1990

Qualitative analysis of the final form exams of the skill awards program from Alpine Canada

Kubeck, Kimberley A.

LAKEHEAD UNIVERSITY

A QUALITATIVE ANALYSIS OF THE FINAL FORM EXAMS OF THE SKILL AWARDS PROGRAM FROM ALPINE CANADA

BY

KIMBERLEY A. KUBECK ©

A THESIS

SUBMITTED TO THE OFFICE OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE

OF MASTERS OF SCIENCE

IN

THEORY OF COACHING

SCHOOL OF PHYSICAL EDUCATION AND ATHLETICS

THUNDER BAY, ONTARIO

ABSTRACT

In 1987, Alpine Canada introduced a skill development program for skiers aged 7 to 15 years of age who were enrolled in one of Canada's entry level racing programs. One of the objectives of the program is to raise the skiing skill level of Canadian youngsters. The program includes eight levels of skiing proficiency. Progression through each of the levels is based on the performance of a final form exam which is the culmination of all the basic skill drills at that level. An investigation was conducted in order to develop a theoretical model of a giant slalom ski turn as the framework for the subsequent qualitative analysis of the skills in the eight final form exams.

Using standardized video procedures, data was collected at six different testing sites. Sixty-two performances were selected for qualitative analysis in order to determine; (a) the existence of critical features, and (b) the description of critical features at each of the eight skill levels. The data was subsequently processed using a variety of descriptive techniques.

The data analysis resulted in the identification of 14 features which were used to anticipate the manifestation of critical features, five features which acted as links between the phases of the turn, and eight critical features which were fundamental to the efficiency of the turn. Balance constraints appeared to take precedence over aerodynamic considerations for the skiers at all eight skill award levels. Although the mastery requirements of the critical features increased from Level 1 to Level 8, individual critical features were not equally weighted by all skiers. Variability between performances was attributed to the different ways in which the non-mastered features were manifested.

Future research needs to focus on the development of deterministic models for all alpine skiing disciplines. In addition, the importance of the development of observation plans in order to guide and standardize both quantitative and qualitative skill analyses was highlighted.

ACKNOWLEDGEMENT

The author would like to express her sincere appreciation to Dr. Moira McPherson for her guidance, the use of her plotter, and for the frequent, motivational thesis meetings. Many thanks as well to Dr. Marcel Bouffard and Dr. Tony Bauer for their timely encouragement and advice. The author is indebted to Katarina Siska, the Alpine Canada representative who provided the videotape footage for this investigation, and to the School of Physical Education and Athletics for providing 24 hour access to the microcomputer room.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

Chapter 1

INTRODUCTION

In the fall of 1987, Alpine Canada Alpin introduced a Skill Awards program for young skiers aged 7 to 15 who were enrolled in one of Canada's entry level racing program. The program has three objectives: (a) To raise the skiing skill level of Canadian youngsters, (b) to provide motivation for youngsters to stay involved in entry level programs, and (c) to provide ski coaches with a skill development tool for teaching (Alpine Canada Alpin, 1987).

In the long run, the program should increase the number of knowledgeable coaches at the entry level of alpine ski racing. These coaches will be better prepared to apply coaching strategies appropriate to the age and skill level of the participants. The program should also increase the number of technically efficient skiers entering higher level racing programs. Ultimately, this will allow Canada to further develop a national alpine ski team which can be competitive in all the World Cup Ski events.

The success of the Skill Awards program and the realization of the long term goals rests in part, on the effectiveness of the program to increase the skiing skill level at a faster rate than is occurring at present.

The program includes eight levels of skiing proficiency. An on-snow ski exam (Final Form exam) is performed at the end of each level. The Final Form exam is the culmination of all the

"basic skill drills" performed at that skill level (see Appendix A for a complete list of exams). Upon reaching the eighth level of skiing proficiency, the young racer is considered to be a technically effective skier and she/he is considered to have all the skiing skills necessary to compete at an elite level.

The final forms represent a radical change in skiing skill acquisition and are based on a skill development model for alpine skiing (Alpine Canada Alpin & Canadian Ski Coaches Federation [CSCF], 1986) rather than on the Canadian Ski Instructors' (CSIA) technique which had been used with all entry level racing programs since 1975 (CSCF, 1987). These final form exams need to be studied, to ensure that young racers are being tested on all the skiing skills which are critical to alpine ski racing at the international level.

The aim of this investigation was to develop a theoretical model of the alpine ski turn and then use that model to conduct a qualitative analysis of the Final Form exams.

Purpose of the study

The purpose of this exploratory study was to determine how the critical features of the giant slalom ski turn were manifested in the final form exams of the Skill Awards program developed by Alpine Canada.

Research Questions

In addition to the purpose of the study, the investigator addressed the following questions:

1. What are the performance criterion, the mechanical constructs and the critical features of an elite giant slalom ski turn?

2. Were there any critical features identified during the development of the deterministic model, which were not manifested during the performance of the Final Form exams?

3. Were there any movements observed during the analysis, which were not associated with an identified critical feature?

4. Were there differences between individuals or groups of skiers, with regards to the weighting of critical features at different skill levels?

Delimitations

The study was delimited to:

1. Male and female skiers aged 7 to 15 years, enrolled in an entry level racing program and the Skill Awards program.
2. Analysis of the Final Form exams listed in the eight levels of the Skill Awards program.
3. Analysis of only those features deemed to be critical following the development of a deterministic model for the giant slalom ski turn.
4. The videotape performances selected for the analysis from the sample submitted.
5. Analysis restricted to performances graded "pass" by the Alpine Canada expert.
6. The environmental, equipment and anthropometric conditions that were present at the filming sites.

Limitations

1. The errors associated with video analysis such as: perspective error and poor resolution.
2. The errors associated with using different video cameras for the recording of the performances.
3. The number of qualified Skill Award program coders.
4. The errors associated with approximations of joint and body part positions caused by bulky clothes.

Assumptions

1. The Final Forms performed in each region were all representative of the standard Final Forms as presented in Skill Awards Program video (Husky Oil - Alpine Canada Alpin, 1987).

2. There were no differences in the descriptors of the Critical Features for males and females.

Definition of Terms

Analysis. Analysis refers to a conceptual breakdown of a movement.

Angulation. Angulation is the lateral angle formed by the ankle, knee and hip between sections of the body (CSIA, 1987).

Body lean. Body lean, or inclination refers to the movement of the body towards the inside of the turn in preparation to counteract any external forces (CSIA, 1987).

Camber of the ski. The camber of a ski is a bend constructed into an alpine ski so that when the ski is lying flat on the snow (without any weight on it), the centre of the ski does not be touch the snow.

Canadian ski instructors' alliance. The Canadian Ski Instructors' Alliance (CSIA) is Canada's official professional ski teaching organization.

Carved ski turn. "A carved ski turn exists where the segments of the ski length ride in the track in the snow created by

preceding ski segments." (Lieu & Mote, 1985, p.118)

Critical feature. Critical features are components of a movement and the environment that are critical to the outcome of the performance, they must be observable and have a reason for being observed. Modification of a critical feature should affect the outcome of the performance (McPherson, 1987).

Descriptors. Descriptors are narrative portraits of how a critical feature is manifested.

Deterministic model. A deterministic model is a theoretical model of a skill where; (a) each factor is solely determined by those factors directly below it, and (b) the factors are expressed in mechanical terms (Hay, 1985).

Entry level racing programs. Entry level racing programs are Canadian programs which introduce ski racing to youngsters aged 7 to 15 years of age.

Final Forms/ Final Form exam. Final form exams are skiing maneuvers of the Skill Awards Program which are deemed to be representative of skiing competency at each of the eight skiing skill levels.

Giant slalom ski turn. A giant slalom ski turn is a variation of the Step-Turn, either the Skating Step-Turn or the Parallel Step-Turn, as defined by the Canadian Ski Instructors' Alliance (1987).

Internal rotary force. Internal rotary forces are rotational forces created through muscular contraction.

Leg independence. Leg independence refers to the concept of the

legs working independent of one another with regards to flexion, extension and angulation.

Mechanical construct. A mechanical construct is a descriptor, based on the principles and laws of physics, which illustrates the mechanical purpose or mechanical concepts (i.e. if F = M x A, then M and A are mechanical constructs of force).

Mechanical purpose. The mechanical purpose of a skill is the desired result of skill expressed in mechanical terms. (i.e. the mechanical purpose of the javelin throw is distance) (Kreighbaum & Barthels, 1985).

Performance criterion. The performance criterion is the description of the desired result of a skill performance, expressed as either an objective or subjective measure (Hay & Reid, 1988).

Pivot the feet. Pivoting the feet refers to turning the feet around the vertical axis of the skier (CSIA, 1987).

Primary and secondary errors. Primary errors are performance discrepancies which must be corrected in order for a skill to be performed correctly. Secondary errors are symptoms of primary errors and will be remediated once the primary errors are corrected (McPherson, 1987).

Projection. Projection is " a turning movement of the trunk and/or in the direction of the intended turn, in order to produce an angular impulse which is subsequently transferred to the skis."(CSIA, 1987, p.9-2).

Qualitative analysis. Qualitative analysis is a systematic

analysis of the result of a performance, and of the factors which contribute to the result. It is based upon the application of appropriate mechanical laws, principles and theories to the performance of a skill (Hay & Reid, 1988).

Quantitative analysis. A quantitative analysis involves describing movement in numerical terms (Kreighbaum & Barthels, 1985).

Ski technique. Ski technique is defined as a skier's response (given his repertoire of actions) to the constantly changing situations that s/he encounters while sliding down a slope (Vagners, 1986).

Skidded ski turn. "A skidded ski turn exists when the ski cuts the snow surface everywhere along its edge, the entire length of the ski cuts new snow." (Lieu & Mote, 1985, p.118).

Skill Awards program. The Skill Awards Program is a ski improvement program developed for entry level racers. It is designed to improve skiing skills by providing amateur coaches with a structured curriculum based on a ski development model and by providing the youngsters with rewards for improvement.

Steering. Steering is a subphase where a skier changes direction by countering external forces through the creation of internal muscular forces (CSIA, 1987).

Tall stance. A tall stance refers to a body position where the knees, hips and trunk are fully extended (within the constraints of the equipment), and the ankles are plantar flexed moving the mass over the skier onto the balls of the feet. The upper limbs

are partially flexed and abducted at the shoulder.

Tangential velocity of entry. The tangential velocity of entry is the instantaneous linear measure of velocity of a body moving in an arc.

Technically efficient skier. A technically effective skier employs the most direct repertoire of actions to successfully accomplish the primary mechanical purpose of a skill.

Transfer of momentum from part to whole. Transfer of momentum from part to whole occurs when there is a redistribution of momentum from one body part to the whole body.

Unweighting. Unweighting is a reduction in the pressure of the skis exerted against the snow (CSIA, 1987).

Upper & lower body separation. Upper and lower body separation refers to the concept of the upper body (head, upper limb, trunk and pelvis) working independently of the lower body (lower limb).

Video analysis. Qualitative analysis of performances recorded on videotape.

Chapter II

REVIEW OF THE LITERATURE

The literature review for this study focused specifically on three topics; research on the biomechanics of skiing, qualitative analysis, and video analysis.

Research on Biomechanics of Skiing

The multi-axial rotations and the out-of-plane movements involved in skiing, have made the analysis of the entire ski turn difficult. In addition, the field setting required for data collection has greatly restricted research in this area. Even so, there have been a large number of quantitative and theoretical studies related to the analysis of the alpine skiing technique completed over the past 15 years. The majority of the quantitative studies examined isolated mechanical variables such as, aerodynamic drag or friction. The remainder of the research focused primarily on establishing theoretical formulae to explain the motion of a skier moving down the fall-line (Watanabe, 1978), going over a bump (Gros, 1979; Watanabe & Ohtsuki, 1977) or, in a steady state turn (Glenne & Glenne, 1979).

Unfortunately, a review of the literature which focused specifically on the mechanics associated with the giant slalom ski turn, indicated that there have been few attempts at the assimilation of these results into comprehensive qualitative descriptions.

Description of a Giant Slalom Turn

Research in the area of skiing mechanics has been addressed by European, Scandinavian, Japanese and North American groups. Since these countries do not have a universal language for the description of skiing, it was necessary to develop a generic approach to the simplification of the ski turn. For this reason, the turn was broken down into 6 phases; (a) stance, (b) preparation, (c) pre-execution, (d) execution, (e) follow through, and (f) recovery. Although each phase is described separately, it should be noted that it is the flow from one phase to the next which determines the excellence of the turn.

Stance. A proper stance must be established prior to entering a turn, and must be maintained throughout the turn. This helps to minimize the aerodynamic drag acting against a skier, as well as help optimize a skier's stability. Before initiating a turn, the skier first creates a platform on which to stand, establishing the centre of mass over the base of support (Major, 1981). The stance is tall to allow for greater muscular and skeletal efficiency and the balance is over the whole foot (Warren, 1988). During this phase the skier attempts to maintain a high velocity by optimising sliding. The results of recent research has indicated, that the velocity achieved going into the turn is the highest reached at any section of the turn (Larsson & Glenne, 1987). The length of this platform phase will vary depending upon the terrain, the distance between the gates, and the tightness of the course (Major, 1981).

The upper body (the trunk and pelvis) in the case of skiing, are counter-rotated in relation to the lower limbs in a position referred to as anticipation. The anticipated position actually being a dynamic movement in which the upper body moves across and down the hill (Bean, 1987).

Preparation. Preparation involves two movements occurring in quick succession. First, the skier moves the centre of mass towards the inside of the turn, creating an angle between the inner edge of the outside ski and the snow (CSIA, 1987). The creation of this edge angle is achieved through a combination of unweighting, body inclination and ankle angulation. Secondly, while the body is unweighted, the skier pivots the skis towards the fall-line. These two movements result in the edge being set into the snow and, given the construction of the skis, initiates the turn. During this phase the skier's speed decreases but, will begin to increase again when the skier is travelling in the direction of the fall-line (Larsson & Glenne, 1987).

Pre-execution/execution. The actual turning of the skis can be broken down into a pre-execution phase (prior to the fall-line) and an execution phase (after the fall-line). During these two phases, the skier guides the skis through an arc using edging and pressure skills (Bean, 1987). Edging and pressure control are increased gradually throughout the turn using angulation at the ankles, knees and hips, and through flexion and extension, respectively (Warren, 1988; CSIA, 1987). Angulation in this context refers to the medial movement of the joint; eversion at

the ankle, and medial rotation at both the knee and hip.

The goal of edging and pressure control is to maintain a moment balance between the forebody and the afterbody of the ski (Lieu & Mote, 1985). The moment balance is essential to carving an efficient turn. The effectiveness of this phase is determined by the skier's ability to carve a turn at high speed. In theory, during the pre-execution phase, a skier can accelerate given the effects of radial acceleration and gravity. In practice though, there is a compromise between carving and speed, due to the difficulty of maintaining high speed while countering centrifugal and gravitational forces.

As the skier exits the fall-line portion of the turn, she/he must actively resist the forces of gravity and centrifuge by maintaining a constant lower limb length over the downhill ski, and by regulating the amount of angulation at the knee and hip. These movements will keep the ski carving throughout the remaining portion of the turn. The compromise between the carved arc and speed becomes more apparent as the turn nears completion. It is often more efficient to increase the radius of the arc at the end of a turn, thus maintaining a given speed, than to increase edging which will hold the radius constant (allowing the skier to travel a shorter distance) but, would decrease the skier's speed (Larsson & Glenne, 1987).

Follow-through/recovery. To end the turn, the skier must stop the rotational action of the skis (follow-through), minimize speed loss (follow-through), and settle into a position

which makes entry into the next turn possible (recovery). The turn should end once the skis are past the fall-line. At that point, the skier is exerting a force through the foot of the downhill ski, and the ski is travelling through a carved arc. The follow through is initiated with an explosive extension of lower limb to release the edge and the energy stored in the reverse camber of the pressured ski (Bean, 1987), along with a simultaneous lateral step onto the uphill ski (Bear, 1977; CSIA, 1987; Jenson, 1985). Depending upon the terrain, the skier will step onto an uphill edge, a neutral ski or the new downhill edge.

The recovery phase is an optional phase, and will only be present in turns where the skier has to re-establish the centre of mass over the base of support before initiating the next turn. This would occur if there is a sudden terrain change from flat to steep or if the centre of mass has fallen behind the ski boots during the previous turn.

Mechanical Principles Governing the Giant Slalom Turn

Numerous studies have been conducted to quantify the mechanical variables which affect a downhill skier. From this research there is agreement that some of the forces acting on a skier in a turn are; aerodynamic drag, sliding friction, centrifugal forces, and gravity. The skier maintains stability and counters these forces through the use of muscular force application.

Stance. The stance of a skier is affected primarily by the

necessity to maintain linear and rotational stability. Stability refers to the body's resistance to losing its dynamic equilibrium (Kreighbaum & Barthels, 1985). The skier's linear stability can be measured by the amount of linear impulse it takes to overcome the body's inertia and cause it to accelerate. Linear stability is therefore affected by the skier-ski mass and the frictional forces between the skis and the snow. Ideally, prior to initiating a turn, the skier minimizes the frictional forces and thus minimizes the linear stability, in order that the impulse delivered at the end of the previous turn can be maximized.

Rotational stability is a measure of the amount of angular impulse (torque) required to upset the rotational equilibrium and thus cause the skier to tip over (Kreighbaum & Barthels, 1985). The skier maximizes rotational stability prior to the turn, by ensuring that the centre of mass passes through the base of support; the area bounded by the skis and ski poles (when they are in contact with the snow). During the turn, the rotational stability can be increased and decreased by the movement of the hips in relation to the base of support.

The skier's aerodynamic position is optimised at the same time as the stability is being optimised. The frontal area, profile shape and clothes texture will determine the amount of drag force acting against the skier. Results of wind tunnel studies have shown that a skier's ability to ski with the arms tightly pressed to the chest is the single most important determinant of drag force (Watanabe & Ohtsuki, 1977).

Preparation. In the preparation phase, the process of pivoting the skis and creating an edge angle are effected through a upward, forward and medial movement of the centre of mass towards the inside of the turn (Sodeyama et al., 1979). The centre of mass can be raised either by an extension of the lower limbs and trunk (up-unweighting) or by retraction of the lower limbs (down-unweighting). The skier should, if possible, maintain a fully extended body position during this phase (within the constraints of the equipment) so that the lateral projection of the centre of mass towards the centre of the turn will not require as much body inclination as it would if the trunk, hips and knees were flexed. The extended body position will result in a more favorable position to counteract the centrifugal force (Sodeyama et al., 1979; Morawski, 1973), and will create an edge angle between the ski and snow.

Pre-execution/execution. For mechanical purposes, the pre-execution phase occurs prior to the fall-line while the execution phase occurs after the fall-line. The goal of pre-execution is the transfer of the skier's linear velocity into angular velocity. The transfer will not result in perfect conservation of momentum as some of the velocity will be lost at the moment which the edge is set. This is caused by an increased amount of friction and work done by the ski against the snow, the resulting decrease in kinetic energy translates into decreased velocity (Vagners, 1985). Add to this any lateral displacement of the edge

due to excessive pressure (skidding), and the velocity is further reduced.

The gradual edging required to minimize the loss is developed through angulation at the ankle and at the knee, with the hips remaining high so that they may be used in the latter stages of the turn (Bacharach & McGuire, 1985). Radial acceleration will cause the skier to accelerate once the skis begin to travel in an arc. The effects of gravity will also cause acceleration as the skier passes through the fall-line.

As the skier exits the fall-line, the radius of the remaining portion of the turn and the velocity of the skier, will be determined by the skier's ability to carve a turn. Lieu and Mote (1985) established that the afterbody of the ski is essential to the carving process, while 30 to 40 percent of the forebody loses contact with the snow during the execution of the turn. To compensate for over rotation, the ski is tilted (through further angulation) and pressure is applied through the foot to increase the depth with which the ski cuts the snow. This results in an increased normal force exerted on the forebody of the ski.

To carve the ski turn, the skier must match the normal force exerted on the forebody with that of the afterbody by adjusting the tilt and pressure applied to the ski. The resulting coupled forces will produce a moment balance, and an efficient (carved) turn will result.

To produce the moment balance the skier is concerned with countering the centrifugal force, and in conserving angular

momentum. The effects of the centrifuge causes the skier to collapse towards the outside of the turn. To overcome this effect, and to keep the skis travelling in a carved arc, the skier must apply a centripetal ground reaction (pressure control) and a centripetal friction force (edge control). A force of too great or too little magnitude will result in a skidded turn. These forces are exerted against the ski edge and ski base through flexion and extension of the leg (Glenne & Glenne, 1979; Morawski, 1973), and through angulation.

To conserve the angular momentum which was developed in the pre-execution phase, the skier minimizes the body's moment of inertia by minimizing its radius of gyration (Kreighbaum & Barthels, 1985). Morawski (1973) has shown that the moment of inertia is decreased by 50% when the skier assumes a low silhouette as compared to a high silhouette.

Follow-through/recovery. The principle of transfer of momentum guides the follow-through and recovery phases of the turn. The turn should end once the skis are past the fall-line. The skier transfers the angular momentum of the turn into linear momentum; the transfer being from part (explosive extension of the leg) to whole (linear movement of the whole body towards the next turn). Few studies have quantified the effects of early weight transfer, or the effects of the linear impulse given to the body upon leg extension at the completion of the turn. One study by Larsson and Glenne (1987) concluded that at the very best, a racer will exit a turn with the same speed that was

developed in the pre-execution phase (at the fall-line). There is no evidence to suggest that there is any acceleration at the end of a turn. When the follow through is performed correctly, the recovery phase is very short, or may not exist.

In cases where recovery is required, the skier re-establishes the centre of mass over the base of support with a movement of the hips and trunk forward. To date, there has been no scientific research to verify the mechanics of the recovery phase.

