A CINEMATOGRAPHIC COMPARISON OF TWO LONG-HANG KIP TECHNIQUES ON THE HORIZONTAL BAR

THESIS

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By

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This study used cinematography to determine differences in velocity, acceleration, moments of force, and body centers of gravity in four different positions of two techniques of the long-hang kip. Three female gymnasts performed five attempts of each technique: the traditional method, with an arch in the lower back at the end of the forward swing, and approximate shoulder angle of 180 degrees or more; and the newer method, with no arch in the lower back and approximate shoulder angle of 90 degrees or less. Three USGF-rated judges scored the kips, and due to inability to distinguish between the two techniques, two subjects were eliminated. Major differences occurred in the swing extension, with the newer technique producing more velocity and a higher center of gravity throughout the movement.
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CHAPTER I

INTRODUCTION

The long-hang kip is one of the most important yet most basic moves in gymnastics as it is a connecting element within routines (4). Until fairly recently there has been only one method of performing the long-hang kip. This technique, as acknowledged by Musker (8), includes an arch of the lower back at the end of the forward swing during which there is an approximate angle of 180 degrees or more between the upper arm and trunk (see Figure 1, p.2). A newer method, as demonstrated by Crouse (3) at the Southwest Regional Gymnastics Clinic in Nevada in 1975, has been introduced. In this long-hang kip there is no arch in the lower back and there is an angle of 90 degrees or less between the upper arm and the trunk (see Figure 2, p.2). Although there have been several studies conducted on the conventional method of the long-hang kip, little research has been done with the newer method. There has been no biomechanical comparison of the two techniques to determine if there are any major differences of acceleration, velocity, moments of force, or the path of the center of gravity. The need for this type of research is best explained by Hay (5) when he
Figure 1--stick figure of the long-hang kip with an arch in the lower back (Technique A).

Figure 2--stick figure of the long-hang kip with no arch in the lower back (Technique B).
questions the features of new techniques by asking how the new techniques contribute to or limit performance.

An excellent means of comparing the two techniques is through the use of cinematography. Hubbard (6) believes that cinematography is "an ideal research tool for studying human movement and sport skill," because one can "enlarge or reduce spatial relations, and slow down or speed up action . . . .". Once the movements have been filmed, a biomechanical analysis can be conducted to observe differences. Hay (5) asserts that "it is only by obtaining data on displacement, angular velocity and acceleration, and moments of forces that a motion can be interpreted." Through the use of cinematography and biomechanics one can assess the mechanical values or weaknesses of new techniques.

Statement of the Problem

This study was conducted to compare two techniques of performing the long-hang kip on the horizontal bar using cinematography.

Purpose of the Study

The purpose of this study was to determine the possible differences in velocity, acceleration, moments of force, and the paths of the centers of gravity between the two different kip techniques on the horizontal bar.
Definition of Terms

Angular acceleration.-- the rate at which the angular velocity of a body changes with respect to time (5, p. 45).

Angular displacement.-- a change in angular position with regards to magnitude and direction (5, p. 44).

Angular motion.-- when a body moves along a circular path about some line in space so that all parts of the body travel through the same angle, in the same direction, at the same time (5, p. 12).

Angular velocity.-- the time rate of change of angular motion (1, p. 22).

Backswing.-- the body moves backwards in space away from the vertical poles of the horizontal bar in an angular motion.

Center of gravity.-- that point at which the effective weight of the body is centered (2, p. 5).

Cinematographical analysis.-- motion picture photography which provides a permanent record for detailed analysis and interpretation of human movement in terms of basic Newtonian principles (6, p. 128).

Forward swing.-- the body moves forward away from the vertical poles of the horizontal bar in an angular motion; the final position before hip flexion.

Hip angle.-- the angle between two lines drawn from the shoulder joint to the hip joint to the lateral malleolus.

Kip.-- an extension of the hips from a pike position (3).
**Long-hang kip.**-- the long-hang kip is a movement performed on the horizontal bar or the uneven bars. There is a forward swing, a pike at the hips, and an extension of the hips to bring the body to a resting position on the bar (7, p. 202).

**Pike.**-- a flexion of the hips (8).

**Moments of force.**-- the turning effect produced when a force is exerted on a body that is pivoted about some fixed point (5).

