balanced seat" by using the muscles of their upper trunk for balance and cueing of the horse (Davis, 1967; McCowan, 1972).

The theoretical aspect of riding a "balanced seat" is the same for the physically handicapped rider as it is for the normal rider. A balanced rider must be in complete unison with the movement and balance of the horse. The rider must adopt a position that corresponds with the center of gravity of the horse. Attainment of the appropriate position is accomplished by placing the weight of the rider deep in the saddle supported by the pelvic or "sitting bones." The back is erect with the muscles relaxed and supple. A stiff or hollow back throws the rider forward on the crotch. A collapsed or rounded back places the weight onto the base of the spine resulting in the rider being "left behind" (Davis, 1967).

Students with spasticity in the leg and trunk muscles enhance their riding seats through cultivation and development of postural sensation (Reichenback, 1976). Postural sensation is developed through relaxation of the spastic muscles. Relaxation is obtained through the natural stretch placed on the spastic muscles when mounted, through the warmth of the horse's body when riding, and through the constant rhythmical movement of the horse (Hengst, 1976; Reichenback, 1976). Once relaxation is attained, the rider will sink deeper into the seat, and strive to maintain the body in a vertical line with the movements of the horse (Davis, 1967).

Students suffering from muscular deterioration enhance their balance and riding seats by constantly attempting to maintain the upper trunk in the "balanced seat" position. Maintenance of the "balanced seat," in view of the muscular deterioration, is dependent upon the extent non-affected muscles are taxed to take the place of the deteriorated muscles. By constantly striving to duplicate and maintain the desired position, non-affected muscles are encouraged to take on the function of the affected musculature. Compensatory positioning of the other parts of the body will aid in maintaining the desired position as well (Davis, 1967).

Riders with amputations of the lower extremities enhance their riding seats through the strengthening of the weakened musculature left intact. Persons with amputations below the knee retain sufficient knee and stump control to maintain a stable seat (Adams, Daniel, & Rullman, 1972).

Persons with bilateral or unilateral amputations above the knee require strengthening of the hip extensors on one or both sides. Weakness in the hip extensors could cause the rider to be thrown from his seat due to the inability of the hip extensors to counter balance the forward motion of the horse (Krusen, Kottke, & Ellwood, 1971). Because of the physical shortening of a muscle, a decrease in the contracting force may require other not normally active muscles to take over the function of the weakened muscle. Retraining of a muscle or muscle group to take over the function of the weakened muscle or muscle group is accomplished through constant repetition and refinement of the task (Davis, 1967).

Available Research on the Body Position of the Rider During Movement Changes of the Horse

Only two studies were found which were focused on the body position of a horseback rider during the movement changes of the horse. In both studies, motion photography was used in order to obtain objective measurements.

ReQua (1939) studied the differences in riding position during a walk, posting trot, and canter for Park-Style, forward seat, and show-ring riding. A checklist of the essential elements involved in proper body positioning during a walk, posting trot and canter was compiled according to statements made by authorities in the literature. Review of the checklist indicated that the rider's position was thought to vary little, if any at all, except during the posting trot.

To substantiate the reports of authorities, motion pictures were taken at the walk, trot, and canter for analysis of the body position of the rider. Data gained through the use of motion pictures were reviewed according to the position of the body parts in relationship to each other and the movements of the body parts to maintain a balanced position.

Four adult subjects were filmed. Three of the subjects were proficient in one of the three designated seats: park, forward, or show. The fourth subject was a beginner in horseback riding.

The films were used to determine whether the riders maintained the same body position during each of the three gaits. In addition, ReQua attempted to determine what type joint movement, if any, occurred in the body while adjusting to the various gaits of the horse.

Tracings were made of each rider during a walk, posting trot, trot, and canter. Each tracing was superimposed on the preceding one. The saddle was kept stationary by using the outline of the cantle as a fixed point; this allowed body deviation to be measured. Angles formed by the hips, knees, and ankles were also determined.

Results indicated that none of the four riders changed position noticeably at the walk. Body position remained virtually the same for the riders of the individual seats during the trot and canter. The only major difference observed between the riders of the individual seats was the height of their "rise" during the posting trot. The beginner showed more movement during the trot and canter than the other experienced riders.

White (1940) studied differences in pelvic, thigh, and lower leg movement of beginning riders before and after the use of a specific teaching method designed to aid in keeping riding seats during a canter. The specific teaching method stressed the preservation of contact with the saddle through suppleness of the back, and tilting of the pelvis in relationship to the horizontal movement of the horse. Motion photography was used to collect and evaluate the results.

Two adults classified as elementary riders were the subjects for the investigation. The subjects received instruction in the canter using the experimental method; instruction was given one hour a day for six consecutive days. A special apparatus designed to measure pelvic, thigh, and lower leg action was worn by the subjects during filming.

Effectiveness of the technique was analyzed by motion pictures taken before and after the teaching method was introduced. Changes occurring in body position were measured by analyzing the film taken from the lateral view.

Each of the riders wore the apparatus and were filmed during three consecutive trials of riding at the canter. Tracings were made of each rider and the position of the apparatus for each of the three trials. The angles formed by the apparatus at the hip and knee were measured by protractors. The results were compared for all trials for each subject before and after the experimental period.

The findings indicated that there was improvements in the ability to ride the canter. Before the introduction of the teaching method, movement of the thigh and lower leg predominated the pattern, causing the riders to lose contact with the saddle. After the introduction of the teaching method, an increase in the action of the pelvis and a decrease in the action of the thigh and lower leg was noted. This change allowed the riders to remain in contact with the saddle.

CHAPTER III

PROCEDURES FOLLOWED IN THE DEVELOPMENT OF THE STUDY

The purpose of the study was to describe differences in (a) positioning of the head and trunk, (b) positioning of the center of gravity, and (c) velocity and acceleration of the trunk between handicapped and nonhandicapped horseback riders during the various movement changes of the horse. The two nonhandicapped riders were chosen to serve as comparison models for interpretation of the positioning and velocity-acceleration differences seen in handicapped riders.

The two handicapped riders with lower extremity involvement were chosen to (a) describe changes in the position of the head, trunk, and center of gravity for a person with minimal contact surface of the legs; (b) describe changes in the position of the head, trunk, and center of gravity for a person with weak and unequal contact in the legs; (c) describe changes in the location of the center of gravity as they relate to stability and head and trunk displacement; (d) describe changes in the velocity and acceleration of the trunk; and (e) compare the nonhandicapped control riders with the handicapped riders for added insight into problem areas specific to each rider.

The procedures used in the development of this study are described in this chapter in the following sections: (a) Preliminary Procedures; (b) Selection and Description of the Subjects; (c) Collection of the Data; (d) Organization and Treatment of Data; and (e) Preparation of the Final Written Report.

Preliminary Procedures

Prior to the collection of data, certain preliminary procedures were followed. Permission to conduct the study was secured from the Human Subjects Review Committee of the Texas Woman's University. All available information pertinent to the study was collected, reviewed, and assimilated. A tentative outline was developed and presented to the Thesis Committee. Suggestions made by the Thesis Committee were incorporated into the revision of the outline. The revised outline was filed in the form of a Prospectus in the office of the Provost of the Graduate School of the Texas Woman's University.

Selection and Description of the Subjects

Selection of the subjects for this study was based upon the following criteria: (a) one female subject, nonhandicapped and proficient in English riding; (b) one male subject, nonhandicapped and proficient in western riding; (c) one female subject, handicapped with trunk or lower extremity involvement, and independent on horseback after 10 weeks of riding instruction; (d) one male subject, handicapped with trunk or lower extremity involvement, and independent on horseback after 10 weeks of riding instruction; (e) handicapped subjects who had medical clearance; and (f) subjects who had signed consent and photographic release forms.

The handicapped subjects involved in the study were college students enrolled at Texas Woman's University, Spring semester, 1977. Each one was contacted individually and the nature of the study was outlined. Consent and photographic release forms were signed and the handicapped subjects enrolled in a 10 week riding program. Independence on horseback was assessed at the end of the 10 week program. The nonhandicapped subjects were also college aged students. The female subject was enrolled at Texas Woman's University, owned her own horses and had ridden in English horsemanship competition for several years. The male subject was employed as a riding instructor and general handyman at Estes Stables in Denton, Texas.

Collection of Data

Prior to filming, 10 weeks of riding instruction was given to the handicapped riders to establish their independence in initiating and riding the movement sequences used in the study. At the end of the 10 week period, a film date was set. Prior to filming, each of the subjects was marked on both sides of the body with black dots on white adhesive tape. These markings were made in order to identify the joint centers.

The instruments chosen to collect film data for the study included three 16mm motion picture cameras. A Locam camera was placed laterally to the subject at a distance of 70.9 ft. (21.61m); a Photosonic IVN-200 was placed in front of and at right angles to the subject at a distance of 144 ft. (43.89m); and a Bell and Howell HR-70 was placed at a 45° angle between the other cameras, 77.2 ft. (23.53m) from the subject. All three cameras were set at 32 frames per second. A Sekonic light meter was used to determine the f-stop setting which varied from 5.6 to 16 during filming. The film used was Kodak black and white Tri-X Reversal film with an ASA of 200. Four film clips were taken of each subject as he or she transversed a 24 ft. (7.32m) area performing the designated movement sequences. Cameras were cued to start filming when the researcher's hand was raised, and to stop when the researcher's hand dropped.

Organization and Treatment of Data

Initial viewing of the film was done on a Lafayette Stop-Action Projector. Frame by frame tracings of each filmed sequence, front and side, were made on a glass top tracing table. Magnification of the projector image onto the tracing table was accomplished through a series of three 45° angled mirrors.

Center of gravity information was extracted from the tracings through the use of the Numonics Graphic Calculator interfaced with a Hewlett-Packard 9810A Calculator/Computer. The computed head/neck, trunk, and center of gravity coordinates were plotted for each subject, tracing by tracing, for each of the movement sequences.

Body movement, when plotted frame by frame, was minimal and no useful information could be obtained. The researcher then plotted coordinate points for every fifth frame; later every tenth frame was traced and plotted. After consultation of the Thesis Committee, a decision was made to use the information obtained from tracings made every tenth frame.

Interested in the effect trunk displacement had on differences in velocity and acceleration, the researcher calculated and plotted the absolute trunk displacement, velocity, and acceleration measured from the lateral view. Displacement was measured by protractor and plotted on graph paper. The researcher then smoothed the curve by hand and corrected points not falling on the line. Tangents representing the time interval between tracings were then drawn to each point on the displacement curve. Measurement of the slope of the tangent for each point resulted in the instantaneous velocity (Plagenhoef, 1971). The calculated velocities were then plotted on graph paper, the curve was hand smoothed, and the points were corrected. As before, tangents were drawn to each point on the velocity curve. The slope of the tangent was measured, and acceleration was calculated. The calculated accelerations were plotted, the curve was hand smoothed, and points not on the curve were corrected. Displacement, velocity, and acceleration curves were compared between the handicapped riders and the control riders.

Preparation of Final Written Report

Preparation of the final written report included presentation of the findings, a summary of the findings, a statement of conclusion, implications of the findings, and recommendations for further studies. References were compiled and an appendix developed to complete the written report.

CHAPTER IV

PRESENTATION OF THE FINDINGS

The present study was conducted to describe and compare changes in positions of the head, trunk, and the center of gravity of handicapped riders and nonhandicapped riders. Differences in trunk displacement, velocity, and acceleration were also examined. Four college students, two with trunk and/or lower extremity handicaps and two without, served as the subjects (see Table 1). The physically handicapped subjects who participated in the study

Table 1

Description of Status Variables of the Subjects

Subject[a]	Age	Orthopedic Status
1	25	Normal
2	21	Released contractures of the internal rotators of the legs
3	24	Normal
4	29	Bilateral amputee (above the knee)

[a]Subjects 1 and 2 were females; subjects 3 and 4 were males.

consisted of one male with bilateral leg amputations above the knee and one female with released contractures of the internal rotators of the legs. The two nonhandicapped riders consisted of one male proficient in Western riding and one female proficient in English riding.

Descriptive data were collected by plotting the coordinates of the head, trunk, and center of gravity as obtained by digitizing the joint centers marked on the film tracings of each rider. The information was examined, described, and compared in the following ways: (a) differences and/or similarities in the trunk movement of the subjects as compared to the pattern of movement outlined in the literature (British Horse Society, 1972); (b) differences and/or similarities in the forward-backward and side-to-side trunk position of the handicapped riders and the control (nonhandicapped) riders; (c) differences and/or similarities in the forward-backward and side-to-side position of the center of gravity between the handicapped riders and control riders; (d) position of the center of gravity in relationship to the boundaries of the base of support; (e) differences and/or similarities in head position between the handicapped riders and the control riders; and (f) differences and/or similarities in the forward-backward trunk displacement, velocity, and acceleration between the handicapped riders and the control riders. The findings are presented in this chapter.

Pattern of Trunk Movement

Authorities believe that horseback riders remain in equilibrium with the horse by keeping the center of gravity over the center of gravity of the horse. Upper trunk movement is believed to be indicative of the rider's attempt to keep his center of gravity over the center of gravity of the horse. Movement patterns of the trunk during different movement phases of the horse are recorded in the literature (British Horse Society, 1972). Variations in the movement of the trunk are based upon the speed, forward-backward, and lateral movements of the horse (Mohan & Mohan, 1963; Prince & Collier, 1974; Weikel, 1971). The problem of this part of the study was to determine whether the riders followed the pattern of movement of the trunk as recorded in the literature.

Recorded and Actual Forward-Backward Movement of the Trunk

Table 2 presents both the upper trunk movements recorded in the literature, as well as the actual movements of the four subjects studied during the following movement changes of the horse: (a) stop-walk; (b) walk-halt; (c) walk-trot; and (d) trot-halt.

Table 2

Forward-Backward Movement of the Trunk During the Movement Sequences of the Horse

Subject[a]/ Recorded Movement	Stop-Walk[b]	
	Initiation	Walk
Recorded Movement in Literature	F B	Moves with Horse
1	F F B B	B F B B F
2	F F B B	B B B F F
3	F F B B	F B B
4	F F F B	B F

Subject[a]/ Recorded Movement	Walk-Halt	
	Walk	Halt
Recorded Movement in Literature	Moves with Horse	B (Progressive Slowdown)
1	B F B B F B F S	B F B F B
2	B B B F B F B F S	B F F
3	F B F F B B F	B F B F F
4	B F F F B B F F	B F F B

Subject[a]/ Recorded Movement	Walk-Trot	
	Walk	Initiation
Recorded Movement in Literature	Moves with Horse	F F B
1	B	F B B B F
2	B	F F B B F
3	F	F F B B F
4	B	F B F B B

Table 2--Continued

Subject[a]/ Recorded Movement	Trot-Halt	
	Trot	Halt
Recorded Movement in Literature	Upper Trunk More Forward; Greater Movement with Horse	B (Progressive Slowdown)
1	B F B F B	B F B B
2	B F B F B F	B F B
3	F B B F B	B F F B
4	B F F B B F	B F F

[a]Subject classification: 1 = nonhandicapped female; 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

[b]Movements and position data are entered according to the following key:

F = Forward movement (decrease in the angulation of the trunk).

B = Backward movement (increase in the angulation of the trunk).

S = Same angle.

Actual trunk movement was measured for each subject by comparing the difference in the angulation of the trunk for each of the four movement sequences. Forward movement of the trunk was determined by decreases between the trunk angle of subsequent positions; backward movement of the trunk was determined by increases between the trunk angle of subsequent positions. Comparisons between the recorded movements and the actual movement of the subjects were made according to the specific phase of the movement sequences (i.e. initiation, halt, walk, and trot).

Stop-Walk

In Table 2, trunk movement during the initiation phase of the stop-walk is recorded as moving forward initially to cue the horse, then backward toward the vertical as the horse moved into the trot. All subjects followed this pattern during the initiation of the stop-walk by moving forward for two or more movements followed by two or more backward movements. Movement during the walking phase was recorded as following the rhythmic movements of the horse. The researcher interpreted the rhythmic movement of the horse as representing a continuous pattern of forward-backward movements common to each rider.

During the walk, Subject 1 (nonhandicapped female) followed a pattern of one forward movement followed by two or more backward movements. Subject 2 (handicapped female) did not exhibit a specific pattern, although her movement was predominantly backward. Pattern of movement during the walk could not be determined for either Subject 3 (non-handicapped male) or Subject 4 (handicapped male), since their lateness in initiating the stop-walk sequence prevented adequate observation of body movement at the walk.

Walk-Halt

Since specific movements of the trunk at the walk were not recorded in the literature, the movement patterns specific to each rider were recorded. Subject 1 and Subject 2 appeared to follow their previous walk patterns until midway through the walk phase; at this point both Subject 1 and Subject 2 switched to a forward-backward, forward-backward pattern. Subject 3 exhibited alternating movements interspersed with sustained movements. Subject 4's movements were sustained in a pattern of two or more forward movements followed by two or more backward movements.

During the halt, trunk movement was recorded as moving backward initially, followed by a backward fluctuation of the trunk during the "slowdown." All four subjects moved backward upon initiation of the halt. Subject 1 and Subject 4 followed the progressive slowdown; Subject 2 and Subject 3 remained forward during the slowdown.

Walk-Trot

The trunk was recorded as moving forward then backward during initiation of the trot from the walk. All four subjects followed the initiation pattern recorded in the literature.

Movement during the trot was not recorded in the literature. The researcher assumed the rider would move forward and backward with the horse. A fluctuating backward-forward movement was exhibited by Subjects 1, 2, and 3 during the trot, and a sustained movement backward was exhibited by Subject 4.

Trot-Halt

Since movement during the trot phase was not recorded in the literature, the movement pattern of each rider was recorded and interpreted. Subjects 1 and 2 both exhibited a forward-backward, forward-backward pattern during the trot. Subjects 3 and 4 exhibited sustained movements during different parts of the trot phase. Subject 3's sustained movements occurred near the beginning, whereas Subject 4's sustained movements were exhibited during the majority of the trot.

All four subjects' trunks moved backward during the initiation of the halt. The trunks of Subject 1 and Subject 2 fluctuated back and forth during the slowdown; the trunks of Subjects 3 and 4 remained forward during the slowdown.

Side-to-Side Movement of the Trunk

The side-to-side fluctuations of the four subjects during the various movement changes of the horse, as viewed from the front, are presented in Table 3. Since no available information was found in the literature regarding the side-to-side movements of the trunk, the researcher noted only the general movement patterns and specific differences between the handicapped riders and the control riders. Movements to the left were represented by decreases in trunk angle between the subsequent positions; movements to the right were represented by increases in trunk angle between the subsequent positions. Movement patterns were compared by the various movement phases of the sequence (i.e. initiation, halt, walk, and trot).

Stop-Walk

As indicated in Table 3, during the initiation phase the trunk of Subject 1 moved right from the initial position. The trunks of Subject 2 and Subject 3 moved left from the initial position. The trunk of Subject 4 followed a left-right, left-right pattern.

The pattern of movement during the walk phase was primarily to the left for Subject 1, whereas Subject 2

Table 3

Right to Left Movement of the Trunk During the Movement Sequences of the Horse

Subject[a]	Stop-Walk[b]	
	Initiation	Walk
1	L R R R	L L R S L
2	L L L R	L L L R R
3	R L L R	L L R
4	L R L R	L R

Subject[a]	Walk-Halt	
	Walk	Halt
1	R R L R R L S	R L R R L
2	R L R L L R L L R	L R L
3	R L L R R L S	L R L L R
4	L S R L L R S R	R L L R

Subject[a]	Walk-Trot		
	Walk	Initiation	Trot
1	R	L R R	L L
2	L	R R L	L R
3	R	L R R	L L
4	R	L S R	R L

Table 3--Continued

Subject[a]	Trot-Halt	
	Trot	Halt
1	R S L S R	L S R L
2	L R R L R L	R S R
3	R L R L L	R S L L
4	L R L S L R	S R R

[a]Subject classification: 1 = nonhandicapped female; 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

[b]Movement and position data are entered according to the following key:

L = (left decreased angulation)

R = (right increased angulation)

S = same angle.

exhibited right movements. The patterns of movement for Subject 3 and Subject 4 were not fully developed because of the reduced number of positions available for analysis.

Walk-Halt

Trunk movements during the walk phase were in opposition for Subject 1 and Subject 2. The pattern of Subject 1 was two movements to the right followed by one movement to the left; the pattern of Subject 2 was two movements to the left followed by one movement to the right. The movement of Subject 3 was sustained to the right or left before it returned to the opposite side. Subject 4 presented a pattern of two movements to the left followed by a movement to the right.

During the halt phase, Subject 1 continued the pattern of two movements to the right followed by one movement to the left. Subject 2 altered her pattern to a left, right, left pattern. Both Subject 3 and Subject 4 exhibited a movement to the right followed by two movements to the left.

Walk-Trot

Only one position comprised the walking phase of this sequence, therefore no movement pattern was determined. The trunk movement of Subject 1 during the initiation phase of the sequence exhibited a pattern of one movement to the left followed by two movements to the right. The trunk of

Subject 3 moved right, whereas the trunk of Subject 4 moved left during the initiation phase. The trot phase consisted of only two positions; the investigator was not able to determine a fully developed pattern of movement during this phase.

Trot-Halt

During the entire trot-halt phase, the trunk of Subject 1 alternated every two positions from right to left. The trunk of Subject 2 moved to the right and remained right for an additional position before alternating between the right and left. The trunk positions of Subjects 3 and 4 alternated from right to left initially, and ended to the left. During the halt, the trunk of Subject 1 was held to the left before alternating from right to left. The trunks of Subjects 2, 3, and 4 remained to the right.

Comparison of Forward-Backward and Side-to-Side Movements

The researcher compared the subjects' forward-backward movements with their side-to-side movements to determine whether a specific movement pattern emerged. The results are presented in Table 4. No distinct movement pattern emerged.

The angular positions of each subject's trunk, as viewed from the side, are presented by movement phase and

Table 4

Forward-Backward and Side-to-Side Movement of the Trunk

Subject[b]	Stop-Walk[a]	
	Initiation	Walk
1	F F B B P R R R	B F B B F L L R S L
2	F F B B P L L R	B B B F F L L L R R
3	F F B B R L L R	F B B L L R
4	F F F B L R L R	B F L R

Subject[b]	Walk-Halt	
	Walk	Halt
1	F B B F B F S R R L R R L S	B F B F B R L R R L
2	B B B F B F B F S R L R L L R L L R	B F F L R L
3	F B F F B B F R L L R R L S	B F B F F L R L L R
4	B F F F B B F F L S R L L R S R	B F F B R L L R

Table 4--Continued

Subject[b]	Walk-Trot		
	Walk	Initiation	Trot
1	B R	F B B L R R	B F L L
2	B L	F F B R R L	B F L R
3	F R	F F B L R R	B F L L
4	B R	F B F L S R	B B R L

Subject[b]	Trot-Halt	
	Trot	Walk
1	B F B F B R S L S R	B F B B L S R L
2	B F B F B F P R R L R L	B F B R S R
3	F B B F B R L R L L	B F F B R S L L
4	B F F B B F L R L S L R	B F F S R R

[a]Movements and position data are entered according to the following key:

F-B = Forward-Backward Movement.

R-L = Right to Left Movement.

F = Decreased angulation between trunk positions (side view).

Table 4--Continued

B = Increased angulation between trunk positions (side view).

P = Trunk or center of gravity is on perpendicular (90°).

S = No change in angulation.

L = Decreased angulation between trunk positions (front view).

R = Increased angulation between trunk positions (front view)

[b]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

sequence in Table 5. Trunk angles were measured from the right of the body's vertical plane (see Figure 1). Angles less than 90° were considered forward angles; angles greater than 90° were considered backward angles. Position and range of forward-backward angulation were compared between the handicapped horseback riders and the control riders.

Stop-Walk

During the initiation phase of the stop-walk sequence, the trunk of Subject 1 fluctuated to forward of then behind the perpendicular. The trunk of Subject 2 remained forward during the entire initiation phase. The range of angulation was greater for Subject 2 than for Subject 1. Trunk position during the walk phase was behind the perpendicular for both subjects. Backward angulation during this phase was greater for Subject 1 than Subject 2.

The trunk of Subject 3 fluctuated backward and forward of the perpendicular during the initiation phase of the sequence. The trunk of Subject 4 was behind the perpendicular during the entire initiation phase. Range of angulation during the initiation phase was greater for Subject 4 than for Subject 3. During the walk phase the trunks of both Subjects 3 and 4 were behind the perpendicular. Backward angulation during this phase was greater for Subject 4 than for Subject 3.

Table 5

Forward-Backward Angulation of the Trunk As Viewed from the Side

Subject[a]	Stop-Walk[b]								
	Initiation				Walk				
1	87.0	85.9	91.0	99.0	102.0	101.0	103.0	106.0	96.0
2	89.5	80.0	85.0	89.0	92.5	96.5	100.0	96.0	94.0
3	91.0	82.0	88.0	93.0	90.0	94.5	99.0		
4	102.0	101.0	100.0	106.0	107.5	105.0			

Subject[a]	Walk-Halt													
	Walk									Halt				
1	100.0	96.0	99.0	105.0	98.0	100.0	99.5			101.0	95.0	97.0	93.5	99.0
2	99.5	101.0	104.0	100.0	111.5	99.5	112.0	103.0	103.0	107.0	105.0	97.0		
3	87.5	92.5	91.0	88.5	92.0	95.0	89.5			90.0	87.5	90.0	89.5	88.0
4	127.0	107.0	103.5	99.5	101.0	106.0	105.0	99.5		107.5	102.5	96.0	98.0	

Subject[a]	Walk-Trot					
	Walk	Initiation			Trot	
1	101.0	100.0	101.0	101.5	102.0	101.0
2	98.5	92.5	79.0	83.0	90.0	88.0
3	84.0	84.0	75.0	83.0	90.0	85.0
4	93.0	79.0	85.0	84.0	88.0	94.0

Table 5--Continued

Subject[a]	Walk-Halt									
	Trot						Halt			
1	107.0	102.0	106.0	98.0	98.5		102.0	100.0	101.0	103.5
2	104.0	96.5	106.5	103.0	106.5	102.0	105.0	104.5	109.0	
3	87.0	87.5	93.5	88.0	90.0		95.5	90.0	83.5	86.5
4	105.0	98.5	94.5	96.0	100.5	97.5	98.5	98.0	92.5	

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

[b]Data are in degrees.