Based on a review and synthesis of the literature, the following is a list of the mechanics which must be addressed in order to optimize performance of the giant slalom ski turn.

1. Aerodynamic drag forces must be minimized and stability must be maintained throughout the turn.
2. The application of an angular impulse is needed to develop the initial momentum and to change the direction of travel of the skis.
3. The centripetal ground reaction force must be precisely equal in magnitude and directed opposite to the centrifugal force, in order to take full advantage of the effects of radial acceleration and gravity.
4. The skier must strive to maximize the conservation of angular and linear momentum throughout the turn.
5. A linear impulse and a transfer of momentum from part to whole will provide the necessary force to counter the rotational action produced during the turn, propelling the skier from an

angular to a linear path.

6. The racer must re-establish the centre of mass over the base of support before starting the next turn.

Qualitative Analysis

Given the complexity of many sport skills, the performance setting, and the exploratory nature of some sport research, qualitative analysis is often more feasible than quantitative analysis. Qualitative skill analysis is a systematic approach to analysis, it involves; pre-observation, observation, diagnosis, and remediation phases (McPherson & Bedingfield, 1985). A number of authors have formulated strategies for conducting qualitative analysis of sport performances.

Kreighbaum and Barthel's (1985) system of qualitative analysis [illegible] the observation of a performance, in comparison with a [illegible] edback to the performer. As part of thi[illegible] broken down into prepa[illegible] observationa[illegible] comparison is similarly divided, its [illegible] determination of the primary mechanical p[illegible]e skill, and the identification of the biomechanical principles which influence the performance of the skill. After the observation of a skill performance, the athlete is provided with feedback to improve the technique of subsequent performances.

Hay (1987) developed a qualitative analysis procedure based

on the development of a deterministic model to be used as a precursor for the analysis of an athlete's performance. The three steps of the analysis involve; (a) observation of the performance and identification of errors, (b) establishment of the priority of the faults, and (c) remediation of the errors. The deterministic approach to the development of a model allows the investigator to determine the mechanics of a skill, and provides a system for the expression of the relationship between the results of the skill and the factors which produced that result. The development stages for a deterministic model include (a) the determination of the performance criterion of the task, and (b) the identification of the factors which produce the result. The optimization of the lower-most mechanical level of a deterministic model will result in the optimization of the performance criterion.

In developing a skill analysis paradigm McPherson (1987), presented a method for using the mechanical factors of a deterministic model as a basis for an observation and diagnostic framework. This method involves the identification of the critical features associated with the mechanical quantities of the model. Critical features are components of a movement, or of the environment, that are critical to the outcome of the performance, they must be observable and have a reason for being observed. The modification of a critical feature should affect the outcome of the performance (McPherson, 1987).

Upon completion of the deterministic model, the investigator

focuses on developing strategies for the observation of specific critical performance features. The observation plan covers factors such as the position of the camera, the scanning procedures, the number of critical features to be viewed during an observation, and the acceptable response range of each feature. During the observation phase, the investigator describes the manifestation of each critical feature, and compares it to an acceptable response range. The differences are diagnosed as errors, and are priorized as either primary or secondary errors. Remediation for the primary errors is prescribed to the performer. For this system to be applied successfully, the critical features must be expressed and defined in a form acceptable to both the coach and the scientist.

Qualitative skill analysis provides researchers with a systematic approach to sport skill analysis. It is suitable for use when quantitative measurement of the mechanical variables is difficult or when an exploratory investigation is required. Alpine skiing, is a good candidate for qualitative analysis because of the isolated field setting in which the sport is practiced, and because of the rotational movements involved in its execution. To date however, it has not been used by ski researchers for scientific analysis.

Video Analysis

Although photostudies and cinematography have been used abundantly in skiing research, videotape analysis has not been as

popular. The reasons for this remain unclear but, video cameras are readily available to coaches and, the newer cameras have better resolution and playback capabilities which can stop and hold the frames for analysis.

Analysis from video recordings has several advantages over film recordings for qualitative analysis. It is inexpensive, provides instant feedback, records in low light and is readily available (Davis, 1984). It is also easier to use out-of-doors. The disadvantage of video is its poor resolution when compared with film (Davis, 1984).

The procedures to follow while videotaping are similar to those for filming. The procedures and precautions when using photo-instrumentation are explained below.

The camera should be fixed, level and the performer should be moving perpendicular to the camera. In order to minimize the perspective error, the camera should be positioned as far away from the performer as possible (long focal length = less perspective error), and it should be equipped with a zoom lens to maintain a large image size. There should also be a concerted effort to normalize the film setting for the athlete (Miller & Nelson, 1973).

Hay and Reid (1988) suggest the following as basic observation criteria:

1. The observer's view can not be obstructed at any time.
2. The performer must not be distracted by the observer, or other persons and events.

3. The performer should be told prior to the observation the number of repetitions that will be recorded.

4. The observer should refrain from commenting on the performance until the recording is finished (this is to eliminate any feedback expectations, reduce performance pressure and, increase the consistency of performance from one trial to the next).

5. A maximum of 15 to 20 repetitions of the skill should be recorded to ensure an accurate and thorough analysis.

6. The observer should be positioned 10 to 40 metres away from the action (depending upon the speed of the action) and, at the midpoint between the start and the finish.

7. The field of view must be limited enough to maximize the resolution of the video.

8. It is important to go through a dry run of the filming procedures at the recording site in order to dissipate the apprehension of the performer and to ensure that the recordings will be of high quality (Lucey & Squire, 1976).

Chapter III

METHODOLOGY

The procedures used for this study were divided into seven stages; (a) the development of a deterministic model and the identification of critical features, (b) development of an observation plan, (c) the development of standardized video procedures, (d) the preliminary investigation, (e) data collection, (f) measurement reliability, and (g) data analysis procedures.

Development of a Deterministic Model for the Giant Slalom Ski Turn and the Identification of Critical Features

The process used for the development of the deterministic model for the giant slalom ski turn was initiated by an extensive literature review in the area of biomechanics of skiing. Based on the synthesis of this information the investigator fulfilled the following conditions: (a) Determined the performance criterion, (b) simplified the performance criterion, (c) determined the mechanical constructs, and (d) identified critical features of the giant slalom ski turn.

The completion of these steps culminated in the development of a deterministic model for the giant slalom ski turn. The model served to focus the investigator's attention to those features of the recorded performances deemed to be critical to the outcome of the ski turn.

Development of an Observation Plan

Following the identification of critical features, an observation plan was developed to guide the videotaping and the preliminary data analysis. To create the plan, the list of critical features was reviewed and the redundant features were removed. The best viewing angle for each critical feature was subsequently determined and the features were assigned a specific observation number. The information contained in each observation plan included; the name of the critical feature, the best viewing angle, and a general description of the scope of the feature.

Development of Standardized Video Procedures

Instructions for the use of commercially available, hand held videotape cameras were written in a non-technical format for use by persons with little or no experience in videotaping skiers. The purpose of the videotaping was outlined in the instructions to ensure a high quality of recordings submitted for analysis (see Appendix B for the video instructions). The procedures emphasized the position of the camera in relationship to the subjects, zoom control, focus control, and the minimum number of turns to be recorded for each performance. Specific video instructions served to standardize the recordings, improve the experimental control, and minimize the perspective error. The investigator was aware that, altering the make and model of the video cameras used at the different sites introduced error in the recordings. However, prohibitive costs in video rental

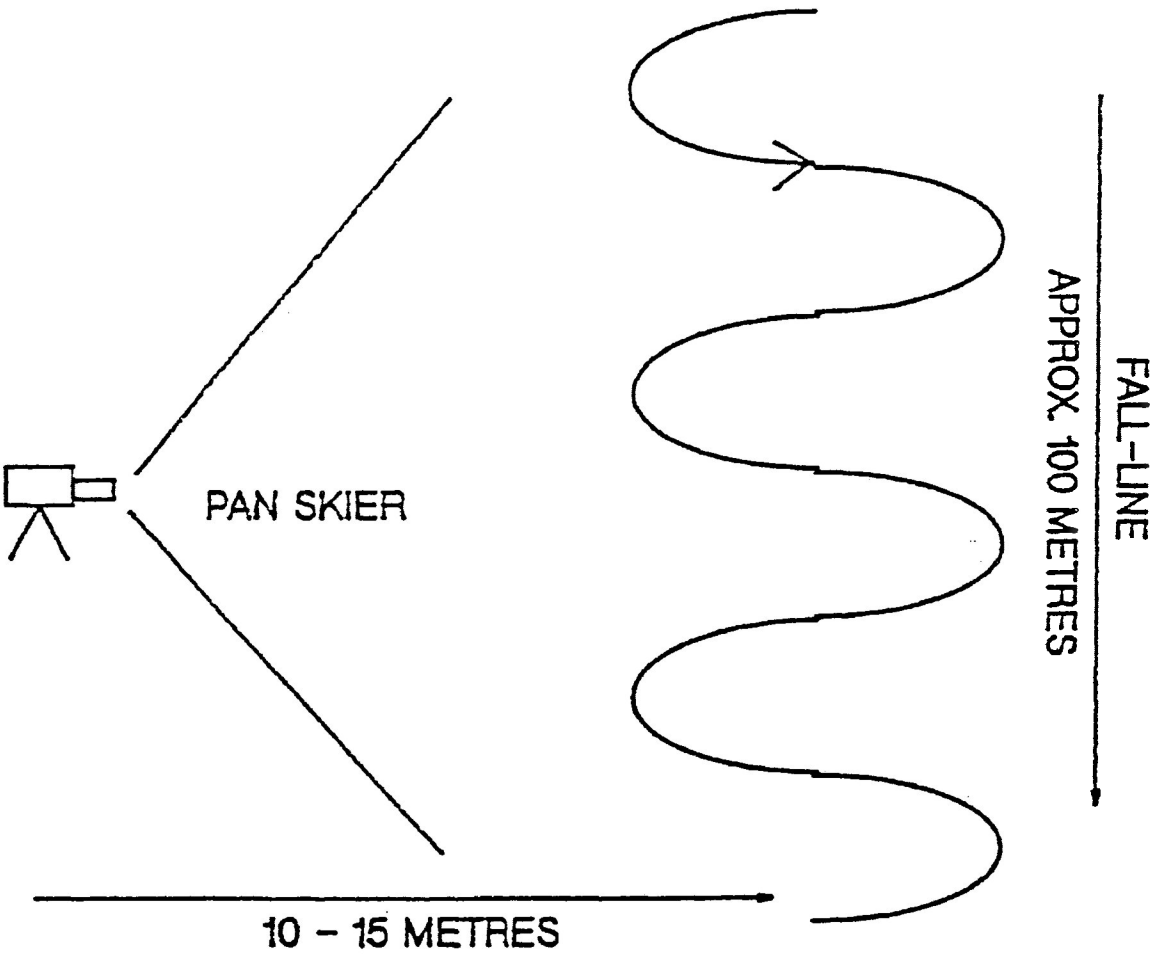


Figure 1. Set-up for videotaping site.

necessitated the use of whatever camera was made available by the club.

The Preliminary Investigation

A preliminary study was conducted to verify the standardization of the videotaping procedures. Instructors for the School of Physical Education Ski Week (February, 1988) were asked to use the videotaping procedures and then to comment on their clarity and ease of application. As a result, the following refinements to the video procedures were made:

1. Two pictures of a skier as they would be seen through a video camera viewfinder were added to the videotaping instructions to exemplify the optimal and, the incorrect skier image size for the recordings.
2. The importance of both marking the trail with either dye or gates, and the importance of telling the performers exactly what was required of them, was highlighted.
3. A performance grading sheet was added to the instructions as a back-up in the event that the audio on the video camera was inoperative.

The material used for the video procedures pilot study is provided in Appendix C.

A preliminary study to determine the feasibility of the data analysis procedures was conducted on November 6, 1988. The Final Form performances recorded on the Husky Oil - Alpine Canada, Skill Awards program demonstration videotape were used as data

for this pilot. The analysis was completed using a Panasonic-Omnivision VHS Digital playback unit equipped with slow motion, stop-frame and single frame advance capabilities. The following refinements to the data analysis procedures were made:

1. An observation plan for each of the Final Form exams was be created as part of a pre-observation strategy.
2. Six observations corresponding to the six phases of the deterministic model were conducted for each performance.
3. All the critical features for one phase of the model were be examined as part of one observation.

Data Collection

The collection of the Final Form videotape performances was conducted under the supervision of an Alpine Canada representative during a cross country tour of all the Nancy Greene clubs in Canada. This representative was chosen based on her expertise in ski accreditation, and as contributor in the development of the Skill Awards program.

The trail used for the data collection was set-up in accordance with the video instructions. The person doing the videotaping and the Alpine Canada representative were situated at the side of the run. Prior to collection, the video person proceeded with the camera set-up, focus, and zoom procedures. The procedures were then tested on two or three skiers. When the camera and trail were set up were functioning satisfactorily, the recording of the performances began.

As each skier completed a run, the performance was graded pass or fail. Performances which were used to test the equipment were graded as test and were not considered for analysis. The words test, pass, or fail appeared either on the audio of the videotape, or on the grading sheets. The use of the grading sheets was designed as a safeguard in the event that the audio was not available or was not operational. Each performer wore a racing bib with a number displayed on its front and back; this number was marked on the grading sheet and the corresponding pass, fail, or test was indicated after each performance. The "Additional Information" sheets which were attached to the video instructions were completed each time that there was a video site change. These sheets indicated the name of the trail, its steepness, snow conditions, trail conditions and the level(s) tested at that site. There were sufficient copies for eight site changes, corresponding to the eight Skill Award testing levels.

Completed tapes and all corresponding written material, were forwarded by mail to the investigator for analysis.

Selection of sample. The target population for this investigation included all members of the Nancy Greene Ski Club system who were using the Skill Awards program to improve their skiing skills.

There were a number of constraints in this study which made the selection of a random sample infeasible, these included; the time and cost of taping individual skiers, establishment of an accurate list of participating clubs and youngsters and, the

unpredictability of the environmental/snow conditions at the taping sessions.

As such, performances which met the following criteria formed the sample; (a) performances which were part of a taping session where the entire skill level of the club was recorded, (b) performances recorded when the snow and trail conditions at the testing site were acceptable, (c) performances recorded when the snow and trail conditions did not change over the course of the taping session and (d), performances recorded when the Alpine Canada representative was present to direct the filming and to assess each performance.

Measurement of Reliability

Observer reliability of the investigator, and assessment reliability of the Alpine Canada representative were established by calculating the inter-observer, and test-retest coefficients, respectively.

The independent observer was familiar with qualitative analysis and was a recreational skier familiar with the basic technical aspects of the sport. After an instructional session to review the scope of each critical feature, the independent observer analyzed one randomly selected performance at each of the 8 Skill Award levels. The independent observer was tasked with determining whether the critical feature was exhibited in that performance or not. The "yes" and "no" scores for both the independent observer and the investigator were then numerically

coded with a "1" and a "2" respectively, and placed in a 2 x 2 contingency table, to facilitate the calculation of the reliability coefficient. The coefficient represented the percentage of agreement scores between the observers at each level, and across all levels.

The same system was used to calculate the test-retest reliability coefficient that determined the reliability of assessment from the Alpine Canada representative. A mixed videotape made up of 10% (22 performances) of the total sample submitted, was re-evaluated by the Alpine Canada representative on the same pass - fail basis. A pass assessment was coded as "1" and a fail as "2". The results of the two sets of assessments was then assigned to the appropriate square of the 2 x 2 contingency table, and the calculation of the test-retest reliability coefficient was undertaken. A Kappa (Cohen, 1960), was performed on both the inter-observer and assessor reliability to correct for chance agreement.

Data Analysis Procedures

The data analysis involved determination of the existence of critical features and, the identification of descriptors for the features at each of the eight Skill Awards levels. The examination was completed using qualitative video analysis guided by an observation plan; the plan contained the identified critical features from the deterministic model of the giant slalom ski turn.

Initially, the data analysis required a review of the selected performances to establish the existence of each critical feature, then the performances were further examined to establish a brief description for each identified feature. The descriptors consisted of short verbal narratives regarding the method in which various body parts were moved to fulfill the requirements of the critical features. Upon completion of the preliminary data analysis, the performances were grouped by Skill Award level and then the frequency of repeated movement patterns were tallied. The result was the identification of the most frequently occurring movements for each critical feature at each level.

The results of the video analysis were further examined for similarities and differences in the movement patterns exhibited. In particular, the weighting of the critical features by different individuals, individual differences between performances at a given level, and the identification of movement patterns which were not recognized in the development of the deterministic model for the giant slalom ski turn.

The frequencies calculated for each Skill Award level were transformed into percentages based upon the number of observed performances at each level. These percentages were then used to determine the incidence of occurrence or non-occurrence of a critical features. The high incidence of occurrence features (90-100%), and the low incidence of occurrence features (0-10%), were used to develop an overall description of the movements required at each level.

The most frequently occurring descriptors were identified for the "high occurrence features", these descriptors were then sequentially connected to form an overall summary of the movements observed at that level. The process was completed for each of the other levels. To identify the difference between the 100% occurrence/non occurrence features, and the 90-99% occurrence/non-occurrence, the phrase "must have" preceded the descriptors of the first group.

Chapter IV

ANALYSIS OF DATA AND DISCUSSION OF RESULTS

The purpose of this investigation was to determine how the critical features of the giant slalom ski turn were manifested in the final form exams of Alpine Canada's Skill Awards program.

The results of the data analysis and discussion are presented under the following headings: (a) development of a deterministic model for the giant slalom ski turn, (b) development of the observation plan, (c) preliminary analysis of data, (d) measurement reliability, (e) occurrence and non-occurrence of critical features, (f) critical feature descriptors, (g) summary of results, (h) discussion of research questions, and (i) supplemental discussion.

Development of the Deterministic Model

The literature review resulted in the development of a deterministic model for the giant slalom ski turn. The model was then used to identify the critical features and to develop an observation plan to guide the investigator's analysis. Figure 2, 3, and 4 illustrate the phases of a ski turn, the simplification of the performance criterion, and the critical features of each phase.

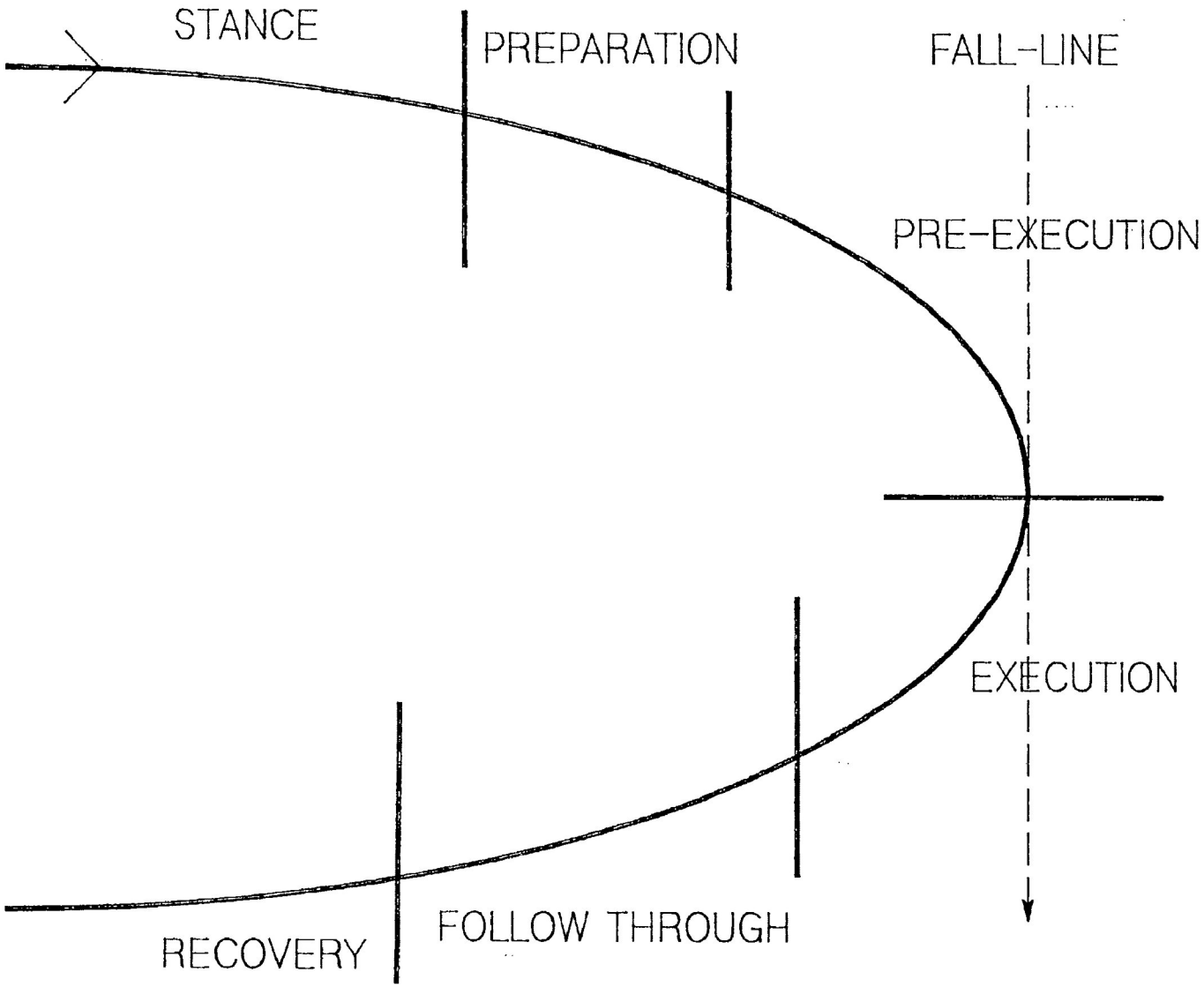


Figure 2. Six phases of an alpine ski turn.