**Radian.**-- one radian is equal to 57.29 degrees of a circle (9, p. 30).

**Segment 1.**-- the part of the body between the ulnar styloid and the shoulder joint.

**Segment 2.**-- the part of the body between the shoulder joint and the hip joint.

**Segment 3.**-- the part of the body between the hip joint and the lateral malleolus.

**Shoulder angle.**-- the angle between two lines drawn from the ulnar styloid to the shoulder joint to the hip joint.

**Technique A.**-- for the purpose of this study, Technique A will be the traditional method of performing the long-hang kip in which the lower back arches at the end of the forward swing and the shoulder angle is approximately 180 degrees or more.
Technique B.-- for the purpose of this study, Technique B will be the new method of performing the long-hang kip where there is no arch in the lower back (the chest hollows) at the end of the forward swing and the shoulder angle is approximately 90 degrees or less.

Velocity.-- velocity is the rate of change of position in a given direction (2, p. 27).

Wrist angle.-- the angle between two lines drawn from the bar to the ulnar styloid to the shoulder joint.

Delimitations of the Study

The study was delimited to the following:

1. Two techniques of the long-hang kip on the horizontal bar were analyzed by cinematography.

2. The camera used was a Red Lake Locam, with a speed of 100 frames per second.

3. The study was conducted with three teen-aged female gymnasts as subjects.

4. The phases of the long-hang kip analyzed were the forward swing, beginning as the body passes directly beside the tension pole of the horizontal bar, the pike, the kip, and the feet passing under the bar.

5. The filming of the performances was restricted to a side view.
Limitations of the Study

The study was limited to the following factors:

1. Three gymnasts were filmed.

2. The filming of the performances was restricted to a side view.

3. The gymnastic judges rated the long-hang kips by subjective evaluation in the selection of the kips to be analyzed.

4. The gymnasts were Calss I, advanced level performers.

Significance of the Study

Too often coaches will accept a new technique of performing a skill without researching the advantages or disadvantages of the new technique. There was a need for this study to be conducted because one of the techniques examined has recently been accepted by many coaches in the field of gymnastics. There has not been a study performed to evaluate the new method of executing the long-hang kip or to compare the two techniques.
CHAPTER BIBLIOGRAPHY


CHAPTER II

REVIEW OF LITERATURE

Introduction

Published research in the area of gymnastics is quite limited. Although this sport has surged forward in the past ten years in popularity and new skills have developed, little has been done to determine what differences exist in the many techniques that are currently used. Through the use of cinematography and other advanced scientific methods the sport of gymnastics could become greatly enhanced. Cinematography offers many advantages in analyzing human motion; velocity, acceleration, and the path of the center of gravity can be charted, as well as many other useful factors.

Long-Hang Kip

Many books and gymnastics manuals contain descriptions and teaching methods of the long-hang kip. A common definition has been provided by Musker (26, p. 221):

The performer jumps forward, grasps the bar and swings forward. On his forward swing he attempts to touch his toes to the mat directly under the bar and then forcefully arches his body. Pressing down on the bar he vigorously pikes his legs forward and upward and raises his shins or insteps to the bar. He holds this position momentarily until
his hips have swung back under the bar at which time he thrusts his legs forward and downward, rotates his body and immediately reaches over the bar with his head and shoulders coming to a front leaning resting position.

This definition describes Technique A. Johnson (23), Loken (25), Ryser (32) and Hughes (22) also state in their books that the back arches at the end of the forward swing. In an article on horizontal bar drills, Biesterfeldt (2) does not indicate the body should arch but that the hand-shoulder-hip line should be straight.

A newer method which is being used more and was seen quite often in the recent Olympic games, is described by Crouse (7):

From the backswing the body is extended and straight; as the body passes vertical the shoulders begin to pull the trunk and raise the body to a horizontal or above position with the shoulder angle 90 degrees or less. The chest is hollow. The hips flex and toes are pulled to the bar. As the toes reach the bar, the hips extend, sending the legs upwards, then outwards, as the shoulders pull down, sending the body to a front support position on the bar.

This method describes Technique B. Cooper and Glassow (6) explain that hollowing the chest is "elevating the shoulder girdle when directly under the point of support." There has been no study performed to analyze this method, as it is relatively new.

