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An Electromyographic and Video Motion Analysis Study of Sprinters at Varying Speeds and Inclines

Christine Ann Rygh

University of North Dakota

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AN ELECTROMYOGRAPHIC AND VIDEO MOTION ANALYSIS STUDY OF SPRINTERS AT VARYING SPEEDS AND INCLINES

by

Christine Ann Rygh
Bachelor of Science in Physical Therapy
University of North Dakota, 1999

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
School of Medicine
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

Grand Forks, North Dakota
May
2000
This Independent Study, submitted by Christine Ann Rygh in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

(Faculty Preceptor)

(Graduate School Advisor)

(Chairperson, Physical Therapy)
PERMISSION

Title An Electromyographic and Video Motion Analysis Study of Sprinters at Varying Speeds and Inclines

Department Physical Therapy

Degree Master of Physical Therapy

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Date ________________________________
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Finally, thank you to my parents who have continuously loved and supported me throughout all my years. They have provided me with the strength and encouragement to pursue my goals and dreams.
ABSTRACT

Athletes desire to succeed in their respective sport. Several training programs claim to enhance athletic performance by loading specific muscles and joints needed for increased speed, power, and strength in a sport specific manner. One such training regimen is the Frappier Acceleration® program, in which the core element involves sprinting on a treadmill at varying speeds and inclines. The purpose of this study is to describe muscle activity and joint motion while running on a treadmill at different speeds and inclines.

Eleven males between the ages of eighteen and twenty-two years of age ran on a treadmill at five different conditions at varying speeds and inclines. One of these trials consisted of the subject walking at 2.4 mph and a 0 percent grade in order to obtain a baseline for comparison of the other four trials. Surface electrodes and joint markers were used to analyze electromyographic activity of eight muscles and calculate joint angles while running. A descriptive analysis was then performed comparing the five trials.

From our results we conclude that the sprinter does adopt different strategies and muscle recruitment patterns to compensate for increases in slope. There is an increase in EMG activity in the Vastus Lateralis, Rectus Femoris, Gluteus Maximus, and Tibialis Anterior when running at 8 mph and 25 percent grade when compared to the level condition, and an increase in the EMG activity of all recorded muscles when running at 13 mph and 25 percent grade vs. level running. Examination of range of motion revealed...
that there was greater overall motion of the hip on the incline trials while displacements of the knee and ankle were relatively similar.
CHAPTER 1
INTRODUCTION

Many athletes desire to succeed in their respective sport. The increasing technology of human performance enhancement has given athletes an outlet to become bigger, faster, and stronger than conventional methods of training. These athletes yearn for ways to optimize their potential above their competitors. Several programs claim to enhance athletic performance by loading of the specific muscles and joints needed for increased speed, power, and strength within a sport specific manner. One such training regimen is the Frappier Acceleration® program, in which the core element involves sprinting on a treadmill at varying speeds and inclines.

Problem Statement

The problem lies in the limited amount of research available to attest to the efficacy of this training technique. Further research is needed to validate the use of this training method in order to endorse its use in training athletes. Although research regarding treadmill training is available, there is a need to evaluate whether differences, if any, exist between level treadmill running and incline treadmill running at speeds above 8mph.

Purpose of Study

The purpose of this study is to describe muscle activity and joint motion while running on a treadmill at different speeds and inclines. Elite sprinters were recruited for this study in order to examine whether or not running on a level treadmill, and on an
incline causes particular muscles to work harder or the sprinter to change their running technique to accommodate the workload of the varying conditions.

Significance of Study

The data collected will provide information concerning muscle activity and joint angles during sprinting at four varying conditions. This information will promote the understanding of the biomechanics of elite sprinters and provide a basis for developing protocols specifically designed for training an athlete.

Research Questions

1) What muscles are active during sprinting?
2) Are these muscles more highly recruited while sprinting on an incline?
3) What body angles are consistent with elite sprinters at high speeds during varying inclines?
4) How do elite sprinters change their running strategies to adapt to higher speeds at these varying inclines?
5) How do elite sprinters change their running strategies to adapt to increased inclines?

Hypothesis

Null: Muscles recruited and joint kinematics do not change while running on an incline compared to level treadmill running.

Alternate: Muscle recruitment and joint angles change with increased speed and incline.
CHAPTER 2

REVIEW OF THE LITERATURE

Introduction

One of the primary goals, in order to better an athlete, is to increase his/her maximum sprint speed. By increasing the two components of speed, stride length and stride frequency, optimal speed may be attained\(^1,2\). Recent training techniques include treadmill running at speeds and grades over 4.5 m/h and 30%, respectively, to improve sprinting performance\(^3\). Substantial gains in sprint times (40 yd. dash) have been associated with such training protocols. The training protocols utilized are designed to increase muscular loading of the hip, knee, and ankle extensors during stance and the hip flexors and extensors during recovery\(^3\). These muscle groups have been suggested to be the primary generators of forward propulsion during running and sprinting\(^4,5\).

Incline running helps each athlete learn and maintain knee drive, proper pelvic and trunk position, forceful contraction of the lower extremity, optimal stride length and properly coordinated upper extremity movement\(^1\). Several studies have been published on the kinematic and EMG analysis of level running\(^4,5,6,7\), but very few have concentrated on incline sprinting. Examination of kinematic and EMG data obtained during incline sprinting may provide insight into how the body adapts to perform under these conditions. Analysis of these factors may enhance our understanding of the effectiveness of training programs that utilize incline sprinting protocols.
Gait Cycle

The gait cycle of walking is divided into two phases: stance and swing. Stance phase usually accounts for 60 percent of the gait cycle and swing phase accounts for 40 percent. The stance phase is then further divided into initial contact, loading response, midstance, terminal stance, and preswing. The swing phase consists of three periods: initial swing, midswing and terminal swing. During the walking gait cycle, there are two periods of double support. These occur during the period of loading response and preswing, the first and last 10 percent of stance phase. Single limb support is experienced during swing phase of the opposite foot.

The running cycle consists of two phases: support and swing. The support phase is further divided into foot contact, midsupport and toe-off. Foot contact occurs from initial contact to full weight acceptance; midsupport is from full weight acceptance until plantar flexion begins; and toe-off defines the period from the beginning of plantar flexion until toe-off. Swing phase consists of three periods: follow-through, forward swing, and foot descent. Follow-through takes place from toe-off until the hip reaches maximum extension. The period of time from the initiation of hip flexion to maximum hip flexion is forward swing, and foot descent occurs until foot contact.