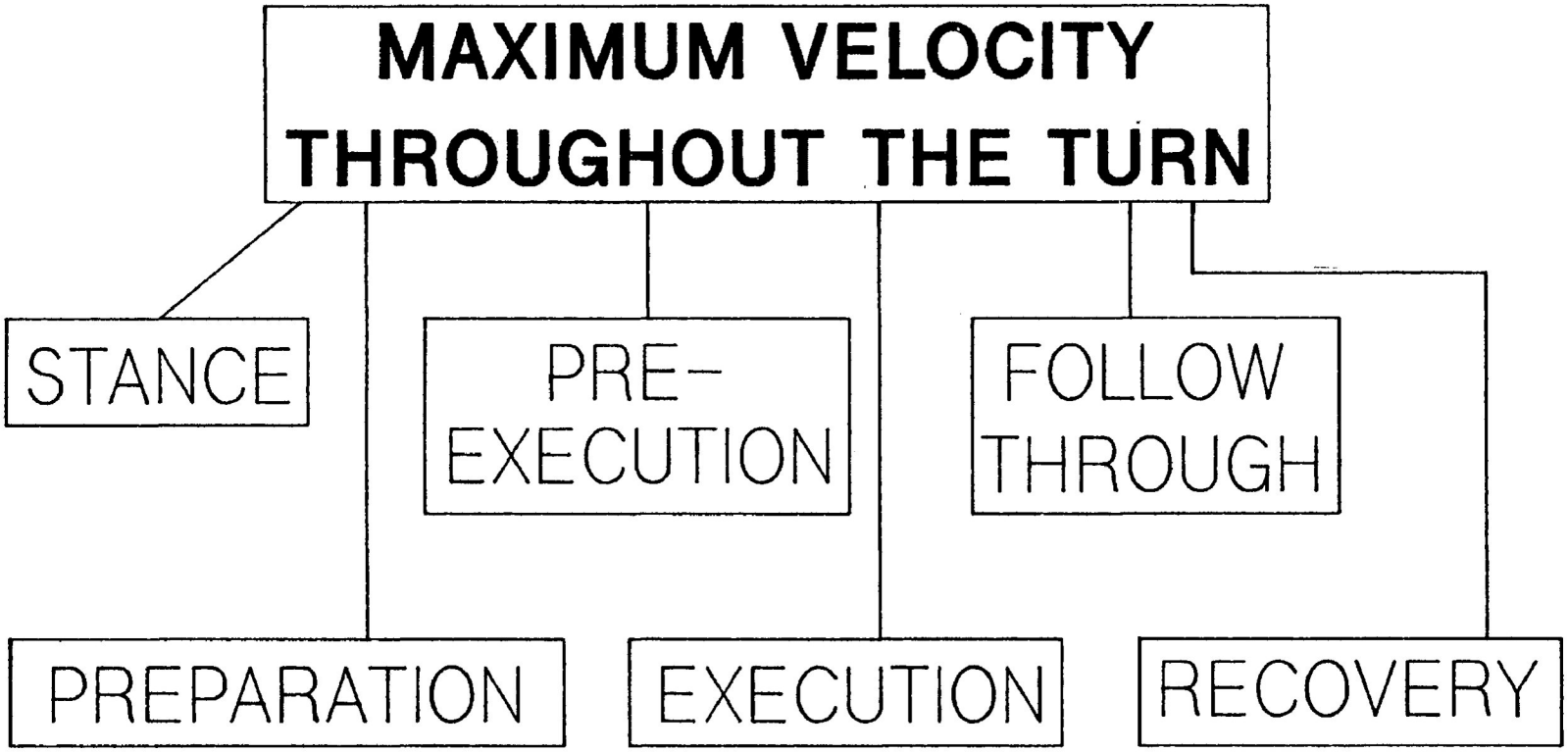


Figure 3. Performance criterion and simplified performance criterion of the giant slalom ski turn.

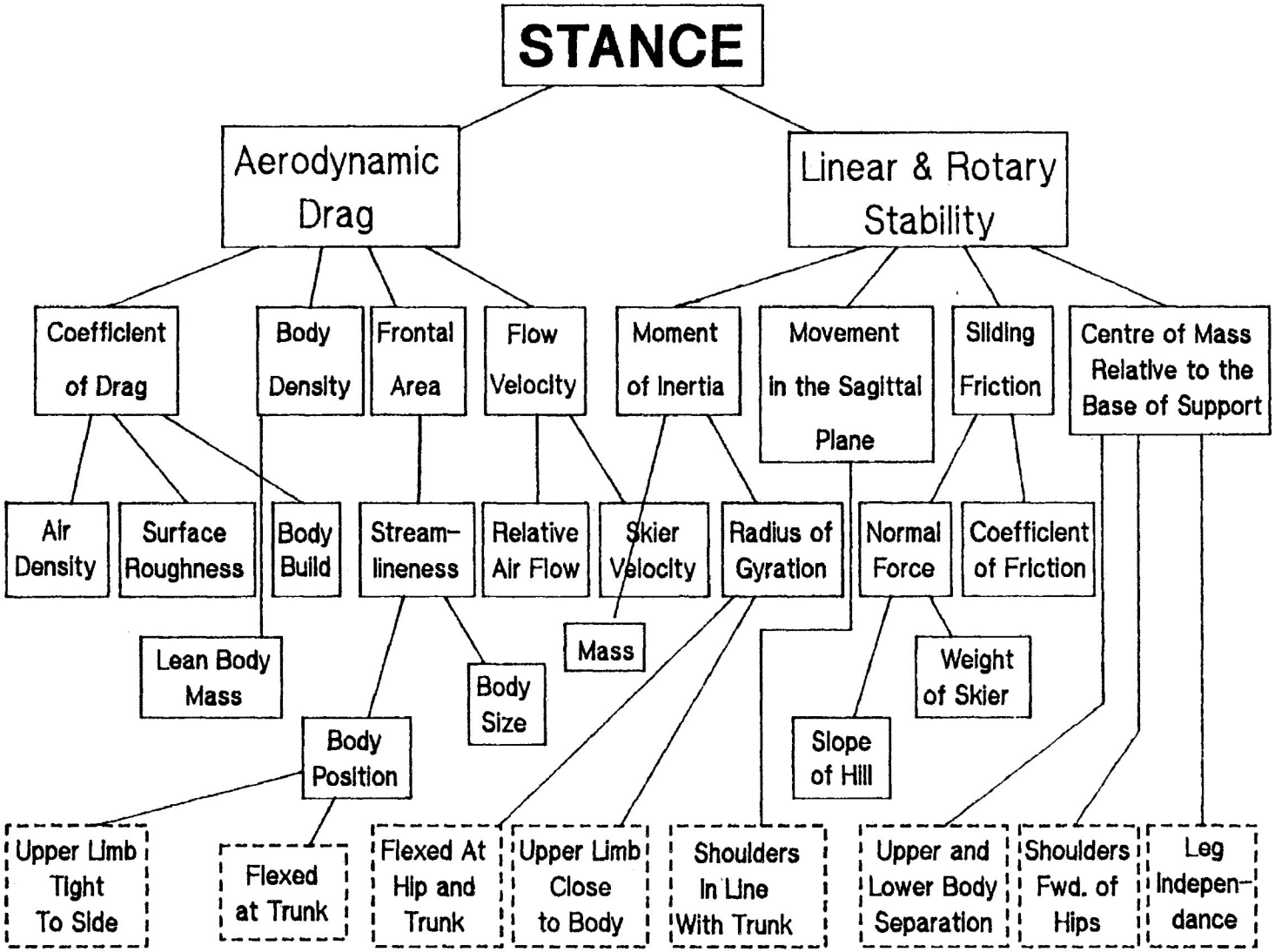


Figure 4. Deterministic model of the giant slalom ski turn; stance phase.

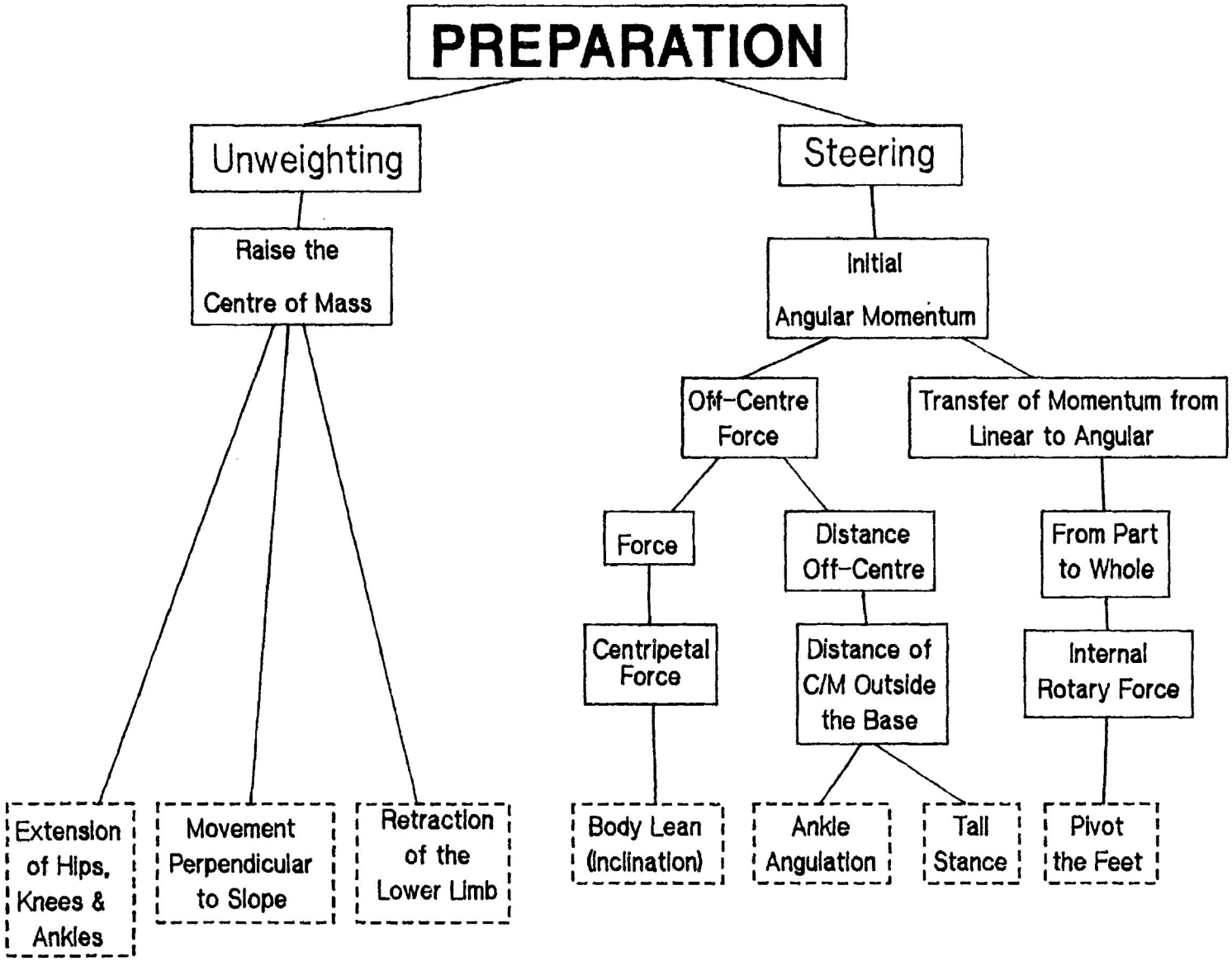


Figure 4. Deterministic model of the giant slalom ski turn; preparation phase.

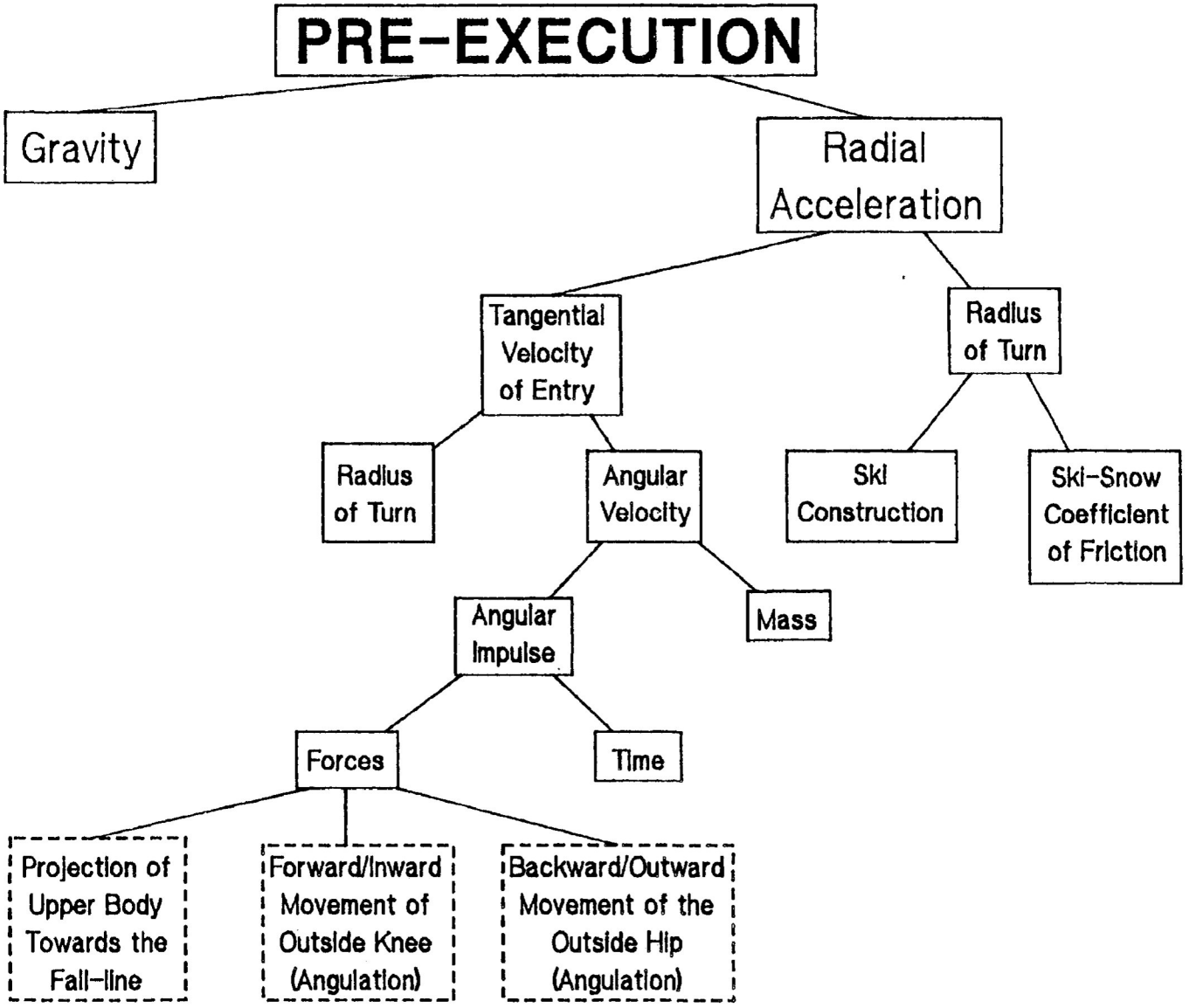


Figure 4. Deterministic model of the giant slalom ski turn; pre-execution phase.

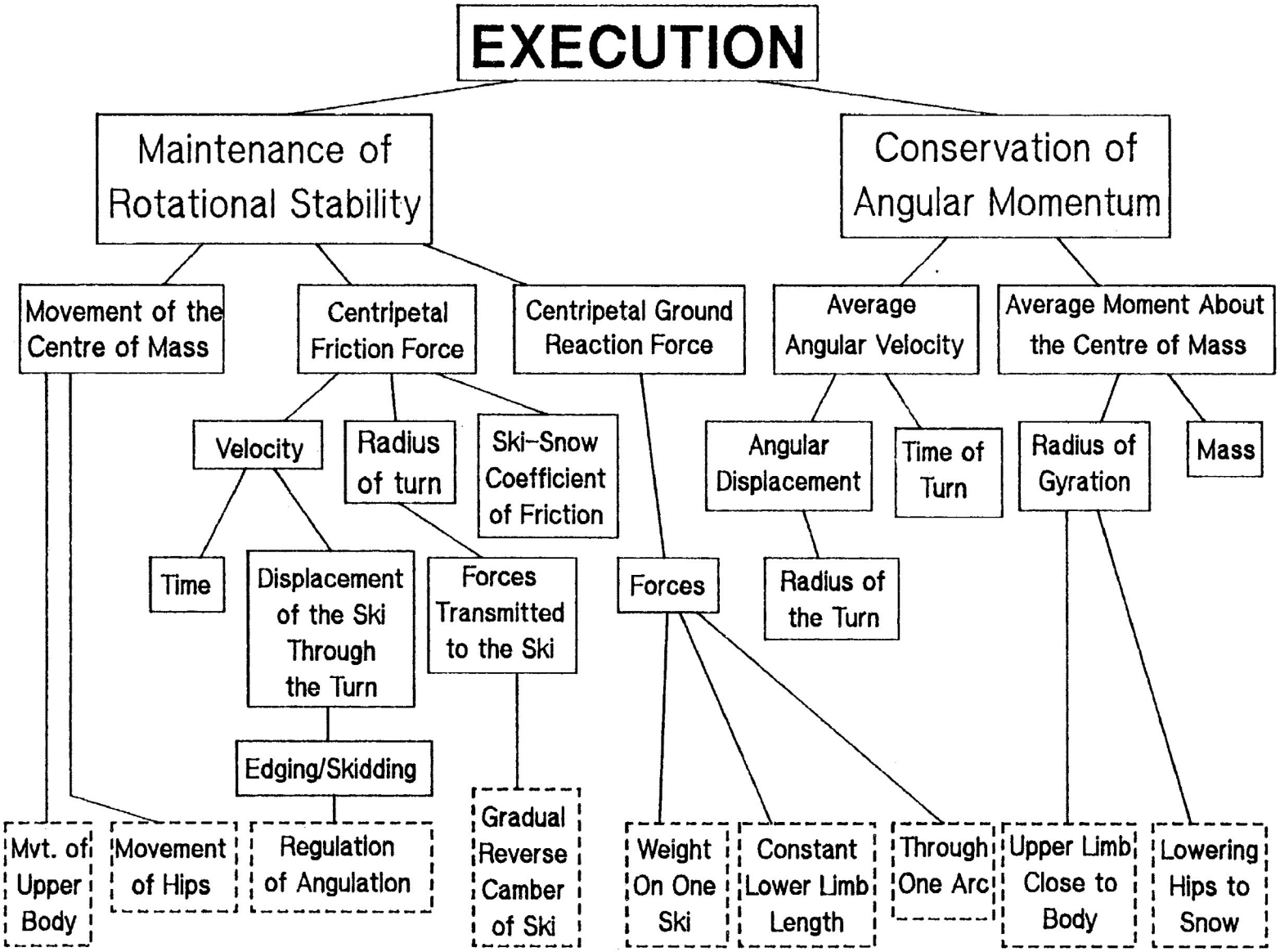


Figure 4. Deterministic model of the giant slalom ski turn; execution phase.

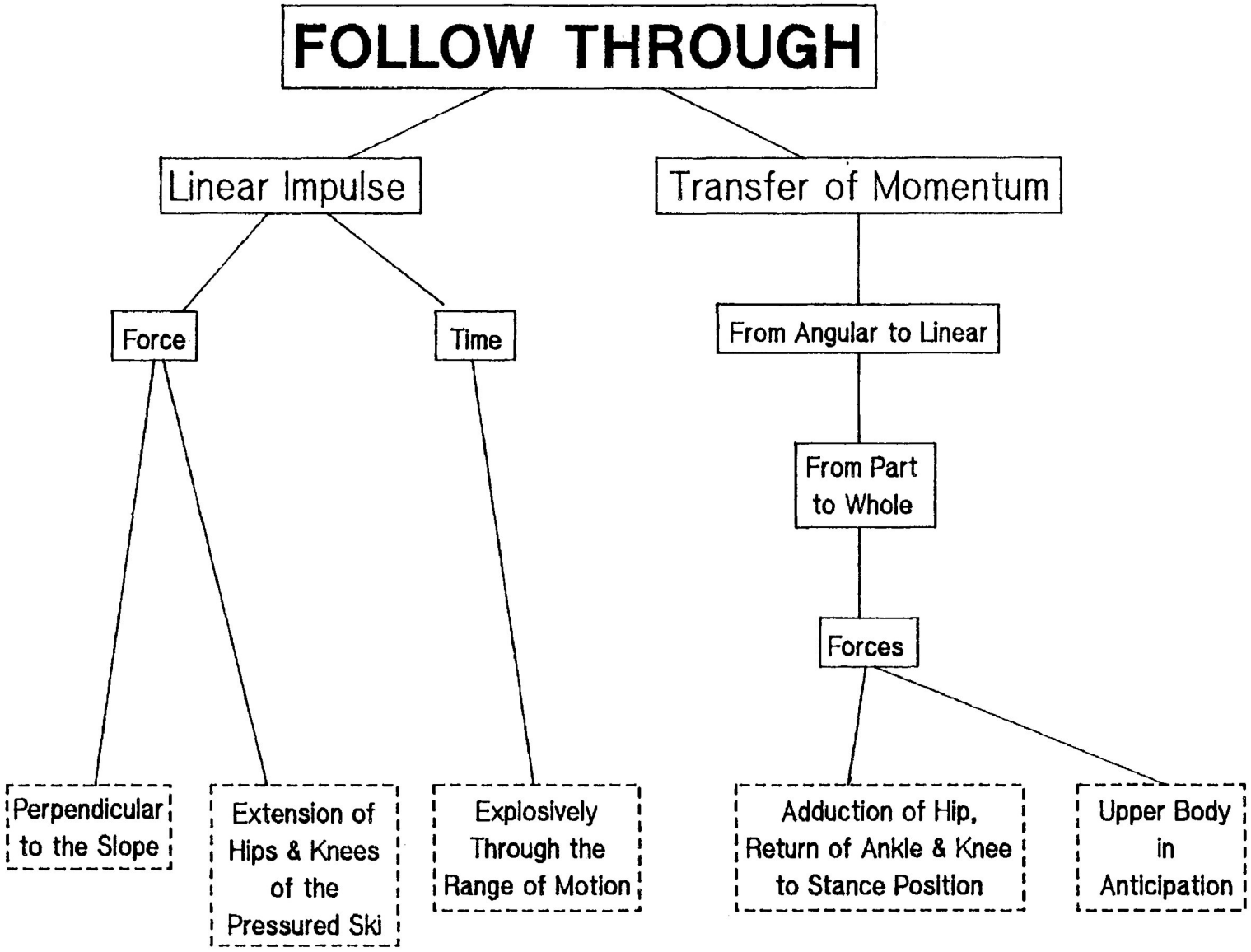


Figure 4. Deterministic model of the giant slalom ski turn; follow through phase.