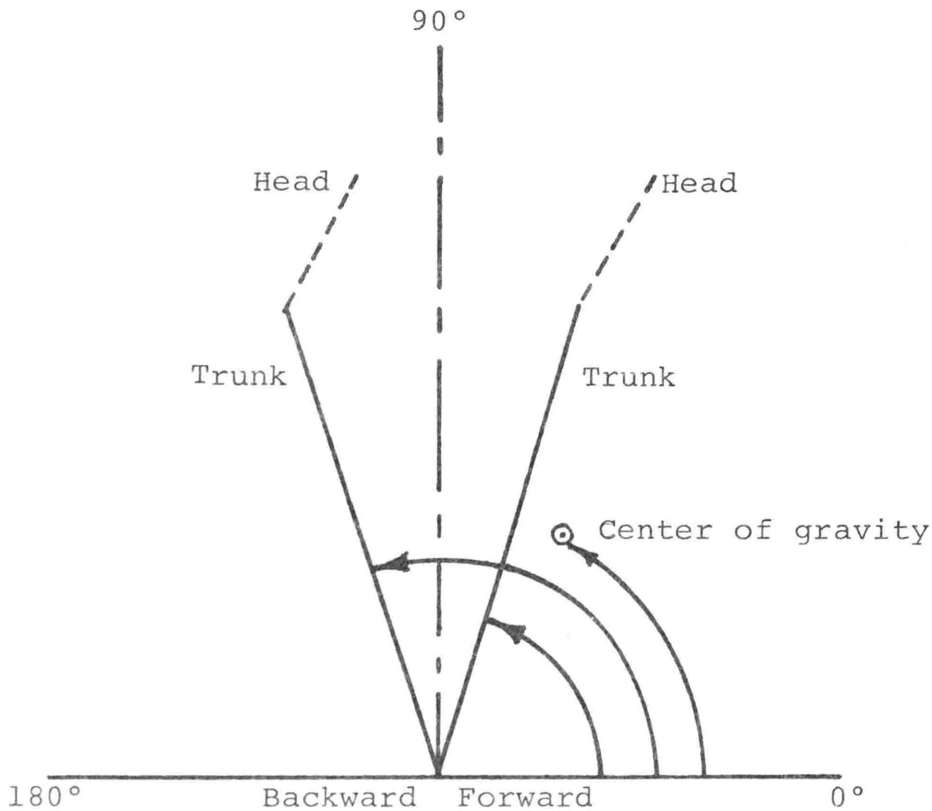


Figure 1. Determination of center of gravity position from side view.

Walk-Halt

The trunks of both Subject 1 and Subject 2 were behind the perpendicular for both phases of the walk-halt sequence. During both phases of the sequence trunk angulation was greater for Subject 2 than for Subject 1.

During the walk phase the trunk of Subject 3 fluctuated forward and backward. The trunk of Subject 4 remained behind the perpendicular. During the halt phase the trunk of Subject 3 was forward of the perpendicular; the trunk of Subject 4 remained behind the perpendicular. Range of angulation during both phases of the sequence was greater for Subject 4 than for Subject 3.

Walk-Trot

The trunks of Subject 1 and Subject 2 were behind the perpendicular during the walk phase of the sequence. The trunk angulation of Subject 1 was 11° behind the perpendicular, whereas it was 8.5° behind the perpendicular for Subject 2. During the initiation phase, the trunk of Subject 1 remained behind the perpendicular; the trunk of Subject 2 fluctuated backward and forward of the perpendicular. Trunk position during the trot phase was behind the perpendicular for Subject 1 and forward of the perpendicular for Subject 2. During both phases of the sequence, the angulation range of the trunk was greater for Subject 2 than for Subject 1.

The trunk of Subject 3 was 6° forward of the perpendicular during the walk phase; for Subject 4 it was 3° back of the perpendicular. During the initiation phase, the trunks of both subjects were forward of the perpendicular. Trunk position during the trot was forward for Subject 3 and fluctuated forward and backward for Subject 4. Range of angulation during all phases of the walk-trot was greater for Subject 3 than for Subject 4.

Trot-Halt

Position of the trunk during the phases of the trot-halt sequence was behind the perpendicular for both Subject 1 and Subject 2. Backward angulation of the trunk during the trot phase was greater for Subject 1 than for Subject 2. Backward angulation of the trunk during the halt phase was greater for Subject 2 than for Subject 1.

During both phases of the trot-halt sequence, the trunk of Subject 3 fluctuated forward and backward of the perpendicular; it remained behind the perpendicular for Subject 4. Trunk angulation was greater for Subject 4 than for Subject 3 during both phases of the sequence.

Side-to-Side Trunk Angulation

Table 6 presents the angular position of each subject's trunk, as viewed from the front, during the four movement sequences. Trunk angles were measured from the

Table 6

Side-to-Side Angulation of the Trunk As Viewed from the Front

Subject[a]	Stop-Walk[b]								
	Initiation				Walk				
1	90.0	90.5	91.0	92.0	89.5	88.5	90.0	90.0	89.5
2	90.0	89.0	87.5	91.0	90.0	87.0	86.0	87.0	88.5
3	89.5	79.5	65.5	87.0	76.5	80.5	82.5		
4	91.0	95.0	90.0	92.5	87.0	88.0			

Subject[a]	Walk-Halt													
	Walk									Halt				
1	94.0	102.0	96.0	97.0	98.0	90.0	90.0			95.0	90.0	91.0	96.5	93.0
2	95.0	92.0	97.5	94.0	92.0	97.0	90.5	90.0	92.5	90.0	93.0	89.0		
3	96.0	92.5	90.0	94.0	97.0	95.0	95.0			90.0	97.0	95.0	90.0	94.5
4	89.0	89.0	89.5	87.0	86.0	89.5	89.5	90.0		93.0	90.5	87.0	90	

Subject[a]	Walk-Trot					
	Walk	Initiation			Trot	
1	93.5	92.0	98.5	100.0	96.0	94.0
2	85.0	90.0	96.5	90.0	89.0	90 0
3	95.0	91.0	93.0	94.0	91.0	90.0
4	90.5	85.5	85.5	90.0	92.0	86.0

Table 6--Continued

Subject[a]	Trot-Halt									
	Trot						Halt			
1	90.5	90.5	90.0	90.0	90.5		89.5	89.5	90.5	90.0
2	90.0	92.0	94.5	90.0	91.5	87.0	89.5	89.5	90.0	
3	93.0	90.0	95.0	91.5	90.5		93.0	93.0	92.5	92.0
4	88.0	93.0	90.0	90.0	85.0	86.0	86.0	90.0	91.5	

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female; 3 = nonhandicapped male; 4 = handicapped male.

[b]Data are in degrees.

right of the body's perpendicular plane. Trunk angles less than 90° were considered left angles, and angles greater than 90° were considered right angles (see Figure 2). Position and range of angulation were compared between the handicapped riders and the control riders during the various phases of the movement sequences.

Stop-Walk

During the initiation phase, the trunk of Subject 1 remained to the right of the perpendicular. The trunk of Subject 2 fluctuated from left to right of the perpendicular. Trunk angulation during the walk phase was to the left for both subjects. Trunk angulation during both phases of the sequence was greater for Subject 2 than for Subject 1.

Position of the trunk during the initiation phase was to the left for Subject 3 and to the right for Subject 4. During the walk phase, trunk positions were left for both subjects. During both phases, range of angulation was greater for Subject 3 than for Subject 4.

Walk-Halt

The trunks of Subjects 1 and 2 remained to the right during the entire walk phase. During both phases, range of trunk angulation was greater for Subject 1 than for Subject 2.

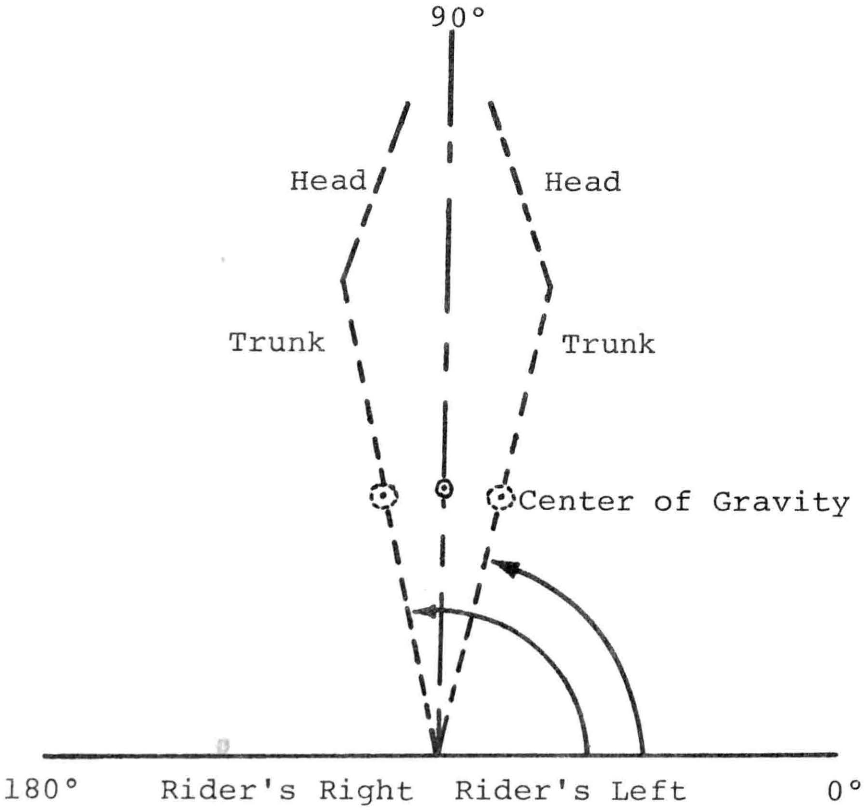


Figure 2. Determination of center of gravity position from front view.

Angulation of the trunk during the walk phase was to the right for Subject 3 and to the left for Subject 4. During the halt phase, the trunk of Subject 3 remained to the left, whereas the trunk of Subject 4 fluctuated from right to left. Trunk angulation was greater for Subject 4 during both phases of the sequence.

Walk-Trot

During the initiation phase, the trunks of both Subject 1 and Subject 2 remained to the right. Position at the trot was to the right for Subject 1 and to the left for Subject 2. Range of angulation during the initiation and trot phases was greater for Subject 1 than for Subject 2.

The trunks of both Subject 3 and 4 remained to the right of the perpendicular during the walk phase. Angulation of the trunk during the initiation phase was right for Subject 3 and left for Subject 4. During the trot, the trunk of Subject 3 remained to the right of the perpendicular; it fluctuated from right to left for Subject 4. Range of angulation during both the initiation and trot phases was greater for Subject 4 than for Subject 3.

Trot-Halt

For both Subject 1 and Subject 2, angulation of the trunk during the trot was to the right. During the halt, trunk position of Subject 1 moved from left to right of the perpendicular; it remained to the left for Subject 2. Trunk angulation was greater for Subject 1 than for Subject 2 during the trot phase; angulation remained the same for both subjects during the halt phase.

The trunk of Subject 3 remained right of the perpendicular during both the trot phase and the halt phase. Subject 4's trunk shifted from right to left during both phases of the sequence. The range of trunk angulation for Subject 4 was greater for both phases of the sequence.

Position of the Center of Gravity

Stability on horseback is dependent upon the rider's ability to maintain the body's center of gravity over the base of support. The body's forward-backward base of support is formed by the area between the buttocks and knees of the rider when seated in the saddle (see Figure 3). The body's side-to-side base of support is formed by the area between the right and left sides of the pelvis (see Figure 4). Center of gravity position angles were measured from the right of the body's vertical plane. This was based upon the assumption that the trunk, and consequently the center of gravity, would fall along the vertical at a standstill (British Horse Society, 1972).

Table 7 presents the angular position of each subject's center of gravity during the four movement sequences

Table 7

Forward-Backward Movement of the Center of Gravity

Subject[a]	Stop-Walk[b]								
	Initiation				Walk				
1	73.5	65.5	76.0	90.0	92.0	82.5	82.5	80.5	76.0
2	86.0	71.0	83.0	83.5	83.0	85.0	89.0	73.0	72.0
3	80.0	57.0	65.0	71.0	69.0	68.0	78.0		
4	92.5	88.0	86.5	90.0	88.0	92.0			

Subject[a]	Walk-Halt													
	Walk									Halt				
1	91.0	63.5	81.0	89.5	78.0	77.0	77.0			87.5	56.0	76.0	52.5	72.5
2	91.0	96.0	91.0	90.0	111.0	86.0	96.0	79.0	66.5	88.0	77.0	61.0		
3	83.0	88.0	82.5	82.0	85.0	81.0	81.0			72.5	53.0	68.0	65.0	63.5
4	146.5	98.0	91.0	82.0	87.0	88.5	88.0	74.5		94.0	88.0	79.0	75.0	

Subject[a]	Walk-Trot					
	Walk	Initiation			Trot	
1	93.5	77.0	77.5	78.0	70.0	77.5
2	92.5	96.0	62.5	74.0	80.0	61.5
3	85.0	76.0	73.0	66.0	72.5	72.0
4	87.0	77.0	66.0	65.0	72.0	66.0

Table 7--Continued

Subject[a]	Trot-Halt									
	Trot						Halt			
1	101.0	78.5	76.0	54.5	65.5		63.0	74.0	55.0	75.0
2	105.0	78.0	99.0	92.5	97.0	90.0	67.5	75.0	87.0	
3	82.5	75.0	82.5	72.5	73.5		74.0	68.0	57.5	61.5
4	100.0	86.0	85.0	86.0	88.0	74.5	78.0	76.0	60.0	

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

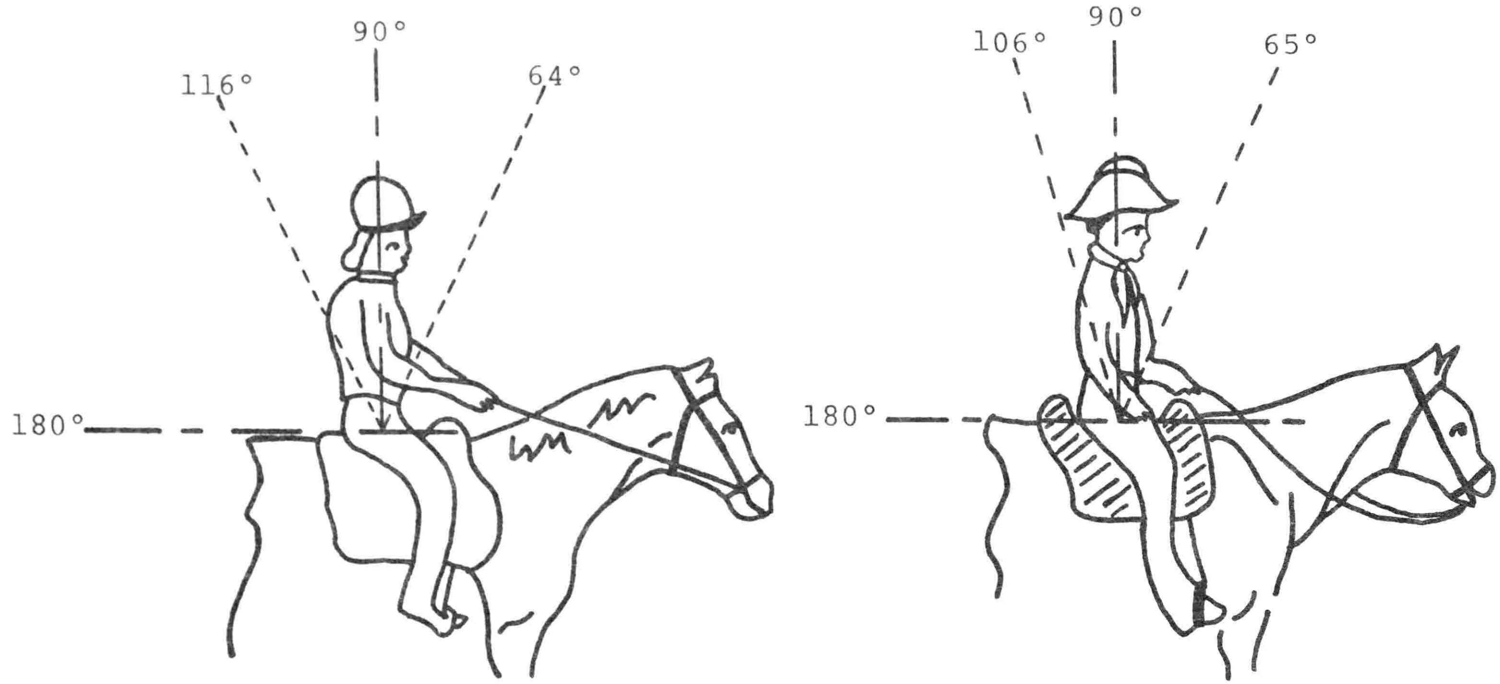
[b]Data are in degrees.

as viewed from the side. Angles less than 90° constituted forward angles, and angles greater than 90° constituted backward angles. The positions of the center of gravity were compared for the handicapped and the control subjects during each phase of the movement sequences. In addition, a comparison between the ranges of the centers of gravity and the estimated range was made to determine stability of the body during the different phases of the movement sequences (see Figure 3).

Stop-Walk

The centers of gravity of both Subject 1 and Subject 2 were forward of the perpendicular during both phases of the sequence. During the initiation phase, the center of gravity of Subject 1 was more forward than it was for Subject 2. The center of gravity of Subject 2 was, however, forward of that of Subject 1 during the walk phase. The centers of gravity of both subjects stayed within the stability range (64° to 116°) for the entire sequential movement.

During the major portion of both phases of the stop-walk sequence, the centers of gravity of Subject 3 and Subject 4 were forward of the perpendicular. The center of gravity of Subject 3 was more forward than that of Subject 4 during both phases. The center of gravity of



English Saddle
(Female Subjects 1 and 2)

Western Saddle
(Male Subjects 3 and 4)

Figure 3. Estimated center of gravity boundaries from side view.

Subject 3 fell outside of the stability range 65°'to 106°) during the initiation phase, but remained within the stability range during the entire walk phase. The center of gravity of Subject 4 remained within the stability range during both phases.

Walk-Halt

During the major portion of the walk phase, the center of gravity of Subject 1 was forward of the perpendicular, whereas it was behind the perpendicular for Subject 2. The centers of gravity of both subjects were forward of the perpendicular during the halt phase. Position of the center of gravity was farther forward during the halt than during the initiation phase for both subjects. Subjects 1 and 2 remained within the stability range during the walk, but fell outside the range during a portion of the halt.

The centers of gravity of Subjects 3 and 4 were forward of the perpendicular during the majority of the walk-halt sequence. For Subject 3 it was more forward than it was for Subject 4 during both phases of the sequence. Both subjects' centers of gravity were farther forward during the halt phase than during the initiation phase. The center of gravity of Subject 3 remained within the stability range during the walk phase, but fell outside the range during the halt phase. The center of gravity of Subject 4 remained within the stability range during both phases.

Walk-Trot

The centers of gravity of Subject 1 and Subject 2 were forward of the perpendicular during both the initiation and trot phases. The center of gravity of Subject 2 was more forward than that of Subject 1 during the majority of the phases. Subject 2 exhibited greater fluctuation in the position of the center of gravity during the initiation and trot phases. During these two phases, the center of gravity of Subject 1 was relatively constant. The centers of gravity of both subjects remained within the stability range during both phases of the sequence.

The centers of gravity of Subject 3 and Subject 4 were forward of the perpendicular during the entire walk-trot sequence. During the major portion of both the initiation and trot phases, it remained more forward for Subject 4 than for Subject 3. Position of the centers of gravity remained relatively constant for both subjects during the initiation and trot phases. During the walk phase both subjects remained within the stability range. During the initiation phase, the center of gravity of Subject 3 fell outside the range in one position, whereas it was outside in two positions for Subject 4. During the trot, the center of gravity of Subject 3 remained within the stability range, whereas it fell outside for Subject 4.

Trot-Halt

During both phases of the trot-halt, the center of gravity of Subject 1 was forward of the perpendicular. For Subject 2, it was behind the perpendicular during the trot phase, and forward of the perpendicular during the halt phase. The center of gravity position of Subject 1 was more forward than it was for Subject 2 during both phases. Both subjects' centers of gravity moved forward during the halt phase. The center of gravity of Subject 1 fell out of the stability range in one position of the trot phase and one position of the halt phase; it remained within the stability range during both phases for Subject 2.

The centers of gravity of Subject 3 and Subject 4 were forward of the perpendicular during both the trot and halt phases of the sequence. During both phases of the sequence, the center of gravity of Subject 3 was more forward than it was for Subject 4. The centers of gravity of both subjects moved forward during the halt phase. The centers of gravity of the two subjects stayed within the stability range during the trot phase, but fell outside the range during one or two positions of the halt phase.

Side-to-Side Movement of the Center of Gravity

The side-to-side movement of the center of gravity for each subject, as measured from the front view, during the four movement sequences is presented in Table 8. Angles less than 90° constituted movement to the left, and angles greater than 90° constituted movement to the right. Position of the center of gravity from the perpendicular was compared between the handicapped and the control riders during each phase of the movement sequences. In addition, a comparison between the ranges of the centers of gravity and the estimated range was made to determine stability of the body during the different phases of the movement sequences (see Figure 4).

Stop-Walk

During the major portion of both phases of the stop-walk sequences, the center of gravity of Subject 1 was left of the perpendicular; for Subject 2 it shifted from right to left of the perpendicular. The center of gravity of Subject 1 was left of that of Subject 2 during the main portion of both phases. Distance from the perpendicular was relatively constant for both subjects during the initiation and halt phases. The center of gravity of each fell within the stability range (65° to 115°).

The centers of gravity of Subject 3 and Subject 4 were left of the perpendicular during both phases of the stop-walk. During the majority of both phases, the center of gravity of Subject 3 was left of that of Subject 4. The position of the centers of gravity for both subjects was

Table 8

Side-to-Side Movement of the Center of Gravity

Subject[a]	Stop-Walk[b]								
	Initiation				Walk				
1	81.5	78.0	81.0	91.5	87.5	80.5	76.0	79.5	83.5
2	94.5	92.0	89.0	88.0	92.0	89.0	85.0	89.0	93.5
3	89.5	79.0	65.5	87.0	76.5	80.5	82.5		
4	82.0	90.0	81.5	89.0	80.0	81.0			

Subject[a]	Walk-Halt													
	Walk									Halt				
1	84.0	96.0	86.0	87.5	87.5	78.5	85.5			95.5	77.0	74.0	86.5	89.5
2	96.5	90.0	101.0	101.5	92.0	104.0	87.5	90.0	99.0	93.0	96.0	87.5		
3	87.5	83.0	77.5	84.0	84.0	85.0	91.5			74.5	92.0	88.5	73.0	80.0
4	83.0	86.5	80.0	81.5	83.0	82.0	81.5	85.5		85.0	80.5	80.0	85.5	

Subject[a]	Walk-Trot					
	Walk	Initiation			Trot	
1	80.5	83.0	88.0	88.5	86.0	82.5
2	83.0	87.0	100.5	80.0	89.5	90.0
3	99.0	75.0	81.0	84.0	75.0	77.0
4	89.5	108.0	80.0	81.5	84.0	82.0

Table 8--Continued

Subject[a]	Trot-Halt									
	Trot						Halt			
1	77.5	70.0	76.0	76.0	79.0		75.0	79.0	77.5	82.0
2	82.5	83.5	93.0	87.0	89.0	87.5	90.0	91.5	90.0	
3	77.0	78.0	78.0	80.0	84.0		87.5	89.0	86.5	88.0
4	81.0	86.0	83.0	88.5	75.0	79.0	76.5	79.5	70.0	

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

[b]Data are in degrees.

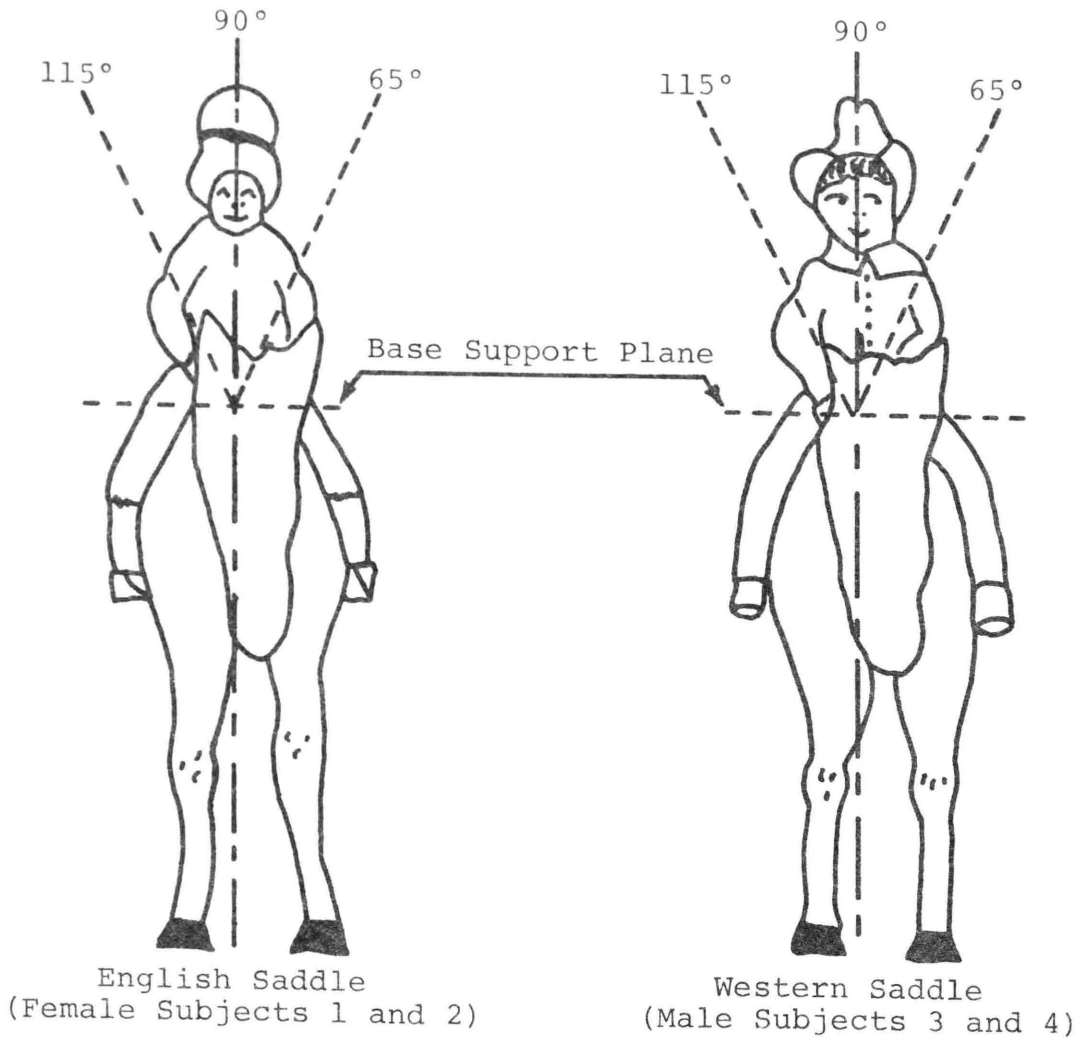


Figure 4. Estimated center of gravity boundaries from front view.

found to be even more to the left during the walk phase. Subjects 3 and 4 remained within the stability range (65° to 115°) during both phases of the sequence.

Walk-Halt

The center of gravity of Subject 1 was left of the perpendicular during both phases of the walk-halt, whereas it was to the right for Subject 2. Position of the center of gravity was closer to the perpendicular for Subject 1 during the walk phase; however, it was closer during the halt phase for Subject 2. The center of gravity of each subject remained within the stability range for both phases.