Sprinting has several characteristics that distinguish it from walking. There is no longer a period of double support, as there is during walking. Instead, a person becomes airborne and displays a double float phase at the beginning and end of swing phase. As velocity increases, there is an increase in float time and a subsequent decrease in time spent in stance to less than 50% of the sprint cycle. Mann (1980) states that as speed increases, stance time decreases from 62 percent of the gait cycle at a walk to 31 percent.
while running and 22 percent while at a sprint. There is also a noted increase in stride length and stride frequency with increased velocity\textsuperscript{1,4,6,9}. A final difference between walking, running, and sprinting is the manner in which the foot first contacts the ground. In walking, the heel strikes the ground first and is followed by a foot-flat phase. Approximately 80% of runners make initial contact with the posterolateral border of the foot, while the other 20% of runners are generally mid-foot strikers. Sprinters differ in that they contact the ground in plantar flexion or with toe-first contact\textsuperscript{6}.

**Joint Angles During Level Sprinting**

As speed increases, the range of motion (ROM) occurring at the hip, knee, and ankle increases. There is generally an increase in hip and knee flexion and ankle dorsiflexion which helps to lower the center of gravity (COG) and prevent excess vertical displacement\textsuperscript{4,6}. Mann et al.\textsuperscript{4} found that hip flexion increases from 40 degrees at a jog to 60 degrees while running and 80 degrees at a sprint with the maximum amount occurring at two-thirds of swing as contralateral toe-off occurs. During support, the hip extends from about 50 degrees to 15 degrees followed by maximum hip extension just at or after toe-off\textsuperscript{4}.

During support phase of a sprint, the knee never fully extends, remaining in about 30-40 degrees of flexion\textsuperscript{4}. During walking, the knee joint flexes approximately 10 degrees, after which extension occurs. While running, the knee joint flexes to approximately 35 degrees and is also preceded by extension. In contrast, approximately 20 degrees of flexion occurs during the support phase of sprinting, with no second period of knee extension. Knee flexion then continues into swing phase and peaks at 130 degrees\textsuperscript{11}. The knee remains in flexion until the toes of the ipsilateral swing leg pass the
knee of the support leg. This keeps the leg mass close to the hip joint, shortening the radius of the lever arm and increasing the angular speed. Momentum is thus decreased, producing a low inertia so it takes less effort to accelerate the limb’s mass\textsuperscript{1,2,12}.

When sprinting, the ankle contacts the ground in about 8 degrees of plantar flexion and moves into 15 degrees of dorsiflexion during stance, followed by 35 degrees of plantar flexion just after toe-off. The degree of dorsiflexion at foot contact decreases, as speed increases. During swing, dorsiflexion occurs through forward swing; then plantar flexion begins, reaching its maximum just prior to foot contact, upon which dorsiflexion begins again\textsuperscript{4}.

**Muscle Activity In Stance**

With an increase in speed, muscle activity in the lower extremity also increases\textsuperscript{7,13}. At the hip, the gluteus maximus (GM) is active concentrically during the first half of support to continue hip extension. Muscle activity then decreases during the remainder of support until swing phase. As the speed of gait increases, early support activity of the GM decreases. The rectus femoris (RF) acts eccentrically following foot contact and early midsupport to stabilize the knee joint as flexion occurs\textsuperscript{4}. The RF has two periods of peak activity, one of which occurs during support phase concurrently with the peak activity phase of the GM and the hamstrings. This co-contraction provides increased stability and support\textsuperscript{7,14}. The second peak of RF activity is experienced during swing while the hamstrings and GM show their lowest activity\textsuperscript{14}. The hamstring muscles demonstrate essentially the same amount of activity in the medial and lateral groups\textsuperscript{4}. The biceps femoris (BF) peak activity occurs at foot-strike and continues, along with the other hamstring muscles, into the first half of support phase\textsuperscript{14}. The greater the speed, the
longer the period of activity. The BF becomes active, once again, during the push-off phase of sprint running\textsuperscript{3,4}.

In the lower leg, the gastrocnemius (GA) is active at foot contact through midsupport and again at toe-off\textsuperscript{15}. During the first half of support, the GA acts eccentrically to control the forward movement of the tibia over the fixed foot as rapid dorsiflexion occurs. At toe-off, the GA undergoes a concentric contraction which plays a primary role in forward propulsion\textsuperscript{7,14,15}. The tibialis anterior (TA) is active during the first half of support phase to assist in stabilizing the ankle joint and probably to assist in dorsiflexion of the ankle joint\textsuperscript{4}.

At the trunk, the erector spinae (ES) displays activity during early mid-support, while the rectus abdominus (RA) performs an eccentric contraction as the hip extends during toe-off of stance phase\textsuperscript{11}.

**Muscle Activity During Swing**

The second peak of the RF begins during swing as it acts concentrically to flex the thigh forward\textsuperscript{4,5,7}. Knee extension in sprinting is a mainly passive phenomenon and is due to the inertia of the tibial segment rather than activity of the quadriceps femoris. An eccentric hamstring contraction acts to continue this passive knee extension and also acts eccentrically just prior to maximum hip flexion to restrain the hip joint\textsuperscript{10}. The short head of the BF continues to flex the knee with the assistance of the momentum provided by active hip flexion\textsuperscript{16,17}. The GM activity peaks during late swing phase as the hip extends\textsuperscript{14}.

At the ankle, the TA shows a twin-peak activation pattern. The first peak occurs at the beginning of swing phase to bring about dorsiflexion at the ankle joint. Activity
continues throughout swing, with a second peak occurring just before foot-strike. At this point, the TA acts as an antagonist to the GA muscle's preparing for foot contact\textsuperscript{14}. The GA acts concentrically at the end of swing phase in preparation for the toe-first contact observed in sprinting\textsuperscript{4}.

**Incline Sprinting**

Swanson\textsuperscript{3} ran subjects at 4.5 m*s\textsuperscript{-1} and +30\% grade and at this same stride frequency on a 0\% grade. His results reveal that during incline sprinting, all lower extremity joints display significantly more flexion at footstrike than when running on a flat surface. The hip extends rapidly at foot-strike, continues to extend at a slower rate during the impact phase (foot strike to the point of peak knee flexion), and rapidly extends during push-off (peak knee flexion to toe off). In comparison, the hip is flexed during impact then extends until toe-off during level running\textsuperscript{3}. An increase in extension ROM is found at toe-off, which places the hip flexors on stretch and facilitates a stronger contraction\textsuperscript{1}.

The knee joint angle remains relatively constant during impact phase of incline running, then rapidly extends for push-off. During level running, it follows the typical flexion/extension sequence of gait. Knee flexion ROM is greater during impact phase of level sprinting as the knee actually extends when on an incline. During push-off, knee extension ROM is significantly greater for the incline condition\textsuperscript{3}.