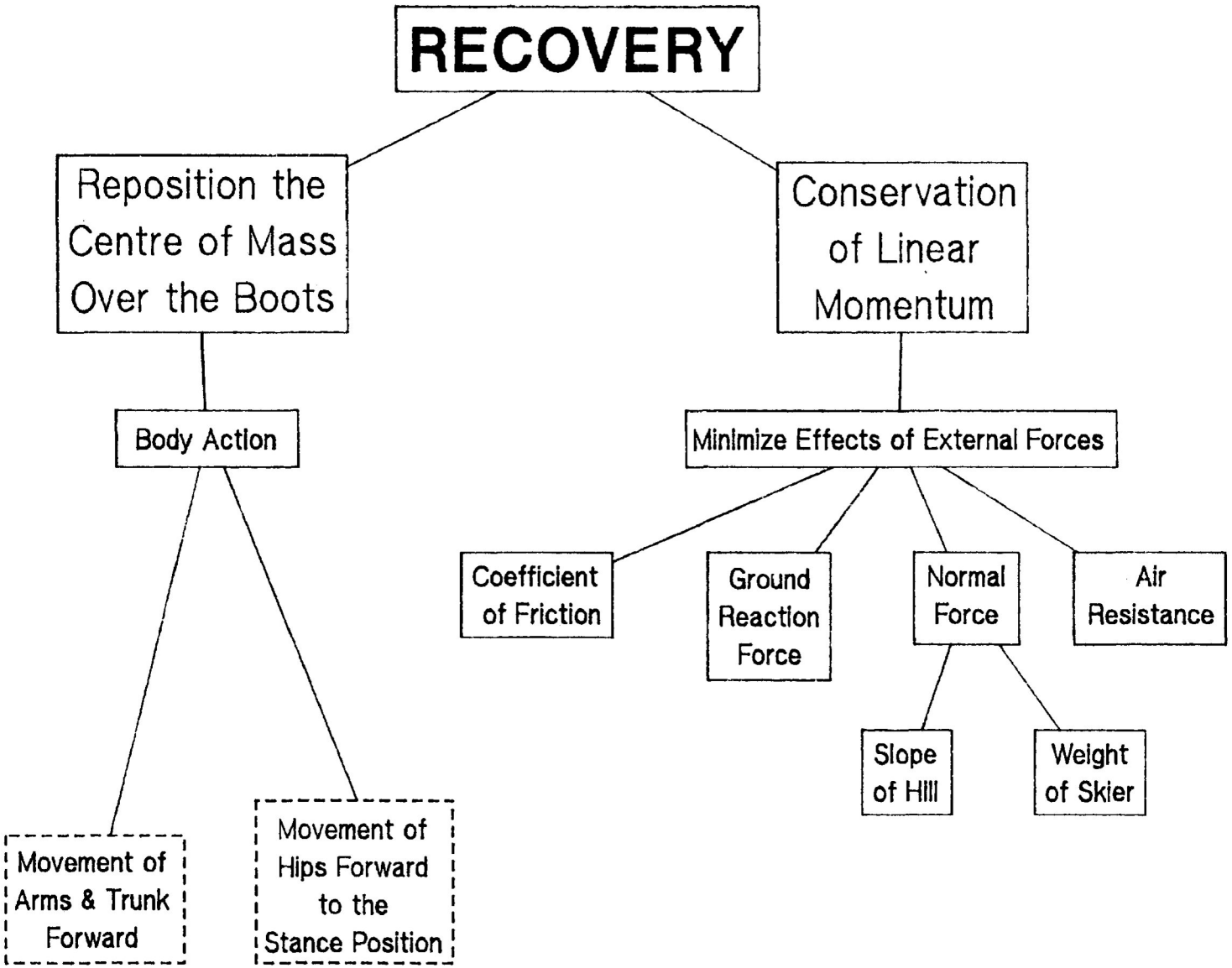


Figure 4. Deterministic model of the giant slalom ski turn; recovery phase.

Observation Plan

There were 6 observations made for each performance, one for each phase. All features for a given phase were viewed and described before proceeding to the next phase. The scope of each critical feature, the optimal viewing angle, and the phase to which it belonged is presented in Table 1.

The performance ranges for each critical feature at all eight skill levels were documented for the selected performances. A total of 220 performances were recorded in British Columbia, Alberta, and New Brunswick, using a hand held VHS video camera. The number of performances was reduced to 150 after the deletion of poor recordings and of performances affected by extreme environmental conditions. Of the 150 performances, 62 pass performances covering the eight Skill Award levels were selected for analysis. The breakdown of performances analyzed per level is presented in Table 2.

Table 2

Sample Size for the Skill Award Levels

Skill Level	1	2	3	4	5	6	7	8	total
Performances Analyzed	19	6	17	6	2	5	4	3	62

Table 1

Observation Plan for Videotaping and Preliminary Data Analysis

Number	Critical Feature	View	Scope
STANCE PHASE - OBSERVATION 1			
1	Upper limb tight to side.	F	- degree of shoulder adduction - degree of elbow flexion - position of hands in relation to trunk
2	Flexed at hip & trunk.	S	- amount of flexion at the hip and trunk.(i.e. upright, slightly flexed or, flexed)
3	Shoulders in-line with trunk.	F/S	- existence of rotation at the shoulders in relation to the trunk. (i.e. in-line, rotated uphill or rotated downhill)
4	Upper & lower body separation.	F/S	- whether the upper body and lower body work independently of one another
5	Shoulders forward of hips.	S	- the position of the shoulders in relation to the hips. (i.e. shoulders are forward, in-line or behind hips)
6	Leg independence.	F	- whether one leg angulates, steers, flexes and extends independent of the actions of the other leg. (i.e. yes or no)
PREPARATION PHASE - OBSERVATION 2			
7	Extension of the hips and knees.	S	- degree to which the legs and hips extend in preparation for the turn. (i.e. complete, incomplete, movement of hips forward only, no extension)

Table 1 Continued

Number	Critical Feature	View	Scope
8	Retraction of lower limb.	S	- existence of a weight shift launched through a retraction of the lower limb.
9	Movement perpendicular to the slope.	S	- whether the extension or retraction is perpendicular to the hill or skis. (i.e. forward, back, slightly forward or back, perpendicular)
10	Body inclination.	F	- amount of body lean towards the inside of the turn prior to any active angulation. (i.e. yes or no)
11	Ankle angulation.	F	- creation of an edge angle through ankle eversion
12	Tall stance.	F/S	- degree of extension in the joints of the lower limb and of the hip. (i.e. full extension within the constraints of the equipment equals a tall stance)
13	Pivot the feet.	F	- existence and degree of turning initiated by pivoting the turning foot.
PRE-EXECUTION PHASE - OBSERVATION 3			
14	Projection of upper body towards the fall line.	F/S	- degree to which the upper body is aimed and extended down the hill during the turn initiation
15	Knee angulation.	F	- existence and amount of medial rotation at the knee

Table 1 Continued

Number	Critical Feature	View	Scope
16	Hip angulation.	F	- existence and amount of lateral and backward rotation at the hip
EXECUTION PHASE - OBSERVATION 4			
17	Upper body movement.	F/S	- degree of change in body position relative to the stance position. (i.e. rotation, flexion, static)
18	Movement at the hips.	F	- movement in relation to the snow and the turn. (i.e. downward, inward, backwards, static)
19	Regulation of angulation.	F	- whether the edging of the turn is controlled through angulation or other means. (i.e. steering, isometric adduction at the hip)
20	Gradual reverse camber of ski.	F	- whether the turn progresses gradually until the ski is fully pressured at the end of turn
21	Weight on one ski.	F	- whether or not the turning ski is weighted through the turn
22	Constant lower limb length.	F	- while the turning ski is weighted, whether the degree of flexion at the knee and hip remains constant
23	Through one arc.	F	- existence of any movement which causes a change in the turning (i.e. steering, flexion of hip, excessive inclination)

Table 1 Continued

Number	Critical Feature	View	Scope
	FOLLOW THROUGH PHASE - OBSERVATION 5		
24	Extension of hips and knee of the pressured ski	S	- degree of extension at the hip and knee during the follow-through
25	Extension perpendicular to the slope.	S	- direction of the extension in relation to the slope
26	Explosively through the range of motion.	F/S	- the quickness of the extension.
27	Adduction of hip, return of hip and knee to the stance position.	F	- whether the skier returns to stance position prior to commencing the next turn. (i.e. yes, no or passes through)
28	Upper body in anticipation.	F/S	- existence, direction and degree of upper body rotation in relation to the lower body
	RECOVERY PHASE - OBSERVATION 6		
29	Movement of trunk, arms and hips forward to stance position.	S	- the manner in which the arms and trunk are moved to the stance position after balance is lost

Note: F = front view

S = side view

F/S = front, side or oblique view

Preliminary Analysis of Data

The preliminary data analysis involved the determination of descriptors for each critical feature of the 62 performances and resulted in the modification of features, the further elimination of redundant features, and the identification of predictive features.

Renamed critical features. There were nine critical features renamed during this period. The changes were made when it became apparent to the investigator, that the original names would be confusing to those unfamiliar with either biomechanics or qualitative models. The majority of the changes reflected grammatical and descriptive refinements. The original and the revised feature names are presented in Table 3. The renaming process took place throughout the preliminary data analysis period and changes, once deemed necessary, were implemented immediately for all subsequent observations.

Eliminated critical features. The preliminary data analysis demonstrated a partial redundancy between the critical features of the preparation phase and the critical features of the follow through phase. The extension of the hip and lower limb perpendicular to the slope observed during the preparation phase was the same as that observed during the follow-through phase. After a review of the deterministic model, the two critical features from the preparation phase were removed from the observation plan. In addition, Critical Feature 6 (upper and

Table 3

Renamed Critical Features

Original Name	Revised Name
Upper limb tight to side.	- Upper limb position close to trunk.
Flexed at hip and trunk.	- Rounded shoulders, flexed at hip and trunk.
Pivot the feet.	- Steering of the foot of the turning ski.
Regulation of angulation.	- Regulation of turning radius through angulation.
Gradual reverse camber of the skis.	- Progressive turning.
Through one arc.	- Turn progression through one arc.
Adduction of hip, return of knee and ankle to stance position.	- Return of hip and lower limb to stance position.
Movement of arms and trunk forward.	- Movement of arms and trunk to stance.
Movement of hips forward.	- Movement of hips to stance.

lower body separation) was removed after it was determined that Critical Features 14 (projection of the upper body towards the fall-line) and Critical Feature 29 (upper body in anticipation), adequately covered the scope of feature 6. The possibility of conserving feature 6 and eliminating features 14 and 29 was rejected, after consideration was given to the individual importance of each of the critical features to the overall understanding of the model.

Predictive features. The identification of predictive features also took place throughout the preliminary data analysis period. To be considered a predictive feature, the displayed movement, or series of movements, must have led to the manifestation of a critical feature. The predictive features were generally critical features from previous phases, or were movement of the ski equipment in response to particular body movements. For example, excessive snow flying off the edge of the turning ski would predict that the skier was not turning progressively. Table 4 contains a summary of the predictive features.

Measurement Reliability

Inter-observer reliability. An inter-observer reliability coefficient was calculated based upon the agreement between numerically coded responses of the investigator and of the independent observer. The yes/no answers regarding the existence of critical features within a randomly selected performance were

Table 4

Predictive Features

Predictive Feature	Critical Feature
Hand position.	- Upper limb position close to trunk.
Roundness of shoulders.	- Shoulders forward of hips.
Legs tight together.	- No leg independence.
Full extension of hips and knees.	- Tall stance
Ski pivots on top of the snow.	- Steering of the foot of the turning ski.
Projection of the upper body towards the fall-line.	- Upper/lower body separation.
Turning radius regulated by hip angulation.	- Movement of the hips.
Excess snow flying off ski.	- No progressive turning.
Progressive turning.	- Turn progression through one arc.
Weight on one ski.	- Leg independence.
Constant lower limb length.	- Turn progression through one arc.
Return of hip and lower limb to stance position.	- Execution of stance phase.
Upper body in anticipation.	- Upper/lower body separation.
Movement of arms, trunk and hips back to stance.	- Execution of recovery phase.

coded 1 and 2 respectively for both the independent and the investigator's observations. The relationship between the two sets of results was then determined and the results were placed in a 2 x 2 contingency table. The frequency of identical scores (either yes-yes or, no-no) over the two sets of observations, was divided by the total number of observation at each level to determine the percentage of agreement. This percent agreement was used as an estimate of reliability. The results are presented in Table 5. A Kappa was also performed to correct for chance agreement. These scores can also be found in Table 5.

Table 5

Inter-Observer Reliability Scores

Skill Level	1	2	3	4	5	6	7	8
Reliability Percentage	81	89	88	85	96	96	93	100
Kappa	.62	.72	.63	.58	.87	.87	.71	1.0

In addition, by collapsing all levels, an inter-observer reliability percentage and the Kappa for the 211 observations was 91% and 0.74, respectively.

Assessment reliability (test-retest). Test-Retest procedures were used to determine the ability of the Alpine Canada representative to consistently assess "pass" and "fail" performances of the Skill Awards program. The representative reassessed 22 performances randomly selected from the sample

selected. The same procedure was used to calculate the assessment reliability as was used for the inter-observer check. A reliability percentage of 100% was obtained with a corresponding Kappa of 1.0.

Occurrence and Non-Occurrence of Critical Features

The information collected during the video analysis was categorized and tallied so that the most frequently occurring critical features across and within the levels could be identified. The percentages displayed in Table 6, represent the number of times a critical feature was observed at each of the Skill Awards level, all results are expressed in percentages in an attempt to normalize the scores from the different sized samples at each level.

A review of the total % column of Table 6, confirmed the existence of critical features which were manifested in a high percentage of successful performances. To qualify for this category a critical feature must have been observed in 90 - 100% of the performances across all eight levels. There were eight "high occurrence features", and for each there was one descriptor which appeared most frequently across the eight skill levels. The following is a summary of those features and the preferred descriptor.

1. Critical Feature 5 - shoulders forward of the hips.

Descriptor: A line extended perpendicularly from the shoulder to the slope, was farther advanced down the hill than a line perpendicularly extended from the hips to the snow.

Table 6

Percent Occurrence of the Critical Features at the Eight Skill Award Levels

Skill Level / Critical Feature	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)	8 (%)	Total (%)
1	52.6	16.6	23.5	0	0	20	0	0	25.8
2	42.1	83.3	94.1	83.3	100	100	100	100	77.0
3	89.5	100	82.4	83.3	100	80	100	100	88.7
4	Eliminated following preliminary analysis								
5	94.4	100	100	100	100	100	100	100	98.4
6	100	100	94.1	100	100	100	100	100	98.4
7	Eliminated following preliminary analysis								
8	0	0	5.6	0	0	0	0	0	1.6
9	Eliminated following preliminary analysis								
10	0	0	100	100	50	100	100	100	59.0
11	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o	n/o
12	47.4	100	70.6	66.6	50	40	25	33.3	58.1
13	100	100	100	100	100	100	100	100	100
14	42.1	83.3	100	100	100	100	100	100	80.3
15	100	100	100	100	100	100	100	100	100
16	13.3	66.6	100	80	100	100	100	100	69.0
17	52.6	66.6	100	100	100	100	100	100	82.3
18	15.8	50	60	100	50	100	100	100	67.7
19	47.4	83.3	100	100	100	100	100	100	82.3

Table 6 Continued

Skill Level / Critical Feature	1 (%)	2 (%)	3 (%)	4 (%)	5 (%)	6 (%)	7 (%)	8 (%)	Total (%)
20	94.4	100	64.7	100	100	100	100	100	88.3
21	100	100	100	100	100	100	100	100	100
22	100	100	100	100	100	60	100	100	96.7
23	94.7	83.3	100	100	100	100	100	100	95.1
24	21.1	33.3	94.1	100	100	100	100	100	67.2
25	92.3	100	100	83.3	100	100	100	100	96.4
26	31.6	16.6	41.2	0	100	100	100	100	45.9
27	100	100	47.1	33.3	0	20	50	0	61.3
28	5.9	0	82.3	66.6	50	80	100	100	51.6
29	10.5	0	11.8	0	0	0	25	66.6	11.3

2. Critical Feature 6 - leg independence. Descriptor: The flexion, extension, abduction, adduction, rotation, steering and pressuring of one leg was accomplished independently of the other leg.

3. Critical Feature 13 - steering of the foot of the turning ski. Descriptor: To initiate turning, the foot of the turning ski was pivoted at the beginning of the preparation phase, throughout the preparation phase or, throughout the preparation phase and into the pre-execution phase.

4. Critical Feature 17 - knee angulation. Descriptor: To edge the ski, the skier initiated knee angulation in the pre-execution phase, either alone, or in conjunction with hip angulation, and/or steering.

5. Critical Feature 21 - weight on turning ski. Descriptor: The majority of body weight was located over the turning ski.

6. Critical Feature 22 - constant lower limb length. Descriptor: The flexion/extension angles at the hip and knee remained static throughout the execution phase.

7. Critical Feature 23 - turn progression through one arc. Descriptor: The arc of the turn progressed smoothly from start to finish during the execution phase.

8. Critical Feature 25 - extension perpendicular to the slope. Descriptor: While extending off the pressured ski, all movements at the trunk, hip and knee were directed perpendicular to the slope.

At the other end of the spectrum, only Critical Feature 8, retraction of the lower limbs, was observed in less than 10% of the performances. Critical Feature 29 (movement of arms trunk and hips back to stance position), was observed in 7 of the 62 performances resulting in an overall occurrence rate of 11.3%. It should be noted that unlike any other feature, the occurrence of this critical feature was observed in only one turn for each of the seven performances, it was not demonstrated consistently throughout the performances as it was not considered a desirable movement. Had the rate of occurrence for all critical features

been calculated on a per turn basis, the rate for this critical feature would have been significantly lower, as such, it was a suitable addition to the 0 - 10% occurrence category.

The descriptors for each critical features, the raw tallies and the corresponding percentages can be found in Appendix D.

Given the results in the total % column, it was possible to determine the high occurrence features and the most frequently occurring descriptors at each of the eight levels. The number of critical features which were demonstrated at a specific level was related to skill difficulty. The total number of high occurrence critical features per Level is presented in Table 7. This table was constructed to illustrate the increased number of critical features which contributed to a successful performance as the skier progressed through the eight skill levels

These results suggest that as the skiers progressed towards a higher skill level, they were required to master a greater number of critical features. Skiers at Level 1 required mastery of 10 critical features, that is to say that they must have demonstrated each of the 10 critical feature in at least 90% of the performances, whereas at Level 8 the skiers had mastered 20 of the 29 observed critical features. The mastery requirements were increased gradually over the eight levels with only the totals for levels three and four, being out of sequence. In most instances, when moving from one level to the next, the skier was

Table 7

Frequency of the High Occurrence Critical Features at Each Skill Award Level

Level	Features with 90 - 100% Occurrence Rates	Total
1	5 6 13 15 20 21 22 23 25 27	10
2	3 5 6 12 13 15 20 21 22 25	10
3	2 5 6 10 13 14 15 16 17 19 21 22 23 24 25	15
4	5 6 10 13 14 15 17 18 19 20 21 22 23 24	14
5	2 3 5 6 13 14 15 16 17 19 20 21 22 23 24 25 26	17
6	2 5 6 10 13 14 15 16 17 18 19 20 21 23 24 25 26	17
7	2 3 5 6 10 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28	20
8	2 3 5 6 10 13 14 15 16 17 18 19 20 21 22 23 24 25 26 28	20

required to demonstrate the critical features of the previous phase plus a few new ones. It was not that the new features were more difficult to grasp than the ones previously learnt but, that the combination of features at each subsequent level was more difficult to master.

The number of high occurrence critical features at a level also affected the amount of variability that was observed between performances at the same level. In fact, the individuality demonstrated by a performer appeared to be inversely proportional to the number of high occurrence critical features exhibited. At each level there was always a certain number of

critical features which were manifested identically throughout all performances, these formed the skill requirements for that level and were present in 90 - 100% of the performances. The manifestation of other features was left to the discretion of the performer, the presence and combination of these other features determined the individual style of the skier. For example, at Level 1, where there were nineteen, non-100% features, there was greater variability between performers when compared with Level 8, where there were only nine.

An examination of Table 6 for the presence of low occurrence critical features, revealed that there were no similar trends to report. With the exception of Critical Feature 6 (retraction of the lower limb), and Critical Feature 29 (movement of the trunk, hip and lower limb to stance during recovery), these features are randomly located throughout the table.