There have been two studies conducted which analyze the traditional long-hang kip or Technique A. Bergemann (1) analyzed the motion of the center of gravity of the body.
during the long-hang kip. Displacement and velocity of the center of gravity, times for the occurrence of specific events, angular changes of the major joints, and the displacement of the high bar were calculated for each trial. It was determined that the center of gravity should be higher during hip flexion than it is at hip extension for added velocity during the kipping action, and that the hips should be flexed prior to the end of the forward swing of the shoulder and hip joints to give a smooth circular change in the direction of the center of gravity. It was also concluded that the hips should be extended slightly before the shoulder joint passes beneath the bar, and that the ascension and hip extension phases exhibit the greatest forces acting upon the bar during this movement.

George (16) performed a mechanical analysis of the arched kip on the high bar. He found that the greatest amount of velocity was realized as the performer's center of gravity passed through the lowest vertical point in the pendulum, and the smallest amount of velocity was realized as the performer's center of gravity passed through the median aspect of the final upward swing. It was stated that the data acquired was insufficient to determine if the height of the center of gravity was a prime factor in performing an arched kip. Although the principles in performing an arched kip were the same for all three subjects,
it was noted that there were variations in techniques among the subjects.

Cinematographical Studies

According to Cooper and Glassow (6), the first efforts to study motion were made in the 1870's when a series of cameras were placed along a track to photograph horses. When the pictures were placed side by side they resembled individual frames of present day motion pictures. Researchers such as Bunn (5) and Plagenhoef (30) have performed many cinematographical studies of sports movements. Cureton (8) noted that "genuine progress in the analysis of rapid movement began with the development of cinematography."

There have been several cinematographical studies involving gymnastics. Ferriter (13) and Guerrera (18) conducted cinematographic studies on side horse vaulting. Different tumbling skills have been researched by several authors (12, 14, 21, 24, 34, 35). Skills on the uneven parallel bars have been examined (10, 15, 20), as have still ring performances (11, 28, 29, 33). Other gymnastic events have been analyzed; George (17) and Deslauriers (9) used cinematography to investigate horizontal bar skills, while Blievernicht (3) and Polacek (31) analyzed pommel horse skills.
Thus, cinematography has been utilized in the sport of gymnastics as it has been in many other sports. The value of cinematography is perhaps best stated by Cureton (8, p. 5):

Fairly precise analysis of the external mechanics of many acts of skill may be made by cinematography. The fundamental principle is that directions of movement (angles), dimensions, time relations, and indirect values of force and velocity may all be obtained from the projected film. Since the science of mechanics is an expression of physical laws of equilibrium or movement in terms of these same fundamental or derived measurements, a mechanical analysis of any movement may be made from measurements taken from the screen. Cinematographical analysis consists of the techniques for taking these measurements.

Center of Gravity

The center of gravity in the human body has been of interest to investigators for quite some time. According to O'Connell and Gardner (27, p. 103) it may be defined as ".... the point at which the sum of all moments is equal to 0.... it is the point at which the body can be balanced and remain motionless in any position, provided that it would be suspended or supported at this center."

Methods of determining the center of gravity in the human body were being employed as far back as the 1600's. Borelli, an Italian physicist, devised a method of placing a subject on a board in prone position and moving the board back and forth on a knife-edged support until it balanced. In 1836 the Webers, two German brothers, performed a
similar experiment where they slid the subject back and forth on a board until the board balanced. The center of gravity was determined to be 56.8 percent of the height of the person. In 1889 Braune and Fischer used four frozen cadavers, balanced on a knife-edged surface, to find the center of gravity. They found the center of gravity to be 54.8 percent of the height of the body. According to Cooper and Glassow (6) the most convenient way to find the center of gravity is that method proposed by Reynolds and Lovett. A board is placed on two knife-edged surfaces, one at each end, which are placed on scales that can be computed mathematically. In 1932 Cotton devised a similar method. He used a gravity board, supported by three adjustable bolts and three scales. The subject would stand on the gravity board and the center of gravity was computed mathematically.

All of the above methods are acceptable for static positions, but in most sports the center of gravity needs to be computed during motion. In 1935 Dawson devised a segmental method for this purpose. To determine the center of gravity using his method one must know the percentage of body weight of each segment, which has been determined by several different investigators, including Bernstein, Plagenhoeft, and Kjeldsen. Other critical factors in determining the center of gravity using Dawson's method are knowing the
location of the center of gravity in each segment, and the horizontal and vertical distance of each body segment center of gravity from a horizontal and vertical axis. Cooper and Glassow (6) state that locating the center of gravity in several frames of film using this method can help determine the path of the center of gravity for the entire movement.