At the ankle joint, more dorsiflexion is noted at footstrike and throughout impact with incline sprinting. This increased dorsiflexion angle, along with similar angles of plantar flexion at toe-off, allows for greater plantar flexion ROM than displayed with level sprinting; however, the maximum plantar flexion angle is actually smaller\textsuperscript{3,18}. An
increased dorsiflexion angle also places the GA/SOL in a more stretched position, which activates the stretch reflex and produces a more powerful contraction at toe-off.  

During swing, the hip displays a greater maximum flexion angle and total ROM when running on an incline. Maximum knee flexion angles and knee and ankle total ROM also increased respectively with the incline condition in Swanson's study. In comparison, Gould et al. did not find increases in maximum knee flexion angles on a 30 degree incline vs. level running.  

The most notable difference between flat and incline conditions was the increase in stance phase activity of the mono-articular muscles (SOL, GM, and VL) and the bi-articular GA and RF. Gould et al. also found increases in activity of the TA, rectus abdominus, and RF when running on an incline. Following footstrike, decreases were found in the antagonist activity of the medial hamstrings (MH) and biceps femoris (BF). Hip extension activity (GM, MH, BF) before footstrike was similar between level and incline running, while the GA displayed higher amplitude during level running. The SOL, VL, and RF displayed similar activity prior to footstrike in both conditions.  

During swing phase of incline running, Swanson's study reveals that the hip displays a similar pattern to level running. This consists of early eccentric hip flexor activity from 0-10% of swing, concentric hip flexor activity from 10-50%, a brief eccentric hip extensor firing period from 50-65% of swing, followed by a concentric hip extensor activity phase. These similarities in muscle activity at the hip displayed during level and incline sprinting suggest that the MH and BF contribute more to energy generation at the hip during incline running, while they serve more to absorb energy at the knee during level running. The knee follows a pattern of eccentric quadriceps activity
for 50% of swing followed by a distinct period of eccentric knee flexor activity at approximately 70% of the cycle. The VL, SOL and GA had higher activation levels in late swing prior to footstrike during incline running.
CHAPTER 3
METHODS

Subjects

Twelve, healthy males gave their informed written consent to serve as subjects in this study (See Table 1). Two subjects were eliminated from this study due to faulty electrodes and irregular EMG data. The study was conducted at Orthopedic Associates in Fargo, North Dakota. The study was approved by the Institutional Review Boards at the University of North Dakota and Orthopedic Associates (See Appendix).

Table 1. Descriptive Statistics of Subjects

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Range</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>19.1 (years)</td>
<td>18-22</td>
<td>1.60</td>
</tr>
<tr>
<td>Height</td>
<td>70.6 (inches)</td>
<td>69-74</td>
<td>1.87</td>
</tr>
<tr>
<td>Weight</td>
<td>164.2 (pounds)</td>
<td>150-195</td>
<td>14.44</td>
</tr>
</tbody>
</table>

Instrumentation

Electromyography

The electromyographic information was collected by a Noraxon Telemyo 8 telemetry unit (Noraxon USA, 13430 North Scottsdale Rd., Scottsdale, AZ 85254). This information was then transmitted to a Noraxon Telemyo 8 receiver and then digitized by an analog digital interface board in the Peak Analog Module (Peak Performance Technologies, 7388 S. Revere Parkway, Suite 601, Englewood, CO 80112-9765). The
video data and the electromyographic data were synchronized using the Peak Event Synchronization Unit. To start the EMG data collection, the synchronization unit was triggered by a footswitch placed in the subject's shoe. Another switch composed of three piezo-resistive sensors was mounted under the bed of the treadmill and allowed the investigators an additional means to identify when initial contact was occurring. Upon contact of the left foot with the treadmill, an LED light was illuminated in the video image via the footswitch, and a small lamp was activated via the treadmill switch. A switch controlled by the investigator allowed the footswitch circuit to be closed only during the EMG collection period.

**Video**

Eight reflective markers were placed on each subject to represent various joint centers in the sagittal plane. The exact placement of each marker is detailed below. The camera used to film the sprinting activity was a Peak High-Speed Video 60/120 Hz camera (Peak Performance Technologies, 7388 S. Revere Parkway, Suite 601, Englewood, CO 80112-9765). A camera frequency of 60 Hz was utilized during the trials with a shutter speed of 1/250 of a second. The trials were taped on a JVC model BR-S378U videocassette recorder (JVC of America, 41 Slater Drive, Elwood Park, MF 07407). The videotape was encoded with a SMPTE time code generator.

After recording all of the trials, the subjects' movements were digitized using the Peak Motus Software package. The tapes were played back on a Sanyo Model GVR-S955 (Sanyo, 1200 W. Artesia Boulevard, Campton, CA 90220) videocassette recorder for the purpose of digitization.
Electrode and Marker Placement

The skin on the lower extremity was prepared by cleansing it with alcohol and shaving away any excess body hair for the placement of the eight (8) surface EMG electrodes over the chosen muscles. These muscles were chosen because they have been shown in previous studies to be active during sprinting (See Table 2).

The placement of the electrodes was determined by finding each muscle by a previously identified measurement from anatomical landmarks. Figure 1 displays these points anatomically along with a descriptive measurement for each one. The ground electrode was placed on the iliac crest.

The electromyographic signals from the electrodes were input directly to a receiver, which then transmitted the signals into a computer for display and recording of the data. This information was stored on the computer hard drive for future analysis.

Eight reflective markers were placed on each subject to represent joint centers of the upper and lower extremity. The markers were placed at the TMJ, acromion, lateral epicondyle of the humerus, dorsal aspect of the wrist, greater trochanter, lateral femoral condyle, lateral malleolus, and the fifth metatarsal head on the left side of each subject. These markers were illuminated during the trials and captured on tape. The marker locations were digitized to allow the sagittal motion of the neck, trunk, arm, forearm, thigh, leg and foot to be analyzed.
Table 2. Origin, Insertion, and Action of Selected muscles for Sprinting.