Critical Feature Descriptors

Based on the results presented in Tables 6 and 7, the critical feature descriptors for each level have been listed using the following guidelines; a descriptor which had a 100% occurrence rate fell under the heading "must have", those with between 90 - 99% occurrence rate fell under the heading "should have". The 90 - 99% category was not present at all levels.

Level 1

In accordance with the data analysis results, to have successfully performed the Power Plow the skier must have:

1. Maintained a wedge position with each leg working independently of the other.
2. Steered the turning ski by pivoting the foot, in order to begin the turn.
3. Initiated some degree of knee angulation during the pre-execution phase.
4. Positioned the body weight over the turning ski.
5. Maintained a constant lower limb length.
6. Returned to a relaxed stance position prior to initiating subsequent turns.

In addition the skier should have:

1. Positioned the shoulders forward of the hips throughout the turn.
2. Progressed through the turn gradually with no excess pressure exerted anywhere through the phase.
3. Travelled through one arc during the turn.
4. Extended the hips and knees perpendicularly, or slightly forward/back when returning to the stance position.

Level 2

To have successfully performed the Open Christie, the skier must have:

1. Kept the trunk and shoulders moving as a block in the same

plane.

2. Held the shoulders forward of the hips throughout the turn.

3. Started with the skis in a wedge position and finished the turn with ski parallel, with the legs working independently of one another.

4. Entered each turn in a tall stance.

5. Steered the skis to begin the turn.

6. Initiated some degree of knee angulation either alone, or in conjunction with the hip during the pre-execution phase.

7. Turned progressively through the gradual application of pressure throughout the execution phase.

8. Positioned the body weight over the turning ski.

9. Maintained a constant lower limb length.

10. Extended perpendicularly, slightly forward, or back when returning to a relaxed stance position.

11. Returning the hips and lower limbs to a relaxed stance position prior to initiating subsequent turns.

Level 3

To have successfully completed the Basic Parallel, the skier must have:

1. Held the shoulders forward of the hips throughout the turn.

2. Inclined the body towards the inside of the turn during the preparation phase.

3. Steered the turning ski to begin the turn.

4. Projected the upper body towards the fall-line at the start of

the turn.

5. Initiated some degree of knee angulation either alone, or simultaneously with the hip during the pre-execution phase.

6. Initiated a small amount of hip angulation near the end of the pre-execution phase.

7. Flexed the trunk and maintained upper body anticipation throughout the execution phase.

8. Regulated turning during the execution phase through angulation at the hip either alone, or in conjunction with steering.

9. Positioned the body weight over the turning ski.

10. Maintained a constant lower limb length.

11. Turned progressively through one constant, smooth arc.

12. Extended perpendicular, or forward of the perpendicular while releasing the pressured ski at the end of the turn.

In addition the skier should have:

1. Skied with rounded shoulders, flexed trunk and flexed hips.

2. Kept the skis parallel with each leg working independently of the other.

3. Extended the hips and knees either completely, or partially when releasing the pressured ski.

Level 4

To have successfully perform the Parallel Around Poles, the skier must have:

1. Held the shoulders forward of the hips throughout the turn.

2. Kept the legs in a wedge position with each leg worked independently of the other.
3. Inclined the body towards the inside of the turn during the preparation phase of the turn.
4. Steered the skis to begin the turn.
5. Projected the upper body towards the fall-line during the pre-execution phase.
6. Initiated some degree of knee angulation during the pre-execution phase.
7. Maintained upper body anticipation and increased flexion of the trunk during the execution phase.
8. Moved the hips towards the snow as a result of the hip angulation.
9. Regulated turning through hip angulation during the execution phase.
10. Turned progressively by gradually applying pressure to the turning ski.
11. Positioned the body weight over the turning ski.
12. Maintained a constant lower limb length during the execution phase.
13. Progressed through one arc.
14. Extended either completely or partially, while releasing the pressured ski during the follow-through.

Level 5

To have successfully completed the Pedal Turns, the skier

must have:

1. Skied with rounded shoulders, a slightly flexed trunk and flexed hip.
2. Kept the shoulders and trunk aligned.
3. Held the shoulders forward of the hips throughout the turn.
4. Kept each leg working independently of the other with the turning ski remaining on the snow, and the other ski either on the snow or in the air. The legs worked in a wedge position.
5. Steered the ski to some degree during the preparation of the turn.
6. Projected the upper body towards the fall-line.
7. Initiated some degree of knee angulation during the pre-execution phase.
8. Initiated a small amount of hip angulation at the end of the pre-execution phase.
9. Increased the amount of trunk flexion, outside arm abduction and upper body anticipation throughout the execution phase.
10. Regulated turning during the execution phase through hip angulation alone, or in conjunction with knee angulation and steering.
11. Turned progressively by gradually pressuring the turning ski.
12. Positioned the body weight over the turning ski.
13. Maintained a constant lower limb length throughout the execution phase.
14. Progressed through one arc.
15. Extended the hips fully, and the knees either partially or

fully when releasing the pressured ski.

16. Moved perpendicular or slightly forward of the perpendicular when releasing the pressured ski.

17. Moved explosively through the range of motion in order to release the pressured ski.

Level 6

To have successfully completed the Dynamic Parallel, the skier must have:

1. Skied with rounded shoulders, a flexed trunk and flexed hips.

2. Held the shoulders forward of the hips throughout the turn.

3. Kept each leg working independently while maintaining a parallel stance.

4. Inclined the body towards the inside of the turn during the preparation phase.

5. Steered the ski during the preparation phase by pivoting the turning foot in order to begin the turn.

6. Projected the upper body towards the fall-line at the beginning of the pre-execution phase.

7. Initiated some degree of knee angulation either alone, or in conjunction with the hip.

8. Angulated at the hip during the pre-execution phase or as the phase neared its end.

9. Increased trunk flexion, outside arm abduction and upper body anticipation through the execution phase.

10. Moved the hips towards the snow as a result of angulation.

11. Regulated turning through the use of hip angulation.
12. Turned progressively by gradually applying pressure to the turning ski.
13. Positioned the body weight over the turning ski.
14. Progressed through one arc.
15. Extended the hips and knees either completely, or partially when releasing the pressured ski.
16. Extended perpendicular, or slightly forward when releasing the pressured ski.
17. Moved explosively through the range of motion while releasing the pressured ski.

Level 7

In order to have successfully completed the Short Radius Turns, the skier must have exhibited all the descriptors from Level 6 as well as:

1. Held the shoulders aligned with the trunk throughout the turn.
2. Maintained a constant lower limb length throughout the execution phase of the turn.
3. Held an anticipated body position at the end of each turn.

Level 8

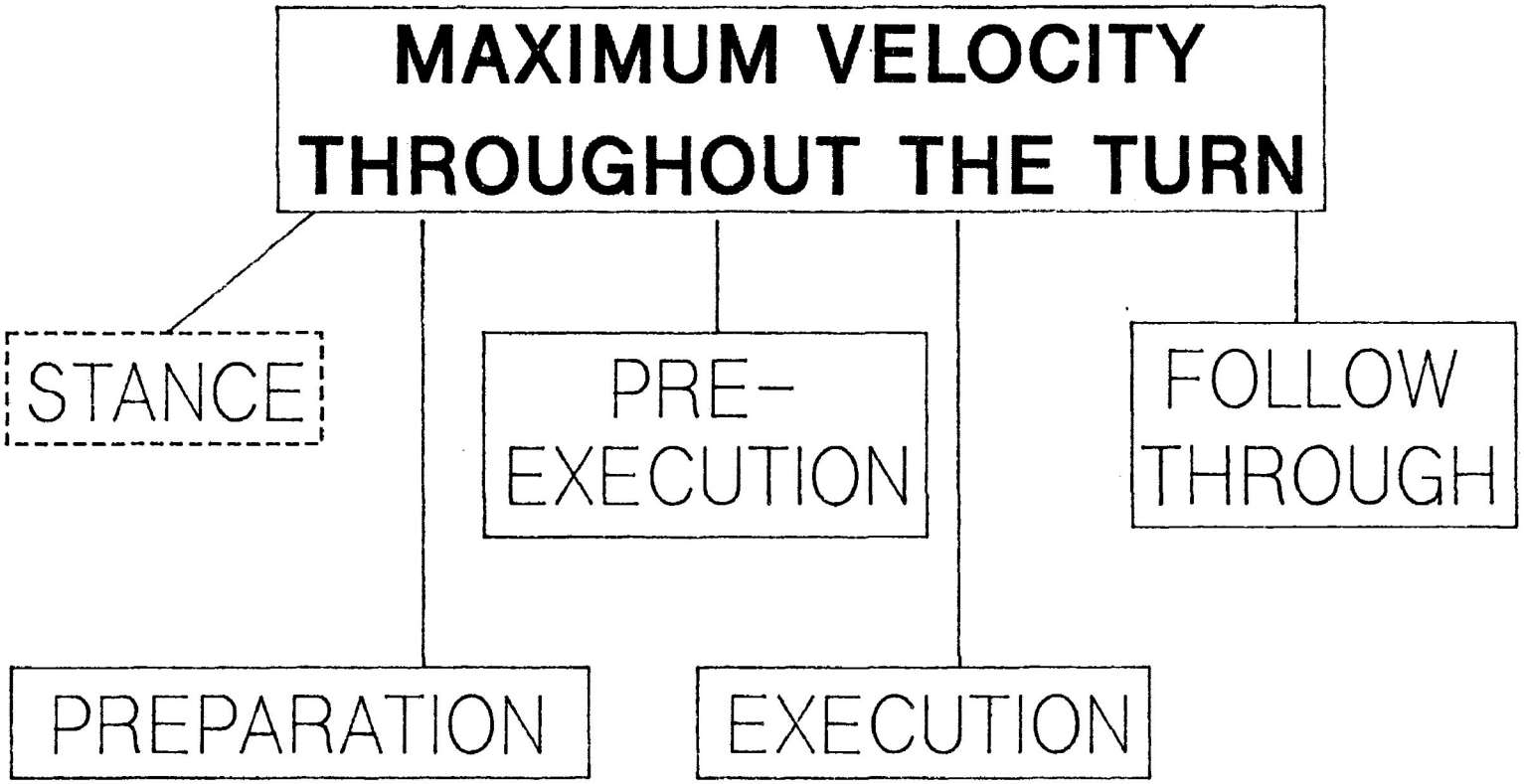
In order to have successfully completed All Snow, All Terrain, the skier must have demonstrated the ability to adapt to changing terrain, speed and snow. In light of this, the skier exhibited a large repertoire of descriptors similar to those

demonstrated in Levels 1 through 7. While demonstrating the ability to vary body movements constantly as the terrain demanded. The classification of each manifested critical feature to one descriptor did not do justice to the scope of responses observed. As a result, a list of descriptors such as those presented for levels 1-7 was not appropriate. All Level 8 skiers exhibited to some degree the critical features noted in Level 7 but, varied the responses to ensure smooth turn progression and linkage.

Summary of Results

To summarize, the data analysis led to the refinement of the deterministic model for the giant slalom ski turn. The revised model is presented in Figures 5 and 6. Nine critical features were renamed to facilitate the understanding of their scope, and 14 predictive features were identified. These adjustments were designed to make the model more user-friendly for the practicing coach.

There were eight critical features which were identified in 90 -100% of the performances across all eight levels. These features were; shoulders forward of the hips, leg independence, steering of the foot of the turning ski, knee angulation, weight on the turning ski, constant lower limb length, turn progression through one arc and extension perpendicular to the slope. These features formed a core of fundamental skill requirements for alpine skiing. In addition, there were two critical features



Note: Recovery phase to occur as required.

Stance position as a phase to occur predominately in the lower skill levels.

Figure 5. Performance criterion and the revised, simplified performance criterion for the alpine ski turn.

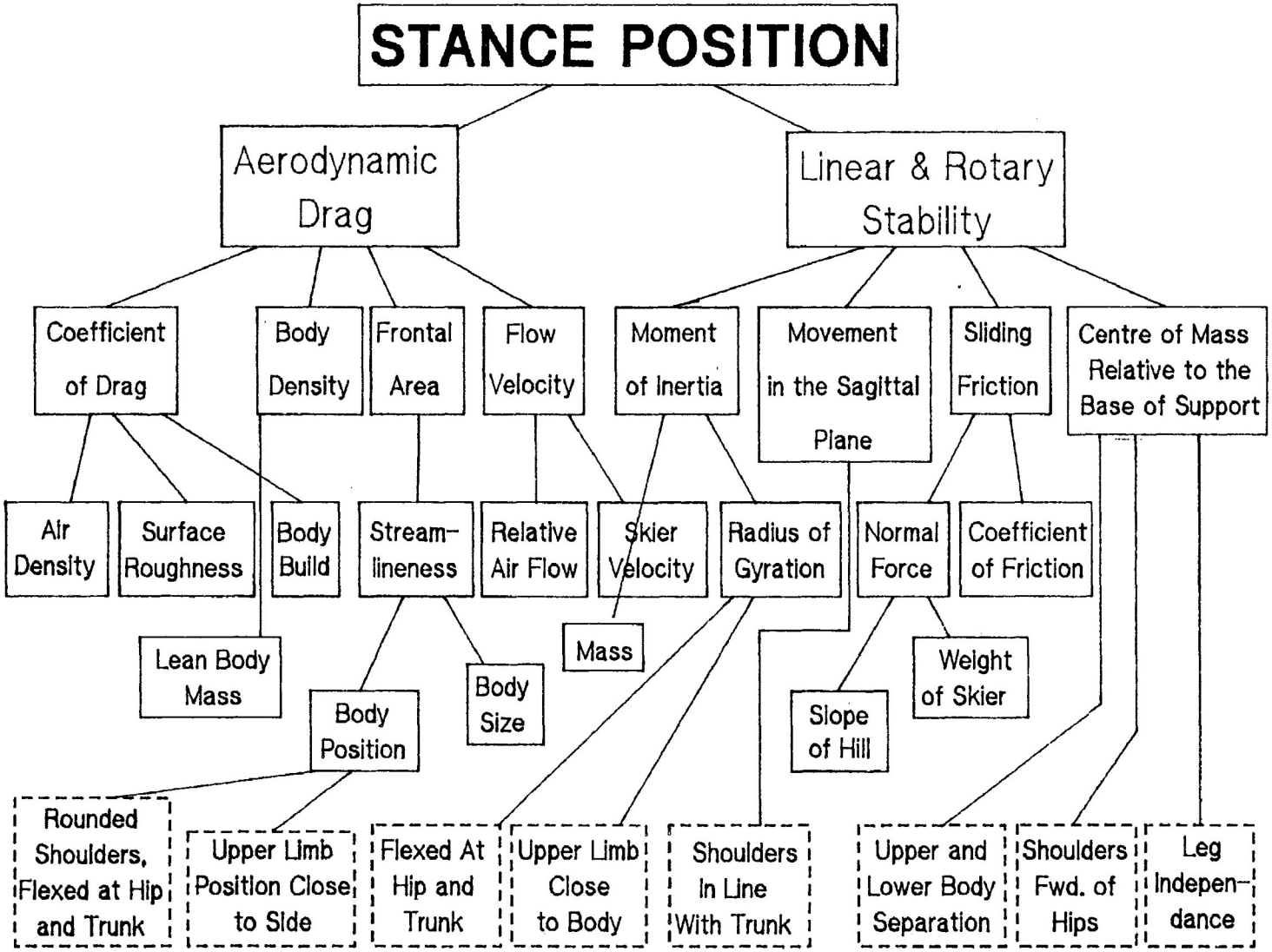


Figure 6. Revised deterministic model of the giant slalom ski turn; stance position.

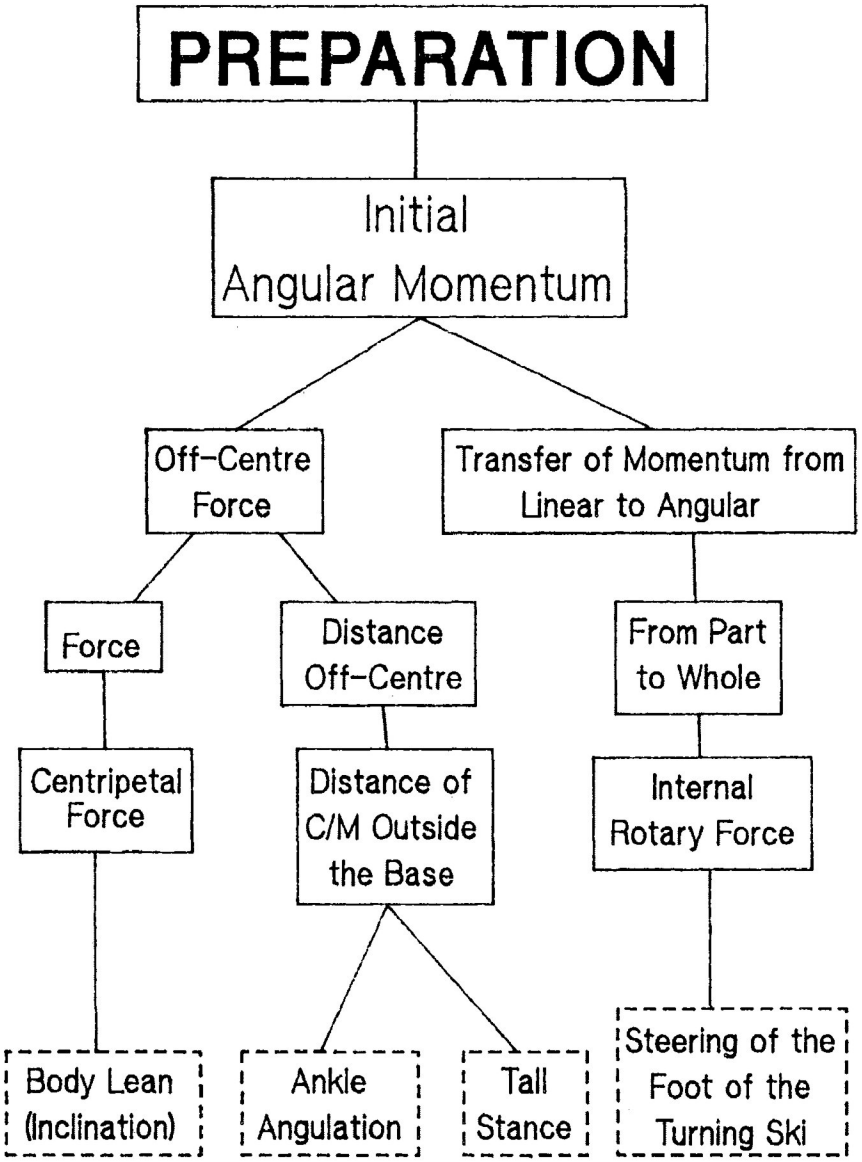


Figure 6. Revised deterministic model of the giant slalom ski turn; preparation phase.

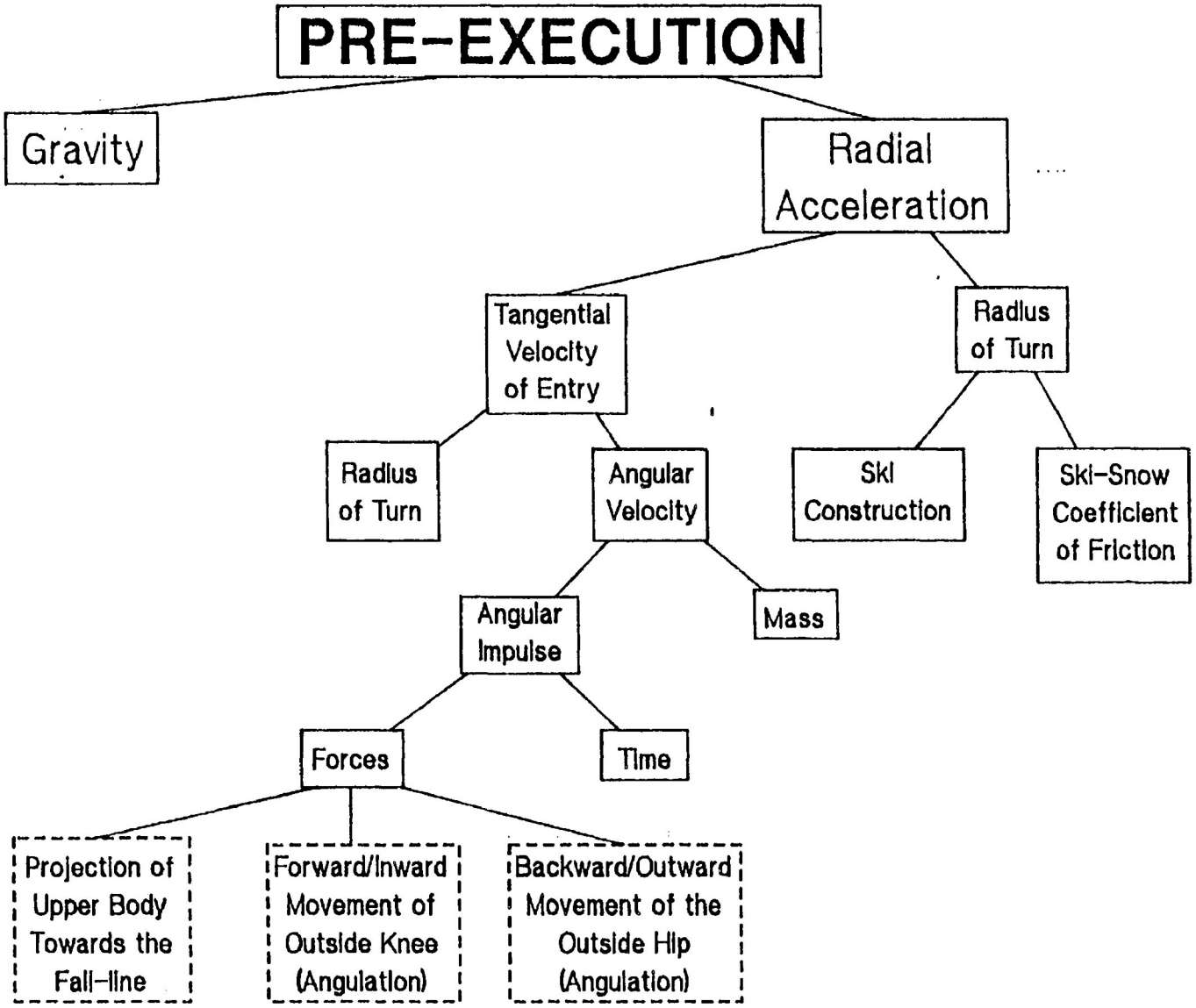


Figure 6. Revised deterministic model of the giant slalom ski turn; pre-execution phase.