Angular Velocity, Angular Acceleration, and Moments of Force

Broer (4) indicates that linear velocity is the distance that an object moves in a given time. O'Connell and Gardner (27) state that angular velocity is calculated much like linear velocity, for when a body moves in an arc, all body parts move through the same angular displacement in the same amount of time. The equation for determining angular velocity, as demonstrated by Hay (19), is:

\[ \omega = \frac{\theta}{t} \]

where \( \omega \) = the angular velocity, \( \theta \) = the angular displacement, and \( t \) = the elapsed time. Plagenhoef (30) explains angular velocity further by stating that it is the first derivative of the displacement of a rotating body segment.

Angular acceleration is the second time derivative of a rotating body segment (30). O'Connell and Gardner (27) define angular acceleration as "the time rate of change of velocity in either speed or direction." Hay (19) gives a
similar definition, noting that angular acceleration is "the rate at which the angular velocity of a body changes with respect to time," and the equation he gives for determining angular acceleration is:

\[ \alpha = \frac{\omega_2 - \omega_1}{t} \]

where \( \alpha \) = angular acceleration, \( \omega_1 \) = the initial angular velocity, \( \omega_2 \) = final angular velocity, and \( t \) = the elapsed time.

Hay (19) defines moment as "the turning effect produced when a force is exerted on a body that is pivoted about some fixed point," and "it is equal to the product of the force and the distance from its line of action to the axis of rotation." According to Plagenhoef (30), the determination of moments of force represent dominant muscle action producing the segment motion. If moments of force are calculated at each segmental center of gravity, it is possible to determine which area of the body is producing more force at a given point during a skill. Moments of force can be calculated for a one, two, or three segment motion. Formulas for all three types of analyses are illustrated by Plagenhoef (30), and it is recommended that a computer be used for the three segment motion analysis.
Summary

This chapter was designed to present literature related to research of the traditional long-hang kip, cinematography, the center of gravity of the human body, angular velocity, angular acceleration, and moments of force. Little research has been conducted on the new technique of performing the long-hang kip even though it is used today by many elite gymnasts. There have been numerous studies in gymnastics using cinematography, but the majority of the studies were conducted to analyze floor skills. There are many methods for determining the center of gravity in a static position, and a method for determining the center of gravity during movement has been devised. Methods of determining angular velocity and angular acceleration are common among authors, and moments of force can be determined best through the use of a computer. With this analysis one can discover dominant muscle action during a skill.
CHAPTER BIBLIOGRAPHY


7. Crouse, Scott, Clinic Lecture, Southwest Regional Gymnastics Clinic, Las Vegas, 1975.


CHAPTER III

PROCEDURES

Three female gymnasts were photographed while performing a series of long-hang kips on the horizontal bar. Using randomized treatment, each subject performed five kips of Technique A and five kips of Technique B. The filming was performed according to procedures recommended by authorities in the field of cinematography. At the completion of filming a computerized analysis of the kips was conducted to determine mechanical differences in the two techniques.

Selection of Subjects

Three advanced level female gymnasts between the ages of thirteen and fifteen years who were adjudged capable of performing both Technique A and Technique B were filmed during five attempts at performing each technique. The gymnasts were between 4'10" and 5'1" in height and weighed between ninety-five and one hundred pounds.

Cinematographical Method

A Red Lake Locam sixteen millimeter camera was used to film the long-hang kips. Due to construction limitations, the gymnasts were filmed from a distance of twenty-six feet,
and the camera was placed perpendicular to the principal plane of movement as suggested by Cureton (2). The camera was locked in place on a tripod to avoid perspective error. A meter stick was photographed at the beginning of the film to provide for conversion factors. To avoid spatial relation problems, the suspension pole of the horizontal bar was used as a vertical reference and a fence line in the background was used as a horizontal reference. The camera was started at the beginning of the backswing and stopped at the completion of the kip.