<table>
<thead>
<tr>
<th>Muscle</th>
<th>Origin</th>
<th>Insertion</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rectus Abdominus</td>
<td>Pubic Symphasis, Pubic Crest</td>
<td>Xiphoid process, 5th to 7th Intercostal cartilage</td>
<td>Flex trunk, Stabilize pelvis during walking</td>
</tr>
<tr>
<td>Gluteus Maximus</td>
<td>Posterior Crest of Ilium, Sacrotuberous ligament</td>
<td>Iliotibial Tract, Gluteal Tuberosity</td>
<td>Extend thigh, Laterally rotate thigh, Extend trunk</td>
</tr>
<tr>
<td>Rectus Femoris</td>
<td>Anterior Inferior Iliac Spine</td>
<td>Base of the Patella, Tibial Tuberosity</td>
<td>Extend leg, Flex thigh</td>
</tr>
<tr>
<td>Biceps Femoris</td>
<td>Ischial Tuberosity</td>
<td>Head of Fibula</td>
<td>Flex knee, Extend thigh, Extend trunk</td>
</tr>
<tr>
<td>Gastrocnemius</td>
<td>Condyles of Femur</td>
<td>Calcaneal Tuberosity</td>
<td>Plantarflexion</td>
</tr>
<tr>
<td>Anterios Tibialis</td>
<td>Upper ½ lateral surface of tibia, Intersosseus membrane</td>
<td>1st Metatarsal, 1st Cuneiform</td>
<td>Dorsiflexion, Inversion</td>
</tr>
<tr>
<td>Vastus Medialis</td>
<td>Medial lip of linea aspera, Intertrochanteric line</td>
<td>Medial surface, top of patella, Tibial tuberosity</td>
<td>Extends knee (leg)</td>
</tr>
<tr>
<td>Erector Spinae</td>
<td>Posterior iliac crest and sacrum, Sacral and inferior lumbar spinous processes, and supraspinous ligament</td>
<td>Fibers run superiorly to angles of lower ribs and cervical transverse processes</td>
<td>Maintain posture, Extend trunk, bilaterally, Rotates trunk, unilaterally</td>
</tr>
</tbody>
</table>
**Gluteus Maximus** - midpoint of a line running from the inferior lateral angle of the sacrum to the greater trochanter

**Rectus Abdominus** - 2 cm superior and 2 cm lateral to umbilicus

**Biceps Femoris** - midpoint of a line from the ischial tuberosity to the lateral femoral condyle

**Semitendinosus** - midpoint of a line from the ischial tuberosity to the medial femoral condyle

**Rectus Femoris** - midpoint of a line from the ASIS to superior pole of patella (minimum of 10 cm above the patella)

**Vastus Lateralis** - along a line ¼ the distance from the lateral knee joint line to the ASIS and over the belly of the vastus lateralis

**Gastrocnemius** - over the muscle belly 1/3 the distance of the leg (fibular head to calcaneus)

**Anterior Tibialis** - over the muscle belly 1/3 the distance of a line running from the lower margin of the patella to the lateral malleolus

Figure 1. Electrode Placement.
Protocol

Conditions

Table 3. Description of Protocol Conditions

<table>
<thead>
<tr>
<th></th>
<th>Speed</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition 1</td>
<td>Walking at 2.4 mph</td>
<td>0% grade</td>
</tr>
<tr>
<td>Condition 2</td>
<td>8 mph</td>
<td>25% grade</td>
</tr>
<tr>
<td>Condition 3</td>
<td>PSF of 8 mph/25% grade</td>
<td>0% grade</td>
</tr>
<tr>
<td>Condition 4</td>
<td>13 mph</td>
<td>25% grade</td>
</tr>
<tr>
<td>Condition 5</td>
<td>PSF of 13 mph/25% grade</td>
<td>0% grade</td>
</tr>
</tbody>
</table>

Calculation of Preferred Stride Frequency

Subjects were allowed to warm-up on the treadmill for 1-2 minutes prior to beginning their trials. Following the completion of the warm-up, the subjects were required to perform 3-4 bouts of exercise on the treadmill at the same speed and incline of condition 2 (8 mph and +25% grade). During each exercise bout, the investigator recorded with a stopwatch the time it took the subject to complete five complete stride cycles. The subjects were allowed to take as much rest as needed between each of the bouts of exercise. The investigator then ran the subject on a 0% grade for condition 3 at a speed that would allow the same preferred stride frequency (PSF) as in condition 2. For condition 3, the investigator timed how long it took the subject to complete five complete stride cycles. The speed for condition 3 at 0% grade was adjusted up or down until the time it took to complete 5 stride cycles for condition 3 was within .2 seconds of the time it took the subject to complete 5 stride cycles for condition 2. Once this was established,
the speed was recorded as the speed that would be utilized for condition 3 in the trials. The subjects then ran 3-4 five second bouts of exercise on the treadmill at the same speed and incline of condition 4 (13 mph and +25% grade) in order to determine the PSF estimation used to dictate the speed that was used in condition 5 on a 0% grade using the same procedure.

Trials

After successful completion of the pre-testing bouts of exercise, each subject completed a total of 5 trials of EMG and kinematic data in only one trial of each condition (C1, C2, C3, C4, C5). Each trial consisted of a six-second bout of exercise on the treadmill. Kinematic and EMG data were collected throughout the trial. The subjects were allowed to take as much rest as needed between trials to minimize any effect of fatigue. Walking was the first trial recorded for all subjects. The four running conditions were performed in a random order determined by blindly drawing out of a hat.

Data Analysis

Prior to videotaping, the camera field was calibrated by videotaping a meter stick. The video footage for each sprinting trial was cropped down to five completed strides and digitized using the Peak system. The software calculated the joint angles and segmental motion. The raw analog data was scaled and matched to the video. Reports were then generated to show anthropometric representation of the motion, joint motion, and integrated EMG data of the sprinting cycles for each trial.

The integrated EMG data was quantitatively processed using the Peak Motus software program. An ensemble average was computed for one complete stride length for each subject. The ensemble average was computed by sampling the EMG activity of
an entire sprinting cycle at 0.5 percent intervals. The ensemble average was computed for one sprinting cycle for each subject with the averaged curves for each subject added together to yield a grand mean curve representative of all the subjects. The data was transferred into the Microsoft Excel program to determine the percent change from walking of each muscle from the ensemble averages of each sprinting condition.

The hip, knee and ankle range of motion was processed similar to the EMG data. That is, an ensemble average was computed for one sprinting cycle for each subject and then averaged to compute a grand mean ensemble average for all of the subjects. Due to the small sample size, statistical testing was not performed.
CHAPTER 4

RESULTS

For each psf/0% grade condition, the speed of the treadmill is increased in an effort to replicate stride frequency of the incline conditions. In Condition 3, the speeds range from 12mph to 13.5mph. In Condition 5, the speeds range from 17mph to 18.5mph. Also, two subjects are eliminated from this study due to faulty electrodes and poor recording of EMG activity. Therefore, nine subjects are used to evaluate EMG and motion analysis.

13psf/0% grade (Condition 5) vs. 8psf/0% grade (Condition 3)

Figure 3 shows the ensemble average curves for hip, knee, and ankle ROM during these two conditions. At the hip joint, Condition 5 has greater total ROM than Condition 3. Differences in total knee and ankle ROM are smaller. At the ankle, Condition 5 elicits the highest degree of plantarflexion peak whereas Condition 3 causes the greatest dorsiflexion.