During the walk-halt sequence, the centers of gravity of Subject 3 and Subject 4 were left of the perpendicular. The center of gravity of Subject 4 was left of that of Subject 3 during the walk phase; however, it was located more to the right during the halt phase. The center of gravity of each remained within the stability range for both phases.

Walk-Trot

For both Subject 1 and Subject 2, the center of gravity was to the left of the perpendicular during the majority of the walk-trot. The center of gravity of Subject 1 was more to the left than that of Subject 2 during the major portion of the phases. The position of the center of gravity appeared to move left for Subject 1 during the trot; it moved to the right for Subject 2. Each subjects' center of gravity remained within the stability range during the entire sequence.

The centers of gravity of Subjects 3 and 4 were left of the perpendicular during the majority of the walk-trot. During the initiation phase, the center of gravity of Subject 4 was found to be more left than that of Subject 3. During the trot, Subject 3's center of gravity was more left than that of Subject 4. The position of the center of gravity moved left for Subject 3 and right for Subject 4 during the trot phase. Each subjects' center of gravity remained within the stability range for the entire sequence.

Trot-Halt

During both phases of the trot-halt sequence, the center of gravity of Subject 1 remained to the left of the perpendicular. For Subject 2, it was left of the perpendicular during the trot phase; however, it moved right of perpendicular during the halt phase. The position of the center of gravity from the perpendicular was relatively constant for Subject 1 during both phases, but moved to the right during the halt phase for Subject 2. Each subjects' center stayed within the stability range during the entire sequence.

The centers of gravity of Subject 3 and Subject 4 were left of the perpendicular during both phases of the trot-halt. The position of the center of gravity of Subject 3 was to the left of that of Subject 4 during the trot phase; however, it was located to the right of that of Subject 4 during the halt phase. The center of gravity moved toward the right during the halt for Subject 3; it moved to the left for Subject 4. Both subjects' center of gravity remained within the stability range.

Forward-backward movement of each subjects' center of gravity in relationship to the movement of the trunk is presented in Table 9. Examination of Table 9 indicates that the forward-backward movement of the center of gravity followed the forward-backward movement of the trunk in approximately 80% of the cases. Discrepancies occurred for each subject, as well as in all phases of the different sequences.

Side-to-side movement of each subjects' center of gravity in relationship to the movement of the trunk is presented in Table 10. As previously done, comparisons were made by movement phases. Examination of Table 10 indicates that the side-to-side movement of the center of gravity followed the side-to-side movement of the trunk in approximately 76% of the cases. It should be noted that discrepancies occurred with each subject and in all phases of the different sequences.

Table 9

Corresponding Forward-Backward Movements of the Center of Gravity and the Trunk as Viewed from the Side

Subject[a]	Stop-Walk[b]	
	Initiation	Walk
1	F F B B[c] F F B B[d]	B F B B F B F S F F
2	F F B B F F B B	B B B F F F B B F F
3	B F B B F F B B	F B B F F B
4	B F F B F F B	B F F B

Subject[a]	Walk-Halt	
	Walk	Halt
1	B F B B F B F B F B B F F S	B F B F B B F B F B
2	B B B F B F B F S B B F F B F B F F	B F F B F F
3	F B F F B B F F B F F B F S	B F B F F F F B F F
4	B F F F B B F F B F F F B B F F	B F F B B F F F

Table 9--Continued

Subject[a]	Walk-Trot		
	Walk	Initiation	Trot
1	B B	F B B F B B	B F F B
2	B B	F F B B F B	B F B F
3	F F	S F B F F F	B F B F
4	B F	F B F F F F	B B B F

Subject[a]	Trot-Halt	
	Trot	Halt
1	B F B F B B F F F B	B F B B F B F B
2	B F B F B F B F B F B F	B F B F B B
3	F B B F B F F B F B	B F F B B F F B
4	B F F B B F B F F B B F	B F F B F F

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

Table 9--Continued

[b]Movements are entered according to the following key:

F = Forward movement--a decrease in angulation.

B = Backward movement--an increase in angulation.

S = Same--no change in angulation.

[c]The first line of data for each subject describes movement of the trunk.

[d]The second line of data for each subject describes movement of the center of gravity.

Table 10

Corresponding Side-to-Side Movements of the Center of Gravity and the Trunk as Viewed from the Front

Subject[a]	Stop-Walk[b]	
	Initiation	Walk
1	P R R R[c] L L R R[d]	L L R S L L L L R R
2	P L L R R L L L	L L L R R R L L R R
3	R L L R L L L R	L L R L R R
4	R R L R L R L R	L R L R

Subject[a]	Walk-Halt	
	Walk	Halt
1	R R L R R L S L R L R S L R	R L R R L R L L R R
2	R L R L L R L L R R L R R L R L R R	L R L L R L
3	R L L R R L S L L L R S R R	L R L L R L R L L R
4	L S R L L R S R L R L R R L L R	R L L R L L L R

Table 10--Continued

Subject[a]	Walk-Trot		
	Walk	Initiation	Trot
1	R L	L R R R R R	L L L L
2	L L	R R L R R L	L R R R
3	R R	L R R L R R	L L L R
4	R L	L S R R L R	R L R L

Subject[a]	Trot-Halt	
	Trot	Halt
1	R S L S R L L R S R	L S R L L R L R
2	P R R L R L L R R L R L	R S R R R L
3	R L R L L L R S R R	R S L L R R L R
4	L R L S L R L R L R L R	S R R L R R

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

Table 10--Continued

[b]Movements are entered according to the following key:

L = Movement to the left--a decrease in angulation.

R = Movement to the right--an increase in angulation.

P = Trunk or center of gravity was 90° (upon initiation)

S = No change in angulation.

[c]The first line of data for each subject describes movement of the trunk.

[d]The second line of data for each subject describes movement of the center of gravity.

Forward-Backward Angulation of the Head

Since head position often influences the position of the body, the researcher examined the differences in the forward-backward and side-to-side angulation of the head. The handicapped subjects were compared to the nonhandicapped subjects. Angulation of the head was measured from the right horizontal of the neck region for both the forward-backward and side-to-side views (see Figures 5 and 6). Descriptive data relative to forward-backward angulation of the head are presented in Table 11. Forward angulation was defined as angles less than 90°; backward angulation was defined as angles greater than 90°. Angles which measured 90° during initiation of the sequence were considered perpendicular. Angulation of the head was compared by movement phase (i.e. initiation, halt, walk, and trot) during the four movement sequences.

Stop-Walk

The head of Subject 1 was behind her trunk during the majority of the stop-walk sequence. The head was forward of the trunk during both phases for Subject 2. Range of head movement was greater for Subject 2 during both phases of the sequence.

Head position during the initiation of the stop-walk was forward of the perpendicular for Subject 3; it was

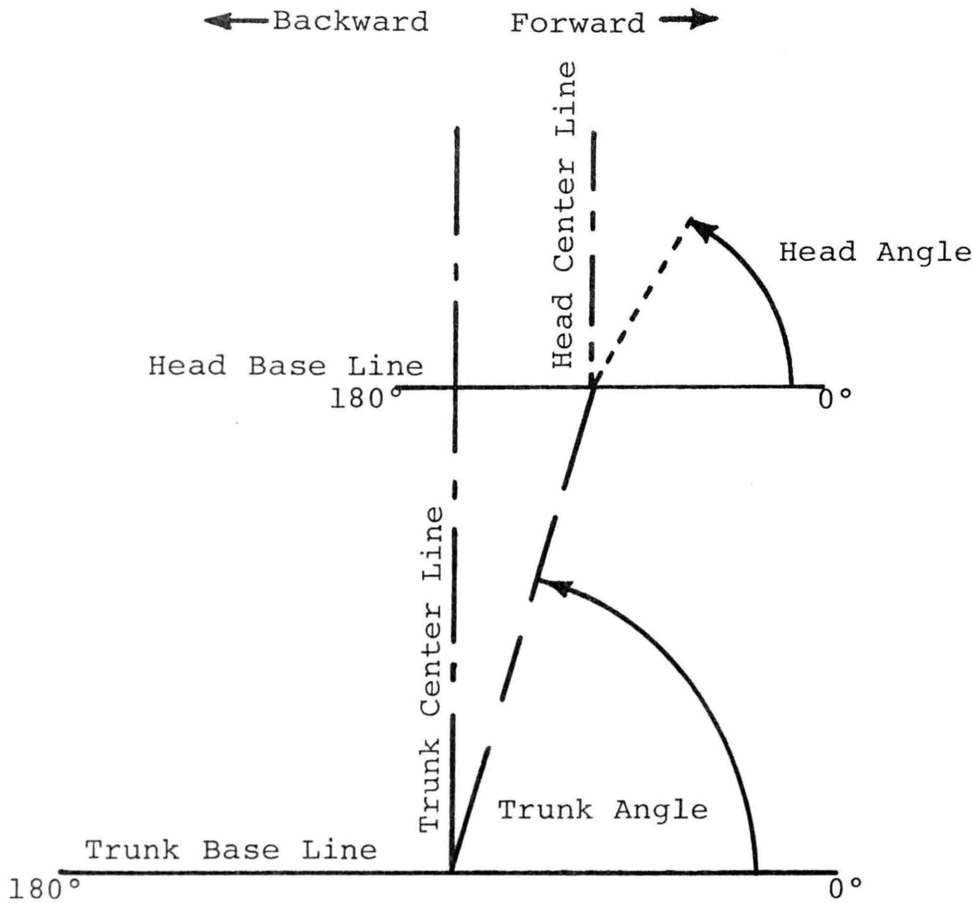


Figure 5. Determination of head position from side view.

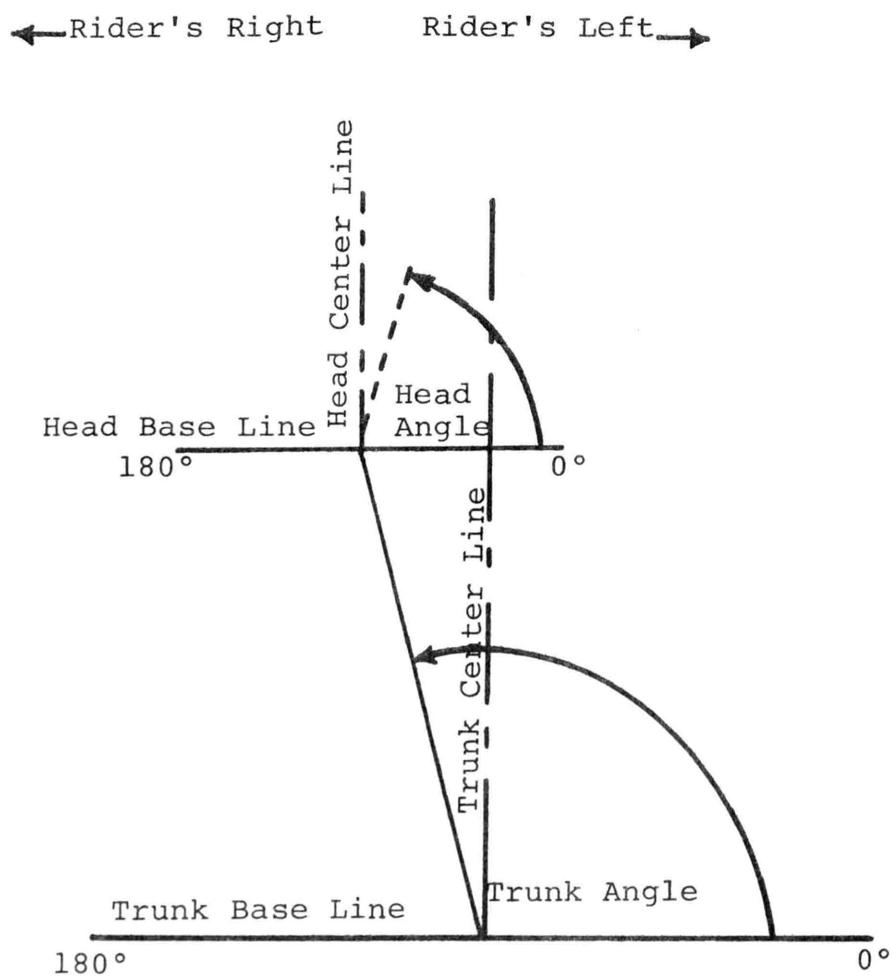


Figure 6. Determination of head position from front view.

Table 11

Forward-Backward Movement of the Head

Subject[a]	Stop-Walk[b]								
	Initiation				Walk				
1	90.0	92.0	89.0	91.5	86.0	86.0	92.5	96.0	93.5
2	86.0	85.0	81.0	85.0	86.0	86.0	85.0	86.0	88.0
3	85.0	86.5	87.5	89.5	92.0	92.5	80.0		
4	90.0	95.5	94.0	94.0	90.0	90.0			

Subject[a]	Walk-Halt													
	Walk									Halt				
1	92.0	85.5	93.5	93.0	90.5	95.0	83.0			80.0	85.5	82.5	90.0	84.5
2	85.0	82.0	86.5	81.5	82.5	83.0	85.0	85.5	90.0	84.5	81.5	79.5		
3	81.0	84.0	90.0	83.5	87.0	85.0	85.0			90.0	83.5	83.5	85.5	87.5
4	93.0	90.0	96.0	93.5	93.0	95.0	90.0	99.0		90.0	92.0	90.0	91.0	

Subject[a]	Walk-Trot					
	Walk	Initiation			Trot	
1	91.0	92.0	90.0	95.0	85.0	85.0
2	76.0	79.0	79.0	81.0	82.0	81.0
3	84.0	83.0	77.0	81.0	79.0	82.5
4	82.5	79.0	79.0	73.5	84.0	80.0

Table 11--Continued

Subject[a]	Trot-Halt									
	Trot						Halt			
1	105.0	90.0	94.0	90.0	90.0		99.0	90.5	81.5	85.5
2	83.5	81.5	106.5	77.5	89.5	85.0	90.0	82.0	82.0	
3	85.0	93.5	89.0	86.0	95.0		92.0	90.0	93.0	91.0
4	91.0	90.0	86.0	90.0	90.0	90.0	87.0	86.0	86.0	

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

[b]Data are in degrees.

behind the perpendicular for Subject 4. Range of motion was greater for Subject 4 than for Subject 3.

Walk-Halt

During the walk-halt sequence, the head of Subject 1 was behind the perpendicular during the majority of the walk and forward of the perpendicular during the halt. The head of Subject 2 was forward of the perpendicular during the entire sequence. Range of head movement was greater for Subject 2 than for Subject 1 during both phases of the walk-halt movement. Head movement was greater for Subject 4 than for Subject 3 during the walk phase; however, it was greater for Subject 3 during the halt.

Walk-Trot

The head position of Subject 1 during both the walk and initiation phase was behind the perpendicular, but it was forward of the perpendicular for Subject 2. The position of the head during the trot phase was forward for both subjects. Head movement was greater for Subject 2 than Subject 1 during the walk, initiation, and trot.

The heads of Subjects 3 and 4 were forward of the perpendicular during all phases of the walk-trot movement. During both the walk and initiation phase, head movement was greater for Subject 4 than for Subject 3. Range of movement of the head during the trot was greater for Subject 3 than for Subject 4.

Trot-Halt

Head position during both phases of the trot was behind or at the perpendicular for Subject 1; it was forward of the perpendicular for Subject 2. The range of head movement was greater for Subject 1 than for Subject 2 during both phases of the sequence.

During the trot, the head of Subject 3 was forward of the perpendicular during the major portion of the phase, whereas it was predominantly at the perpendicular for Subject 4. Head position during the halt was behind the perpendicular for Subject 3 and forward of the perpendicular for Subject 4. Range of head movement was greater for Subject 3 during both phases of the sequence.

Side-to-Side Angulation of the Head

Data related to side-to-side angulation of the head are presented in Table 12. Angulation of the head to the left was defined as angles less than 90°, whereas angulation to the right was defined as angles greater than 90°. Angles which measured 90° were considered perpendicular. Comparisons between the handicapped and nonhandicapped subjects were made according to the various movement phases.

Stop-Walk

During the major portion of the initiation phase of the stop-walk, the head of Subject 1 was to the right of

Table 12

Side-to-Side Movement of the Head

Subject[a]	Stop-Walk[b]								
	Initiation				Walk				
1	95.0	93.5	90.0	95.0	90.0	89.5	90.0	88.5	90.0
2	90.0	90.0	90.5	91.0	90.0	95.0	93.0	90.0	94.5
3	90.5	91.0	90.0	91.0	84.5	90.0	93.0		
4	88.5	86.5	86.5	90.0	90.0	86.0			

Subject[a]	Walk-Halt													
	Walk									Halt				
1	89.0	90.0	90.5	91.0	104.0	90.0	94.0			102.5	96.0	90.0	91.0	89.5
2	96.0	101.0	90.5	91.0	90.5	90.0	101.0	90.0	99.0	95.5	90.0	87.5		
3	93.5	87.0	89.5	85.0	91.0	90.0	90.0			89.5	89.0	90.0	89.5	90.0
4	89.5	90.0	88.5	87.5	90.0	90.0	90.0	89.0		88.5	87.0	87.0	88.0	

Subject[a]	Walk-Trot					
	Walk	Initiation			Trot	
1	90.0	94.5	91.0	90.0	92.0	90.0
2	88.5	90.0	91.0	89.5	90.0	95.0
3	88.5	88.5	85.0	90.0	90.0	88.5
4	87.0	89.0	89.5	88.5	88.0	89.5

Table 12--Continued

Subject[a]	Trot-Halt									
	Trot						Halt			
1	90.0	84.0	87.0	79.0	90.0		90.0	90.0	81.5	89.5
2	90.0	90.0	89.5	90.0	100.0	89.0	93.5	90.0	89.0	
3	88.0	90.0	90.0	89.0	88.0		91.5	96.5	91.0	97.0
4	89.0	90.0	89.0	88.0	83.0	86.0	84.0	89.5	90.0	

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

[b]Data are in degrees.

the perpendicular; it was perpendicular for Subject 2. Head position during the walk phase was perpendicular or slightly to the left of the perpendicular for Subject 1. The head remained perpendicular or to the right of the perpendicular for Subject 2. Range of head movement was greater for Subject 1 during the initiation phase; however, it was greater for Subject 2 during the walk phase.

Head position during the initiation phase of the stop-walk sequence was either perpendicular or to the right of the perpendicular for Subject 3; the head position of Subject 4 was either perpendicular or left of the perpendicular. During the walk phase, the head of Subject 3 shifted from left to right of the perpendicular. The head was either perpendicular or left of the perpendicular for Subject 4. The range of head position was greater for Subject 4 than Subject 3 during the initiation phase; the range for Subject 3 was greater than for Subject 4 during the walk phase.

Walk-Halt

During the majority of both phases of the walk-halt sequence, head positions for both Subjects 1 and 2 were perpendicular or to the right of the perpendicular. Head movement was greater for Subject 1 than Subject 2 during both phases of the sequence.

The head of Subject 3 moved from the left to right of the perpendicular during the walk phase; it shifted from right of the perpendicular to the perpendicular for Subject 4. During the halt phase, the head of Subject 3 moved from left of the perpendicular to perpendicular, whereas it was left of the perpendicular for Subject 4. Head movement was greater for Subject 3 during the trot phase; it was greater for Subject 4 during the halt phase.

Walk-Trot

During the entire walk-trot sequence, the head of Subject 1 was either to the right of the perpendicular or perpendicular. The head of Subject 2 moved from right to left of perpendicular during the same sequence. Head movement was greater for Subject 1 than Subject 2 during the initiation phase, but was less than that of Subject 2 during the trot phase.

Head position for both Subject 3 and Subject 4 was either perpendicular or left of the perpendicular during the entire walk-trot sequence. Head movement was greater for Subject 3 than Subject 4 during both the initiation and trot phases.

Trot-Halt

During both phases of the trot-halt sequence, the head of Subject 1 was either perpendicular or to the left of the perpendicular; Subject 2's head moved from right to left of the perpendicular. Range of head movement was greater for Subject 3 during both phases of the sequence.

Head position during the trot phase was either perpendicular or left of the perpendicular for both Subject 3 and Subject 4. During the halt, position of the head was right of the perpendicular for Subject 3, and either left of the perpendicular or perpendicular for Subject 4. Range of head movement was greater for Subject 4 during the trot phase, whereas it was greatest for Subject 3 during the halt phase.

Displacement, Velocity, and Acceleration of the Trunk

Displacement of a body part is influential in determining its velocity and acceleration. Forward-backward displacement, velocity, and acceleration of the trunk were calculated from the side view tracings. Displacement, velocity, and acceleration values were calculated relative to each subject's starting position. Tables 13-23 present the displacement, absolute velocity, and absolute acceleration of each subject's trunk during the four movement sequences, respectively. Positive numerical values in the tables reflect forward motion; negative values reflect backward motion. Direction and magnitude of the displacement, velocity, and acceleration of the trunk are illustrated in Figures 7-30. Comparisons between the subjects were made for each of the phases (i.e. initiation, walk, trot, and halt) of the four movement sequences.

Displacement of the Trunk During the Stop-Walk

The displacement of the trunk during the stop-walk phase is presented in Table 13. During the initiation of

Table 13

Displacement of the Trunk During the Stop-Walk Phase

Subject	Stop-Walk[a]						
	Initiation			Walk			
1	2.0	-4.0	-12.0	-15.0	-14.0	-17.0	-19.0
2	9.5	4.5	.5	-3.0	-7.0	-10.5	-6.5
3	8.0	2.0	-3.0	0	-5.0		
4	0	1.0	-5.0	-6.5			

Note. No sign = forward displacement; negative sign = backward displacement.

[a]Data are in degrees.

the stop-walk movement, the trunk of Subject 1 moved forward, then backward of the starting position. For Subject 2 it remained forward of the starting position. Trunk displacement during the walk phase was behind the starting position for both subjects. Magnitude and fluctuation of displacement was greater for Subject 1 than Subject 2 during both phases of the sequence (see Figure 7).

The trunks of Subjects 3 and 4 shifted forward, then back of the starting position during the initiation phase. During the walk phase, the trunk of Subject 3 moved backward and then forward of the starting position. The trunk of Subject 4 remained behind the starting position. Magnitude and fluctuation of trunk displacement were greater for Subject 3 than for Subject 4 (see Figure 8).

Absolute Velocity of the Trunk During the Stop-Walk

As indicated in Table 14, the velocity of the trunk of Subject 1 remained negative (backward) during the initiation phase, whereas for Subject 2 it fluctuated from positive (forward) to negative (backward). Velocity during the walk phase fluctuated from negative to positive for both subjects. Magnitude and fluctuation of velocity were greater for Subject 1 during both phases (see Figure 9).

The velocities of the trunks of both Subjects 3 and 4 fluctuated from positive to negative during the initiation phase of the stop-walk. During the walk phase, the velocity of the trunk of Subject 3 remained negative,

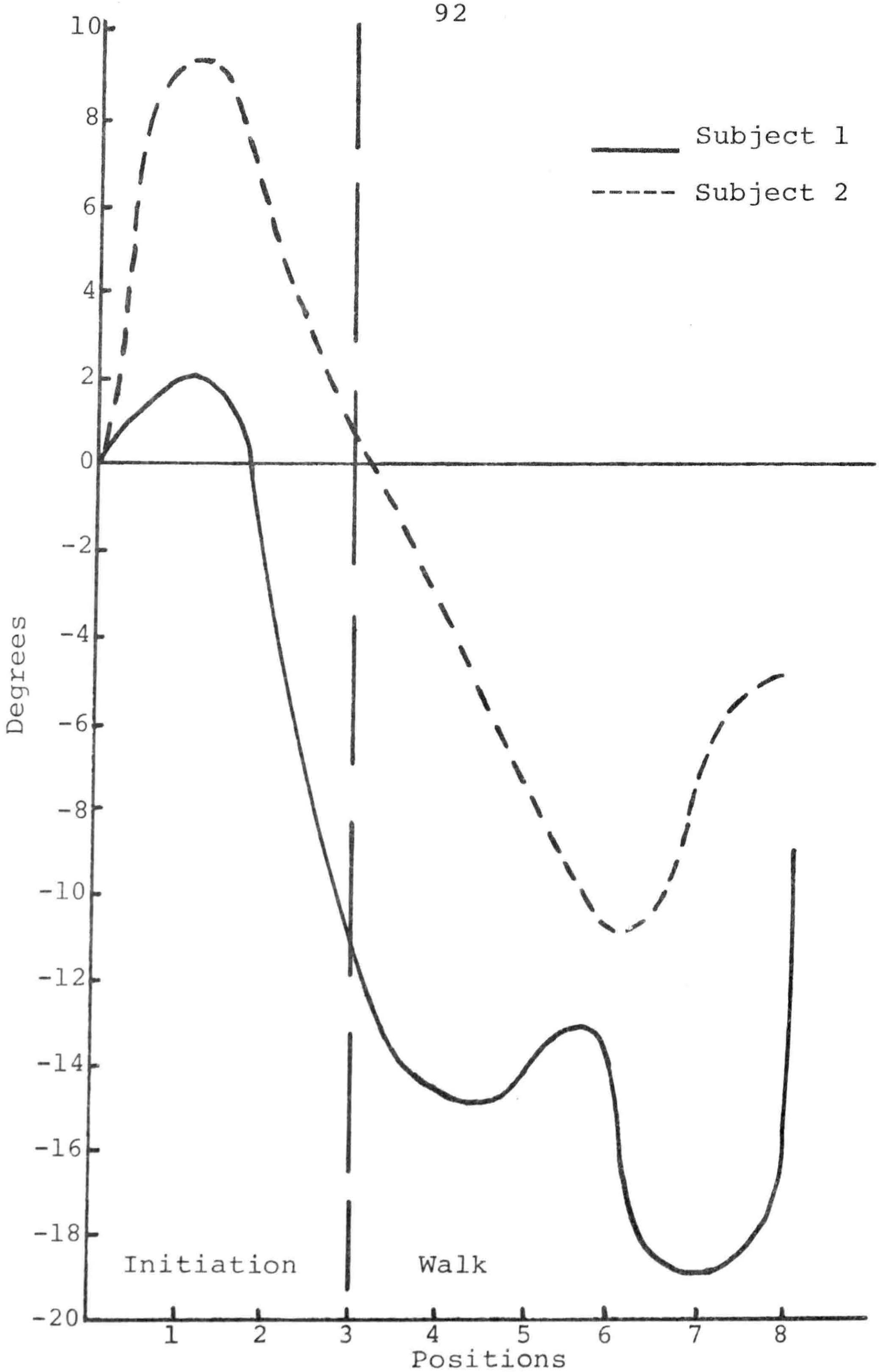


Figure 7. Trunk displacement data of subjects 1 and 2 during the stop-walk.