Camera Speed and Calibration

Plagenhoef (4) suggests most fast motions to be filmed with a camera setting of at least sixty-four frames per second. Although this motion is not considered extremely fast, a faster setting was needed in order to determine the exact moment on film when the gymnasts changed positions. The camera was set at one hundred frames per second for this study. The camera was internally calibrated with a timing light generator; accuracy of frames per second is reported by the manufacturer to be plus or minus one frame per second. This has been verified in accordance with Cureton's (2) method of photographing a falling object.
Preparation of the Subjects

The subjects were weighed to the nearest half pound and body height was measured to the nearest half inch so that the segmental method of determining the center of gravity during motion could be computed in the analysis (1). Landmarks were determined by palpation as suggested by Plagenhoef (4). To help locate joint centers on film, white tape was placed horizontally on the wrist, shoulder, hip, and ankle joints of the subjects. The distances from the wrist to shoulder, shoulder to hip, and hip to ankle were measured to the nearest half inch (4), allowing for a three segment analysis. In filming from a side view, only one-half of the body can be observed, as both arms and legs are doing the same movement. When a kip is performed correctly the only joint centers bending are the wrist, shoulder, and hip; the arms and legs remain straight as if they were only one segment. Plagenhoef (4) gives segment centers of gravity for whole limbs to help compute moments of force for this type of movement.

Analysis of Data

Judging of the Data

Three USGF rated judges scored all five performances of each technique of all three gymnasts. The judging took place in a private room with all three judges scoring the
kips on film at the same time. The judges were instructed to note that the kip was either Technique A, which was defined to them, or Technique B, which was also defined. They were then to assign a score to each kip. The highest possible score could be 9.0, with three points allotted to amplitude, three points to technique, and three points to execution.

**Selection of Data**

Each gymnast performed five long-hang kips of each technique. All three judges judged each kip (see Appendix, p. 52); the three scores were then averaged. The ratings were compared for each kip and the score of Technique A most closely related to the score of Technique B of each gymnast determined which kip of each technique of each gymnast would be used. The judges were unable to distinguish between the two methods on two of the subjects, so only one subject could be used.

**Positions Analyzed**

The positions analyzed were: (1) the forward swing, which is the position just before the hips began to flex, (2) the kip flexion, which began as the hips started to flex, (3) kip extension which began as the hips started to extend, and (4) the feet passing under the bar. The forward swing was analyzed
because of the differences in the body position at the end of the swing, and the last three positions mentioned were selected to be analyzed because at each of these positions the body was changing directions.

**Obtaining Data from the Film**

To obtain data from the film, the film was projected on a Recordak projector and tracings of positions were made (5). A Numonics digitizer, attached to a computer, was used to obtain angles of segments, segment lengths, and segment centers of gravity. Lawton's (3) computer program of forces and moments was utilized to determine angular velocity, angular acceleration, moments of force, and the body center of gravity for the positions.

**Comparison of Technique A and Technique B**

When the data was computed, the two techniques were compared with respect to velocity, acceleration, moments of force, and the paths of the center of gravity. The comparison was made by the use of descriptive statistics for each dependent variable measured in both techniques. Conclusions drawn from the study were based on observed differences in each dependent variable in a contrast of the two performance techniques as reflected by the cinematographical analysis.
CHAPTER BIBLIOGRAPHY


CHAPTER IV

INTERPRETATION OF DATA

Three teen-aged female gymnasts performed five kips of Technique A and five kips of Technique B, with randomized treatment, on the horizontal bar during a filming session. The kips were to be analyzed after three judges rated the performances.

Judging of the Data

Three USGF rated judges simultaneously viewed a film of three gymnasts performing two techniques of the long-hang kip. The judging took place in a private room with a USGF regionally rated, state rated, and associate rated judge scoring the gymnasts. The definitions of the two techniques were read to the judges to help clarify the techniques before the judging began (see Appendix, p. 53). Since the judges were rating only a kip and not a complete routine, the judging form required that the judge check whether or not the kip was Technique A or Technique B (see Appendix, p. 52). The different techniques viewed were randomized so the judges would not know which technique they were rating until they saw the kip. If all three judges did not agree on the technique, that kip was discarded. The kips were rated on a nine point basis, with three points allotted to amplitude,
three to execution, and three to technique. The same deductions from amplitude, execution, and technique that would be made in a regular gymnastic routine were made. The scores for all three judges were averaged to arrive at a composite score. The score of the kips most closely related in each technique of each gymnast was to be used. Due to inability of the judges to distinguish between the two techniques, two subjects were eliminated from the study.

**Interpretation of Data**

When the scores were computed, both kips had received a score of 8.2. The two kips were then analyzed with respect to velocity, acceleration, moments of force, and centers of gravity in four positions.