Figure 4 and 5 show the ensemble average curves for EMG activity of the eight muscles selected. Condition 5 exhibits a higher EMG activity total for all muscles selected compared to Condition 3. In Figure 2, the four muscles showing the largest difference in percent change from walking are RF (340%), RA (288%), VL (221%), GM (219%). The muscle showing the least difference is the GA (91%).

13mph/25% grade (Condition 4) vs. 8mph/25% grade (Condition 2)
Figure 6 shows the ensemble average curves for hip, knee, ankle, ROM during these two conditions. Little difference is noted in hip and knee ROM. At the ankle, Condition 6 displays a greater degree of plantarflexion throughout the entire stride length when compared to Condition 2.

In Figure 7 and 8, the GM, GA, and VL elicit a higher peak in EMG activity during Condition 4 than in Condition 2. However, Condition 4 displays a higher average EMG activity for all muscles selected. The four muscles showing the largest difference in percent change from walking are the RF (654%), RA (522%), BF (371%), and ST (318%), as shown in Figure 2. The muscle showing the least difference is the GA (96%).

8mph/25%grade (Condition 2) vs. 8psf/0%grade (Condition 3)

Figure 9 shows the ensemble average curves for hip, knee, ankle ROM during these two conditions. At the hip, Condition 2 exhibits a greater degree of hip flexion throughout the entire stride when compared to its counterpart. Condition 3, however, attains a higher peak of ROM in both knee flexion and extension. At the ankle, Condition 2 achieves the highest peak of ROM for dorsiflexion.

Figure 10 and 11 show EMG activity for these two conditions. During Condition 2, the VL, RF, GM, GA, and TA exhibit a greater average EMG activity when compared to the level condition. During Condition 3, the RA, BF, and ST are higher in average EMG activity. The muscles that show the largest difference in percent change from walking are the VL (186%), RF (133%), and GM (121%). The muscle showing the least percent change is the TA (13%).

13mph/25%grade (Condition 4) vs. 13psf/0%grade (Condition 5)
Figure 12 shows the ensemble average curves for hip, knee, and ankle ROM during these two conditions. At the hip, Condition 4 exhibits a greater degree of hip flexion throughout the entire stride cycle when compared to Condition 5. However, the level condition elicits the highest peak in ROM for both knee flexion and extension. At the ankle, Condition 5 achieves the highest peak of ROM for dorsiflexion.

In Figure 13 and 14, Condition 5 elicits a higher peak in EMG activity for the GM, VL, BF, ST, GA, and TA when compared to this incline condition. However, Condition 4 shows higher average EMG activity for all eight muscles examined compared to the level condition. The four muscles showing the largest difference in percent change from walking are RF (447%), VL (222%), RA (152%), and GM (136%) as shown in Figure 2. The muscle showing the least is the GA (33%). In addition, Condition 4 displays the greatest average EMG activity for all the muscles tested when compared with the other conditions.
Figure 2. Average EMG activity during treadmill sprinting expressed as a percent change from treadmill walking.
Figure 3.
Figure 4.
Figure 5.
Figure 6.
Figure 7.
Figure 8.
Figure 9.
Figure 10.
Figure 11.
Figure 12.
Figure 13.
EMG Activity Condition 4 vs. Condition 5

Figure 14.
Figure 15.
Figure 16.
EMG Activity for Conditions 2-5

Figure 17.
CHAPTER 5

DISCUSSION

Condition 3 vs. Condition 5

The ensemble average ROM curves show that the hip joint displayed greater total ROM in C5 than in C3. This is consistent with previous results which found that as the speed of gait increased, the total ROM of the hip joint increased along with greater hip flexion. ROM of the knee joint was essentially the same for both running conditions. In contrast, Mann and Hagy\textsuperscript{11} found that as the speed of gait increased, the knee joint demonstrated increased flexion, but the degree of extension decreased. The two speeds being compared in this study may not have had a large enough difference between them to produce changes in ROM at the knee joint such as this. There was little difference in total ROM at the ankle joint between the two conditions. However, the peak plantarflexion angle was slightly greater for C5 than for C3, while C3 displayed greater dorsiflexion following foot contact. This is similar to other research, which found that the degree of dorsiflexion at the ankle joint at foot contact decreased as the speed of gait increased.\textsuperscript{4,11}

When comparing EMG data between C3 and C5, the average EMG activity of the eight muscles examined was greater during C5. These finding are supported by previous research, which concluded that increased electrical activity is seen in all muscle groups as
the speed of gate increases.\textsuperscript{3,4,7,14} The greatest percent change in EMG activity, as compared to the walking baseline EMG, was seen in the RF, RA, VL, and GM, while the smallest increase was shown in the GA.

**Condition 2 vs. Condition 4**

Very little differences in hip and knee joint total ROM were noted when comparing sprinting in C2 and C4. Slight increases were displayed in hip flexion at the faster speed, which is again consistent with the findings of Mann et al.\textsuperscript{4} Total ROM at the ankle was the same for both conditions, although the degree of dorsiflexion was consistently greater throughout the stride cycle at the slower 8 mph/25 percent grade condition, as in the previous comparison.

Increased average EMG activity was again recorded at the faster condition (C4) compared to activity recorded in C2, however, the peak EMG activity of the GM, GA, and VL was greater in C2 just prior to foot contact. Knee extension is initiated secondary to the momentum developed by the rapid hip flexion, and this extension occurs without any electrical activity in the quadriceps. The extension at the knee joint is linked to the flexion of the hip to produce forward movement of the lower extremity.\textsuperscript{4} This burst of VL activity in C2 may be due, in part, to the decreased activity of the hip flexors at this slower speed.

**Change in Incline**

This study revealed that high speed running elicited distinct changes in segmental and muscular coordination. By running the subjects at the same stride frequency for both level and incline conditions, any changes can be attributed to the increase in incline rather than changes in stride frequency. At the hip joint, increases in hip flexion were displayed
throughout the entire stride cycle when running at both speeds on a 25 percent grade vs. the same stride frequencies on a level surface. This is consistent with previous studies which found that the hip flexion angle increased when running on an incline in order to assist in clearing the foot off of the treadmill. Swanson also recorded an increase in the amount of hip extension ROM at push-off on an incline; this was not found in this study in either C2 or C4.

The subjects displayed greater knee flexion and knee extension ROM when running at 0 percent grade in C3 and C5. Swanson found an increase in the knee flexion ROM during the impact phase of stance, as well as during the swing phase when running on a level surface vs. an incline. During push-off, he also recorded an increase in knee extension ROM on the incline condition; this was not consistent with the findings of this study, which recorded equal amounts of knee extension at push-off for all conditions.