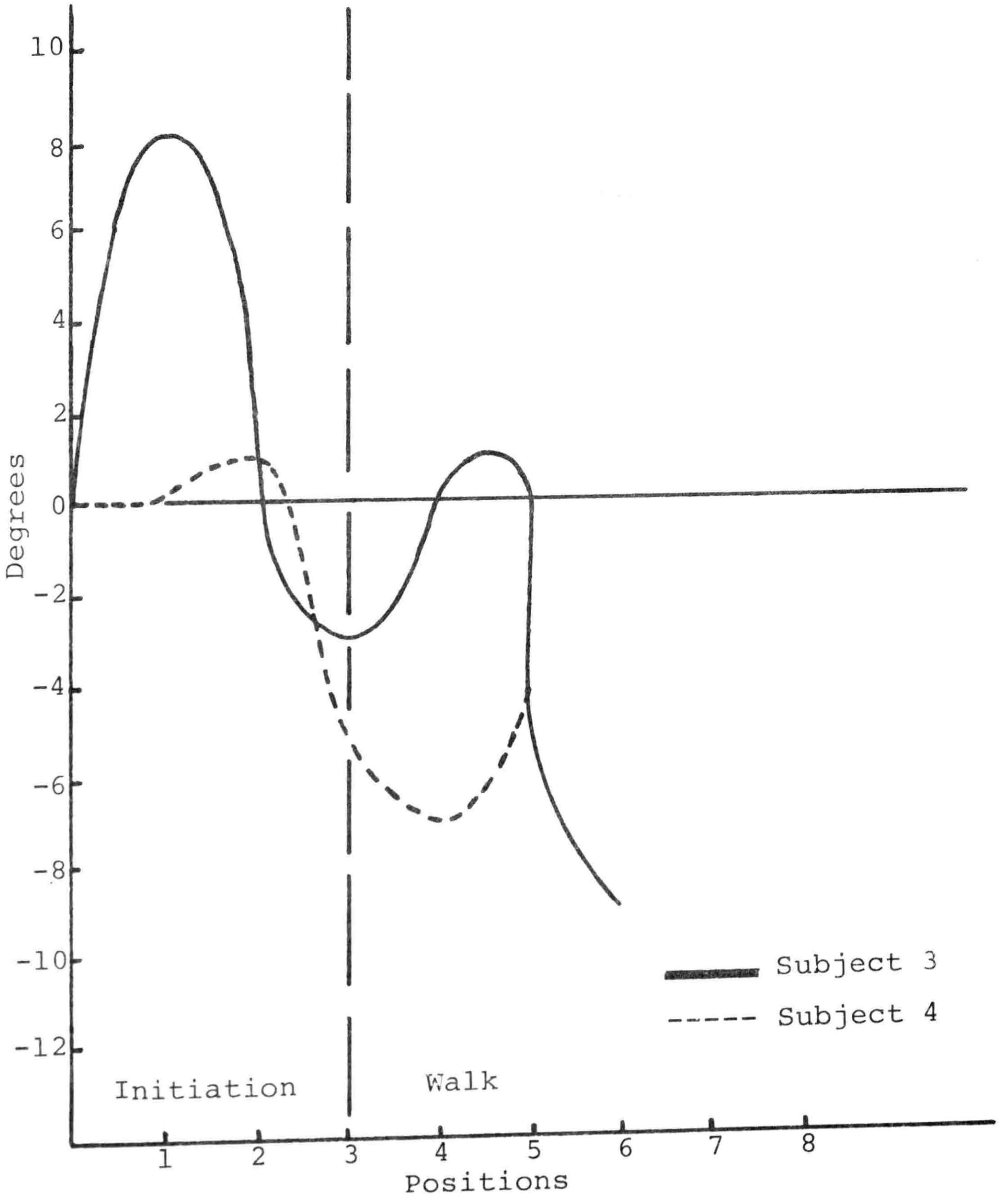


Figure 8. Trunk displacement data of subjects 3 and 4 during the stop-walk.

Table 14

Absolute Velocity of the Trunk

During the Stop-Walk Phase

Subject	Stop-Walk[a]						
	Stop			Walk			
1	-.10	-.38	-.29	-.06	-.03	-.14	.19
2	.13	-.21	-.21	-.20	-.20	-.02	.06
3	.08	-.23	-.05	-.05	-.25		
4	.06	-.13	-.23	.02			

Note. No sign = positive velocity (forward); negative sign = negative velocity (backward).

[a]Data are in radians/second.

whereas for Subject 4 it fluctuated from negative to positive. Magnitude of velocity was similar for both subjects, but it fluctuated more often for Subject 3 than for Subject 4 (see Figure 10).

Absolute Acceleration of the Trunk During the Stop-Walk

Subject 1 and Subject 2 exhibited trunk acceleration that was negative during the entire initiation phase (see (Table 15). Trunk acceleration during the walk phase fluctuated from negative to positive for both subjects.

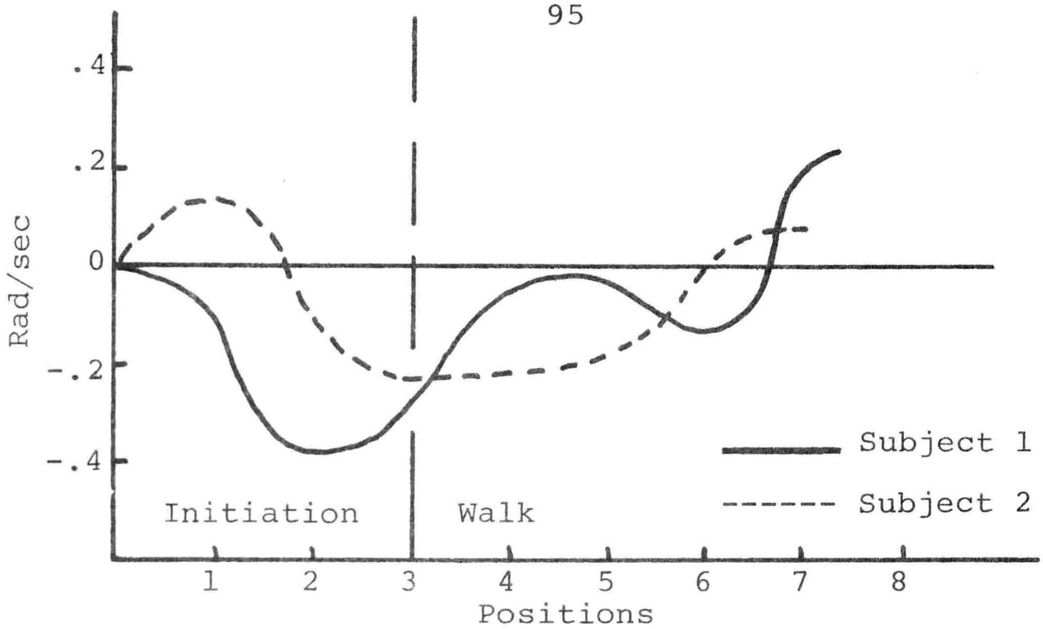


Figure 9. Absolute velocity of the trunks of subjects 1 and 2 during the stop-walk.

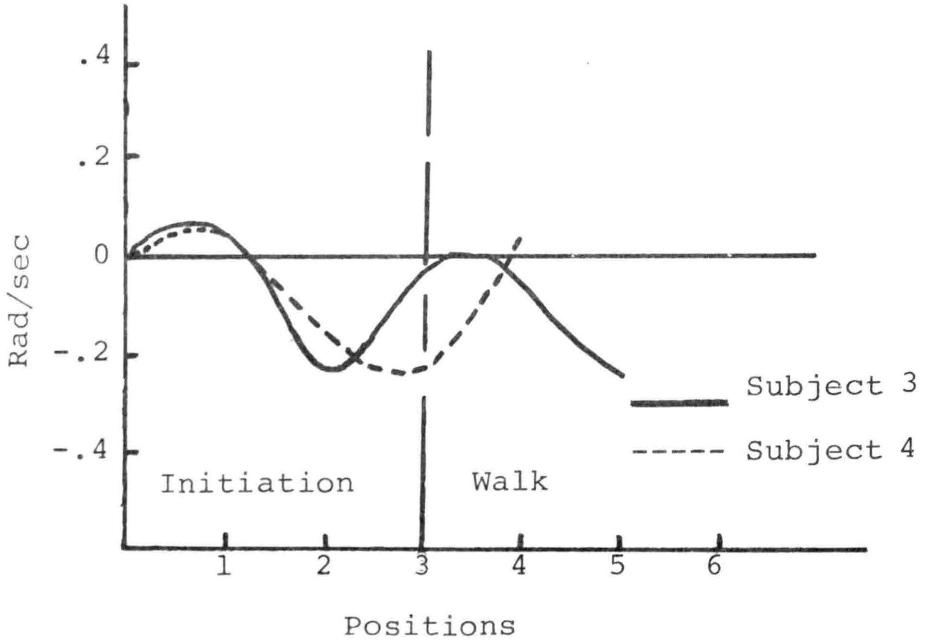


Figure 10. Absolute velocity of the trunks of subjects 3 and 4 during the stop-walk.

Table 15

Absolute Acceleration of the Trunk

During the Stop-Walk Phase

Subject	Stop-Walk[a]					
	Stop			Walk		
1	-.60	-.31	.50	.41	-.13	.39
2	-.32	-.55	.02	.02	.30	.44
3	-.78	-.20	.31	-.33		
4	-.31	-.46	.24			

Note. No sign = positive acceleration (forward); negative sign = negative acceleration (backward).

[a]Data are in radians/second^2.

Magnitude and fluctuation of acceleration was greater for Subject 1 during both phases of the sequence than for Subject 2 (see Figure 11).

The acceleration of the trunks of Subjects 3 and 4 was in the negative direction during the initiation phase of the stop-walk. Trunk acceleration during the walk phase fluctuated from positive to negative for Subject 3, and negative to positive for Subject 4. Magnitude and fluctuation of acceleration was greater for Subject 3 than for Subject 4 during both phases of the sequence (see Figure 12).

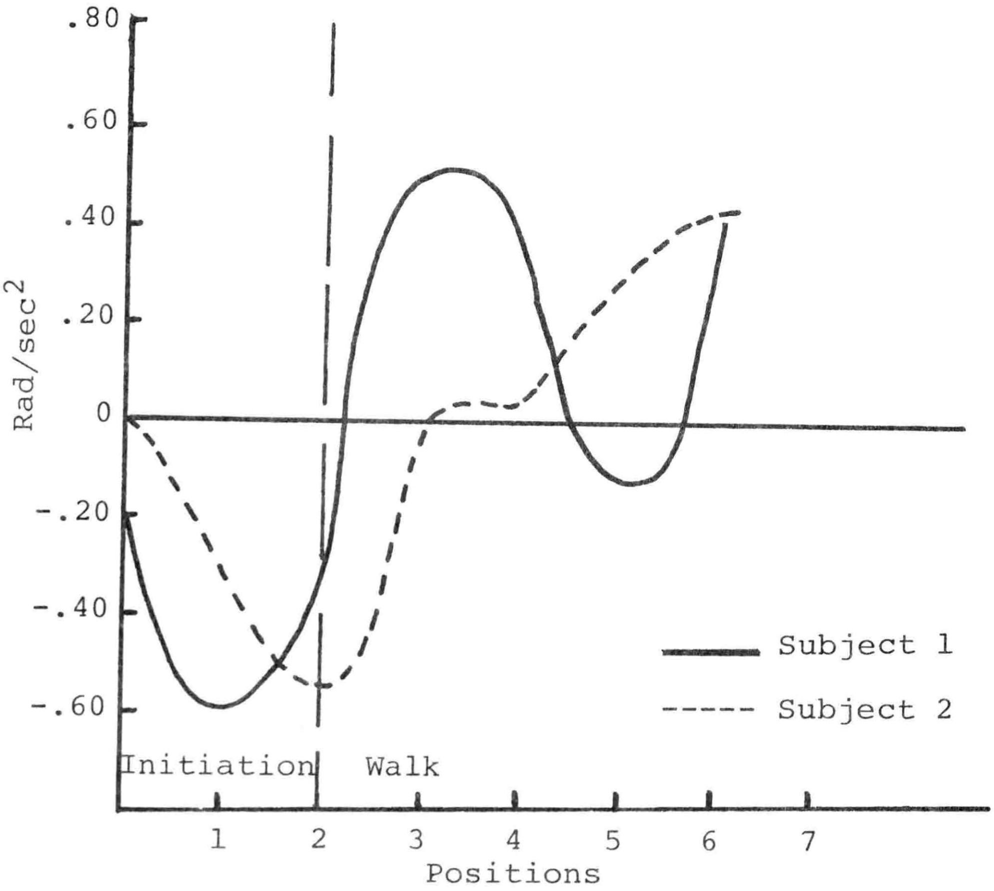


Figure 11. Absolute acceleration of the trunks of subjects 1 and 2 during the stop-walk.

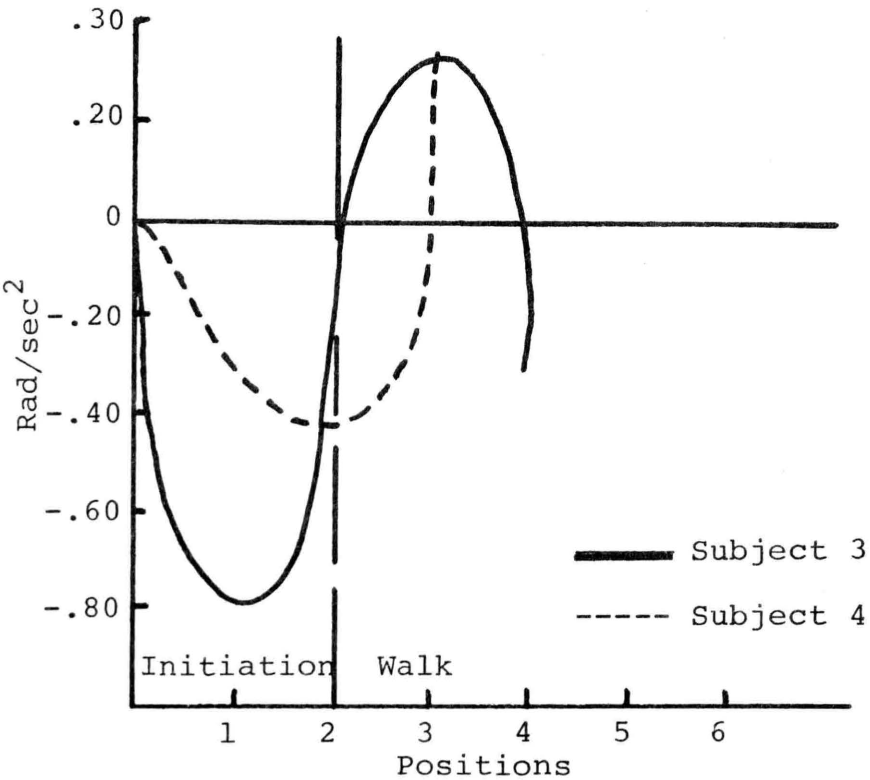


Figure 12. Absolute acceleration of the trunks of subjects 3 and 4 during the stop-walk.

Displacement of the Trunk
During the Walk-Halt

Data relative to the displacement of the trunk during the walk-halt are presented in Table 16. For Subject 1, trunk displacement was forward during the majority of the walk-halt phase, and for Subject 2 it was behind the starting position. Magnitude of displacement was greater for Subject 2 than for Subject 1; this was true for both phases of the sequence. An erratic, fluctuating pattern existed for both subjects during the entire walk-halt (see Figure 13).

Displacement of the trunk from the starting position was positive (forward) for Subject 3 and negative (backward) for Subject 4. This was exhibited during both phases of the sequence. Magnitude of displacement was greater for Subject 4 than for Subject 3 as was fluctuation of its direction (see Figure 14).

Absolute Velocity of the
Trunk During the Walk-Halt

Table 17 presents those data related to the absolute velocity of the trunk during the walk-halt. Trunk velocities of Subject 1 and Subject 2 fluctuated negatively and positively during both phases of the walk-halt. Magnitude of velocity was greater for Subject 1 than Subject 2 during

Table 16

Displacement of the Upper Trunk During the Walk-Halt Phase

Subject[a]	Walk-Halt[b]											
	Walk								Halt			
1	4.0	1.0	-5.0	8.0	0	0.5			-1.0	5.0	3.0	6.5
2	-1.5	-4.5	-0.5	-12.0	0	-12.5	-3.5	-3.5	-7.5	-5.5		
3	20.0	26.4	27.5	26.0	21.0	22.0			27.5	19.5	24.5	31.5
4	-5.0	-35.0	-1.0	-45.0	-7.5	-2.0	-2.5		0	-2.5	-2.0	

Note. No sign = forward displacement; negative sign = backward displacement.

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

[b]Data are in degrees.

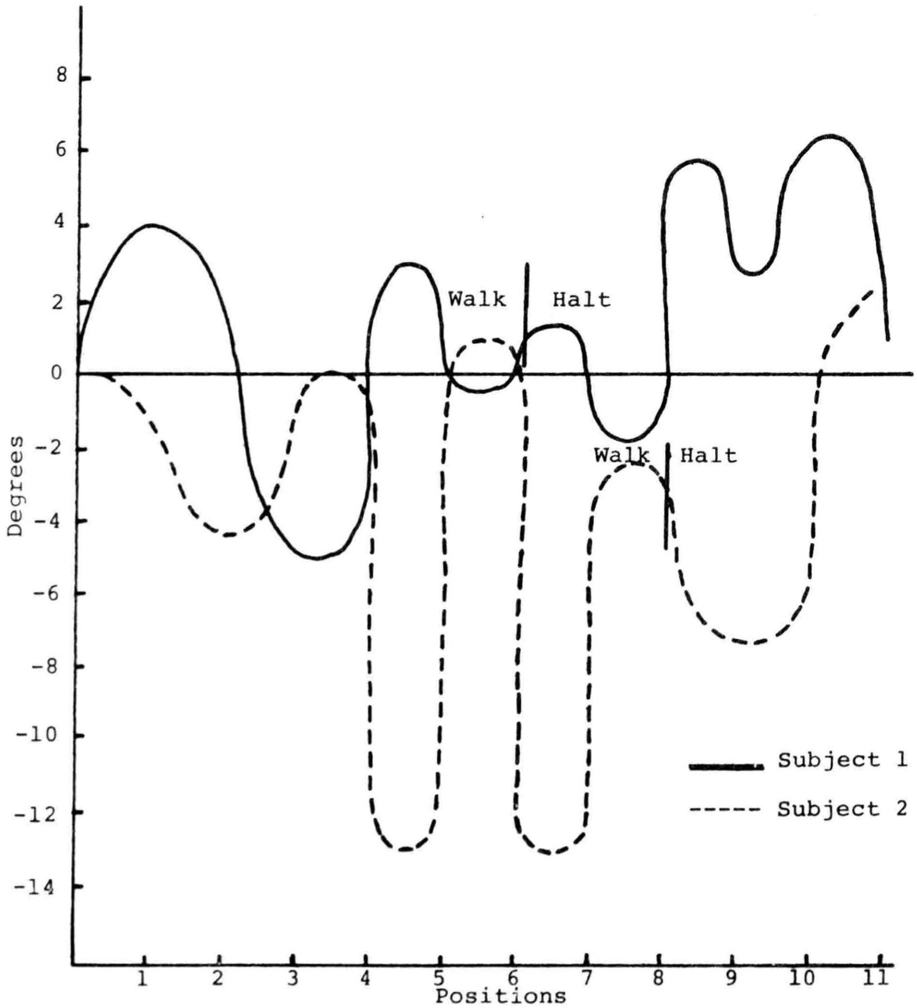


Figure 13. Trunk displacement data of subjects 1 and 2 during the walk-halt.

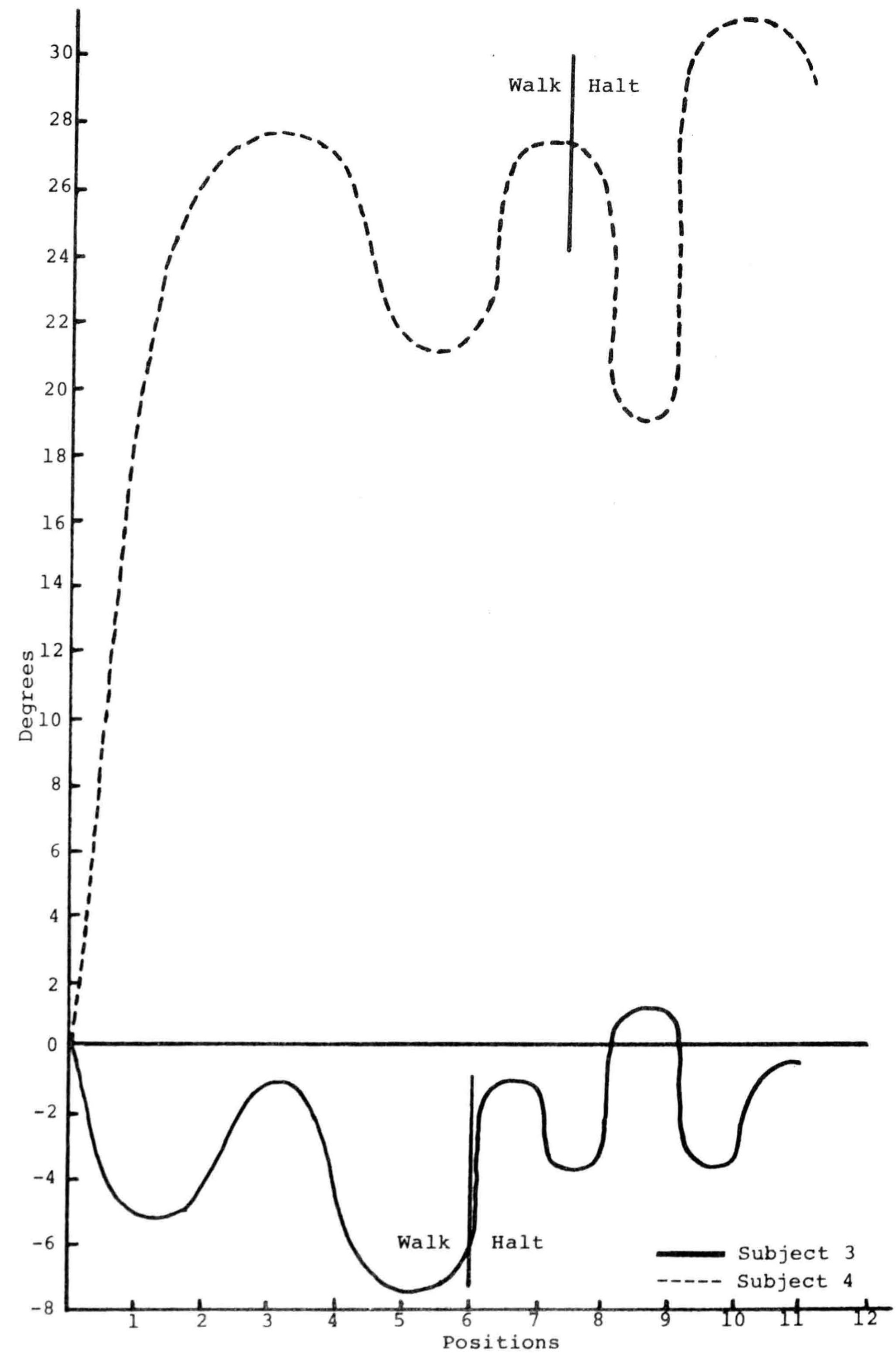


Figure 14. Trunk displacement data of subjects 3 and 4 during the walk-halt.

Table 17

Absolute Velocity of the Upper Trunk During the Walk-Halt Phase

Subject[a]	Walk-Halt[b]											
	Walk								Halt			
1	.03	-.25	.04	.14	-.04	-.03			.13	.11	.04	-.06
2	-.12	.03	-.21	.01	-.01	-.10	.26	-.11	-.05	.28		
3	-.09	.11	-.03	-.18	.06	.13			.06	0	-.06	.06
4	1.14	.19	-.01	-.18	-.11	.21	-.07		-.09	.32	.12	

<u>Note</u>. No sign = positive velocity (forward); negative sign = negative velocity (backward).

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

[b]Data are in radians/second.

the walk phase; magnitude of velocity during the halt phase was, however, greater for Subject 2. The trunk velocity of Subject 2 exhibited more frequent fluctuation during both phases of the sequence than was the case for Subject 1 (see Figure 15).

The trunk velocity of Subject 3 and Subject 4 fluctuated from negative to positive during both phases of the walk-halt. Magnitude of velocity was greater for Subject 4 than for Subject 3 during both phases of the sequence. Trunk velocity of Subject 3 fluctuated more during the walk phase than it did for Subject 4. For Subject 4, it fluctuated more frequently during the halt phase than it did for Subject 3 (see Figure 16).

Absolute Acceleration of the Trunk During the Walk-Halt

Acceleration of the trunks of Subject 1 and Subject 2 fluctuated negatively and positively during both phases of the walk-halt. These data are presented in Table 18. Magnitude of trunk acceleration during the walk phase was greater for Subject 1 than for Subject 2. Magnitude of acceleration during the halt phase was greater for Subject 2 than for Subject 1. Fluctuation during both phases of the sequence was greater for Subject 2 than for Subject 1 (see Figure 17).

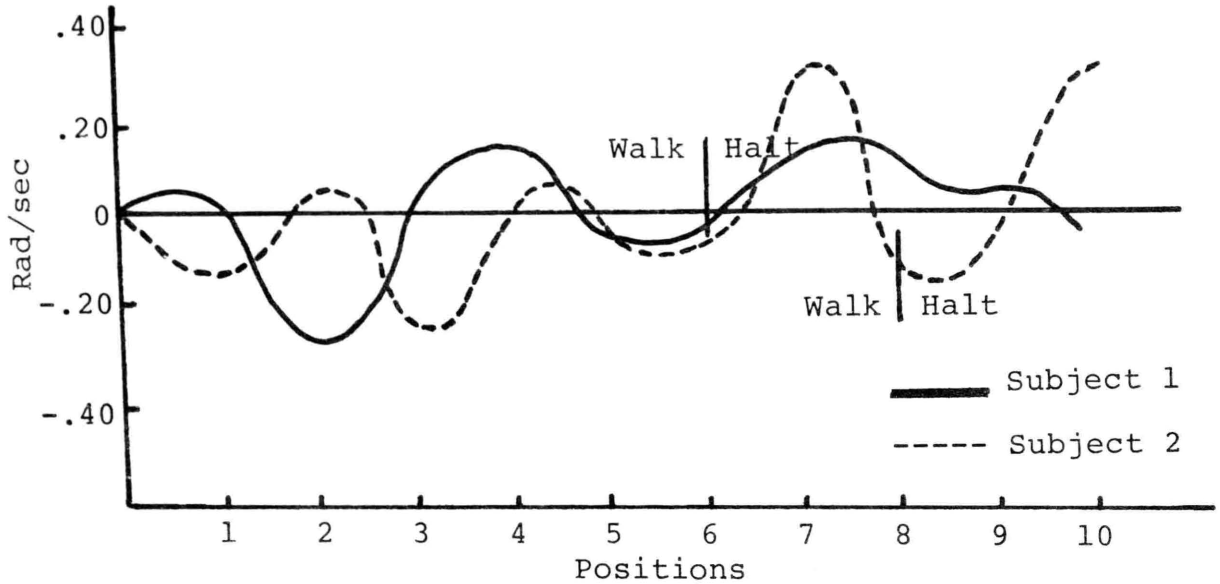


Figure 15. Absolute velocity of the trunks of subjects 1 and 2 during the walk-halt.