**Results of the Study**

**Forward Swing**

The forward swing, which was the position just prior to hip flexion, exhibited some major differences, as indicated in Table I (p. 30). All three segments were moving faster in Technique B than in Technique A. There was strong muscle action at the shoulder in Technique B, with the latissimus dorsi muscles and pectoral muscles (6) probably doing most of the pulling as the gymnast was still elevating the body forward and upward to a shoulder angle of 86 degrees and a hip angle of 180 degrees (see figure 3, p. 31). The moments of force were greater in segment one
TABLE I
FORWARD SWING

<table>
<thead>
<tr>
<th>Segments</th>
<th>Moments of Force (gr./cm.)</th>
<th>Velocity (radians per sec.)</th>
<th>Acceleration (velocity)</th>
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<td>-52.7</td>
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<td>Tech. B</td>
<td>3035.4</td>
<td>8.7</td>
<td>291.1</td>
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In both techniques, but Technique B showed more muscle force being exerted. Perhaps this is due to the fact that, as noted by devries (3), "When a muscle pulls at right angles to the bone it is moving, sides A and B will coincide, and all of the muscle's force becomes available to do useful work." Broer (1) adds to this statement by saying, "The more nearly the muscle's angle of pull approaches 90 degrees, the more effective the contraction." This stronger pull at the shoulder and shortening of the radius would justify the faster movement of the legs in Technique B, as "...the radius of movement between the center of rotation and the center of weight must be shortened in order to accelerate velocity" (2). In Technique A the body was stretched from wrist to toe with a shoulder angle of 162 degrees (see figure 4, p.32).
Fig. 3 -- The four positions of Technique B

- Forward Swing
- Kip Flexion
- Kip Extension
- Feet Under the Bar
Fig. 4--The four positions of Technique A
The trunk was arched, causing a hip angle of 193 degrees. The radius was lengthened here, slowing the entire movement down at the end of the swing. However, it is possible to continue the movement successfully using the swing extension in Technique A because the iliopsoas and pectineus (6) muscles of the hip were put on stretch. According to Broer (1) and deVries (3), the more a muscle is put on stretch, the more force it can exert when it contracts. Moments of force indicated that the dominant muscle action for both techniques was in the wrist flexors, with more action being demonstrated by Technique B.

**Kip Flexion**

In Technique A segments two and three were moving very fast and much faster than segments two and three of Technique B, as demonstrated in Table II.

### TABLE II

**KIP FLEXION**

<table>
<thead>
<tr>
<th>Segments</th>
<th>Moments of Force (gr./cm.)</th>
<th>Velocity (radians per sec.)</th>
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<td>Tech. B</td>
<td>7264.0</td>
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<td>-454.8</td>
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<tr>
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<td>76.5</td>
<td>25.3</td>
<td>-531.5</td>
</tr>
</tbody>
</table>
This might be due to a coriolis force of the trunk and legs. According to Plagenhoef (5), a coriolis force is a force produced when a segment is rotating about an axis that itself is rotating. Since the arms had slowed down considerably at the extension in Technique A, the trunk and legs were whipped forward with great force, rotating at the hip and shoulder joints. In the Technique B kip, however, the arms and trunk were still moving upward as the legs began to pike. The dominant muscle action of the wrist flexors in Technique A was in segment one during this position according to the moments of force as listed above. This finding might be attributed to the fact that "even a slight movement at the end of a long lever causes considerable reaction at the other end (1)." When the legs whip upward and forward, the wrist flexors must react. Dominant muscle action in Technique B was in segment two in the pectoralis muscles (6) as indicated by the moments of force; at the beginning of flexion, the shoulders were still pulling the body upwards. In Technique B the body had passed horizontal, and according to Hay (4) "The body reaches an angular velocity of zero at horizontal." This may be the reason for the very small moments of force in segment three; the moment of inertia was decreased and allowed the body to make an easier change of direction (4).
Kip Extension

Techniques A and B showed all three segments accelerating. This may be attributed to the fact that the muscles at all joints were exerting force as the body's center of gravity passed under the bar. Broer (1, p. 274) states:

In order to properly execute swinging suspension movements, it is necessary that force be exerted when the body is directly under the point of support. The performer pulls towards the center of rotation (along the line of the radius), thus increasing the acceleration of the angular velocity. The center of weight rises fast, and this coupled with a shortening of the radius enables the performer to move rapidly.