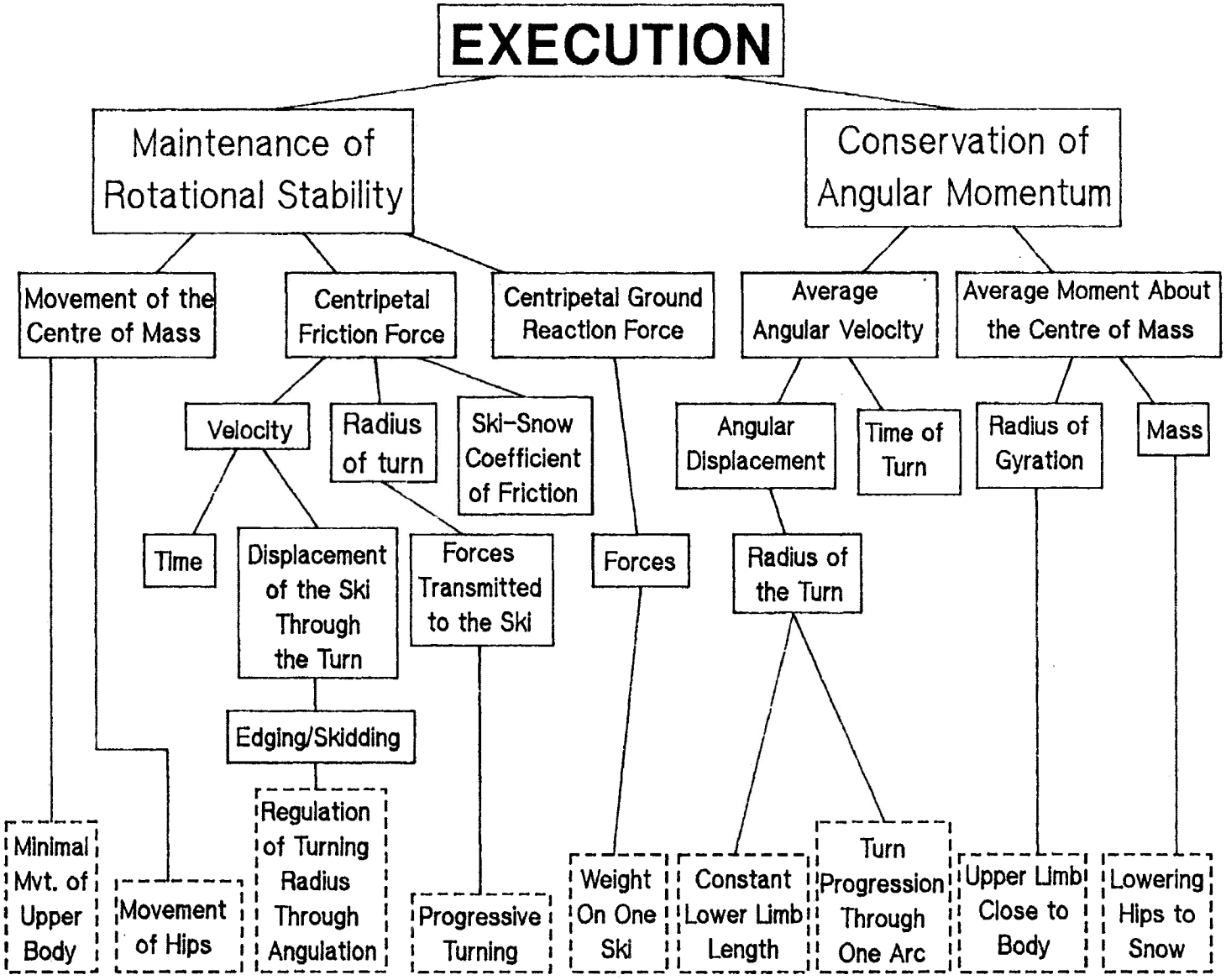


Figure 6. Revised deterministic model of the giant slalom ski turn; execution phase.

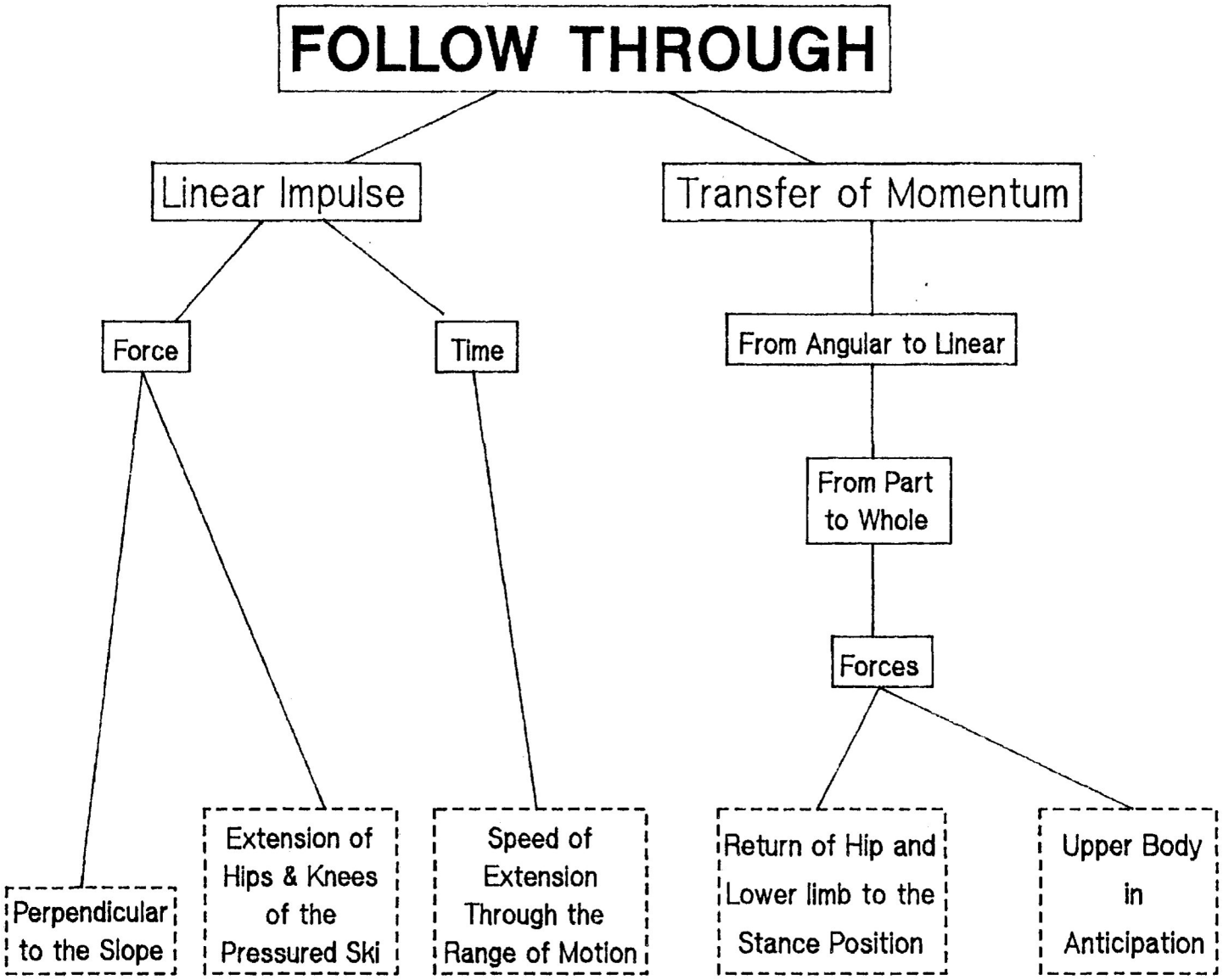


Figure 6. Revised deterministic model of the giant slalom ski turn; follow through phase.

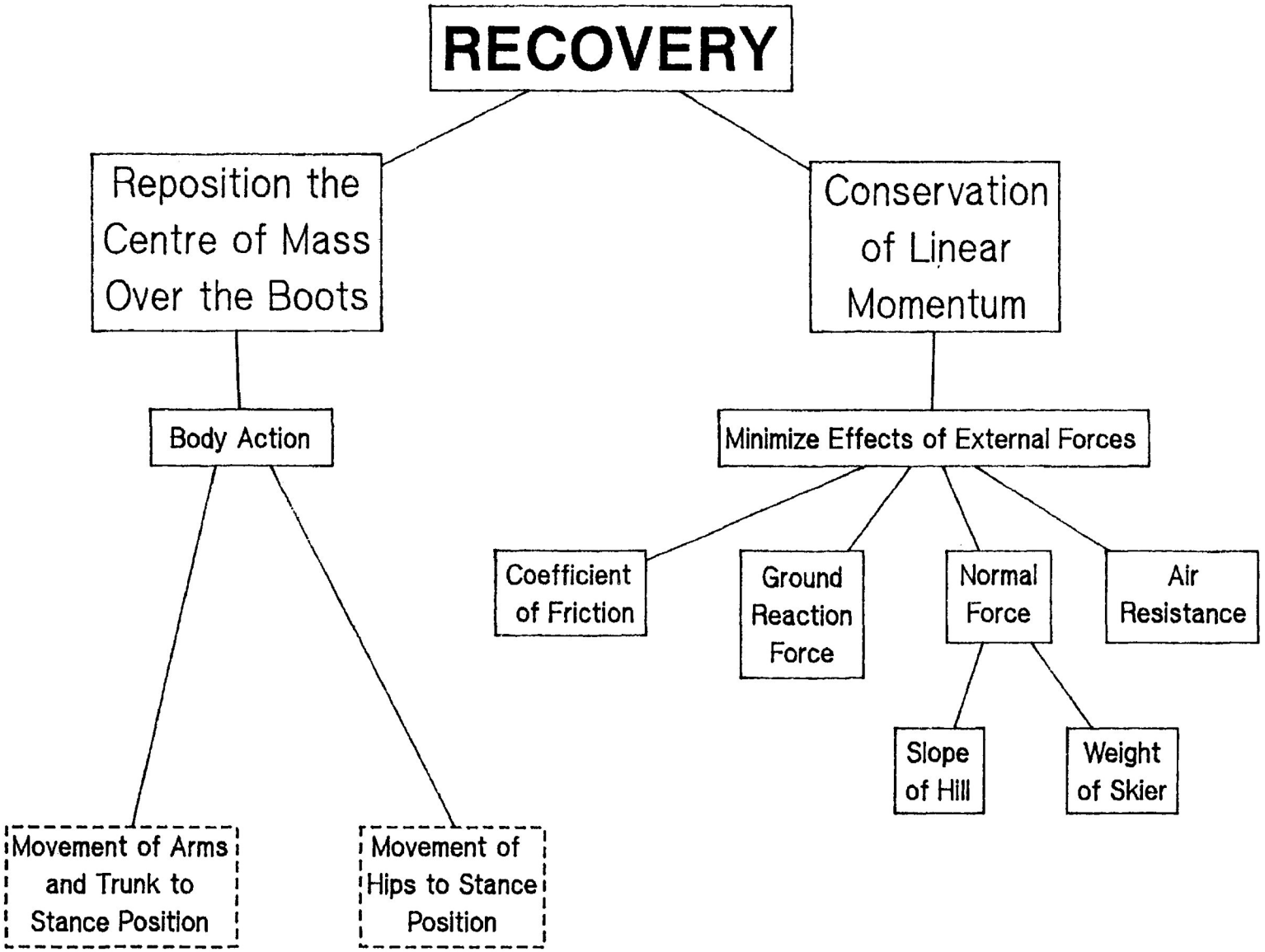


Figure 6. Revised deterministic model of the giant slalom ski turn; recovery phase.

which were present in less than 10% of the performances, they were retraction of the lower limb during weight transfer, and return of trunk, hip and lower limb to the stance position during recovery. Retraction of the lower limb was infrequently viewed because, the preferred method of weight transfer was through extension of the lower limb. In the second case, the use of the critical feature from the recovery phase was indicative of a failed turn and was therefore present in very few of the pass performances.

Progressing from Level 1 to Level 8 of the Skill Awards program, the number of critical features which were exhibited in 90 - 100% of the performances at each level, increased from 10 at Level 1 to 20 at Level 8. The features mastered at the lowest levels included the eight critical features which were fundamental to all eight skill levels. As the skier progressed towards Level 8, they added to the mastery list until at Level 8, all critical features were manifested in 100% of the performances with the exception of upper limb position close to trunk, retraction of the lower limb, tall stance, movement of trunk and lower body back to stance prior to commencing subsequent turns and, movement of arms, trunk, hips and lower limb to stance position after recovery.

The presence of non-100% features in different combinations for different skiers, accounted for the variability in the performances at each level. Greater variability was thus expected and seen, at the lower levels of the Skill Awards

program where there were more non-100% critical features, when compared with the higher levels of the program.

Combining the results from the specific sections of the completed data analysis, an overall summary of all movements observed at each skill level was developed and is presented in the following section.

Summary of Movements at Each Level

Level 1 - Power Plow. In order to have successfully completed Level 1, the skier must as part of the stance, have kept the shoulders in-line, or forward of the hips, maintained a wedge position and leg independence throughout the turn. The upper limb positioned varied from close to the body with the hands held low, to away from the body with hands held about rib cage height. The hips were usually flexed with the trunk held in either an upright or slightly flexed position. During the preparation phase, the skier steered the turning ski to initiate turning. There was no body inclination or retraction of the lower limb observed. In the pre-execution phase, the skier used some knee angulation to further edging while the hips remained high and uninvolved or were isometrically adducted to aid in edging. Steering may have continued during this phase with the upper body remaining in-line with the lower body. As the skier passed into the execution phase, the turning ski was weighted gradually so that the turn progressed in a smooth arc, while the skier maintained a constant lower limb length. The turning radius was

regulated primarily through steering and isometric adduction of the hip. The trunk remained as per the stance position, except that it became slightly more flexed in some skiers. Finally, as part of the follow through, the skier moved perpendicular to the slope to return to a relaxed stance position prior to commencing the next turn. The movement back to stance was either explosive or gradual, and no upper body anticipation was observed.

Level 2 - Open Christie. To have successfully completed Level 2, the skier must as part of the stance, have maintained leg independence, kept the shoulders in-line with trunk and forward of the hips throughout the turn. The legs began each turn in a wedge and progressed to a parallel position as the skier moved towards the execution phase. The upper limb was usually abducted at the shoulder, flexed at the elbow with the hands held about mid rib cage height. The trunk position varied between upright, slightly flexed and flexed. The shoulders were rounded and the hips were flexed. The skier entered the preparation phase in a tall stance, and initiated turning by steering the foot of the turning ski. There was no evidence of body inclination or retraction of the lower limb during weight transfer. Entering the pre-execution phase, the upper body was often projected towards the fall-line and,the skier used knee angulation either alone or, in combination with steering to edge and turn the ski. Hip angulation was used by some whereas others demonstrated an involved hip position. As the skier passed into the execution phase, the turning ski was gradually weighted while the lower

limb was held in a static position resulting in a smooth turn. The upper body position varied from static to increased flexion and anticipation. The regulation of the turning radius was accomplished through hip angulation, for those who employed it, or through a combination of steering, isometric adduction, and knee angulation. During the follow-through phase, the skier either extended perpendicularly off the pressured ski to return to stance or, moved back to stance through relaxation of the muscles of the lower limbs. The extension was gradual and there was a dead spot between turns. There was no anticipation observed at this level.

Level 3 - Basic parallel. To have successfully completed Level 3, the skier must as part of stance, have kept the shoulders forward of the hips and, maintained leg independence while the skis ran parallel throughout the turn. The upper limb was generally abducted at the shoulder, flexed at the elbow with the hand held about rib cage height. Hips were flexed, the trunk was flexed or upright, and the shoulders were rounded. Some upper body rotation was observed but, the skiers usually kept the shoulders in-line with the trunk. The skier generally entered the preparation phase in a tall stance, the skier then initiated turning through body inclination and by steering the foot of the turning ski. Entering the pre-execution phase, the skier projected the upper body towards the fall-line and, as steering decreased initiated knee angulation either alone, or in conjunction with the hip. The hip began to angulate as the phase

ended. In the execution phase, The trunk was often positioned in anticipation and usually became more flexed as the phase progressed. The hips lowered towards the snow as angulation at the hip proceeded, the radius of the turn was regulated by the angulation at the hip. The body weight was positioned over the turning ski while the lower limb maintained a constant length resulting in a turn which progressed through one arc. As part of the follow-through, the hips and knees tended to extend perpendicularly to the slope. The extension was either gradual or explosive with a small, if any, dead spot. The skier finished the turn in an anticipated body position.

Level 4 - Parallel Around Poles. To have successfully completed Level 4, the skier as part of stance, held the upper limb abducted at the shoulder, flexed at the elbow with the hands held away from the body at about rib cage height. The hips were flexed and the shoulders rounded while the trunk position varied from upright to flexed. The shoulders were generally held in-line with the trunk and forward of the hips. The legs worked independently of one another in a parallel stance. Steering of the turning foot and body inclination initiated turning in the preparation phase. The skier's stance entering the turn varied from tall to flexed. There was no retraction of the lower limb observed. The upper body was projected towards the fall-line to some degree, either at the end of the preparation phase or at the beginning of the pre-execution phase. Knee angulation was initiated as steering decreased during the pre-execution phase

and hip angulation began as the phase neared completion. Throughout the execution phase, the trunk was positioned in anticipation, and the arms were held closer to the body than in stance as the skier passed the pole. The hips moved downward towards the snow as a result of hip angulation, which in turn regulated the turning radius. The turns progressed smoothly with gradual application of pressure. The skier weighted the turning ski and maintained a constant lower limb length throughout this phase. To follow through, the skier extended either fully or partially at the hips and knees. The extension was directed slightly forward, slightly back or, perpendicular to the slope, and was gradual throughout the range of motion. The upper body position at the end of the turn varied from anticipated to over-rotated and the skier either passed through stance or returned to stance depending upon the length of time to the next gate.

Level 5 - Pedal Turns. To have successfully completed Level 5, the skier as part of the stance, held the upper limb abducted at the shoulder, flexed at the elbow with the hands away from the body at about mid-rib cage height. The hips were flexed, the trunk slightly flexed and the shoulders rounded. The shoulders remained in-line with trunk and forward of the hips throughout the turn, while the legs worked independently of one another. The legs were positioned in a wedge with only the turning ski in contact with the snow. Steering was used to begin the turn during the preparation phase, followed by projection of the upper body towards the fall-line, knee angulation, and hip angulation in the

pre-execution phase. The trunk flexed and was positioned in anticipation during the execution phase. The turning radius was regulated by angulation at the hip and knee either alone, or in conjunction with steering. The turns were linked and quick but still progressed smoothly with a gradual application of pressure. Only the turning ski was weighted with the lower limb maintaining a constant length throughout the phase. As part of the follow-through, the hips extended fully and the knees extended either fully, or partially with the movement being slightly forward or perpendicular to the slope. The extension was completed explosively. The body passed through the stance position and immediately began the next turn.

Level 6 - Dynamic Parallel. To have successfully completed Level 6, the skier as part of stance, held the upper limb abducted at the shoulder, flexed at the elbow with the hands held away from the body at about mid-rib cage height. The hips and trunk were flexed and the shoulders were rounded. The shoulders remained in-line with the trunk and forward of the hips throughout the turn. In addition, the legs worked independently of one another in a parallel position. To initiate turning in the preparation phase, the body was inclined towards the inside of the turn and the turning foot was steered in the desired direction of the turn. The stance was generally not tall, as the hips remained slightly flexed. The skier projected the upper body towards the fall-line and angulated the knee either alone or in conjunction with hip as the pre-execution phase progressed.

Throughout the execution phase the trunk was positioned in anticipation, with the hips lowered towards the snow as a result of angulation at the hip used to control the radius of the turn. The turns progressed through gradual application of pressure and the turning ski was actively weighted. Entering the follow-through phase, the skier extended the hips and knees either fully or partially. The extension was either directed slightly forward or perpendicular to the slope, and was completed quickly. The hip and the lower limb passed through the stance position to begin the next turn immediately with the upper body positioned in anticipation.

Level 7 - Short Radius Turns. To have successfully completed Level 7, the skier as part of stance, held the upper limb abducted at the shoulder, flexed at the elbow with the hands held at about rib cage height. The hips were flexed the trunk at least slightly flexed and the shoulders were rounded. The shoulders remained in-line with the trunk and forward of the hips throughout the turn. The legs worked independently of one another in a parallel position. Turning was initiated by steering the foot of the turning ski and through body inclination. The stance was usually flexed due to incomplete hip extension and no retraction of the lower limb was observed. Entering the pre-execution phase the upper body was projected towards the fall-line, the knee was angulated to some degree, and the hip was angulated as the phase neared completion. During the execution phase, the trunk was positioned in anticipation, and the hips

lowered towards the snow as a result of the hip angulation used to control the radius of the turn. The turn progressed gradually through one arc, the weight was positioned over one ski and the lower limb maintained a constant length throughout the phase. The hips and knees extended explosively and perpendicularly in order to release the pressured ski in the follow-through phase. The skier generally passed through the stance position and immediately began the next turn, and upper body was positioned in anticipation.