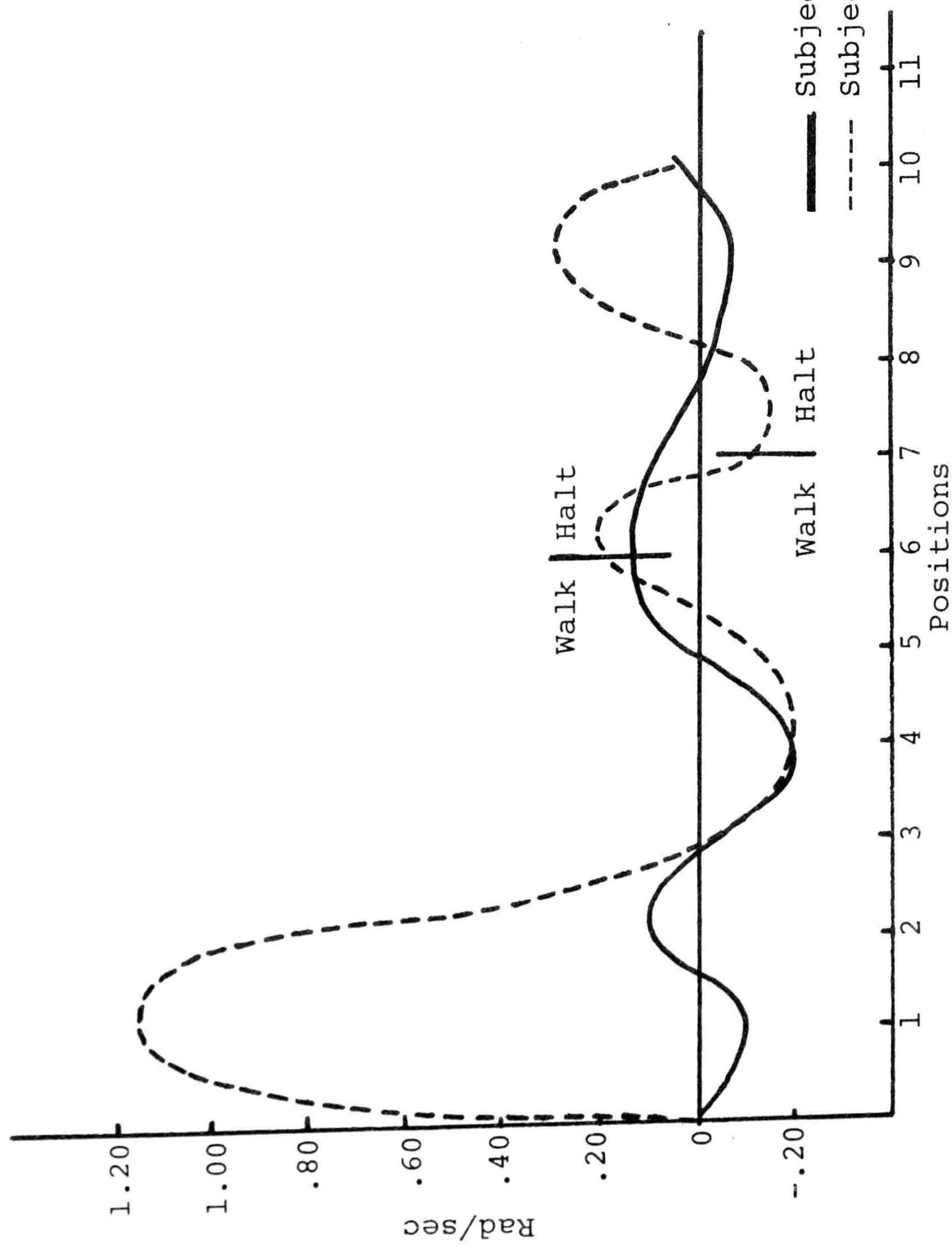


Figure 16. Absolute velocity of the trunks of subjects 3 and 4 during the walk-halt.

Table 18

Absolute Acceleration of the Upper Trunk During the Walk-Halt Phase

Subject[a]	Walk-Halt[b]										
	Walk							Halt			
1	-.42	.03	.64	-.14	-.48			.28	.43	-.15	-.36
2	.05	-.16	-.04	.33	-.18	.42	-.04	-.48	.62		
3	.19	.12	-.49	.15	.50			0	-.21	-.20	.08
4	1.29	-1.79	-1.88	-.17	.59	.06		-.47	.63	.32	

Note. No sign = positive acceleration (forward); negative sign = negative acceleration (backward).

[a]Subject classification: 1 = nonhandicapped female, 2 = handicapped female, 3 = nonhandicapped male, 4 = handicapped male.

[b]Data are in radians/second^2.

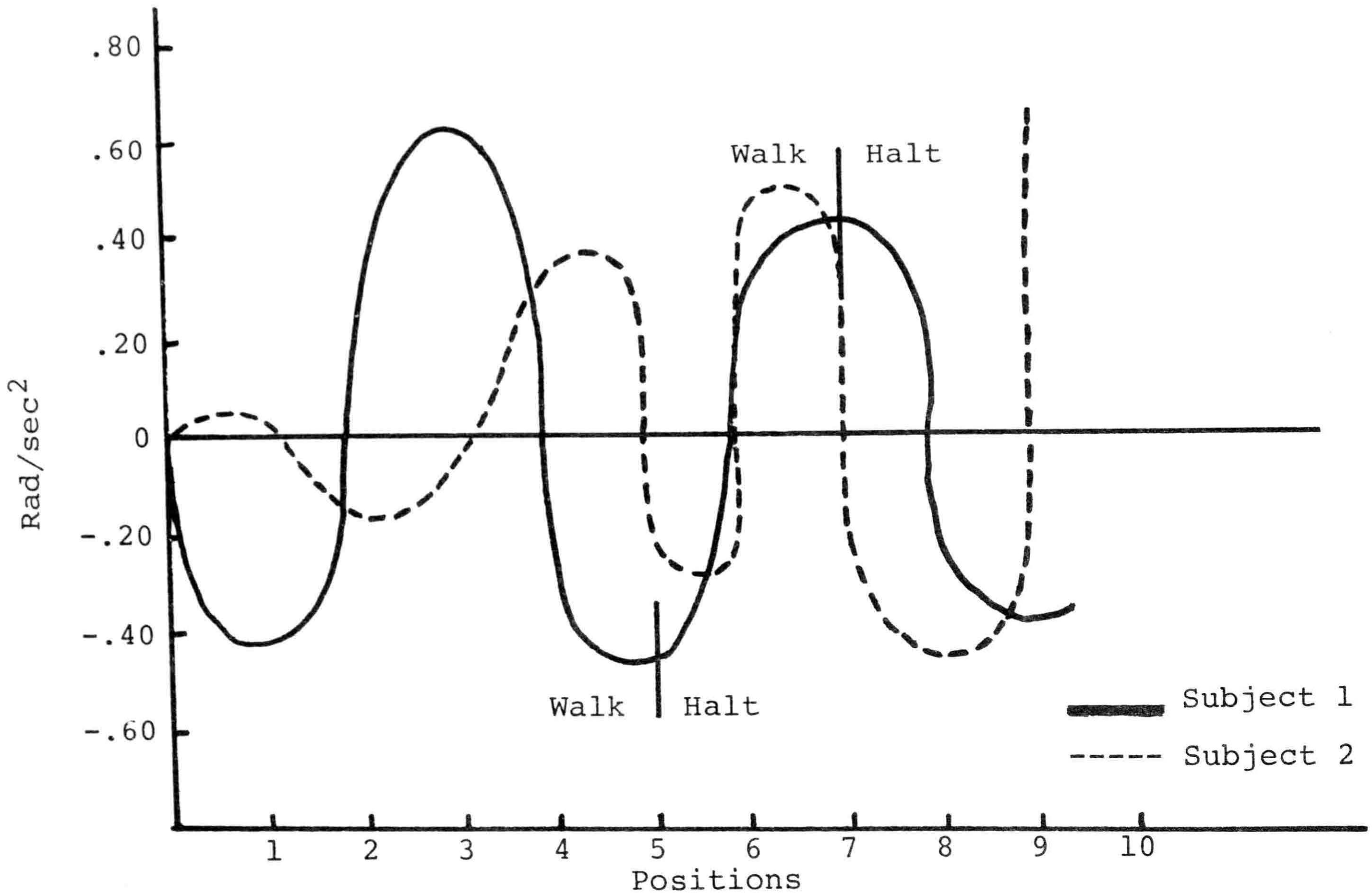


Figure 17. Absolute acceleration of the trunks of subjects 1 and 2 during the walk-halt.

Acceleration of the trunk during the walk-halt fluctuated positively and negatively for both Subjects 3 and 4. Magnitude and fluctuation of acceleration were greater for Subject 4 than for Subject 3 during both phases of the sequence (see Figure 18).

Displacement of the Trunk
During the Walk-Trot

The starting position of the walk-trot was the only position recorded for the walk phase; therefore, displacement, velocity, and acceleration of the trunk were not calculated for any of the subjects during this phase of the sequence. Displacement data are presented in Table 19.

Table 19

Displacement of the Trunk During the Walk-Trot Phase

Subject	Walk-Trot[a]				
	Walk	Initiation			Trot
1	0	1.0	0	-.5	-1.0
2	0	6.0	19.5	15.5	8.5
3	0	9.0	1.0	-6.0	-1.0
4	0	14.0	8.0	9.0	5.0

[a]Data are in degrees.

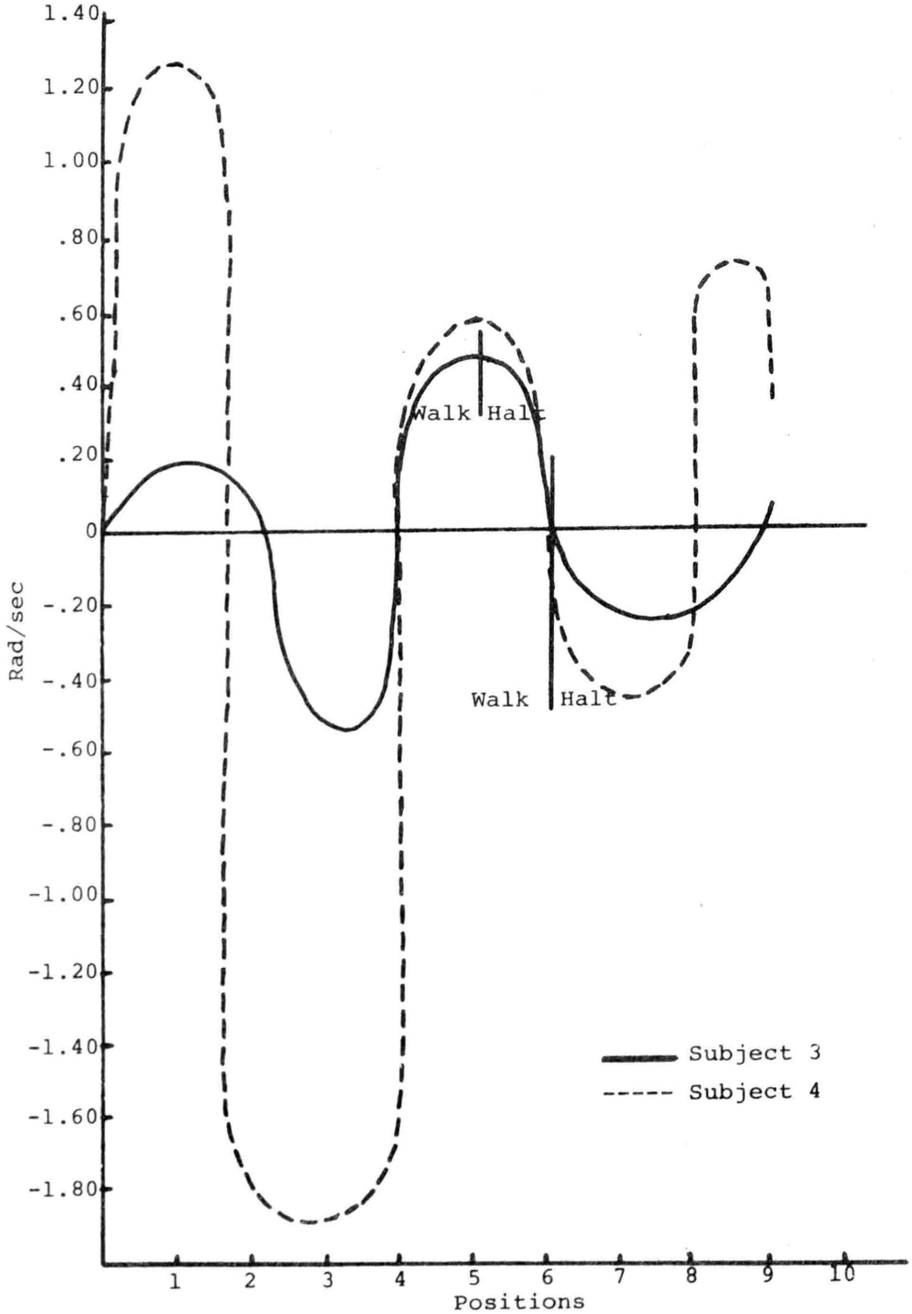


Figure 18. Absolute acceleration of the trunks of subjects 3 and 4 during the walk-halt.

During the initiation phase of the walk-trot sequence, the trunk of Subject 1 shifted forward and backward of the starting position. The trunk of Subject 2 remained forward of the starting position. Trunk displacement during the trot phase was forward of the starting position for Subject 2 and backward of the starting position for Subject 1. During all phases of the sequence, magnitude of trunk displacement was greater for Subject 2 than for Subject 1. Fluctuation during the initiation phase was greater for Subject 1 than for Subject 2. Fluctuation during the trot phase was greater for Subject 2 than for Subject 1 (see Figure 19).

During the initiation phase of the walk-trot, the trunk of Subject 3 shifted from forward of the starting position to behind the starting position. For Subject 4, it remained forward of the starting position during the entire phase. During the trot phase, trunk displacement was forward of the starting position for Subject 4; it was backward for Subject 3. Magnitude and fluctuation of displacement was greater for Subject 4 than for Subject 3 during both phases of the sequence (see Figure 20).

Absolute Velocity of the Trunk During the Walk-Trot

The absolute velocity data are included in Table 20. Trunk velocity during both the initiation and trot phases

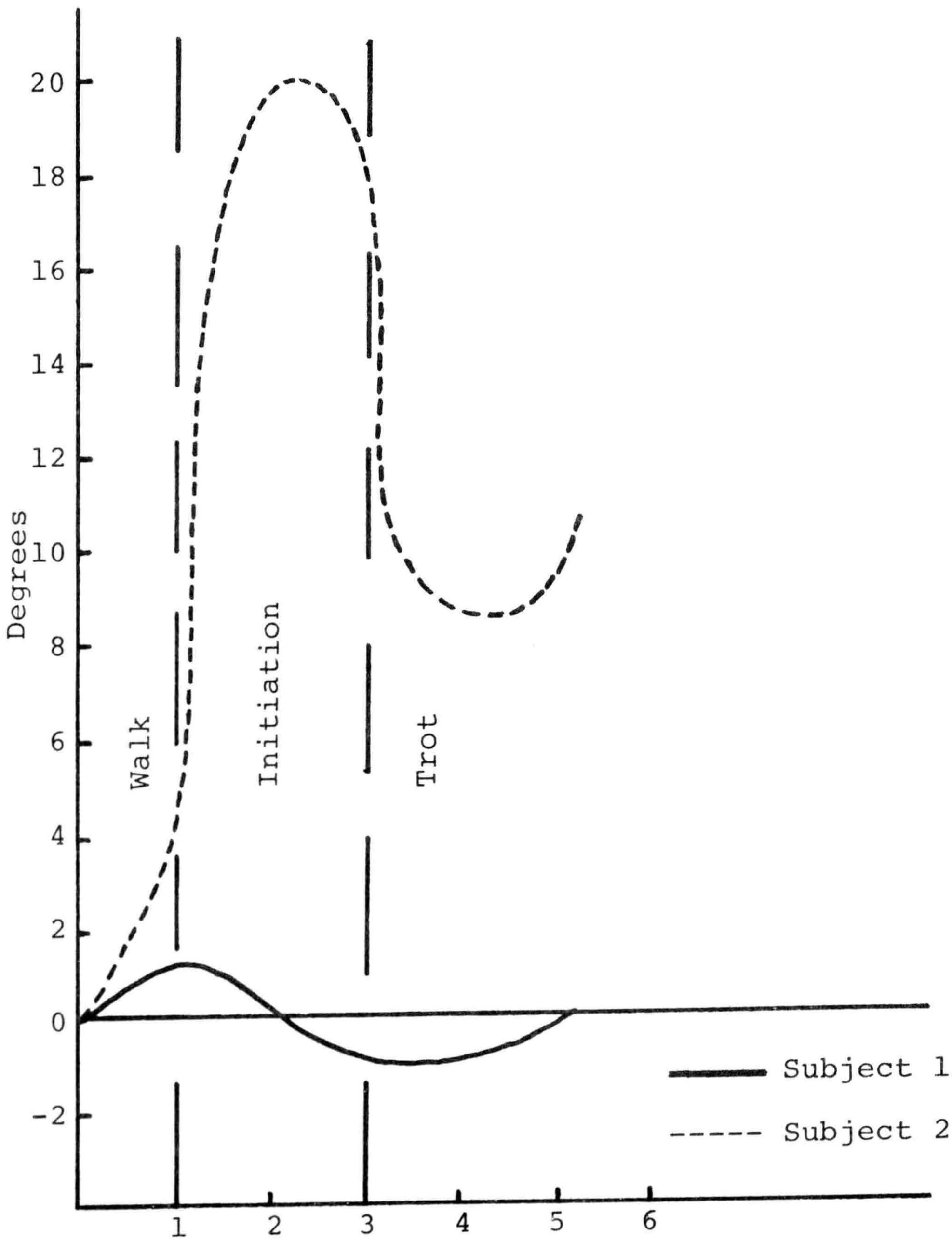


Figure 19. Trunk displacement data of subjects 1 and 2 during the walk-trot.

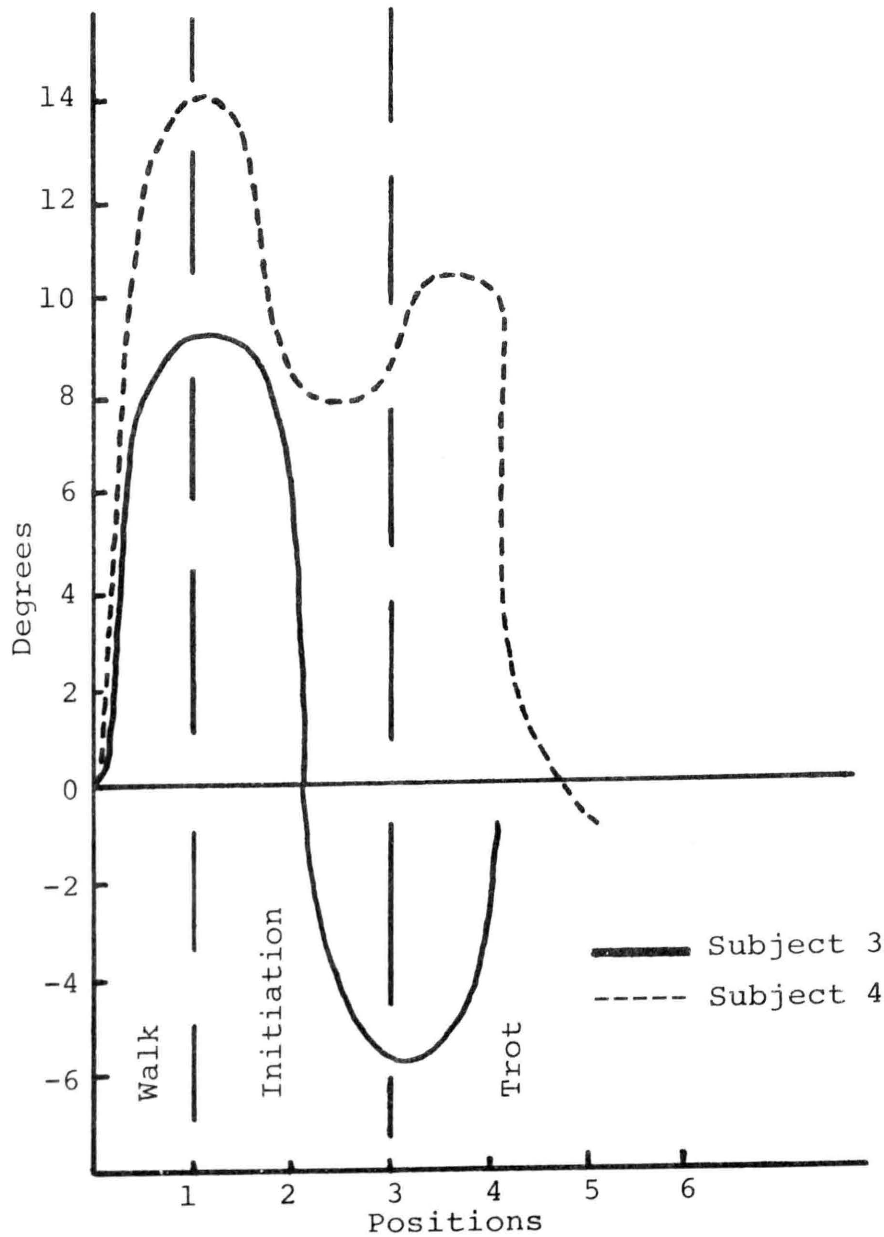


Figure 20. Trunk displacement data of subjects 3 and 4 during the walk-trot.

Table 20

Absolute Velocity of the Trunk

During the Walk-Trot Phase

Subject	Walk-Trot[a]				
	Walk	Initiation			Trot
1	0	0	-.03	-.03	-.01
2	0	.51	.25	-.30	-.14
3	0	.25	.03	-.43	-.06
4	0	.22	-.14	-.08	-.27

Note. No sign = positive velocity (forward); negative sign = negative velocity (backward).

[a]Data are in radians/second.

of the walk-trot was negative for Subject 1; it fluctuated between positive and negative for Subject 2. Magnitude and fluctuation of trunk velocity were greater for Subject 2 than for Subject 1 during both phases (see Figure 21).

Both Subject 3 and Subject 4 fluctuated in trunk velocity from positive to negative during the initiation phase of the walk-trot. Velocity remained negative for both subjects during the trot phase of the sequence. Magnitude of velocity was greater for Subject 3 than for Subject 4. Fluctuation of velocity during both phases was greater for Subject 4 than for Subject 3 (see Figure 22).

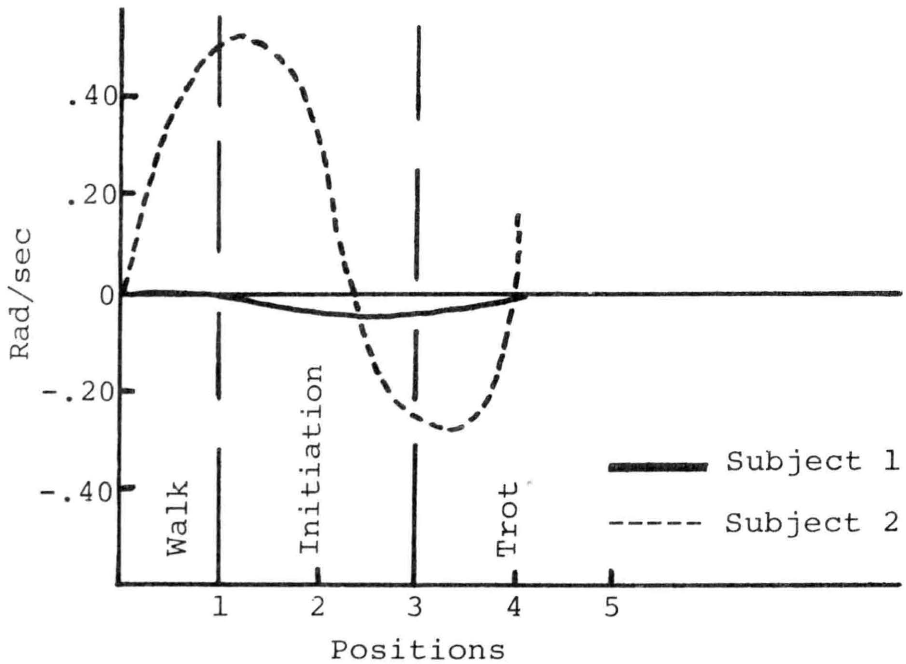


Figure 21. Absolute velocity of the trunks of subjects 1 and 2 during the walk-trot.

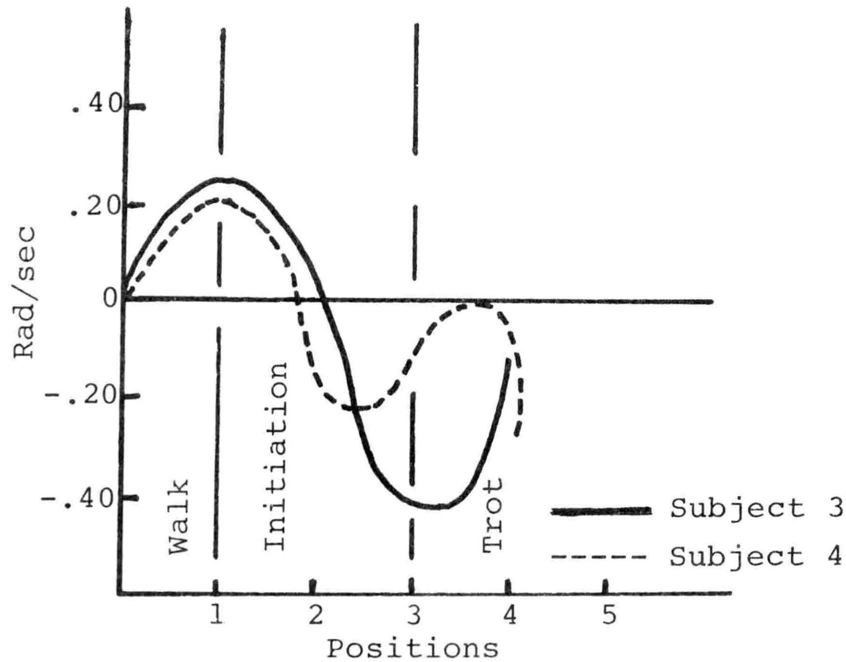


Figure 22. Absolute velocity of the trunks of subjects 3 and 4 during the walk-trot.