The ankle remained in plantarflexion throughout the entire sprint cycle which is in agreement with previous studies. Kinematic results at the ankle differed between C2 and C4 when compared to their respective PSF speed at 0 percent grade. Subjects sprinting at C2 displayed an increase in dorsiflexion ROM at foot contact and throughout the entire stride cycle, as well as an increase in total plantarflexion ROM when compared to C3. In contrast, C5 results showed a greater peak and total dorsiflexion ROM and total plantarflexion ROM than in C4 on the incline. The difference in results may be due to the differences in speed on the incline conditions. Swanson’s results support the findings of C2 in which there is an increase in the degree of dorsiflexion at foot contact when sprinting on an incline, a decreased amount of total dorsiflexion ROM, and an increase in total

40
plantarflexion ROM up to push-off. Gould et al. also supports these findings, as they found increases in dorsiflexion angles when running on an incline in order to clear the foot from the treadmill.

Incline sprinting elicited distinct changes in EMG activity of the muscles measured. The peak amplitude (PA) and average amplitude (AA) of EMG activity for the VL, RF, GM, GA, and TA were greater for C2 vs. C3; while the RA, BF, and ST had a higher PA and AA in C3. The greatest percent change from the baseline walking EMG was seen in the VL, RF, and GM, while the smallest change was in the TA. Swanson found increased activity in these same muscles when he ran his subjects on an incline. He also reported decreased activity at stance in the MH and BF at 0 percent grade. The decrease in hamstring activity on an incline suggests that there is antagonistic inhibition occurring to allow for greater power generation from the hip flexors. Alternately, the subjects may have found the slower speed at 0 percent grade to be very easy and tended to want to run faster. Thus, the increase in hamstring activity in the level condition may be attributed to eccentric, decelerating activity to slow the advancement of the hip and maintain the slower speed. The increase in RA activity on the level condition may be caused by the need to assist in keeping the hips directly underneath the trunk rather than extended behind the subject. When running on an incline, the increase in hip flexion makes this less of a problem. Patterns of activation are also similar to the study by Gould et al., which found increased EMG activity in the GA, TA, RF, and RA on the incline condition and increase activity in the BF and GM on the level sprinting condition. The increase in GM activity in this study is postulated to be caused by the increase in speed that was seen on this level condition. In comparison, the AA of the
EMG activity for C4 was greater for all muscles measured, but the PA was higher for the GM, VL, BF, ST, FA, and TA during C5. The greatest percent change from the baseline walking EMG was again in the VL, RF, and GM with the addition of the RA, but the smallest percent change at this condition was seen in the GA, rather than the TA.

Limitations

A major limitation of this study was the small number of subjects tested. Due to the small sample size, we were unable to run a statistical analysis of the results. We also had some problems with keeping the electrodes on the subjects which made it difficult to obtain accurate EMG data. This caused us to have to eliminate two subjects from the study. When digitizing the data, some subjects required us to manually mark the joints which is less accurate than when done by the Peak system. We also needed to manually mark when foot strike was occurring. The light used to record foot strike was not always bright enough to be seen and resulted in less accurate recording of the event. A more reliable system needs to be developed for further studies. Finally, the PSF was calculated manually with a stopwatch. It would have been more accurate if we could have used a video timing system.

Clinical Implications

The results of this study suggest that incline training may be an effective activity for enhancing sprinting speed. Running on an incline elicited an increased amount of EMG activity in all muscles except the BF, VL and RA, as compared to level running at the same stride frequency. Previous studies have suggested that the extensor muscles are primarily responsible for the propulsive force generated during push-off. Other research claims that the hip musculature becomes the dominant source of work in sprinting with significant
contributions from both the hip flexors and extensors. In contrast, Mann et al. postulates that the majority of the forward propulsion is brought about by the rapid hip flexion of the swing limb, rather than by push-off of the stance limb. The results showed that all mono-articular hip extensors and flexors exhibited higher EMG values during the incline conditions, thus incline training would appear to be beneficial in increasing forward propulsion forces and speed, regardless of the source of generation. The general patterns of EMG activity and joint kinematics were similar between level and incline sprinting providing evidence that incline training is a sport-specific and high velocity activity for increasing speed.

Conclusion

The data revealed that high-speed incline running elicited distinct adaptations in muscular coordination and kinematics. Included in these adjustments are increased EMG activity in the VL, RF, GM, GA, and TA in C2 and all eight muscles in C4, as well as increased hip flexion in both conditions. These results indicate that it may be beneficial for clinicians and trainers to further develop and utilize sprint training protocols on an incline. Such protocols would enhance the specific muscular coordination patterns needed for athlete's to increase their strength and speed effectively.
REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW
University of North Dakota Institutional Review Board

DATE: June 7, 1999

PROJECT NUMBER: IRB-9906-261

Thomas Mohr, Marc Sondreal, Christy Rygh, Jeremy Zimney

NAME: Christy Rygh, Jeremy Zimney

DEPARTMENT/COLLEGE: Physical Therapy

PROJECT TITLE: An Electromyographic and Video Motion Analysis Study of Elite Sprinters at Varying Speeds and Inclines

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on June 11, 1999 and the following action was taken:

☐ Project approved. EXPEDITED REVIEW No. 4

☐ Next scheduled review is on June 2000

☐ Project approved. EXEMPT CATEGORY No. ___________________. No periodic review scheduled unless so stated in the Remarks Section.

☐ Project approved PENDING receipt of corrections/additions. These corrections/additions should be submitted to ORPD for review and approval. This study may not be started until final IRB approval has been received. (See Remarks Section for further information.)

☐ Project approval deferred. This study may not be started until final IRB approval has been received. (See Remarks Section for further information.)

☐ Project denied. (See Remarks Section for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairperson or ORPD.

PLEASE NOTE: Requested revisions for student proposals MUST include adviser's signature.

cc: T. Mohr, Adviser

Signature of Designated IRB Member
UND's Institutional Review Board

Date

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 310 Form may be required. Contact ORPD to obtain the required documents.