The shoulders showed considerably more acceleration in both kips, as the shoulders were changing direction and pushing down on the bar to move upward. According to Hay (4), a change in the direction of a motion of a body requires that it be accelerated. This part of the movement involves hip extension, so the hips were beginning to open from the pike (see Fig. 3 and 4, pp. 31-32). In Technique A, the arms were accelerating very fast and much faster than the arms in Technique B, as illustrated in Table III:
TABLE III
KIP EXTENSION

<table>
<thead>
<tr>
<th>Segments</th>
<th>Moments of Force (gr./cm.)</th>
<th>Velocity (radians per sec.)</th>
<th>Acceleration (velocity&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td>S₁ Tech. A</td>
<td>33278.1 924.8</td>
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<td>170.2 -88.8</td>
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<td>S₂ Tech. A</td>
<td>33478.8 6284.8</td>
<td>7.8 5.2</td>
<td>-195.3 -191.0</td>
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<td>S₃ Tech. A</td>
<td>-1970.4 -1019.5</td>
<td>13.3 5.9</td>
<td>-19.5 52.0</td>
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Therefore, the wrist flexors in Technique A were already doing a large amount of pulling in this position. Dominant muscle action in both techniques was in the shoulder flexors - the pectoralis muscles (6) which were pulling to help raise the body above the bar.

Feet Under the Bar

As the feet passed under the bar (see figures 3 and 4, pp. 31-32), both Technique A and B indicated that the trunk and legs accelerated, with the acceleration much greater in Technique B. Table IV indicates this information:
### TABLE IV

FEET UNDER THE BAR

<table>
<thead>
<tr>
<th>Segments</th>
<th>Moments of Force (gr./cm.)</th>
<th>Velocity (radians per sec.)</th>
<th>Acceleration (velocity^2)</th>
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<tr>
<td>Tech. B</td>
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<td></td>
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<tr>
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<td>-161.3</td>
</tr>
<tr>
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<td>586.1</td>
<td>-4.00</td>
<td>-343.8</td>
</tr>
<tr>
<td>Tech. B</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Acceleration at this point is due to the legs swinging downward with the forces of gravity (2). However, segment one is accelerating much more in Technique A, indicating the arms moving forward at a faster rate. The dominant muscle action in this position in Technique A was also in wrist flexors, whereas in Technique B the dominant action was in the upper arm flexors. There was more muscular force exhibited in Technique B in all segments. Since the arms slowed down considerably, a coriolis force might have caused the acceleration of the trunk and legs. The term "moment of force" is used to describe the effective force producing rotary motion (1), and the lever kip, or Technique B, appeared to be producing more muscular force which may lead to an easier cast to a handstand or another element on the bars.
**Center of Gravity**

The center of gravity was higher in Technique B than in Technique A throughout the movement. In Technique B the arms pulled the trunk to a higher position (this shortened the radius) at the end of the forward swing, and it remained higher in all four positions (see figure 5, p. 39). This higher center of gravity may provide for an easier change of direction through the entire motion, for Hay (4, p. 150) states, "If the mass is concentrated close to the axis, it is much easier to alter the angular motion of a body than if the same mass is farther away."

**Summary of the Results**

Three rated judges scored three gymnasts performing five long-hang kips each of two different methods on the horizontal bar. Due to inability of the judges to differentiate between the two methods, only one gymnast could be analyzed. The results of the comparison of Technique A and Technique B revealed that the major differences were:

1. In the forward swing, segments one and two in Technique B were moving faster than segments one and two in Technique A. Dominant muscle action for both techniques was in the wrist flexors. The arms and trunk were moving slowly in Technique A. Moments of force were greater in Technique B in all segments.
1. Swing Extension
2. Kip Flexion
3. Kip Extension
4. Feet Under the Bar

Fig. 5--Path of the center of gravity
2. In Technique A acceleration of segments two and three was much greater than in Technique B during kip flexion. In Technique A dominant muscle action was in the wrist flexors where Technique B demonstrated dominant muscle action in the latissimus and pectoral muscles.

3. In the kip extension phase, both Technique A and B showed acceleration in all three segments, with the trunk demonstrating the most. Segment one in Technique A showed considerably more acceleration than segment one in Technique B. Dominant muscle action was in the hip extensors for both techniques.

4. As the feet passed under the bar, the trunk and legs in Technique B were accelerating much faster than in Technique A. Dominant muscle action in Technique A was in the wrist flexors, where in Technique B the action was in the hip extensors. Technique B showed more muscle force in all segments in this phase than Technique A.
CHAPTER BIBLIOGRAPHY


CHAPTER V

SUMMARY, FINDINGS, AND RECOMMENDATIONS

Summary

The purpose of this study was to compare two techniques of performing the long-hang kip on the horizontal bar with the use of cinematography. The two techniques, for the purpose of this study, were designated as Technique A and Technique B, with Technique B representing an arched kip and Technique B representing the lever kip.