Absolute Acceleration of the
Trunk During the Walk-Trot

Table 21 presents absolute acceleration data for the trunk during the walk-trot. Absolute acceleration during

Table 21

Absolute Acceleration of the Trunk
During the Walk-Trot Phase

Subject	Walk-Trot[a]			
	Walk	Initiation		Trot
1	0	-.04	-.04	.07
2	0	.44	-1.65	-.63
3	0	.05	-1.06	-.15
4	0	-.22	-.46	-.20

Note. No sign = positive acceleration (forward); negative sign = negative acceleration (backward).

[a]Data are in radians/second^2.

the initiation phase of the walk-trot sequence was negative for Subject 1; it fluctuated from positive to negative for Subject 2. Acceleration of the upper trunk during the trot phase was negative for Subject 2, whereas it fluctuated from negative to positive for Subject 1. Magnitude and

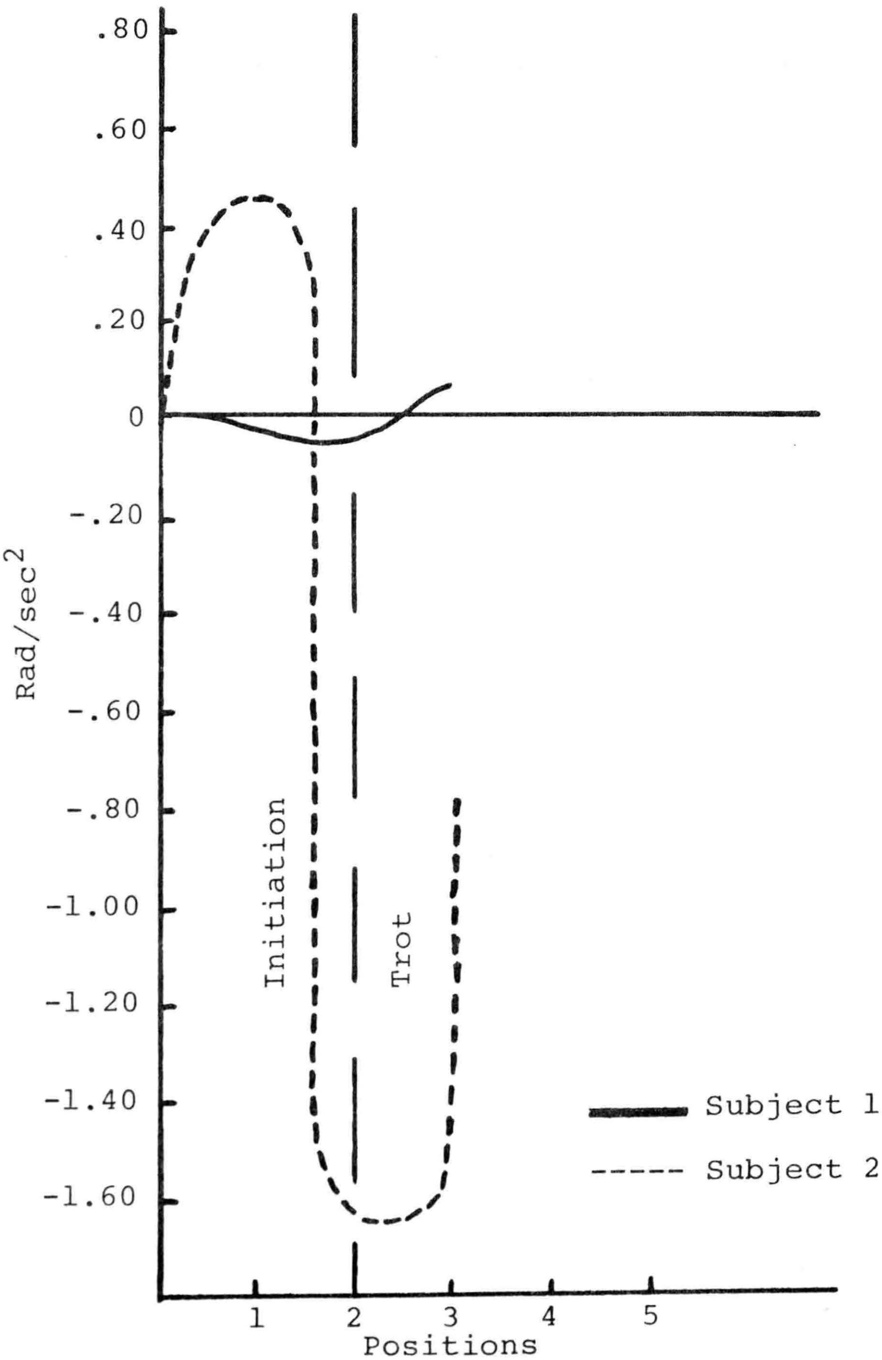


Figure 23. Absolute acceleration of the trunks of subjects 1 and 2 during the walk-trot.

fluctuation of trunk acceleration was greater for Subject 2 than for Subject 1 (see Figure 23).

Acceleration of the trunk during the initiation phase fluctuated from positive to negative for Subject 3; for Subject 4, it remained negative. Acceleration during the trot phase was negative for both subjects. Magnitude of trunk acceleration was greater for Subject 3 than for Subject 4 during both phases. During the initiation phase, fluctuation of trunk acceleration was greater for Subject 3; it was similar for both subjects during the trot phase (see Figure 24).

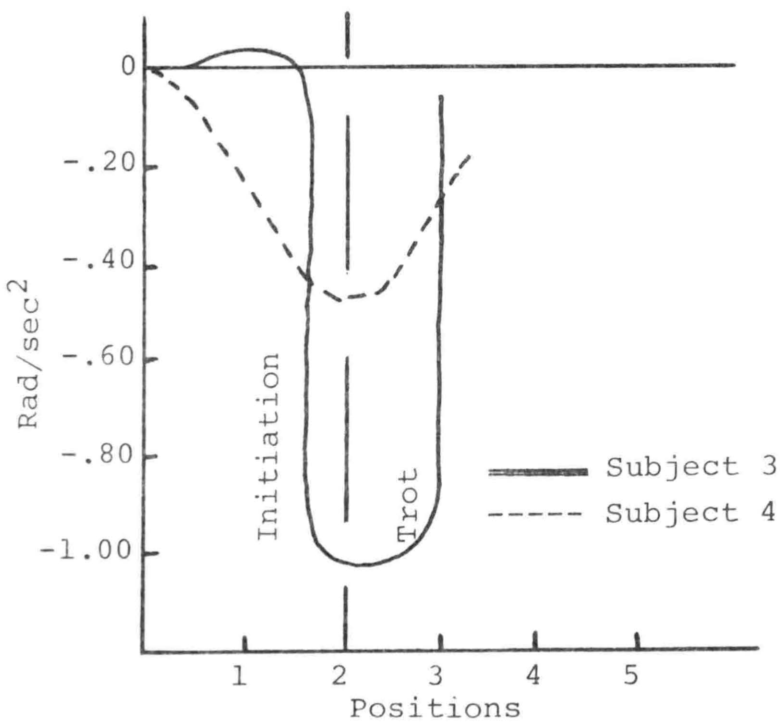


Figure 24. Absolute acceleration of the trunks of subjects 3 and 4 during the walk-trot.

Displacement of the Trunk During the Trot-Halt

Data relating to displacement of the trunk during the trot-halt are presented in Table 22. During both phases

Table 22

Displacement of the Trunk During the Trot-Halt Phase

Subject	Trot-Halt[a]							
	Trot					Halt		
1	5.0	1.0	9.0	8.5		5.0	7.0	6.0
2	7.5	-2.5	0	-2.5	2.0	-1.0	-.5	
3	-.5	-6.1	-1.0	-3.0		-8.5	-3.0	3.5
4	6.5	10.5	9.0	4.5	7.5	-6.5	7.0	

[a]Data are in degrees.

of the trot-halt, upper trunk displacement of Subject 1 was forward of the starting position, whereas it shifted from in front of to behind the starting position for Subject 2. Magnitude of displacement was greater for Subject 1 than for Subject 2. Fluctuation of trunk displacement was greater for Subject 2 than for Subject 1 during both phases of the sequence (see Figure 25).

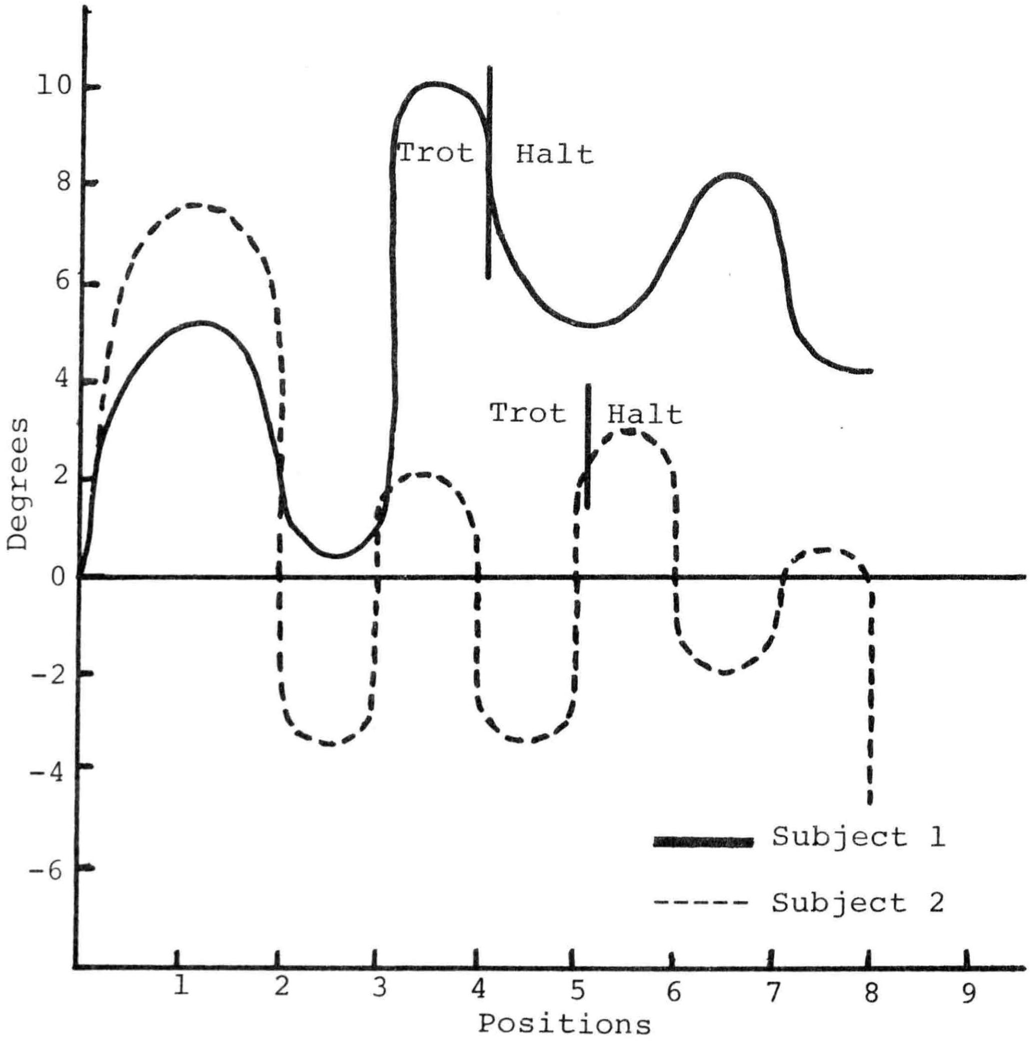


Figure 25. Trunk displacement data for subjects 1 and 2 during the trot-halt.

Trunk displacement of Subject 3 was forward of the starting position. For Subject 4, it was backward of the starting position during the trot phase of the sequence. During the halt phase, trunk displacement of Subject 3 was forward of the starting position. For Subject 4, it shifted from backward to forward of the starting position. Magnitude of displacement was greater for Subject 4 than for Subject 3 during both phases. Fluctuation of displacement was similar for both subjects during the entire sequence (see Figure 26).

Absolute Velocity of the Trunk During the Trot-Halt

Table 23 presents data relative to absolute velocity of the trunk during the trot-halt. The velocities of the trunks of both Subject 1 and Subject 2 fluctuated positively and negatively during the trot phase. Velocity during the halt was negative for Subject 2; it ranged from negative to positive for Subject 1. Magnitude of velocity was greater for Subject 1 than for Subject 2 during the trot phase, whereas it was greater for Subject 2 during the halt phase. Fluctuation of trunk velocity was similar for both subjects during the trot phase, but was greater for Subject 1 than for Subject 2 during the halt phase (see Figure 27).

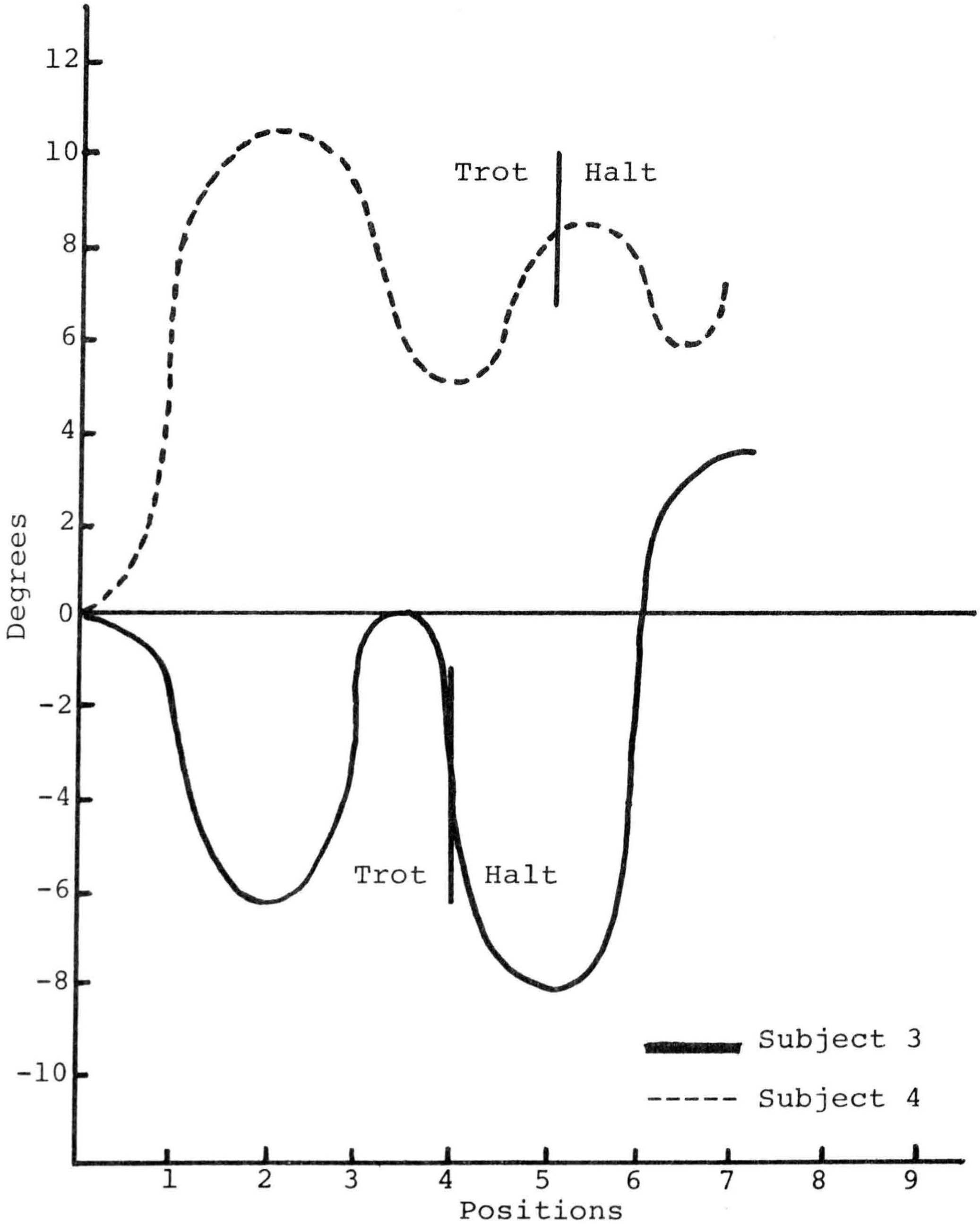


Figure 26. Trunk displacement data for subjects 3 and 4 during the trot-halt.

Table 23

Absolute Velocity of the Trunk

During the Trot-Halt Phase

Subject	Trot-Halt[a]							
			Trot				Halt	
1	.03	.11	.21	-.11		-.14	.03	-.08
2	-.07	-.17	0	.03	.04	-.07	-.11	
3	-.18	-.01	.10	-.20		0	.33	.10
4	.28	.07	-.17	-.04	.06	-.01	.17	

Note. No sign = positive velocity (forward); negative sign = negative velocity (backward).

[a]Data are in radians/second.

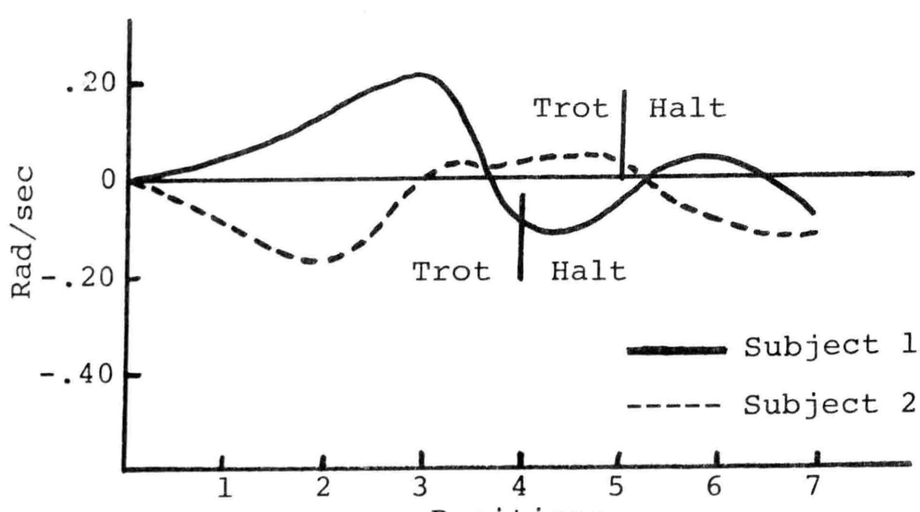


Figure 27. Absolute velocity of the trunks of subjects 1 and 2 during the trot-halt.

Trunk velocities of Subject 3 and Subject 4 fluctuated positively and negatively during both phases of the trot-halt sequence. Magnitude of trunk velocity during the trot phase was greater for Subject 4 than it was for Subject 3; magnitude of velocity during the halt phase was greater for Subject 3. Fluctuation of trunk velocity was greater for Subject 4 than for Subject 3 during the trot phase; it was similar for both subjects during the halt phase (see Figure 28).

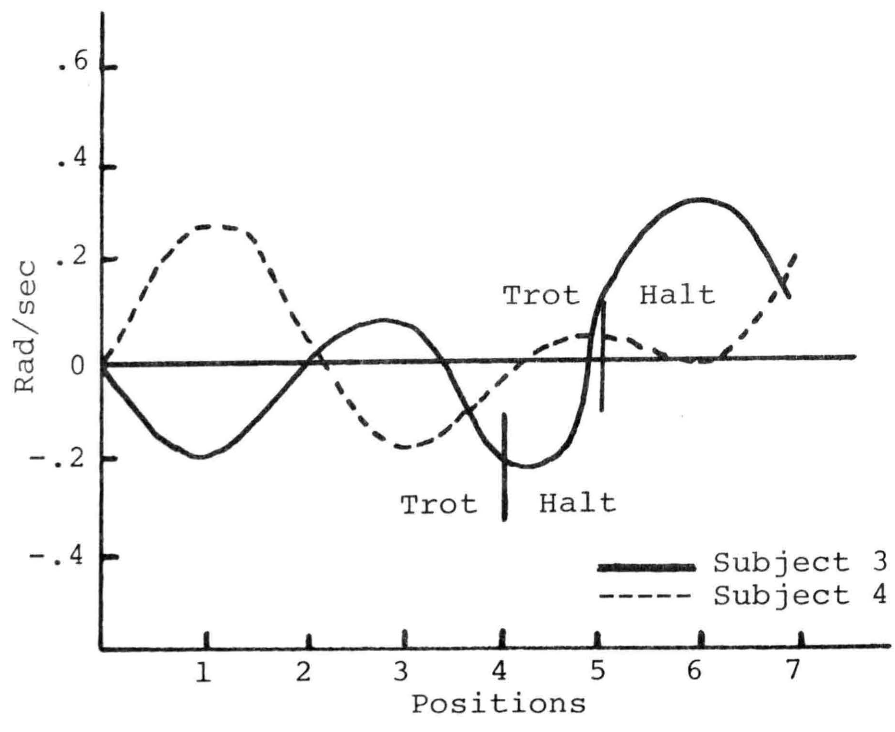


Figure 28. Absolute velocity of the trunks of subjects 3 and 4 during the trot-halt.

Absolute Acceleration of the Trunk During the Trot-Halt

Data collected which relate to absolute acceleration of the trunk during the trot-halt are shown in Table 24.

Table 24

Absolute Acceleration of the Trunk During the Trot-Halt Phase

Subject	Trot-Halt[a]						
	Trot				Halt		
1	.18	.29	-.35		-.39	.15	-.07
2	-.27	.12	.46	.03	-.17	.41	
3	-.02	.47	-.31		-.16	.88	.16
4	.10	-.71	-.16	.38	.05	.20	

Note. No sign = positive acceleration (forward); negative sign = negative acceleration (backward).

[a]Data are in radians/second^2.

Acceleration of the trunk during both phases of the trot-halt sequence fluctuated positively and negatively for both Subjects 1 and 2. During the trot phase magnitude and fluctuation were greater for Subject 2 than for Subject 1. Magnitude of acceleration during the halt phase was similar for both subjects; fluctuation of acceleration was greater for Subject 1 (see Figure 29).

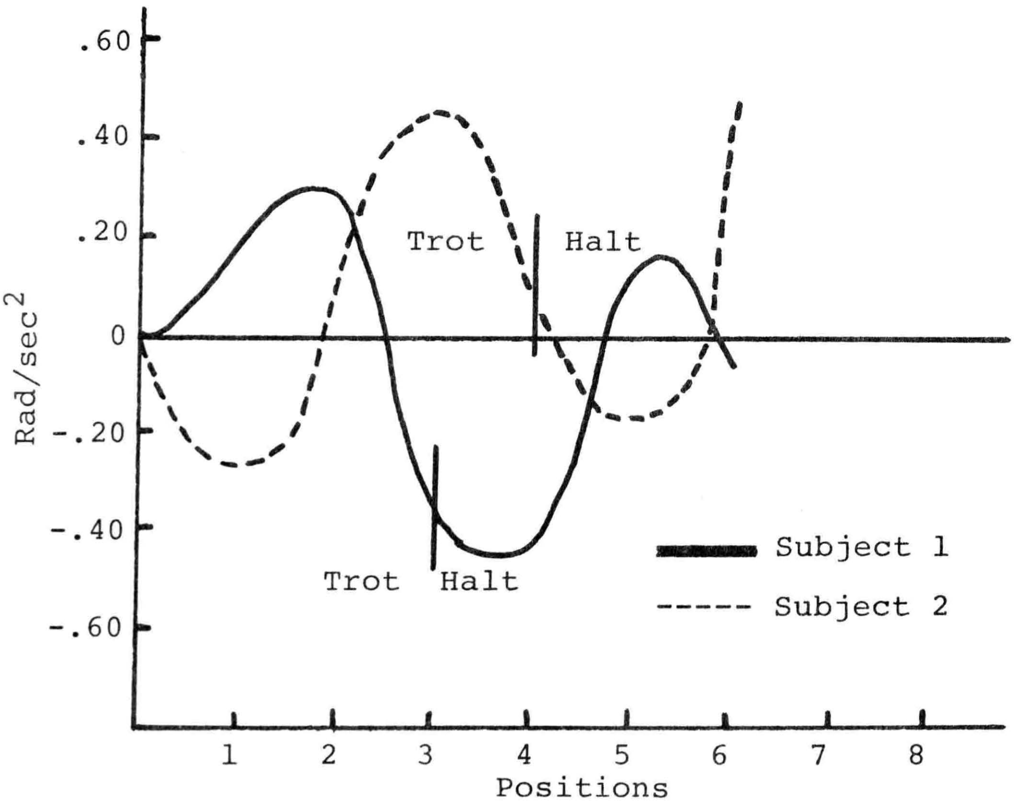


Figure 29. Absolute acceleration of the trunks of subjects 1 and 2 during the trot-halt.

During both phases of the trot-halt sequence, absolute acceleration of the trunks of Subject 3 and Subject 4 fluctuated negatively and positively. Magnitude and fluctuation of trunk acceleration were greater for Subject 4 than Subject 3 during the trot phase; this was also true for Subject 3 during the halt phase (see Figure 30).

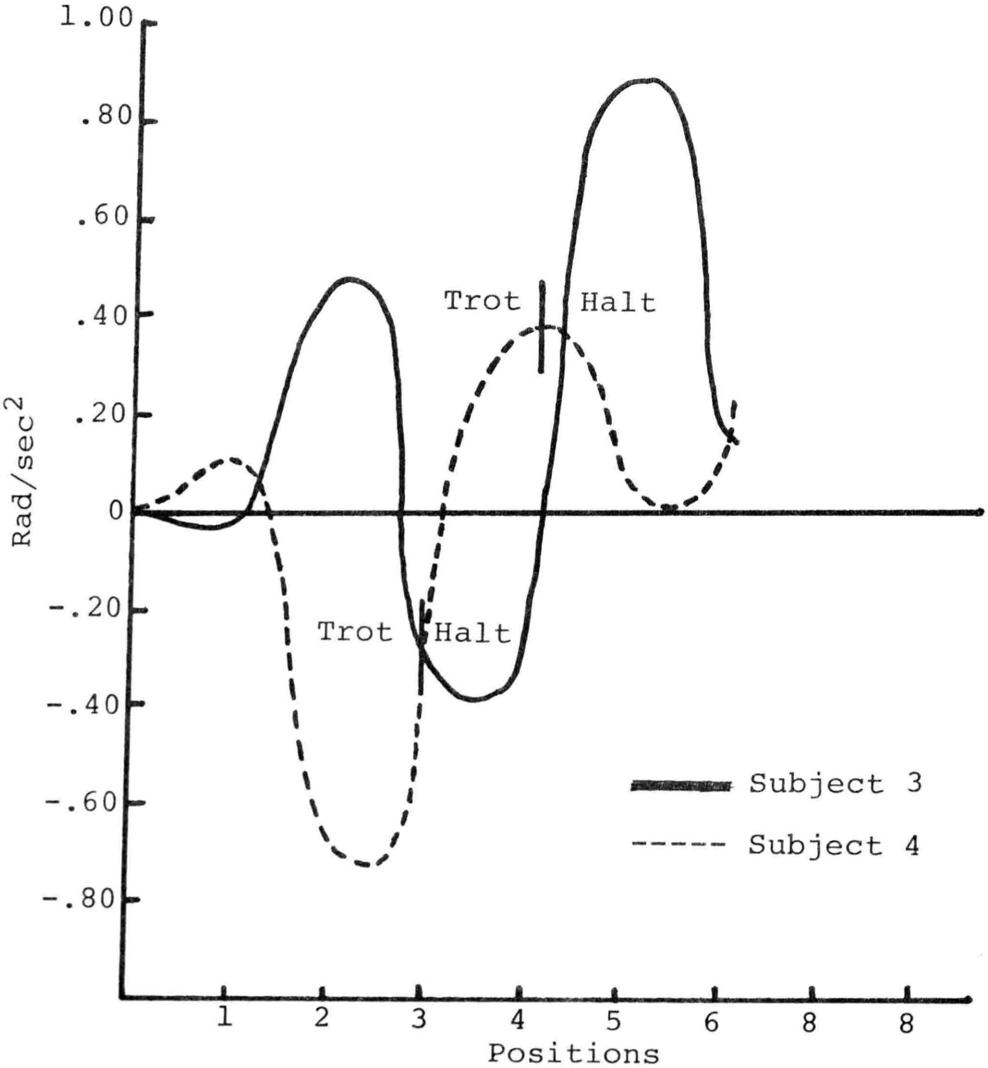


Figure 30. Absolute acceleration of the trunks of subjects 3 and 4 during the trot-halt.