(1/98)
EXPEDITED REVIEW REQUESTED UNDER ITEM 3 (NUMBER[S]) OF HHS REGULATIONS

EXEMPT REVIEW REQUESTED UNDER ITEM ____ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED PROJECTS INVOLVING HUMAN SUBJECTS

PRINCIPAL INVESTIGATOR: Thomas Mohr, Marc Sondreal, Christy Rygh, Jeremy Zimney

ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT: PO Box 9037, Dept. Of Physical Therapy, UND

PROPOSED SCHOOL/COLLEGE: Medicine & Health Sciences DEPARTMENT: Physical Therapy PROJECT DATES: 5/1/99 to 5/1/00 (Month/Day/Year)

PROJECT TITLE: An Electromyographic and Video Motion Analysis Study of Sprinters at Varying Speeds and Inclines

FUNDING AGENCIES (IF APPLICABLE): None

TYPE OF PROJECT (Check ALL that apply):

X NEW PROJECT ___ CONTINUATION ___ RENEWAL ____ DISSERTATION OR THESIS RESEARCH X STUDENT RESEARCH PROJECT
___ CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER: Thomas Mohr, PT, Phd

PROPOSED PROJECT: ___ INVOLVES NEW DRUGS (IND) ___ INVOLVES NON-APPROVED USE OF DRUG X INVOLVES A COOPERATING INSTITUTION

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATIONS, PLEASE INDICATE THE CLASSIFICATION(S):

MINORS (<18 YEARS) ___ PREGNANT WOMEN ___ MENTALLY DISABLED ___ FETUSES ___ MENTALLY RETARDED
PRISONERS ___ ABORTUSES ___ UND STUDENTS (>18 YEARS)

IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE

IF YOUR PROJECT HAS BEEN WILL BE SUBMITTED TO ANOTHER INSTITUTIONAL REVIEW BOARD(S), PLEASE LIST NAME OF BOARD(S): Red River Sports Medicine, Fargo, ND

Status: _____ Submitted; Date X Approved; Date 5/6/99 ______ Pending

1. ABSTRACT: LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.

Sports training facilities are inundated every year with athletes who want to enhance performance. The challenge is to develop training techniques to meet these performance goals. One technique that is being utilized clinically is training athletes on high quality treadmills. These treadmills allow the athlete to run at high speeds and various grades of incline that simulate functional activities.

The purpose of this research project is to describe muscle activity and joint motion while running on a treadmill at different speeds and inclines. The muscle activity will be collected via electromyographic procedures using surface electrodes. Motion analysis video equipment will be utilized simultaneously to film the subject. This will allow us to analyze the EMG data along with joint movement. The data from this study will be used to describe normal patterns of muscle activity and joint motion which will be used in developing training protocols for athletes.

Normal, trained, healthy subjects will be used in this research project. Human subjects are needed for this EMG research study in order to determine when the selected muscles are active when running at high speeds and at various grades of incline.
PLEASE NOTE: Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

2. PROTOCOL: (Describe procedures to which humans will be subjected. Use additional pages if necessary.)

Subjects:
It is anticipated that we will recruit 10 male subjects between ages 18 and 28. The subjects for the study will be recruited from the present UND track team. These subjects will participate voluntarily. These subjects will be chosen due to their athletic abilities since they will be required to run at high speeds and various inclines. They will also have participated in a previous training program, which included treadmill running. The project will be completed at Orthopedic Associates in Fargo, ND. Prior to performing, each subject will be asked to complete a consent form. The subjects will not be compensated.

Methods:
Prior to the running trials, each subject's age, height, and weight will be recorded. During the trial, we will measure electromyographic (EMG) activity in selected trunk and lower extremity muscles. We will measure activity in the following muscles while the athletes are running on the treadmill: 1) rectus abdominus, 2) gluteus maximus, 3) rectus femoris, 4) biceps femoris, 5) anterior tibialis, 6) gastrocnemius, 7) vastus medialis and 8) erector spinae. The study will be performed by Thomas Mohr, chairman of the physical therapy department and three graduate students: 1) Marc Sondreal, 2) Christy Rygh, and 3) Jeremy Zimney.

To record EMG activity, adhesive electrodes will be placed over each muscle. The precise electrode placement will be determined from standard electrode placement charts. Prior to placing the EMG electrodes, the skin over each placement site will be prepared by cleansing the skin with alcohol. The EMG signals will be transmitted to a receiver unit and then fed into a computer for display and recording of data. Prior to beginning the experimental trial, the researcher will apply manual resistance to the subject's lower extremity in order to elicit a maximal voluntary contraction from each muscle being monitored in this study. The muscle activity recorded during the maximal voluntary contraction will be considered as a 100% EMG activity level to which the EMG activity during exercise on the treadmill can be compared. This procedure is done to normalize the EMG data for later analysis.

Video analysis will be used to measure upper extremity, lower extremity and trunk range of motion during the activity. Reflective markers will be attached to the trunk and lower extremity using double-sided adhesive tape. We anticipate placing markers on the shoulder, elbow, wrist, hip, knee and ankle. Video cameras will be placed on the side of the subject and will film the subject's trunk and lower extremity markers and motion during the experimental trial. This will be recorded on videotape and will be transferred to a computer for analysis.

The athlete will walk at 0% treadmill incline, and then run at approximately 8.0 and 13.0 mph with 0% and 25% grades of the treadmill incline. At each incline the athlete will walk and then run for a total of six seconds at each level in order to obtain the necessary data for analysis. A typical trial would consist of the subject walking at 0% incline for six seconds, followed by a three minute rest period. The subject would run for six seconds at one of the four speeds and grades (i.e. 8.0 mph @ 0%, 13.0 mph @ 0%, 8.0 mph @ 25%, 13.0 mph @ 25%). The subjects will be given a three minute rest period between trials. The order of the running trials will be determined by random assignment.

Data analysis:
Descriptive statistics describing the subjects' anthropometric profiles will be provided. The mean activity of each monitored muscle will be calculated. The EMG data collected during the experimental trials will be expressed as a percentage of the EMG activity recorded during the maximal contraction prior to the experimental trials (i.e. normalized). The video image will be converted to a stickman-like figure, from which we can determine joint angles and limb velocity. The EMG data is synchronized with the video data, to determine the level of EMG activity during the various running trials.
3. **BENEFITS:** (Describe the benefits to the individual or society.)

The data collected throughout this research study will be analyzed to determine which muscles are active when the athlete is running at high speeds and various inclines. The body angles will also be analyzed to examine the running strategies at these various speeds and inclines. The data should provide information on which muscles are active during running, and this information will provide the basis for developing protocols specifically for training athletes. It will also further the available knowledge base of research in this area.

4. **RISKS:** (Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject’s dignity and self-respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to insure the confidentiality of data obtained, including plans for final disposition or destruction, debriefing procedures, etc.)

The risks involved in this research project are minimal. The EMG and video analysis equipment causes no discomfort to the subject, since they are both monitoring devices. Because the video information is converted to stickman-like diagrams, the actual subject’s video is not used in data reporting. Therefore, the subject is not recognizable.

The process of physical performance testing does impose a potential risk of injury to the muscle. The testing will occur in a controlled setting, and because only subjects who have already been trained on the treadmill at the proposed speeds and inclines, the risk of injury is minimal. The participant will be closely observed throughout the activity on the treadmill to decrease the potential of harm. However, the activity that this athlete will be performing carries with it the same amount of risk as running at the elite levels to which the participant is accustomed. The investigator or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. Since the electrodes are used for recording only, there is no risk of injury from them. There may be a slight redness following removal of the electrodes, but this will only be temporary.