Level 8 - All Snow, All Terrain. To have successfully completed Level 8, the skier as part of stance, held the upper limb abducted at the shoulder, flexed at the elbow with the hands held away from the body at mid-rib cage height. The hips and trunk were flexed while the shoulders were rounded and held forward of the hips throughout the turn. The legs worked independently of one another. Body inclination and steering of the foot of the turning ski were used in the preparation phase to initiate turning. The stance varied from tall to flexed with some retraction of lower limb observed. The upper body was projected towards the fall-line, the knee and hip were angulated as the skier progressed through the pre-execution phase. In execution, the trunk was positioned in anticipation with increased flexion as the phase progressed. The hips lowered towards the snow as a result of the hip angulation used to control the radius of the turn. Gradual pressure application combined with constant lower limb length and weight on one ski resulted in a turn which

progressed in a smooth arc. Signalling the follow-though phase was the explosive extension of the hips and knees to release the pressured ski. The extension was directed perpendicularly to the slope, the body then passed through the stance position to immediately begin the next turn. The upper body finished each turn in an anticipated body position. The Level 8 skiers showed more recovery than at other levels. The need for recovery was generally due to excess rotation at the shoulders which caused the upper body to rotate uphill.

Discussion of the Research Questions

1. What are the performance criterion, the mechanical constructs and the critical features of an elite giant slalom ski turn?

The refinements to the deterministic model for the giant slalom ski turn were presented in Figures 5 and 6. The changes resulted from the reassessment of the performance criterion of the skill, and the analysis of the results. The overall performance criterion of maximum velocity throughout the turn remained unchanged but, the simplification of the performance criterion into the six phases of a turn, was modified to improve the model's adaptability to all eight Skill Award levels.

Two phases, stance and recovery were removed from the normal cycle of phases. The stance phase was removed because it became clear that the critical features which made up that phase (Critical Features 1 to 6) were not isolated to one particular time frame, but rather were manifested throughout the entire turn. The "stance phase" should, therefore, be regarded as a "stance position", a position which differed from skier to skier but was always a balanced relaxed position which acted as a frame of reference for the investigator's observations.

Although it was true that the skier established the centre of mass over the base of support prior to each turn as reported by Major (1981), it was not necessarily effected by simply creating a platform on which to stand, but rather was achieved by

positioning the body segments to create an overall balanced body position which could be maintained throughout the turn. This balanced body position was most visible between turns but must also have existed at the end of each phase during a turn. If it did not, then the skier would not have moved on to subsequent phases and would have introduced a recovery phase to recapture the balanced position in which the turn could be effectively completed. In this way, the stance position also acted as a link between phases.

The recovery phase was removed, because it was not a regularly occurring event within the normal cycle of a turn. It was present in just 7 turns of the 62 performances. The manifestation of the critical features from this phase were involved any time the body became unstable, and the skier could not effectively continue the turn. In such cases, forward progression through the phases of the turn was stopped until the arms, trunk and hips returned to the stance position. At that point, a decision was made by the skier to either continue the turn from the point where the instability occurred or, to start over from the beginning. Although the reason for one choice or the other remains unclear, it is suspected that the length of time spent in the recovery phase may have bearing upon the decision.

The last modification made to the six phases of the giant slalom ski turn involved the preparation, and the follow-though phases. Depending upon the skill level involved, the follow-

through phase from one turn and the preparation phase from the next combined to create one phase. For example, with the higher skilled skiers in Levels 5-8, there was less time needed to prepare for each subsequent turn. As a result, the length of time spent in the stance position between turns was greatly reduced or eliminated. The ability to add, or eliminate a phase, is important in light of the observations made by Major (1981) who reported that at the elite level, the length of the platform phase (stance position) was dependent upon factors such as the terrain, distance between gates and the type of race course. The skier must therefore be proficient at both riding a flat ski through a long stance, and at linking turns to eliminate any stance. Both these skills are being taught through the Skill Awards program.

To reflect the possible variations in turn linkage, while preserving the original list of critical features and maintaining both a follow-through and a preparation phase, it was necessary to reorganize the model. The act of extension became solely the domain of the follow-through phase, while the Preparation phase involved steering and weight transfer to the new turning ski. Figure 7 illustrates two possible variations of phase linkage.

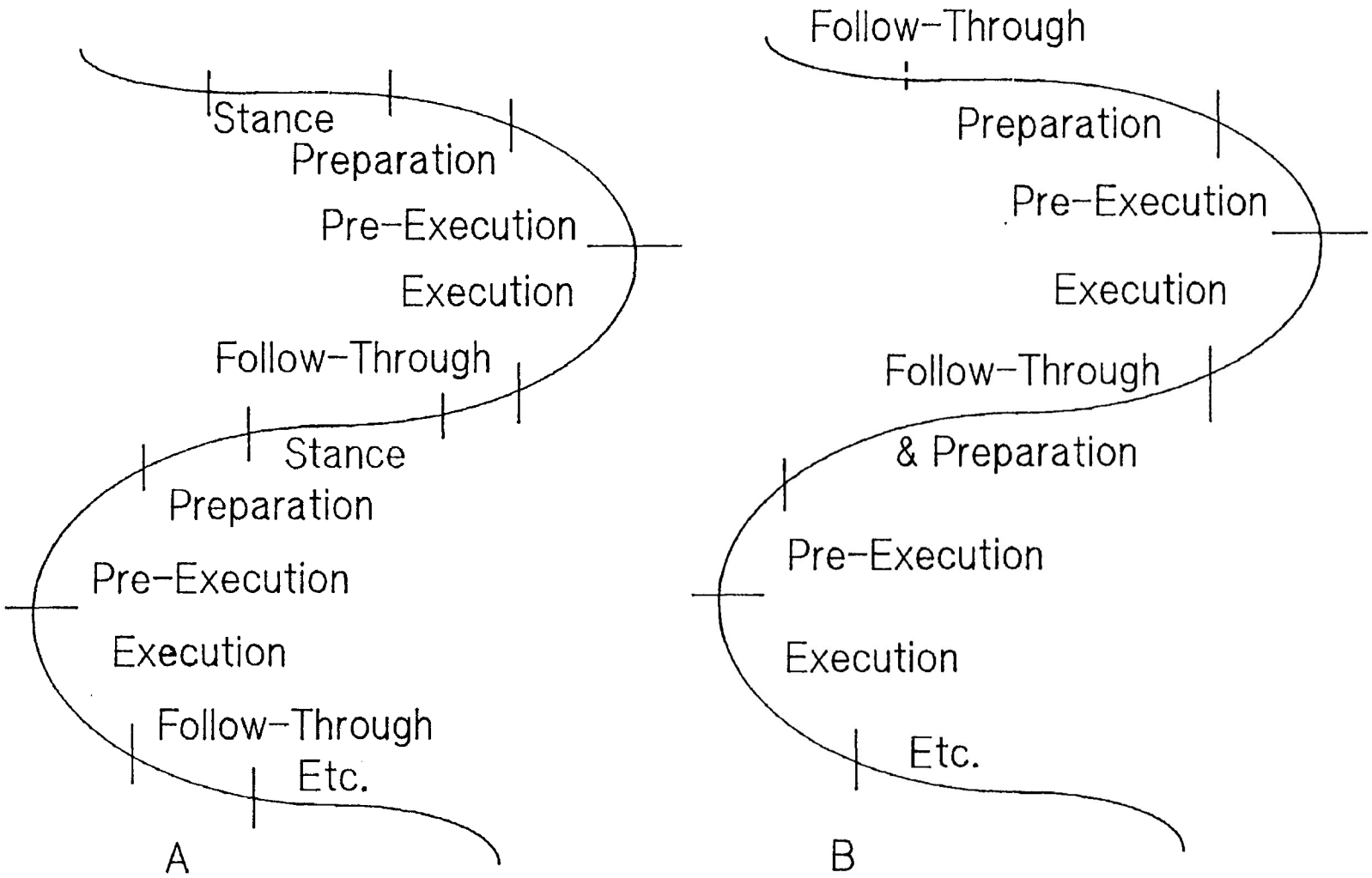


Figure 7. Phase and turn linkage variations for the alpine ski turn.

2. Were there any critical features identified during the development of the deterministic model, which were not manifested during the performance of the final form exams?

The critical features of the recovery phases were not deliberately displayed in any of the final form exams of the Skill Awards program, nor are they taught in any of the skill acquisition drills outlined in the program's handbook. This is not surprising since skiers have historically been taught to stay in a balanced position, since in theory that is the only position in which a turn came effectively be completed. In reality though, the ideal body position can not always be maintained and loss of balance occurs at all levels of skiing ability. A skier's skill level can be judged not only by the smoothness of the turns but also by the ability to recovery quickly from unfavorable situations. By ignoring the development of this aspect of skiing, skiers are being denied the chance to establish a repertoire of recovery moves. The critical features of the recovery phase should be intentionally exercised to develop medial-lateral, anterior-posterior, and rotation recovery.

Retraction of the lower limbs, in order to unweight the skis and thus facilitate weight transfer, was included in the deterministic model as an alternate critical feature for leg extension to unweight. This move is not often used in free skiing on smooth, groomed terrain but it is a very useful move on bumpy terrain, a rutted race course, or when there are extreme slope

changes. In the observed performances, this critical feature was manifested in a few turns of the Level 8 skiers and in one Level 3 skier. However, it is not taught, exercised, or emphasized in any of the program's skill acquisition drills. As with the critical features of the recovery phase, this lack of instruction is unfortunate because the larger the repertoire of skills mastered by a youngster, and the greater the exposure to varied situations, the more likely the skier is to succeed when confronted with similar situation at other skill levels.

One final critical feature, the upper limb position close to the trunk, was rarely exhibited by the skiers. Although this arm position would significantly reduce drag as reported by Watanabe and Ohtsuki (1977), it was not conducive to maintaining a balanced body position and was therefore dropped in favour of a more abducted position. Considering the significance of drag forces in alpine skiing, young skiers should be taught to use the arms sparingly for the maintenance of balance. For instance, the skier should avoid abducting two arms when one arm will do the job. In light of this observation, it was justifiable to conclude that balance took precedence over aerodynamics during the performance of the eight final form exams.

3. Were there any movements observed during the video analysis, which were not associated with any previously identified critical features?

There were a number of movements observed during the video analysis, which were not covered by the scope of the original list of critical features. In particular, the regulation of the turning radius through steering and isometric adduction, returning to the stance position (releasing the pressured ski) through relaxation of the musculature of the hip and lower limb, as well as the consistency of the hand and shoulder positions as part of the upper body position. In all cases, the descriptors for observed movements were similar enough to an already identified critical feature to be added to its scope.

The first two movements relate primarily to the lower skill levels (1 and 2). In executing the Power Plow and the Open Christie the skier maintained a wedge position through the execution and follow-through phases. This position effectively limits the amount of hip angulation that could be used to turn the skis. In place of hip angulation, the skier used steering and what can be termed as isometric adduction of the hip to complete the radius of the turn.

This method of turning the skis has an effect on the second movement, the extension of the leg off the pressured ski in the follow-through phase. Since the hips remained high and uninvolved the skier was already in an extended body position. To release

the edge of the pressured ski at the lower skill level, the skier relaxed those muscles involved in isometric adduction and returned the body to a relaxed stance position.

Hand and the shoulder positions noted in the video analysis were not expected given the observations of Watanabe and Ohtsuki (1977), which suggested that ideal arm position would be close to the body, instead upper limb position proved to be a good predictors of upper body position and balance. The location of the skier's hands in relation to the trunk, was associated with the amount of abduction and flexion noted in the upper limb. In cases where the ski jackets were bulky, the upper limb position could therefore be estimated from the hand position. The roundness of the shoulders was a good indicator of the position of the shoulders relative to the hips. To maintain the desirable, balanced position with the shoulders forward of the hips, the skier elevated the shoulder girdle producing a hunched appearance. In performances where the skier maintained an erect position, there was less likelihood that the shoulders were forward of the hips.

These conclusions were all, in some way, inconsistent with reported results based on investigations using elite athletes. Bean (1987) had reported that the follow-through was initiated with an explosive extension off the pressured ski, and it was generally reported that the skis were guided through the turn using angulation, flexion and extension (Bacharach & McGuire, 1985; Bean, 1987; CSIA, 1987 & Warren, 1988). There was no

mention of steering or isometric adduction. In addition, the investigator noted that the lower limb always maintained a constant length, and that neither flexion nor extension was observed. The findings suggest that the population investigated (7 -15 year olds) may not be considered mini-elite-adults. The progression of how a critical feature is being manifested at Level 1 through Level 8, should be reviewed to determine if what is being taught and tested for at the lower levels develops the skier to perform optimally at the higher Skill Award levels and at the elite levels of skiing. Furthermore, the performances of elite skiers should be reviewed to specifically note the manifestation of critical features as they are displayed at lower skill levels. If there is any similarity, progression, or shaping of skills, then these movements should continue to be exercised. If they only appear at a lower level and are not shaped into a useful skill or linked with other skills to produce the final form at Level 8, then their inclusion in the program should be questioned.

4. Were there differences between individuals, or groups of skiers, with regards to the weighting of critical features at different skill levels?

There were considerable differences in the manifestation of features at different Skill Award levels as well as between identifiable groups within skill levels. In general, at the lower

skill levels all movements were geared towards the maintenance of a stable body position. This was reflected in the type of movements displayed by the skiers at those levels. Body inclination for example, a movement considered to be important for creating an edge angle (CSIA, 1987 & Sodeyama et al., 1979) was nonexistent at the Levels 1 and 2. This may be explained by the fact that the body positions held at those levels made the lateral shift of body weight towards the inside of the turn difficult, as well the movement tends to bring the centre of mass close to the border of the region of stability. In the place of body inclination the skier used other movements to shift the body weight over the turning ski. However, from Levels 3 to 8, all skiers showed some degree of body inclination at the beginning of the turn. Other critical features such as upper body movement, anticipation, and return to stance, also showed trend differences between groups:

1. Upper body movement: From Level 3 onwards, the skiers showed more dynamic movements of the upper body during the execution of the turn as well as more flexion at the hip and trunk, and greater abduction and/or adduction of the upper limbs. Prior to Level 3, it was not uncommon to see the upper body remain static from one phase to the next.

2. Anticipation: The anticipated body position was non-existent at Levels 1 and 2 but, was more frequently observed as the skiers progressed towards Levels 7 and 8, where there was 100% occurrence of this feature.

3. Return to stance: The trends with regard to this critical feature were related to very fundamental differences between the individual Skill Award levels. Less skilled skiers required more time to prepare for subsequent turns, whereas higher level skiers linked their turns by using the energy stored in the pressured ski to propel them into the next turn. For example, the difference between Level 3 (basic parallel), and Level 6 (dynamic parallel), was the ability to properly time the follow-through extension so that the turns remained linked without any dead spots between the turns. Dead spots were periods in a turn where the skier did not work the ski and they occurred when the skier returned to the stance position prior to initiating a new turn.

The noted differences appear to be related to balance, strength, and timing, this may indicate that the growth and development of the skier may be a limiting factor to alpine skiing advancement.

Just as there were some very clear differences in the manifestation of some critical features, there were also those which were exhibited identically across the the eight skill levels. This group of descriptors formed a "fundamental skills group" for the eight levels. Features which fell into this category included shoulders forward of hips, leg independence, steering of the turning ski, knee angulation, turns progression through one arc, constant lower limb length, extension off the pressured ski perpendicular to the slope, and weight on the turning ski.

Seven of these eight fundamental skills concerned movements of the lower body, and the majority of the seven were manifested during the execution phase of the turn. The significance of this is illustrated in Figure 8. Figure 8A is a stick figure tracing taken from the video recordings, of the lower body of a Level 1 skier during the execution phase of the power plow. Figure 8B is a tracing of a level 7 skier during the execution phase of the short radius turns, and Figure 8C is a representation of Andreas Wenzel of the Liechtenstein National Ski Team at the 1986 World Cup Finals at Bromont, Quebec (Lang, 1986). The similarities between lower body position, in particular the position of the working leg, is not coincidental but rather it is a demonstration of the fundamental skills of alpine skiing. The fact that the descriptors for eight critical features transcend all levels of skiing indicated that complete mastery of those skills was required to properly edge and pressure a ski through a turn at any level. If these critical features were properly executed, regardless of any additional movements exhibited, the turn was successfully completed.

For each pass performances at a given level, the variability in the manifestation of "non fundamental" features, was related to individual style differences. This confirmed the fact that a turn could be successfully completed without every skier doing precisely the same movement. Based on this analysis, it is justifiable to conclude; (a) the demonstration of some critical features was more important than for others, therefore errors in

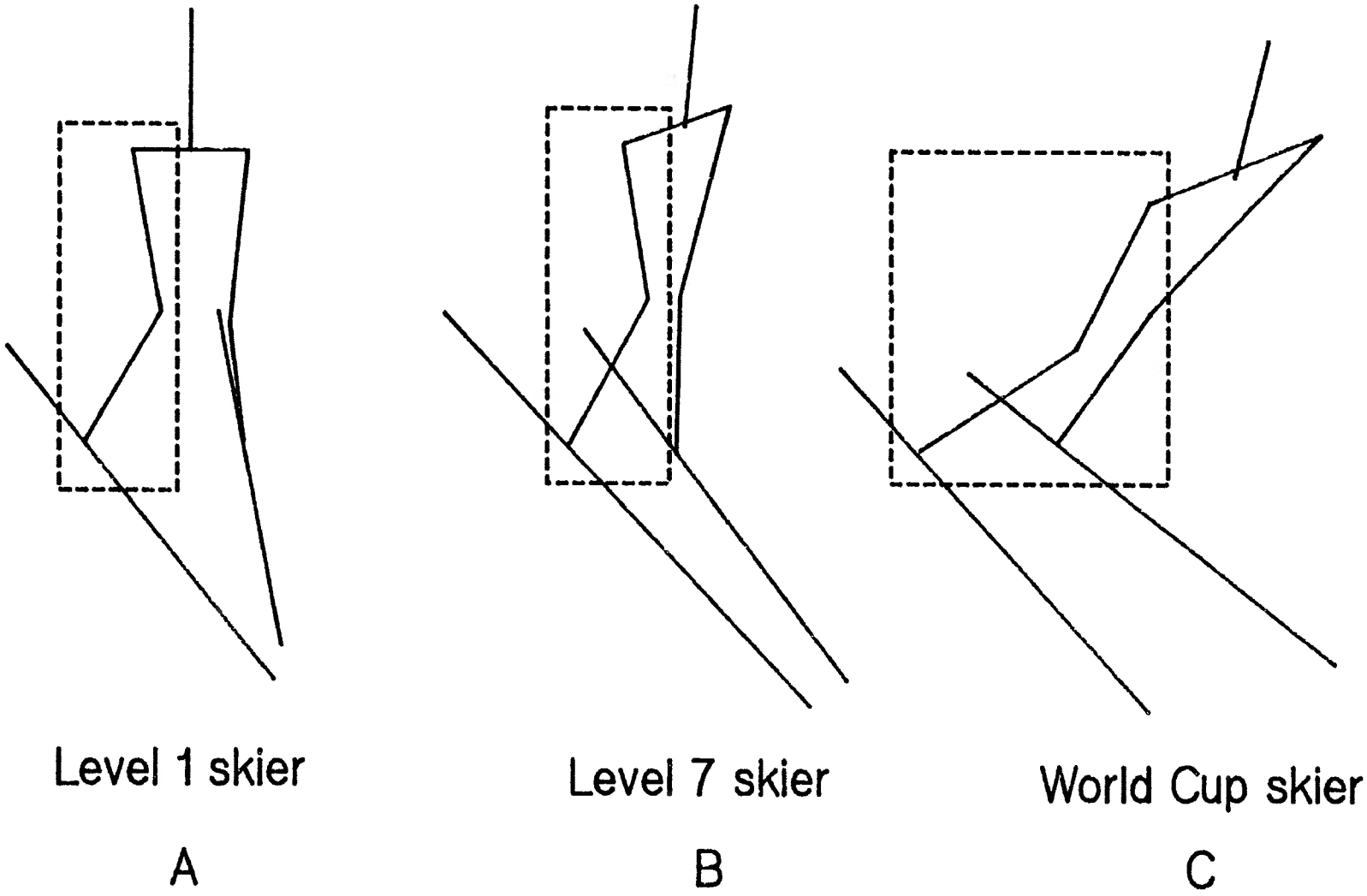


Figure 8. Lower body illustrations of skiers at Level one, Level seven, and of a World Cup performer, respectively.

the manifestation of the fundamental critical features must be corrected first, and (b) the correctness of movement at the lower body (where the majority of fundamental critical features were manifested) took precedence over movement of the upper body.

Within most levels there was one identifiable group of small sized skiers. There was no subject data collected for this investigation, so that the chronological age of the skiers in that group can not be determined. It was, however, evident throughout the data analysis that the smaller skiers performed certain skills differently from their larger counterparts. The smaller skiers in Level 1, 2 and 3 skied with their trunk more upright and hips more flexed creating an illusion of sitting on a chair while turning. Their method of turn regulation also differed, where a larger skier might use knee angulation, the smaller ones appeared to use more hip angulation. Neuromuscular considerations, as well as others may play a role in this observed difference.