Displacement, velocity, and acceleration of the side-to-side positions of the trunk were not calculated for this portion of the study. Difficulty in selecting the corresponding side-to-side positions of the four subjects led the researcher to doubt the validity of the results which would have been calculated.

Summary of the Findings

Two handicapped horseback riders, one female and one male of college age, were compared with two proficient and nonhandicapped horseback riders of the same sex and age. The handicapped female rider was classified as having released contractures of the internal rotators of the legs. Her nonhandicapped female control rider and she rode English saddle. The handicapped male rider, a bilateral amputee (above the knee) was compared to the nonhandicapped male control rider; both rode Western saddle.

Comparisons between the handicapped and nonhandicapped riders were made according to four specific movement sequences of the horse: the stop-walk, walk-halt, walk-trot, and trot-halt. Movements compared between the riders included forward-backward and side-to-side position of the trunk, the center of gravity, and the head. Trunk velocities and accelerations were also examined.

Examination of the forward-backward data obtained on the female subjects revealed differences in all areas of comparison between the two subjects. Trunk and center of gravity positions during the majority of the initiation sequences were more forward for the handicapped subject than for the nonhandicapped subject. Trunk and center of gravity positions during the majority of the walk, trot, and halt were more forward for the nonhandicapped subject. Head position of the handicapped rider was forward of the body; it was also more forward than that of the nonhandicapped subject during all of the sequences.

Examination of the side-to-side data obtained on the female subjects showed both subjects' trunks to be to the right. Trunk position of the handicapped subject was less to the right of that of the nonhandicapped subject during all phases of the movement; the only exception was during the trot. The center of gravity was to the left of the perpendicular for the nonhandicapped subject; it was located closer to the perpendicular for the handicapped subject. Head position fluctuated from right to left of perpendicular for the nonhandicapped subject, but remained primarily to the right for the handicapped subject.

A review of the forward-backward displacement of the female subjects revealed a greater forward displacement of the trunk for the handicapped rider during the initiation sequences, whereas greater forward displacement of the trunk for the nonhandicapped rider occurred during the walk, trot, and halt. Magnitude of velocity (positive and negative) was greater for the nonhandicapped female during the initiation of the walk, walk, and trot; it was greater for the handicapped female during the initiation of the trot and halt. Magnitude of acceleration (positive and negative) was greater for the nonhandicapped subject than for the handicapped subject during the movement phases.

A review of the forward-backward data obtained on the male subjects revealed the following information. The handicapped male subject's trunk and center of gravity were behind those of the nonhandicapped male during the initiation of the walk, walk-halt, and trot-halt. During the walk-trot, the trunk and center of gravity positions were similar for both subjects. Head position of the handicapped male was behind the trunk; it was more behind than that of the nonhandicapped male during the initiation of the walk, walk-halt, and trot. Position of the head during the walk-trot and trot-halt was similar for both male riders.

Examination of the side-to-side data obtained on the male subjects showed trunk position to be to the right for the nonhandicapped subject. It fluctuated from right to left for the handicapped subject. The position of the center of gravity of each subject was left of the perpendicular. The handicapped rider's center of gravity remained closer to the perpendicular during the initiation and trot sequences, whereas the nonhandicapped rider's center of gravity was closer to the perpendicular during the walk and halt sequences. Head position of the handicapped rider was to the left of the trunk; it was also located more to the left than that of the nonhandicapped rider during the majority of the four movement sequences.

Comparison of trunk displacements of the male subjects indicated that the trunk of the handicapped male was displaced further forward during the walk-halt, walk-trot, and trot-halt than was the trunk of the nonhandicapped male. Only during the stop-walk did the forward displacement of the nonhandicapped rider exceed that of the handicapped rider.

Velocity was greater for the nonhandicapped subject during initiation of the walk and trot as well as during the halt phase of the trot-halt. A greater velocity was exhibited by the handicapped rider during the walk-halt and trot. Acceleration was greater for the nonhandicapped subject during the initiation sequences and the halt phase of the trot-halt; it was greater for the handicapped rider during the walk-halt and trot.

One additional fact was noted regarding acceleration of the trunk for both the female and male subjects.

Magnitude of acceleration decreased after the initial change in direction for the nonhandicapped subjects, whereas it increased for the handicapped subjects.

CHAPTER V

SUMMARY, FINDINGS, DISCUSSION, CONCLUSION, IMPLICATIONS, AND RECOMMENDATIONS FOR FURTHER STUDIES

In Chapter V information relative to the investigation is presented under the following headings: (a) Summary of the Study, (b) Findings of the Study, (c) Discussion of the Findings, (d) Conclusion, (e) Implications of the Study, and (f) Recommendations for Further Studies.

Summary of the Study

Scientific investigation of the body position of handicapped and nonhandicapped horseback riders during the various movement patterns of the horse is almost nonexistent. Only two cinematographic investigations were found; these were designed to investigate the movements exhibited by normal horseback riders during various movement patterns of the horse. ReQua (1939) found that the body position of proficient horseback riders did not vary significantly regardless of the type of saddle or "seat" ridden; the only exception to this was noted during the posting trot. White (1940) found that horseback riders had a better "seat" during a canter when the pivot point of the body became the pelvic region rather than the thigh and leg region. No studies involving handicapped riders were found.

To fill the void of information regarding body position of physically handicapped riders on horseback, it was the intent of this investigator to observe and compare the riding positions of two handicapped riders with two nonhandicapped riders during various movement sequences of the horse. Comparisons were made with regard to the forward-backward and side-to-side positioning of the head, trunk, and center of gravity. The comparisons were completed in order to determine what effects, if any, two selected types of handicap might have on riding position.

Filming of the subjects took place in May, 1977. The subjects involved in the study included two females and two males who ranged in age from 21 to 29. The handicapped female who was classified as having released contractures of the internal rotators of the legs was compared with a nonhandicapped female; both rode English saddle. The handicapped male rider with bilateral amputations of the legs (above the knee) was compared with a nonhandicapped male; both males rode Western saddle.

Film data were obtained using the following 16mm motion picture cameras: (a) Locam, (b) Photosonic IVN-200, and (c) Bell and Howell HR-70. Head, trunk, and center of gravity coordinates were obtained from the film clip tracings through use of the Numonics Graphics Calculator.

Data were plotted on graph paper; the head, trunk, and center of gravity positions were measured by protractor to determine differences in position between the handicapped and nonhandicapped horseback riders during each of the movement sequences. Differences in position were compared according to sex. Velocities and accelerations of the trunk were also examined.

Findings of the Study

Differences in positions of the trunk, center of gravity, and head were evident between the handicapped and nonhandicapped subjects. Trunk position (side view) was more forward for the female handicapped subject and backward for the male handicapped subject than for the nonhandicapped subjects; the only exceptions were observed during the initiation phases. Trunk position (front view) of the handicapped subjects was consistently to the left of that of the nonhandicapped subjects.

The centers of gravity of both handicapped subjects were closer to the perpendicular (front and side views) than were those of the nonhandicapped subjects. The centers of gravity of the handicapped subjects remained within the estimated boundaries during all sequences; the centers of gravity of the nonhandicapped subjects fell outside the boundaries only occasionally.

Head position of the female handicapped subject was forward of her trunk; it was also more forward of the nonhandicapped subject's head. The head position of the male handicapped rider fell behind his trunk, as well as behind the position assumed by the male nonhandicapped rider's head. From the front view, the position of the head was to the right of the trunk for the handicapped female subject; this was also more to the right when compared to the nonhandicapped female. It was to the left for the male handicapped subject.

In addition, it was noted that displacement of the trunk from the starting position was greater for the handicapped female subject during the initiation phase; displacement of the trunk for the handicapped male rider was greater than that of the male nonhandicapped rider during the majority of the phases. Absolute velocity and acceleration were greater for both handicapped riders than for the nonhandicapped riders during the initiation, trot, and halt phases of the sequences.

Discussion of the Findings

Forward displacement of the trunk of the handicapped female during the initiation phases, as well as backward displacement during the other movement phases, may have been a result of the weakened internal rotators of the legs. It may also have been a pattern characteristic of a novice horseback rider. Weakened internal rotators, as well as inexperience on horseback, may have resulted in poor leg grip and lack of pivoting action in the pelvic region.

Greater forward displacement during the initiation phase may have been caused by an ineffective attempt to administer subtle leg cues to the horse in order to urge it into a faster gait. In attempting to overcome the inability to guide the horse into a faster gait, novice riders often move their bodies further forward for additional cueing. In addition, onset of a faster gait usually throws the inexperienced rider forward as a result of an unstable "seat."

Unable to remain well balanced on the horse, the rider with poor leg grip, or the inexperienced rider, will often ride very stiffly. This restricts the forward-backward movement of the body which tends to throw the rider off balance. Therefore, forward movement of the trunk will not be as great for an inexperienced rider as for an experienced rider who is balanced and able to ride in concert with the movement of the horse. The above facts may account for the trunk position of the handicapped female during the various phases of the movement sequences.

The backward position of the trunk of the handicapped male may have been a result of three factors specific to his disability. A bilateral amputee (above the knee) has a small base of support and a high center of gravity. Forward movement of the trunk will be restricted to the narrow base of support in an attempt to avoid loss of balance. Further contribution to the amputee's instability is the loss of strength in the hip extensors. Once the amputee's center of gravity falls outside its base of support, the powerful hip flexors will take over and throw him out of the saddle (Krusen, Kottke, & Ellwood, 1971). To keep within the diminished base of support, the amputee kept the head, trunk, and center of gravity inclined behind those of a normal rider.

Positioning of a physically handicapped subject's trunk to the left or right of the perpendicular during the walk or trot may have been indicative of a weakness to that side. According to Krusen, Kottke, and Ellwood (1971), people who have a left or right sided weakness tend to lean to the weakened side during physical movement.

The body is displaced laterally during both the walk and trot. In most cases lateral displacement during the walk can be easily controlled by the horseback rider. During the faster pace of the trot, however, an increased displacement to either side often results. This increased lateral displacement is not as easily controlled as the lateral movement which occurs during the walk; therefore, people with decreased leg strength, or riding experience, will exhibit movement toward the weaker side. Displacement to the left side of the trunks of both the handicapped subjects during the trot may have illustrated this point.

The close placement of the handicapped riders' centers of gravity to the perpendicular may have indicated an attempt to remain stable on horseback. Positioning of the nonhandicapped subjects' centers of gravity close to the perpendicular may have occurred because of a minimal amount of head and trunk movement during movement sequences.

Head position forward of the trunk may have been indicative of an attempt on the part of the subject to bring about a forward movement of the center of gravity to counteract the backward velocity of the trunk. Head position behind the trunk may have been indicative of an attempt to move the location of the center of gravity backward to counteract the forward velocity of the trunk. Placement of the head to the right or left of the trunk may have been indicative of the body's attempt to keep the center of gravity within its small base of support in order to counteract trunk velocity to the right or left side.

Large displacement from the initial starting position would be characteristic of a novice rider, or a rider with limited gripping power in the legs, whose pivot point is at the leg rather than at the pelvic region. Large displacement from the starting position would also occur in a rider whose stationary position is behind the perpendicular.

Instability of the subject in the saddle because of weakness in the trunk or lower extremities, or an inability to utilize subtle leg cues, would result in a greater velocity and acceleration during the initiation, trot, and halt phases of the movement sequences. It was during these sequences that trunk movement tended to be greatest.

Conclusion

Findings of this study seem to indicate that differences exist in trunk, center of gravity, and head positions between handicapped and nonhandicapped horseback riders. However, of the differences noted, only a small portion could be linked with a specific handicapping condition.

Implications of the Study

If horseback riding is to be used as a rehabilitation tool for the physically handicapped, more extensive research is needed in both horsemanship and the movement patterns of the physically handicapped. Cinematographic as well as electromyographic studies should be conducted.

Gross differences between the body positions of the handicapped and nonhandicapped subjects were distinguishable in this study; these were noticeable even with the limited sophistication of the instrumentation used. Although some of the differences between the subjects could not be attributed solely to the existence or nonexistence of a particular handicap, they did provide cues to problem areas that might be corrected through adapted teaching methods.

It is hoped that this initial study of the differences between handicapped and nonhandicapped horseback riders will inspire further study of horsemanship in general, as well as the movement patterns of the physically handicapped rider. Through additional investigations a better understanding of problem areas pertinent to other handicaps, as well as improved teaching methods to be used with the physically handicapped, may be attained.

Recommendations for Further Studies

As a result of this investigation the following recommendations for further studies are made.

1. Limitation of the movement pattern of the horse and rider to one sequence which can be studied intensively.

2. Lengthening of the distance over which the sequence is executed.

3. Utilization of the same horse and gait pace for each rider in order to provide more valid results.

4. Involvement of handicapped subjects whose disabilities have distinguishable characteristics; this would aid in the interpretation of the results.

5. Comparison of handicapped riders with novice riders to assist in distinguishing differences in riding patterns.

6. Comparison of novice with proficient riders to assist in distinguishing differences in riding patterns.

7. Utilization of electromyography to aid in distinguishing whether different muscles are employed by handicapped, novice, and proficient riders.

8. Limitation of the number of body parts or factors to be studied.

APPENDIX

THERAPEUTIC HORSEBACK RIDING PROGRAM

TEXAS WOMAN'S UNIVERSITY

January 1977

______________________ has my permission to be photographed
(Student)
by the Texas Woman's University during participation in the Therapeutic Horseback Riding Program to be held Spring Semester 1977. It is understood that: (1) the 16 millimeter films taken will be used for biomechanical analysis of human movement during horseback riding and will therefore become part of the Health, Physical Education, and Recreation's Department film library used for that purpose.; (2) any photographs or slides taken will be used to illustrate various teaching techniques, aids, and/or equipment used during instruction on horseback and may be included in a slide show presentation, or article depicting the particular technique, aid or equipment photographed; and (3) videotapes taken of the various riding sessions will be used to evaluate the effectiveness of the various teaching techniques, aids and equipment used during the riding sessions.

Signed: ______________________________ Date: ____________
(Signature of parent or guardian)

____
Authorized Representative of the Texas Woman's University

PHYSICIAN'S REFERRAL

NAME_______________________________ Date OF BIRTH______________

OCCUPATION____

PARENT OR LEGAL GUARDIAN (If Any)______________________________

ADDRESS_________________________ CITY__________ STATE__________

DIAGNOSIS______________________________ DATE OF ONSET__________

MEDICAL HISTORY____

____

____

____

MEDICATIONS____

VISUAL DEFECTS__________________________ AUDITORY DEFECTS_______

SPEECH DEFECTS____________________ CIRCULATION__________________

NEURO-SENSATION____

BALANCE_________________________ COORDINATION___________________

SPASTICITY and/or RIGIDITY_____________________________________

BRACES__________________________ ASSISTIVE DEVICES______________

SEIZURES________________________ INCONTINENCE___________________

In my opinion, this patient can receive riding instruction under appropriate supervision. In conjunction with the riding program I concur in the referral of the patient to the staff physical therapist for evaluation of his physical abilities and/or limitations in performing exercises.

PRECAUTIONS OR CONTRAINDICATIONS to PHYSICAL THERAPY___________

____

Signed_________________________

Participant's Physician

THERAPEUTIC HORSEBACK RIDING PROGRAM

TEXAS WOMAN'S UNIVERSITY

February 1977

I, ______________________________, do hereby grant permission to Texas Woman's University, Estes Stables, and others interested in therapeutic horseback riding to photograph, reproduce, and use my image during participation in the Therapeutic Horseback Riding Program at Texas Woman's University, Spring Semester 1977. It is understood that: (1) the 16 millimeter films taken will be used for biomechanical analysis of human movement during horseback riding and will therefore become part of the Health, Physical Education, and Recreation Department's film library used for that purpose; (2) any photographs or slides taken may be used in a slide show presentation, or with an article illustrating various teaching aids, techniques, and/or equipment used; and (3) videotapes taken during the riding sessions will be used to evaluate the effectiveness of the teaching aids, techniques, and equipment.

With respect to the foregoing matters, no inducement or promises have been made to me to secure my signature to this release other than the intention of the Texas Woman's University to use or cause to be used such photographs, films and pictures for the primary use of research in and promotion of therapeutic horseback riding.

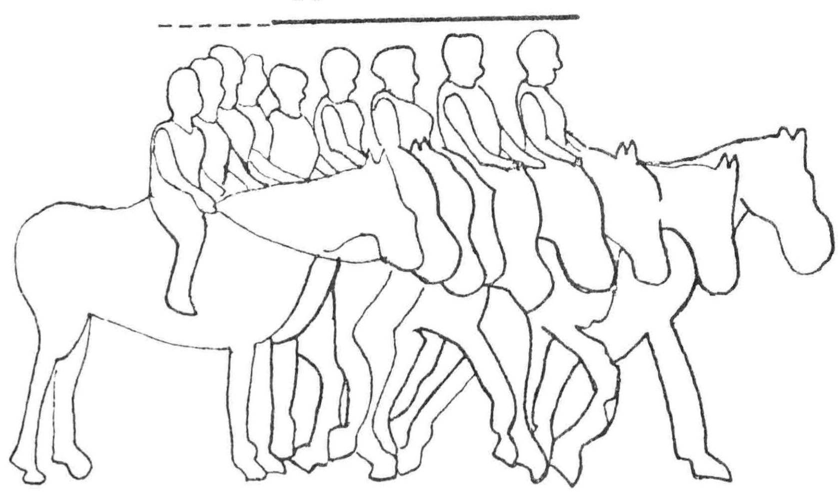
Dated this__________day of___________, 19__

______________________________ ______________________________

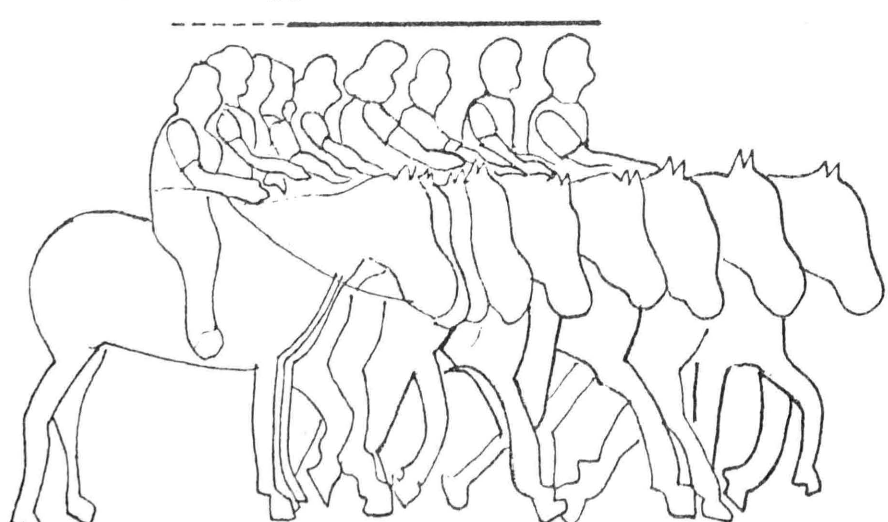
Authorized Representative-TWU Signature of participant

Side View Tracings of Handicapped and Nonhandicapped Subjects Performing the Stop-Walk

a. Subject 1 (Nonhandicapped Female)



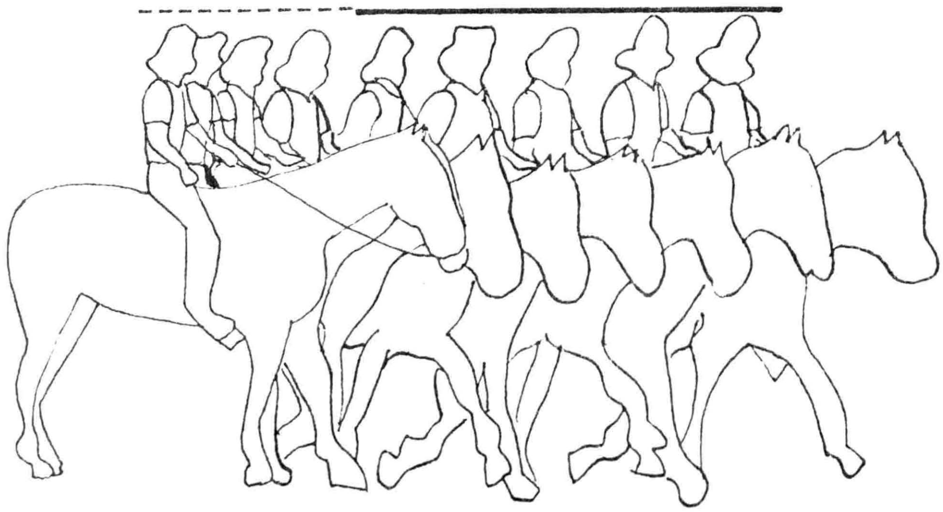
b. Subject 2 (Handicapped Female)



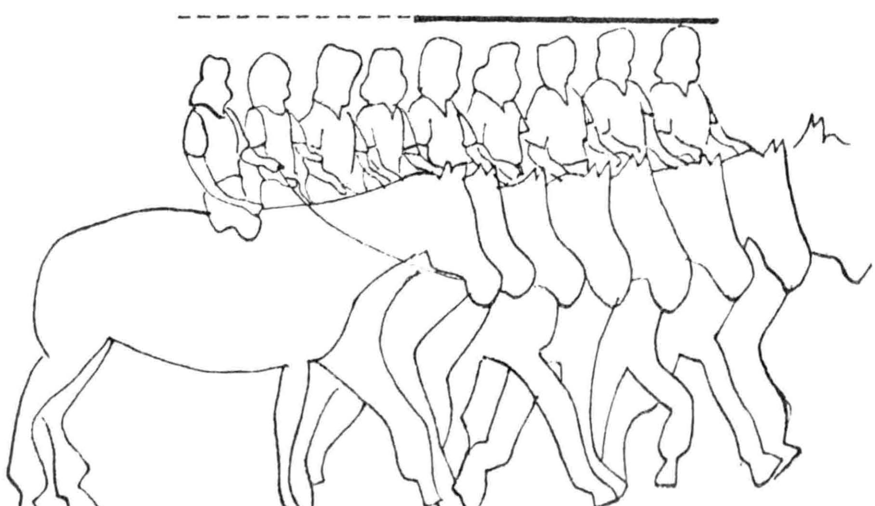
----- Initiation Walk

_____ Walk Phase

c. Subject 3 (Nonhandicapped Male)



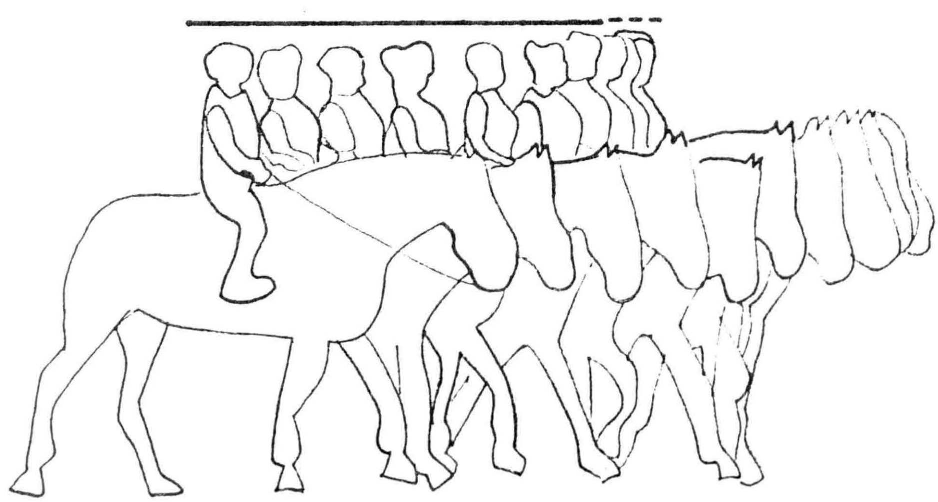
d. Subject 4 (Handicapped Male)