In reviewing the literature, it was concluded that there have been studies performed on Technique A but not on Technique B. In these studies, one researcher looked at the path of the center of gravity in the long-hang kip and the other looked at mechanical aspects during specific points in the kip.

The long-hang kips were filmed from a distance of twenty-six feet perpendicular to the principle plane of movement. Three female gymnasts performed five kips of each technique. Three rated gymnastic judges viewed the film and judged the kips, but due to inability to determine which kip was Technique A and which was Technique B, only one subject could be used. The scores given were 8.2 and 8.2.
When the kips were scored, a mechanical analysis was completed. Four positions were compared: the forward swing, the kip flexion, the kip extension, and the feet passing under the bar. The mechanical values investigated were velocity, acceleration, moments of force, and the body's center of gravity.

The results of the study indicated that major differences in the forward swing were that segments one and two were moving faster in Technique B and that the dominant muscle action in both Techniques was in the wrist flexors. In the kip flexion phase, segments two and three were moving faster in Technique A than in Technique B. Dominant muscle action in Technique A was in the wrist flexors again, while in Technique B the dominant action was in the hip flexors. During the kip extension phase all three segments were accelerating in both techniques. In both techniques during this position the hip extensors were doing more work than in other segments. Segments two and three were accelerating in both Technique A and Technique B as the feet passed under the bar. Dominant muscle action in the last position for Technique A was in the wrist flexors, while in Technique B the upper arm flexors were producing more force.
Findings
Within the limits of the study, the following findings were evidenced:

1. The major differences between Technique A and Technique B were in the swing extension. The radius in Technique B was shortened, causing the body to move faster, but in Technique A there was a long lever, slowing the swing down.

2. Possibly due to a coriolis force, the legs in Technique A were accelerating much faster as the hips began to flex. This caused moments of force to be greatest in the arms because of the law of action-reaction. In Technique B dominant muscle action was in the trunk; there was no coriolis force produced in this type of swing extension before hip flexion.

3. The center of gravity was higher in all positions of Technique B.

Conclusions
1. Since the center of gravity was higher in all positions of Technique B and closer to the axis of rotation, it can be concluded that this method would be easier for this gymnast to perform.
2. As there was more acceleration in Technique B as the feet passed under the bar, it can be concluded that for this gymnast this method would more easily facilitate subsequent movement in a routine.

Recommendations

If further studies were to be conducted on this skill, it is recommended that:

1. Several different body types be analyzed and compared performing both kips.
2. Male gymnasts be used to see if the same results occur.
3. A larger population be utilized and statistical data drawn.
4. Judges be experienced at judging this specific movement and be aware of technique differences.

Bowers (1) and Kjeldsen (2) suggest attending clinics and workshops to stay informed of current techniques.

# SUBJECTS

## Personal Data:

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<tr>
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<th>Subject A</th>
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## Measurements Between Joint Centers:

<table>
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<tr>
<td>Segment 3</td>
<td>29½&quot;</td>
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<td>31½&quot;</td>
</tr>
</tbody>
</table>
Score Sheet

1. **Arched** ____  **Lever** ____  **Score** ____
   - Amplitude ________
   - Technique ________
   - Execution ________

2. **Arched** ____  **Lever** ____  **Score** ____
   - Amplitude ________
   - Technique ________
   - Execution ________

3. **Arched** ____  **Lever** ____  **Score** ____
   - Amplitude ________
   - Technique ________
   - Execution ________
Definitions Read to the Judges

An arched kip will be determined by an arch in the lower back at the end of the forward swing and an approximate angle of 180 degrees at the shoulder. A lever kip will be determined by no arch in the lower back at the end of the forward swing and an approximate shoulder angle of 90 degrees or less.
BIBLIOGRAPHY

Books


deVries, Herbert A., Physiology of Exercise, Iowa, Wm. C. Brown Co., 1975.

Frederick, A. Bruce, Gymnastics for Women, Iowa, William C. Brown Co., 1966.


Reports

Crouse, Scott, Clinic Lecture, Southwest Regional Gymnastics Clinic, Las Vegas, 1975.

Articles


Publications of Learned Organizations


Unpublished Materials