In the event that this research activity (which will be conducted at Orthopedic Associates) results in a physical injury, medical treatment will be available, including first aid, emergency treatment and follow up care as it is to a member of the general public in similar circumstances. Payment for any such treatment must be provided by you and your third party payment, if any.

The subjects' names will not be used in any reports of the results of this study. Any information that is obtained in connection with this study and that can be identified with the subject will remain confidential and will be disclosed only with the subject's permission. The data will be identified by a number known only by the investigator.
5. **CONSENT FORM:** A copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject’s rights will not occur.

Describe where signed consent forms will be kept and for what period of time.

Consent forms will be kept in the Physical Therapy Department at the University of North Dakota for a period of 3 years, after which time they will be shredded.

6. For **FULL IRB REVIEW** forward a signed original and thirteen (13) copies of this completed form, and where applicable, thirteen (13) copies of the proposed consent form, questionnaires, etc. and any supporting documentation to:

   Office of Research & Program Development
   University of North Dakota
   Grand Forks, North Dakota 58202-7134

   On campus, mail to: Office of Research & Program Development, Box 7134, or drop it off at Room 105 Twamley Hall.

   For **EXEMPT** or **EXPEDITED REVIEW** forward a signed original and a copy of the consent form, questionnaires, etc. and any supporting documentation to one of the addresses above.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University’s policies and procedures governing the use of human subjects.

**SIGNATURES:**

Principal Investigator

Date

Project Director or Student Adviser

Date

Training or Center Grant Director

Date

(Revised 3/1996)
May 6, 1999

Dr. Tom Mohr, Chairman
UND School of Medicine
P.T. Department, Box 9037
Grand Forks, ND 58202-9037

Dear Dr. Mohr,

This is to inform you that I have read the research proposal titled “An Electromyographic and Video Motion Analysis Study of Elite Sprinters at Varying Speeds and Inclines”. I support this study and look forward to working together with you and the research team. Thank you for the opportunity to participate in this study.

Sincerely,

John Frappier
President of API
May 6, 1999

Dr. Tom Mohr, Chairman
UND School of Medicine
P.T. Department, Box 9037
Grand Forks, ND 58202-9037

Dear Dr. Mohr,

I have reviewed the research proposal “An Electromyographic and Video Motion Analysis Study of Elite Sprinters at Varying Speeds and Inclines”. As the Medical Director of the Red River Valley Sports Medicine Institute, I approve of and fully support this research endeavor. We look forward to working together with you.

Sincerely,

Mark A. Lundeen, MD
Medical Director RRVSMI
INFORMATION AND CONSENT FORM

TITLE: An Electromyographic and Video Motion Analysis Study of Sprinters at Varying Speeds and Inclines

You are being invited to participate in a study conducted by Marc Sondreal, Christy Rygh, Jeremy Zimney and Thomas Mohr from the physical therapy department at the University of North Dakota. The purpose of this study is to study muscle activity in your trunk and lower extremity while you are running at different speeds and inclines on the treadmill. We will also be measuring the angles of the joints of the upper extremity, lower extremity and trunk while you are exercising. We hope to describe the muscle activity and the different angles that you employ during this bout of exercise. Only trained, normal, healthy subjects will be asked to participate in this study. Your participation, as a member of the UND track team constitutes the proper level of training required for this study.

You will be asked to run on the treadmill for a total of five (5) trials consisting of the following: 1) Walking on the treadmill at 3.4 mph with 0% grade, 2) Running on the treadmill at approximately 8 miles per hour with 0% grade, 3) Running on the treadmill at approximately 8 mph with 25% grade, 4) Running on the treadmill at approximately 13 mph with 0% grade, and 5) Running on the treadmill at approximately 13 mph with 25% grade. You will be given a rest period between trials.

The study will take approximately one hour of your time. You will be asked to report to the Acceleration Training Department at Orthopedic Associates in Fargo, ND, at an assigned time. You will then be asked to change into gym shorts for the experiment. We will first record your age, gender, height and weight. During the experiment, we will be recording the amount of muscle activity and the angles of your joints that is present when you run on the treadmills at the five different settings.

Although the process of physical performance testing always involves some degree of risk, the investigator in this study feels that, because of your prior training, the risk of injury or discomfort is minimal. In order for us to record the muscle activity, we will be placing nine electrodes on your trunk and lower extremity. The recording electrodes are attached to the surface of the skin with an adhesive material. We will also attach reflective markers at various points on your arm, leg and trunk. These devices only record information from your muscles and joints, they do not stimulate the skin. After we get the electrodes and markers attached, we will give you a brief training session to re-familiarize you with the treadmill. The amount of exercise you will be asked to perform will be moderate. There may be a slight redness following removal of the electrodes, but this will only be temporary.

Your name will not be used in any reports of the results of this study. The video taped data will be analyzed by a computer and the markers placed on your body will be used to construct a "stick man" like figure. Your real, photographic image will not be used in reporting of the findings of the study. After analysis, the video tapes are erased. The consent forms are kept in the physical therapy department for three years and then are shredded. Any information that is obtained in connection with this study and that can be identified with you will remain
confidential and will be disclosed only with your permission. The data will be identified by a number known only be the investigator. The investigator or participant may stop the experiment at any time if the participant is experiencing discomfort, pain, fatigue, or any other symptoms that may be detrimental to his/her health. Your decision whether or not to participate will not prejudice your future relationship with the Physical Therapy Department or the University of North Dakota. If you decide to participate, you are free to discontinue participation at any time without prejudice.

The investigator involved is available to answer any questions you have concerning this study. In addition, you are encouraged to ask any questions concerning this study that you may have in the future. Questions may be asked by calling Dr. Thomas Mohr at (701) 777-2831. A copy of this consent form is available to all participants in the study.

In the event that this research activity (which will be conducted at Orthopedic Associates) results in a physical injury, medical treatment will be available, including first aid, emergency treatment and follow up care as it is to a member of the general public in similar circumstances. Payment for any such treatment must be provided by you and your third party payment, if any.

ALL OF MY QUESTIONS HAVE BEEN ANSWERED AND I AM ENCOURAGED TO ASK ANY QUESTIONS THAT I MAY HAVE CONCERNING THIS STUDY IN THE FUTURE. MY SIGNATURE INDICATES THAT, HAVING READ THE ABOVE INFORMATION, I HAVE DECIDED TO PARTICIPATE IN THE RESEARCH PROJECT.

I have read all of the above and willingly agree to participate in this study explained to me by one of the investigators.

Participant's Signature ___________________ Date _____________
REFERENCES