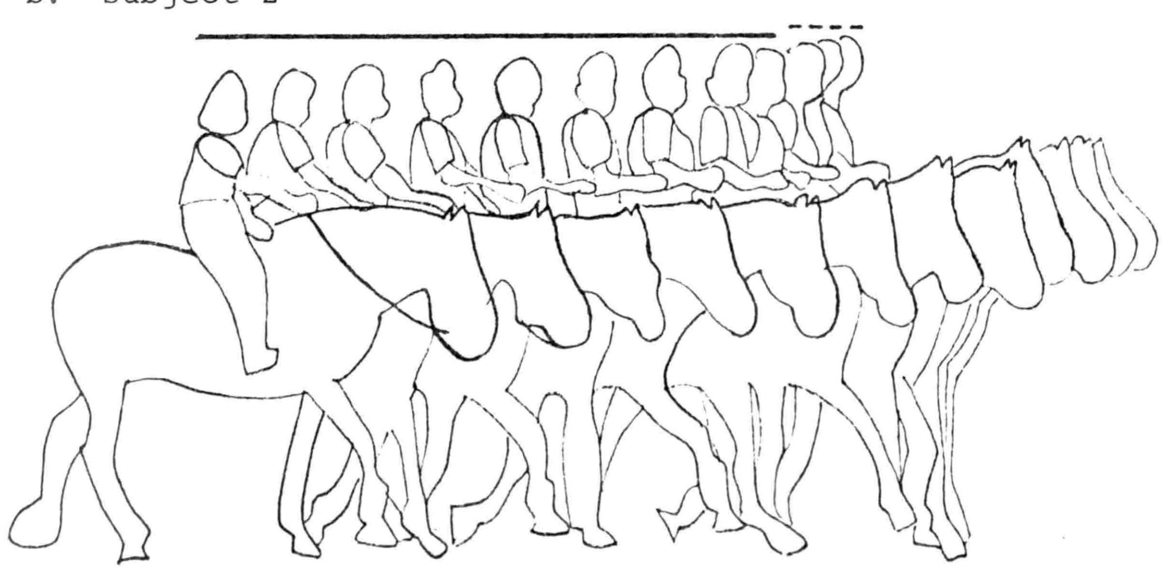
----- Initiation Walk
_____ Walk Phase

Side View Tracings of Handicapped and Nonhandicapped Subjects Performing the Walk-Halt

a. Subject 1



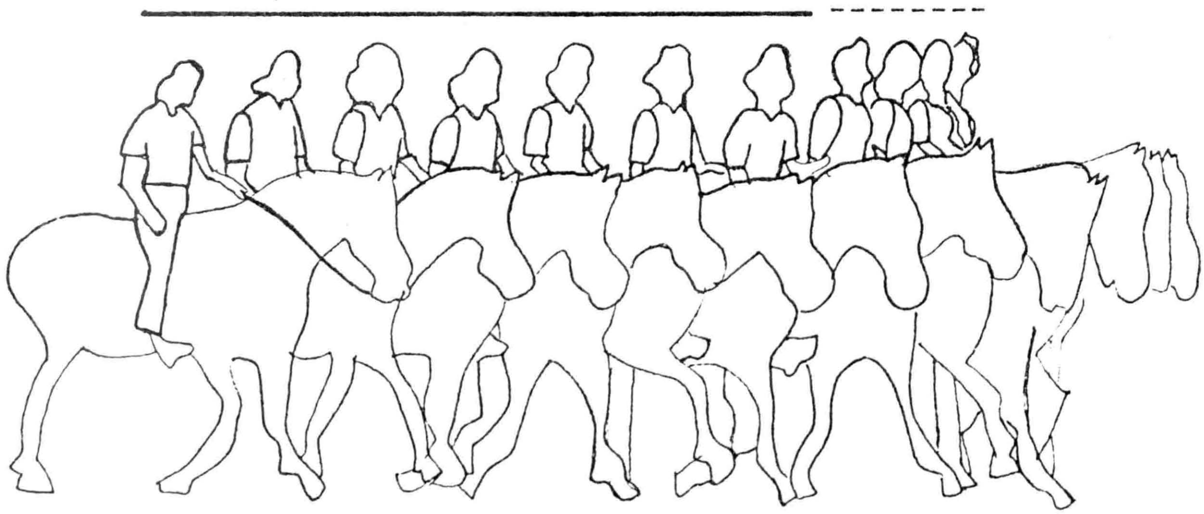
b. Subject 2



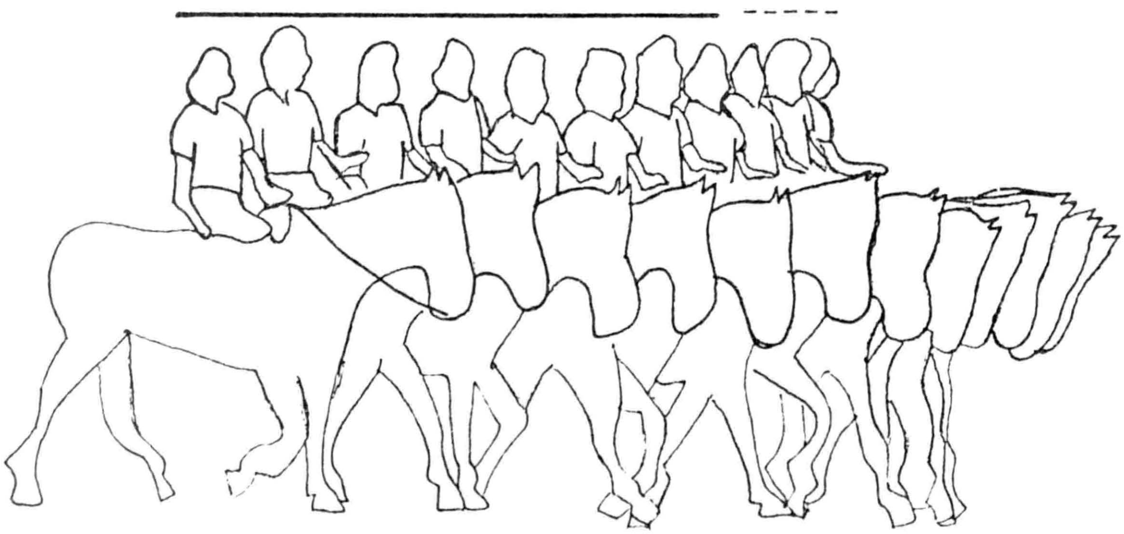
——— Walk Phase

----- Halt Phase

c. Subject 3



d. Subject 4

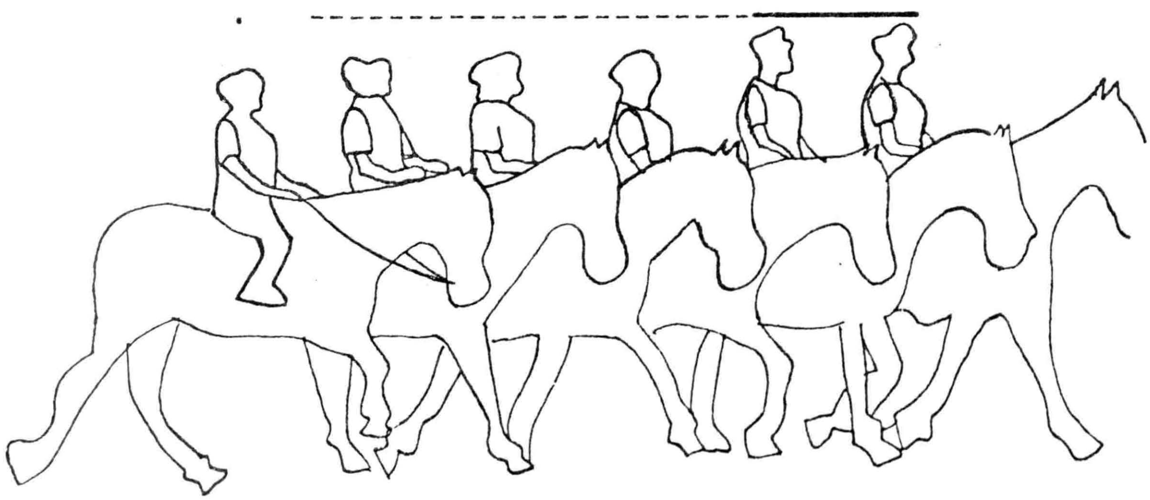


——— Walk Phase
----- Halt Phase

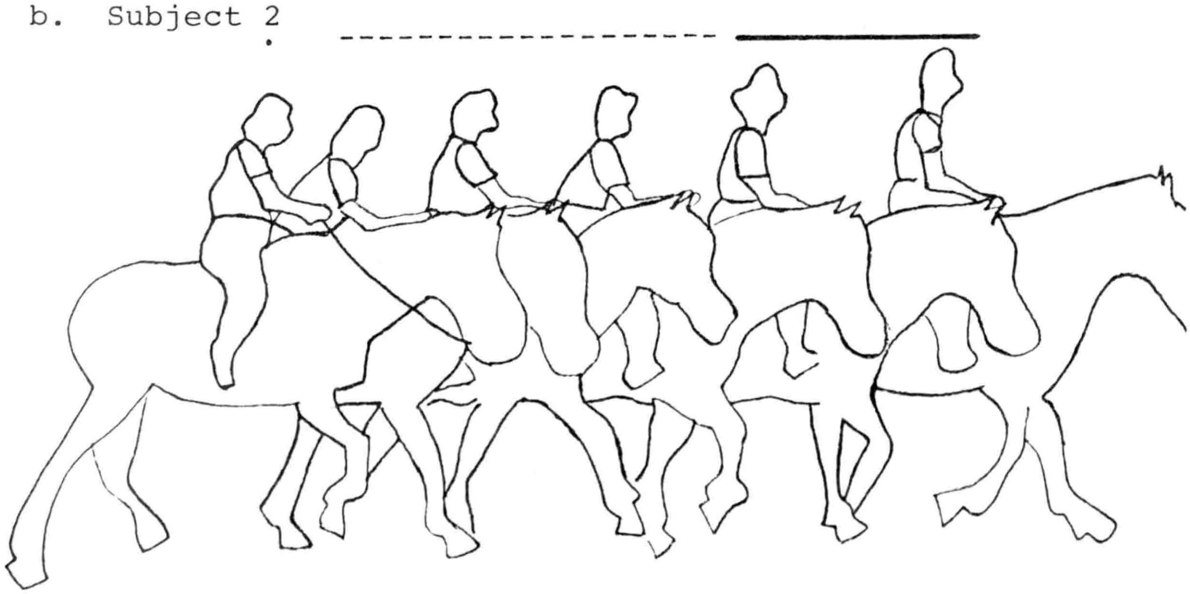
Side View Tracings of Handicapped and Nonhandicapped

Subjects Performing the Walk-Trot

a. Subject 1

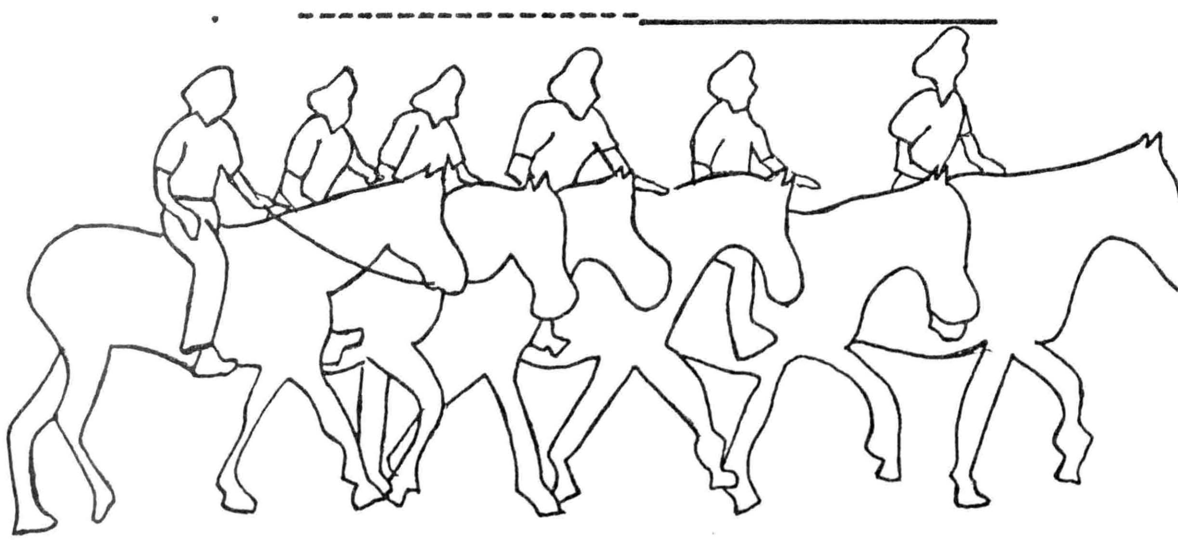


b. Subject 2

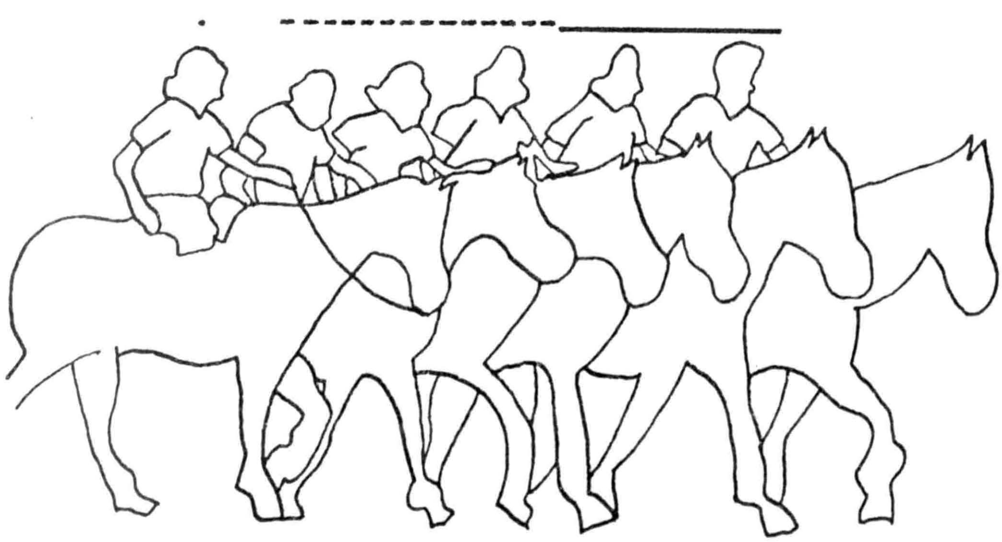


. Walk Phase
----- Initiation Phase
______ Trot Phase

c. Subject 3



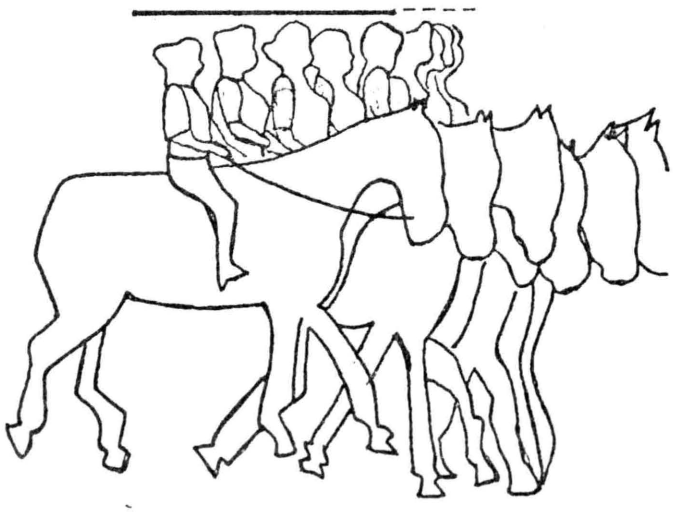
d. Subject 4



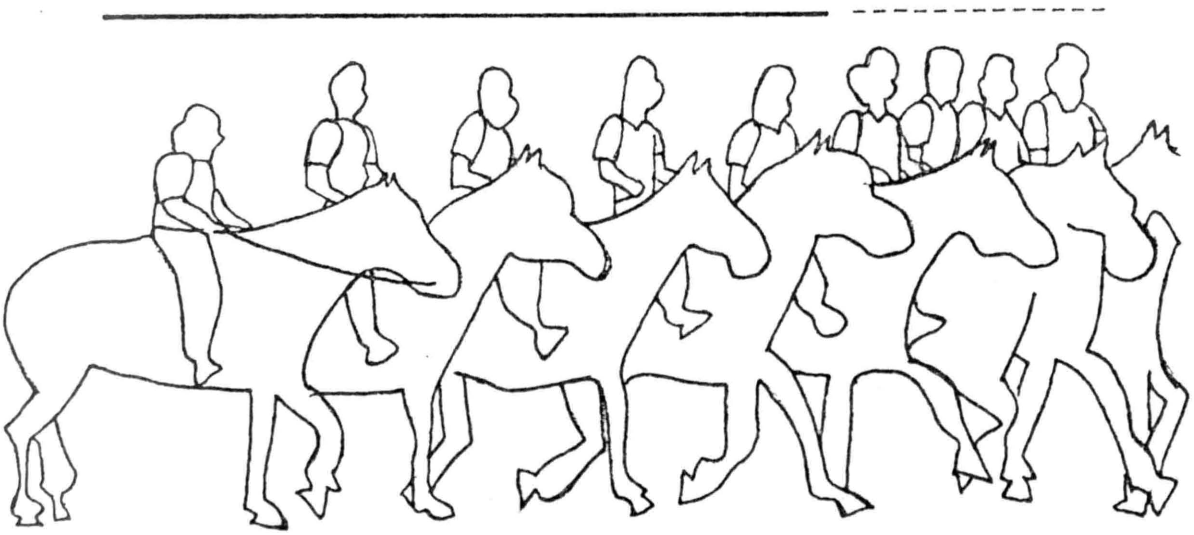
. Walk Phase
----- Initiation Phase
_____ Trot Phase

Side View Tracings of Handicapped and Nonhandicapped Subjects Performing the Trot-Halt

a. Subject 1

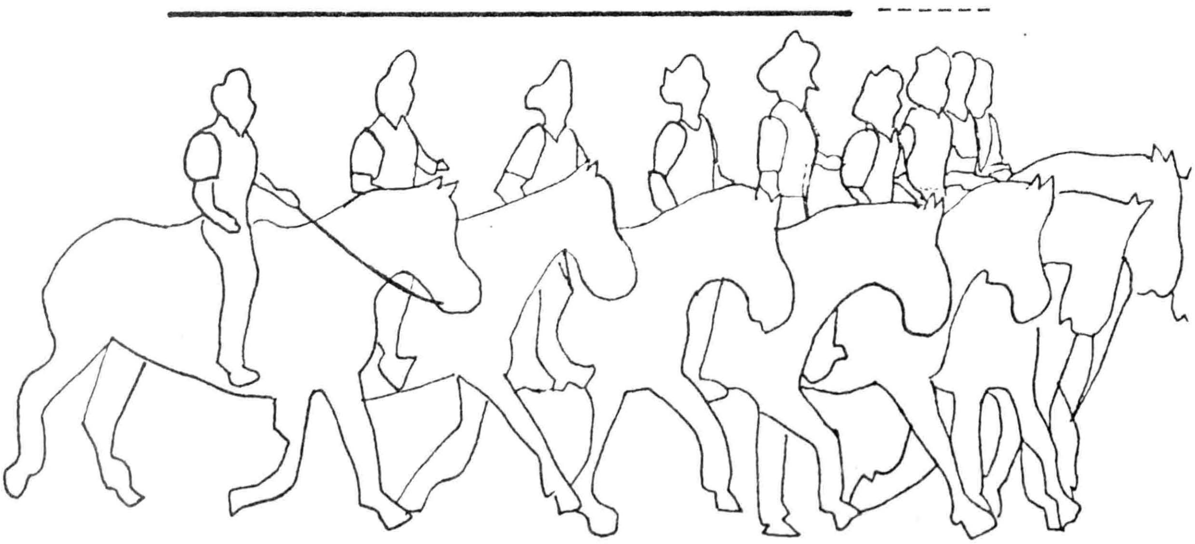


b. Subject 2

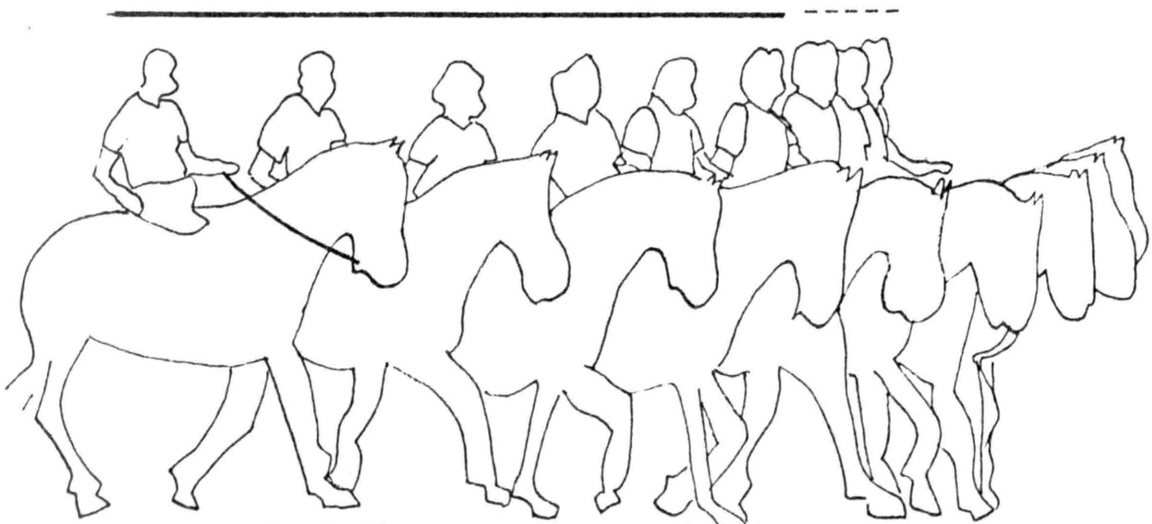


______ Trot Phase ----- Halt Phase

c. Subject 3



d. Subject 4

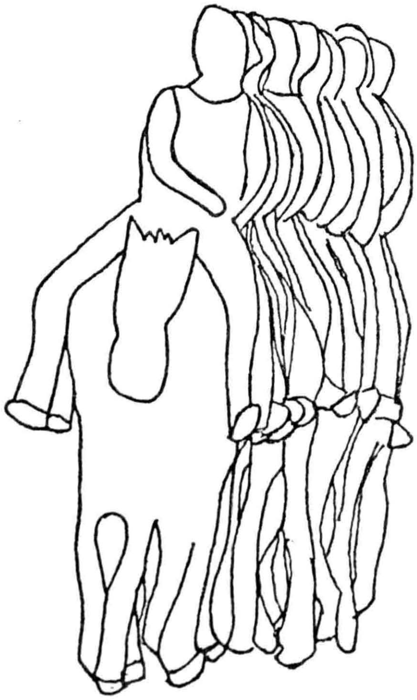


_____ Trot Phase ----- Halt Phase

Front View Tracings of Handicapped and Nonhandicapped Subjects Performing the Stop-Walk

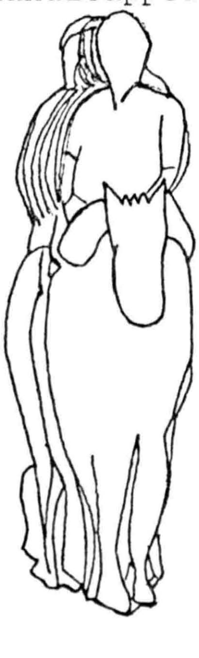
a. Subject 1 (Nonhandicapped Female)

b. Subject 2 (Handicapped Female)



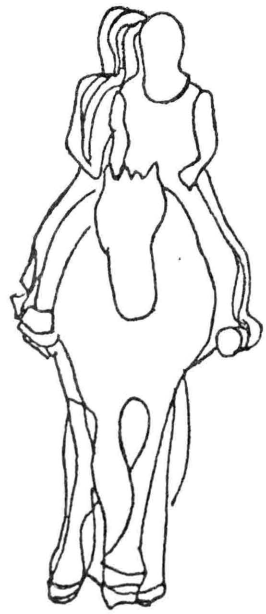
c. Subject 3 (Nonhandicapped Male)

d. Subject 4 (Handicapped Male)

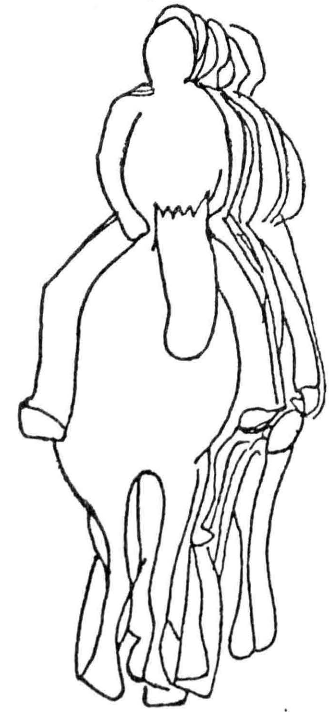


Front View Tracings of Handicapped and Nonhandicapped Subjects Performing the Walk-Halt

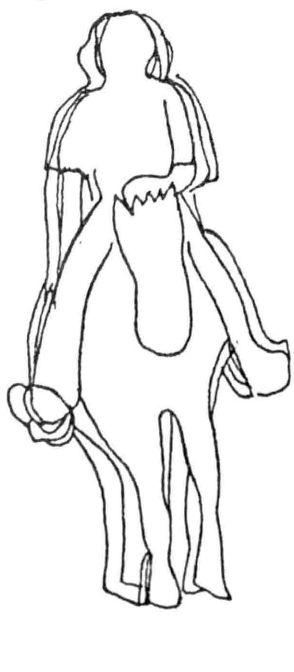
a. Subject 1



b. Subject 2



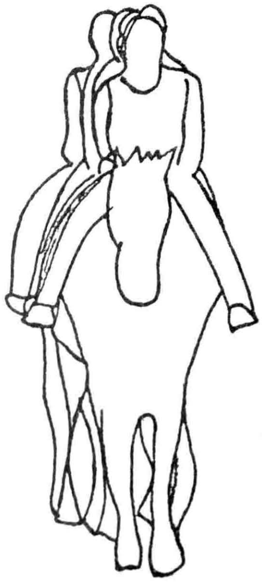
c. Subject 3



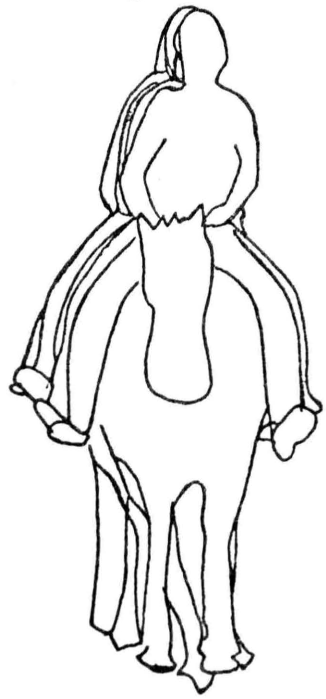
d. Subject 4

Front View Tracings of Handicapped and Nonhandicapped Subjects Performing the Walk-Trot

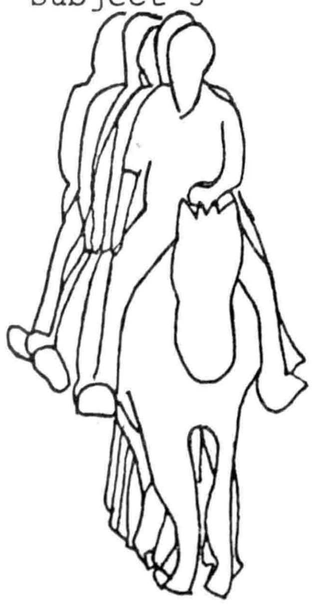
a. Subject 1



b. Subject 2



c. Subject 3

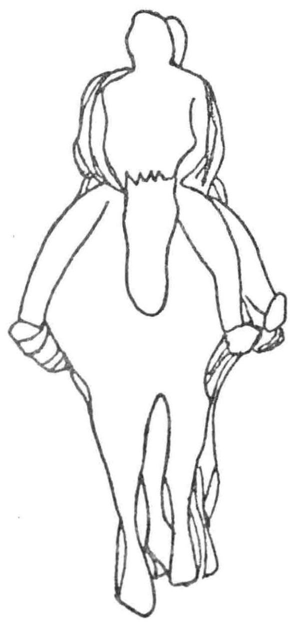


d. Subject 4

Front View Tracings of Handicapped and Nonhandicapped

Subjects Performing the Trot-Halt

a. Subject 1



b. Subject 2

c. Subject 3

d. Subject 4

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