Supplemental Discussion

"Linkage" critical features were identified during the data analysis, these were features which produced a flowing continuation from one phase to the next. Linking the preparation phase to the pre-execution phase were; steering of the foot of the turning ski and knee angulation. As the steering decreased, knee angulation increased. Linking the pre-execution and the execution phases were knee angulation and hip angulation. As soon

as the knee angulation was optimised during the pre-execution phase, hip angulation, steering, or isometric adduction took over as the means of regulating the radius of the turn. It was then gradually increased throughout the phase. Linking the execution and follow through phases was the extension off the pressured ski. Whether it was gradual or explosive, it had to be constant until the pressured ski was released if the phases were to be connected smoothly. Finally, connecting the follow-through to either the stance or, the next preparation phase was return of the trunk, hip and lower limb to the stance position. If the skier passed through the stance position, then the follow-through was linked with the next preparation phase whereas, if the skier returned to stance then the follow-through was linked with a stance phase.

The identification of linkage critical features was a important discovery as they were directly related to the smoothness of ski turn execution and to the rhythm of an overall ski run. The ability of the skier to properly time the execution of these critical features resulted in a smooth, rhythmic turn, which was not only aesthetically pleasing but was also mechanically efficient. The linkage features are presented in the perforated boxes of Figure 9.

One particular constraint on this investigation was the variability in the sample sizes at each level. The size of the sample submitted at each level was similar but, the number of performances graded with a pass covered a broad range. At levels

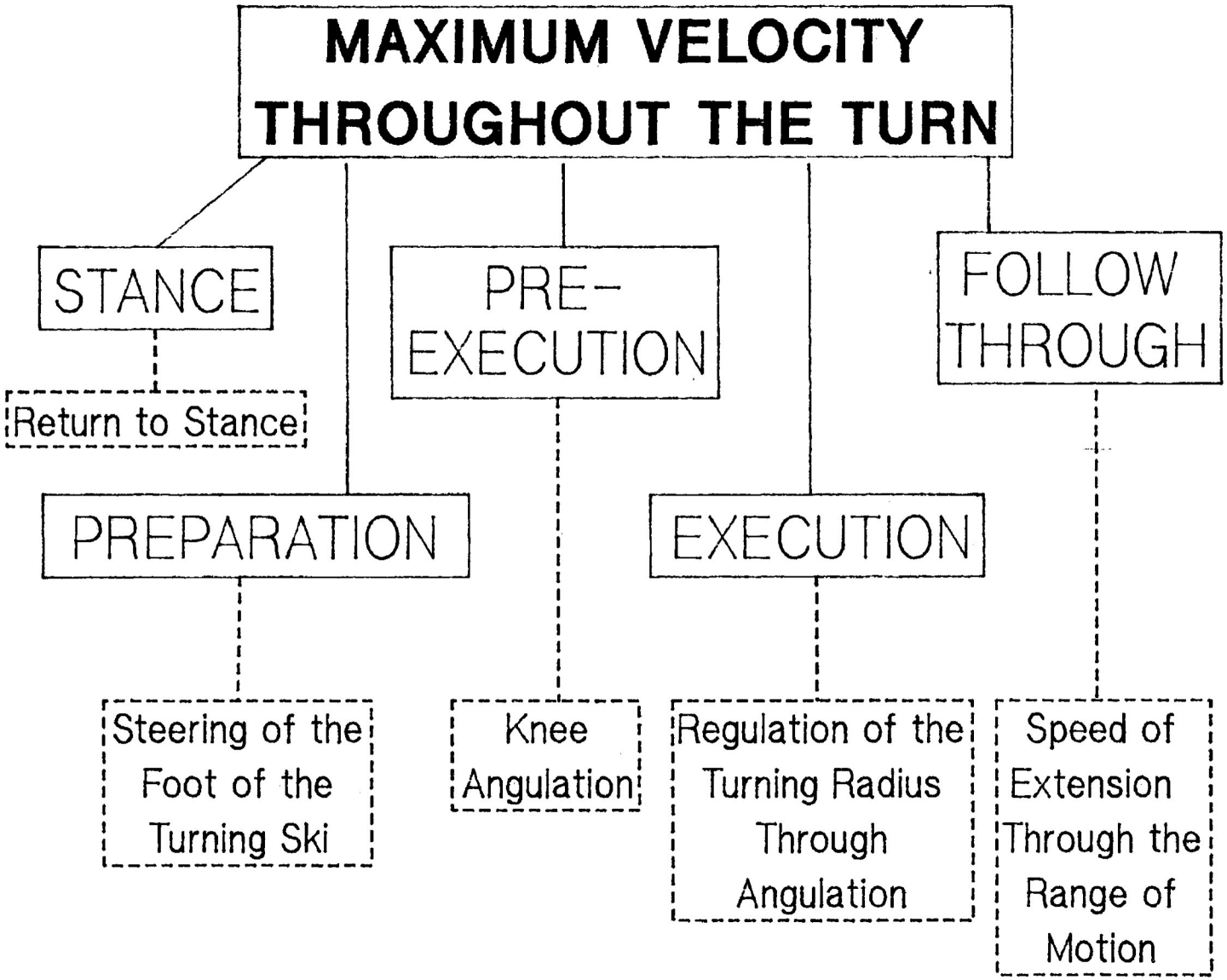


Figure 9. Linkage Critical Features.

2 and 5 for instance, there was only 10 and 7%, respectively which were graded as pass performances.

The failure rates may be indicative of problems with the instruction of the tests. For example, the Open Christie (Level 2) and Pedal Turns (Level 5), are not manoeuvres which coaches would have normally learnt during their formal training. Therefore, without very explicit instructions on how the skill is performed, each coach's interpretation of the skill may have differed, which may have resulted in the large range of performances observed. Another explanation may have to do with the tests themselves: (1) The manoeuvres may not be testing the skills taught at that level, so that the skiers encountered foreign concepts when they perform the exam or, (2) the exams were too difficult given the age, maturity level, or previous skill levels passed. Those levels with high failure rates should be reviewed to determine their value within the program.

Related to the difficulties with individual final form exams was the sequencing of the exams. Table 7 showed that the number of critical features mastered at Level 3 was greater than at Level 4, indicating a possible sequencing problem. The high failure rate at Level 5 (93%) as compared to that at Level 6 (50%), may indicate too large a jump from Level 4. Considering the similarities between Level 5 (Pedal Turns) and Level 7 (Short Radius Turns), a possible solution may be to reverse the order of Level 5 and Level 6. Further investigation is required to determine the proper sequencing of the Skill Award program levels

as well as to establish the desirability for the elimination, or the replacement of some final form exams.

Finally, the most efficient method of teaching the skills which relate to individual critical features must be addressed. In the Skill Awards program, there appears to be a basic assumption that no one critical feature is more difficult than any other to master and therefore, the skills are taught individually, mastered individually, and then simply connected together to produce the desired end-result; the final form at Level 8. In other words, the list of critical features which must be mastered is added to as the skier progresses towards Level 8. A number of the critical features, for example steering of the foot of the turning ski, are taught to be performed identically whether the skier is at Level 1, or Level 8. There is no consideration as to the growth and development characteristics of the average skier at each of these levels. This may not be the most effective method of instruction for young skiers.

A possible alternative would be to use shaping techniques (National Coach Certification Program, 1988) so that the skills taught at Level 1 may not in any way resemble the desired final form of that feature at Level 8 rather, they would be shaped into the final forms as the skier progressed through the levels, taking into consideration all aspects of growth and development. It is also possible that the young skiers should be taught multiple, even redundant, combinations of critical features in order that the skiers would eventually be able to perform a

similar skill in many different ways, as opposed to knowing only one efficient method of performance. These teaching considerations and others deserve further examination.

The following points summarize the discussion section.

1. The critical features of the stance and the identified linkage features acted to affect the flowing continuity from one phase to one another. Timing was critical to the flow.
2. The critical features of the recovery phase were manifested anytime stability was upset, and the critical feature of the stance combined to act as a phase only in the lower levels of the program where set-up time was required.
3. Redundant and corrective critical features were not exercised in the Skill Award program.
4. Balance took precedence over aerodynamics, and the correctness of movement of the lower body took precedence over the correctness of movement of the upper body.
5. There are eight fundamental critical features of alpine skiing which must be properly manifested to complete a turn at any level. Errors manifested in the fundamental features must be corrected before any other.
6. Smaller skiers appear to manifest certain critical features differently than larger skier. Growth and development may be a limiting factor to progression through the Skill Awards program.
7. High failure rates, sequencing of levels, shaping versus linking of skills and, continuity of skills from Level 1 to Level 8 all need further investigation.

Chapter V

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Summary

The problem addressed by this investigation was the identification of critical features for alpine skiing, and the manifestation of these critical features in the final form exams of Alpine Canada's Skill Awards program. In addition, the development of a deterministic model and observation plan for the qualitative analysis of a giant slalom ski turn was undertaken and formed the basis of this study. The purpose of the study was to determine how the critical features of the giant slalom ski turn were manifested in the final form exams of the Skill Awards program developed by Alpine Canada. It was felt that the final form exams should undergo examination, to ensure that young skiers were being taught, and tested on all the skiing skills which were deemed critical by the development of the deterministic model for the giant slalom ski turn.

Experimental Procedures. The subjects for the investigation were ski racers from British Columbia, Alberta, and New Brunswick who participated in the Skill Awards Program sponsored by Alpine Canada and Husky Oil. Using standardized video procedure, data was collected on VHS videotapes at six test sites. Sixty two selected performances underwent a qualitative video analysis in order to determine; (a) the existence of critical features, and (b) the description of critical features at the eight Skill Award

levels. The data was analyzed using the slow motion and freeze frame capabilities of a digital VHS playback unit. The data was subsequently processed using a variety of descriptive techniques.

Findings

The findings of the investigation are presented under the following headings; (a) the deterministic model, (b) identification of special critical features, (d) mastery requirements and, (f) trends.

Deterministic Model

1. The performance criterion for the deterministic model of the giant slalom ski turn was determined to be maximum velocity throughout the turn.
2. The performance criterion was simplified into six phases; stance, preparation, pre-execution, execution, follow-through and recovery.
3. The mechanical breakdown of each phase resulted in the identification of 35 critical features for the giant slalom ski turn. After preliminary data analysis, the number of features deemed to be critical was reduced to 28.

Identification of Special Critical Features

The data analysis resulted in the identification of 14 predictive features which were used to anticipate the manifestation of critical features, and five linkage features

which acted as links between the phases of a turn. In addition, the following eight critical features surfaced from the analysis as fundamental:

1. Shoulders forward of hips.
2. Leg independence.
3. Steering of the foot of the turning ski.
4. Knee angulation.
5. Weight on the turning ski.
6. Constant lower limb length.
7. Turn progression through one arc.
8. Extension perpendicular to the slope.

Mastery Requirements

1. Results of the analysis indicated that skiers were required to have mastered 10 critical features at Level 1 and progressed towards the mastery of 20 at Level 8.
2. Variability between performances was attributed to the different ways in which the "non-mastered" features were manifested. Variability in these features resulted in individualized skiing styles.
3. The importance of optimally sequencing the mastered critical features was highlighted.

Trends

1. Smaller skiers performed certain critical features differently than their larger counterparts.

2. At skill Levels 1 and 2 the skier progressed through all the identified phases, whereas from level 3 onwards, the skier generally jumped from the follow-through to the preparation phase by omitting the stance.

3. Balance appears to take precedence over aerodynamic considerations for the skiers at all eight Skill Award levels.

4. It appears that the ability to display proper lower body movements was more important to the success of the turn than the display of correct upper body movements.

Conclusions

Within the limits of this investigation, the following conclusions seem justified:

1. Based on a literature review, it is possible to develop a deterministic model that highlights the phases of the giant slalom turn, the mechanical determinants, and the critical features.

2. Based on the analysis of the critical features exhibited at each of the 8 levels, the following conclusions were justified; (a) the manifestation of the critical features of the stance position and of the linkage features, affected the bridging of each phase of the giant slalom ski turn, (b) the stance was completely eliminated from the model when the turns were linked, and (c) the recovery phase was not a normally occurring phase within the model, it was only implemented when stability was decreased.

3. As a result of the analysis on the 28 critical features the following conclusions were justified; (a) the individual critical features of the deterministic model were not equally weighted for all skiers. Differences between skill levels and individual skiers was noted, (b) in order for the turn to be successfully completed at any level the manifestation of the eight fundamental critical features was required, and (c) the amount of variability between performances decreased as the number of critical features mastered by the skier increased. More variability was exhibited at the lower skill levels as compared to the higher levels.
4. The use of an observation plan and video analysis can result in the description of required movements at the eight Skill Award levels.

Implications and Recommendations

1. Both coaches and ski examiners should develop observation plans in order to guide and standardize their future analyses.
2. The description of the critical features of the final form exams could be used as minimum performance requirements for each of the Skill Award final form levels. Coaches could use these requirements to guide them in the analysis of their skier's technique.
3. The development of the deterministic model should serve as a precursor in future attempts to quantify the variables associated with the mechanical efficiency of the giant slalom turn.
4. Development of deterministic models for the slalom, super

giant slalom, and downhill, should provide a more thorough comprehension of the skills included in alpine skiing.

In addition, future research needs to be conducted in order to address the following issues:

1. The effects of growth and development on skill acquisition.
2. The effectiveness of traditional ski development programs.
3. The high incidence of failure at Skill Award Levels 2 and 5.

REFERENCES

Alpine Canada Alpin (1987). Husky oil - alpine canada: Alpine skill awards program. Ottawa, Ont: Author.

Alpine Canada Alpin & Canadian Ski Coaches' Federation. (1986). Alpine ski racing: A skill development model. Ottawa, Ont: Author.

Bacharach, D. & McGuire, M. (1985, September). Cinematographical analysis of the lower limb angles during the control phase of an alpine turn. The Journal of Professional Ski Coaching and Instruction, 69-70.

Bean, D. (1987). Fundamentals of giant slalom. American Ski Coach, 11(2).

Bear, R. (1977). Lateral connection. Learn to ski the hottest racing-technique innovation of the past decade. Skiing, 29(6), 81-84.

Canadian Federation of Ski Coaches. (1987). Coach certification: Level I technical manual. Vanier, Ont: Alpin Canada Alpin & Coaching Association of Canada.

Canadian Ski Instructors' Alliance (1987). Skiing and methodology (3rd ed.). Montreal, Quebec: Author.

Cohen, J. A. (1960). Coefficient of agreement for nominal scales. Educational and Psychological Measurement, 20, 37-46.

Davis, D. B. (1984). Sport biomechanics: Olympians cutting edge. High Technology, July, 34-41.

Glenne, B., & Glenne, M. (1979). Mechanics of fall-line skiing. Journal of the United States Ski Coaches Association, 2 (3), 12-16.

Gros, H. J. (1979). Basic mechanics and aerodynamics applied to skiing. In J. Terauds & H. J. Gros (Eds.). Science in skiing, skating and hockey (pp. 9-21). Del Mar: Academic Publishers.

Hay, J. G. (1987). The development of deterministic models for qualitative analysis. In R. Shapiro & J. R. Marett (Eds.). Proceedings of the second national symposium on teaching kinesiology and biomechanics in sport.

Hay, J. G., & Reid, G. (1988). The anatomical and mechanical bases of human motion (2nd. ed.). Englewood Cliffs: Prentice-Hall.

Husky Oil - Alpine Canada Alpin (1987). Skill awards program [VHS video tape]. Vanier, Ont.: National Sport and Recreation Centre.

Jenson, S. L. (1985, September). Perpendicularity: Skiing's two right-angled movements. The Journal of Professional Ski Coaching and Instruction, 71-75.

Kreighbaum, E., & Barthels, K. M. (1985). Biomechanics: A qualitative approach to studying human motion (2nd. ed.). Minneapolis: Burgess Publishing.

Lang, S. (1986). Twenty-one years of world cup ski racing. London: Grafton Books.

Larsson, O., & Glenne, B. (1987). Accelerating out of the turn: Myth or reality. Skiing, 40(3), 90-92.

Lieu, D. K., & Mote, C. D., Jr. (1985). Mechanics of the turning snow ski. In R. J. Johnson & C. D. Mote, Jr. (Eds.). Skiing Trauma and Safety: Fifth International Symposium, ASTM STP 860, pp. 117-140.

Lucey, E. & Squire, P. (1976). Research film in the sporting context. Momentum, 1(3), 42-48.

Major, J. (1981). Tamara's technique. A photo analysis of how the u.s. team's tamara mckinney won last year's giant slalom world cup. Skiing, 34(3), 151-153.

McPherson, M. N. (1987). The development, implementation, and evaluation of a program designed to promote skill analysis competency. Unpublished doctoral dissertation, University of Alberta, Edmonton.

McPherson, M. N., & Bedingfield, W. (1985). Development of instructional videotape for qualitative analysis. In J. Terauds & J. N. Barham (Eds.), Biomechanics of sport II (pp.385-389). Del Mar: Academic Publishers.

Miller, D. I., & Nelson, R. C. (1973). Biomechanics of sport. Philadelphia: Lea & Febiger.

Morawski, J. M. (1973). Control systems approach to a ski-turn analysis. Journal of Biomechanics, 6, 267-279.

National Coach Certification Program. (1988). Coaching theory level 2 manual. Vanier, Ontario: Coaching Association of Canada.

Sodeyama, H., Muira, M., Ikegami, Y., Kitamura, K., & Matsui, H. (1979). Analysis of the body position of skiers during turns. In J. Terauds & H. J. Gros (Eds.). Science in skiing, skating and hockey (pp. 33-40). Del Mar: Academic Publishers.

Vagners, J. (1985, September). Technically speaking. The Journal of Professional Coaching and Instruction, pp. 8 & 11.

Vagners, J. (1986, winter). Technically speaking. Journal of Professional Ski Coaching and Instruction, pp. 8 & 10.

Warren, J. (1988, winter). The centre line. The Professional Skier, pp. 33-35.

Watanabe, K. (1978). Running speed of skiing in relation to posture. In F. Landry & W. A. Orban (Eds.), Biomechanics of sport and kinanthropometry: Vol. 6. International congress of physical activity sciences (pp. 203-210). Miami, Florida: Symposia Specialists.

Watanabe, K., & Ohtsuki, T. (1977). Postural changes and aerodynamic forces in alpine skiing. Ergonomics, 20 (2), 121-131.

Appendix A

Skill Awards Program Overview

LEVEL	1. PASSPORT REQUIREMENTS			FINAL FORM EXAM	RECOGNITION
	a) Basic Skill Drills	b) Event Specifc Exercises	c) Education Component Theme		
SAFETY	----------	---	• Skiers Responsibility Code • Signage	----------	Safety Badge
ONE	Straight Running Skating I Skating II Simulated Finish	Yes	• Line-Up Courtesy • Responsibility	Power Plow	Green Badge
TWO	Low Tuck Single Ski Traverse Pole Plant Exercise "Blue" Bumps	Yes	• Accident Management Procedures	Open Christie	Blue Badge
THREE	Gorilla Hops Forward and Back Sideslip Simulated Start High Tuck	Yes	• Recognition Of Ski Hill Signs	Basic Parallel	Yellow Badge
FOUR	Sidehills Fall Line Sideslip Javelin Turns "Controlled" Air	Yes	• Ski Equipment Care	Parallel Around Poles	Red Badge
FIVE	Single Ski Snowplow Side Step Exercise 6 Pole Flush	Yes	• General Ski Racer Courtesy	Pedal Turns	Black Badge
SIX	Boot Exercise Single Ski Truns Ride The Rails Advanced "Controlled" Air	Yes	• General Race Course Rules And Signs	Dynamic Parallel	Bronze Badge
SEVEN	Speiss 15 Gate Slalom	Yes	• Ski Waxing	Short Radius	Silver Badge
EIGHT	Ski On One Ski Advanced Start	Yes	• General	All Snow	Gold Badge & Certificate

Appendix B

Standardized Video Instructions

To: Katarina Siska (for information to:)
Nancy Greene Coaches
Skill Award Program Conductors
Nancy Greene Chairpersons

Fm: Kim Kubeck, Lakehead University

Because of your involvement with the Skill Awards Program, you are being asked to participate in a nationwide study of the Final Form exams of this Alpine Canada program. The purpose of this study, is to determine whether the critical features of a giant slalom ski turn are being tested through the final form exams. If they are, then the investigator hopes to compile a list to describe precisely how each of the critical features are manifested at each of the 8 final form levels. For example, if balance is a critical feature of skiing, then what does the skier do differently to maintain balance at the power plow level when compared with short radius turn level?

To accomplish this goal, the investigator needs a great deal of data to analyze. Katarina Siska, an Alpine Canada representative along with the investigator have chosen your club as a participant. As such, she will need to videotape your youngsters performing the Final Form exams from the Skill Awards Program.

The quality of the analysis is dependant upon the quality of video recordings. The investigator has therefore included standardized videotaping procedures. Following these instructions will decrease the amount of perspective error and distortion so please, follow them VERY carefully. If you have any questions concerning these instructions please contact Katarina.

Thank you for taking part in this study and good luck with your teams.

EQUIPMENT NEEDED

One VHS camera
One VHS videotape
One Tripod (recommended)
Markers - to indicate start and finish of filming area for skiers
Numbered bibs for all participants

Video Procedures for Skill Awards Program

Camera Set up

* Refer the visual diagram on the following page.

1. Place (use a tripod if possible or hold steady) the camera half way down the filming run (100 metres down the run).

2. Make sure you have an unobstructed view of the entire filming area

3. Place the camera so that no skier will pass closer than 10 metres at the nearest point (See distance A on figure).

4. MARK OUT THE TRACK FOR THE SKIERS TO USE (I.E. A START AND FINISH) USING GATES OR DYE SO THAT THEY MAY PASS AT RIGHT ANGLES TO THE CAMERA AND, INSTRUCT SKIERS.

5. Keep the camera level and still during the filming.

Focus

1. Turn on the camera as per the manufacturers' instructions.

2. Zoom in on a skier at the top of the run and focus. The focus need not be touched again

3. Have a skier stand at position B (see figure) and zoom out so that the entire skier will be filmed but, the surroundings are not. Make allowances for flexion and extension movements of the skiers.

4. Film at that zoom and focus position for the entire session.

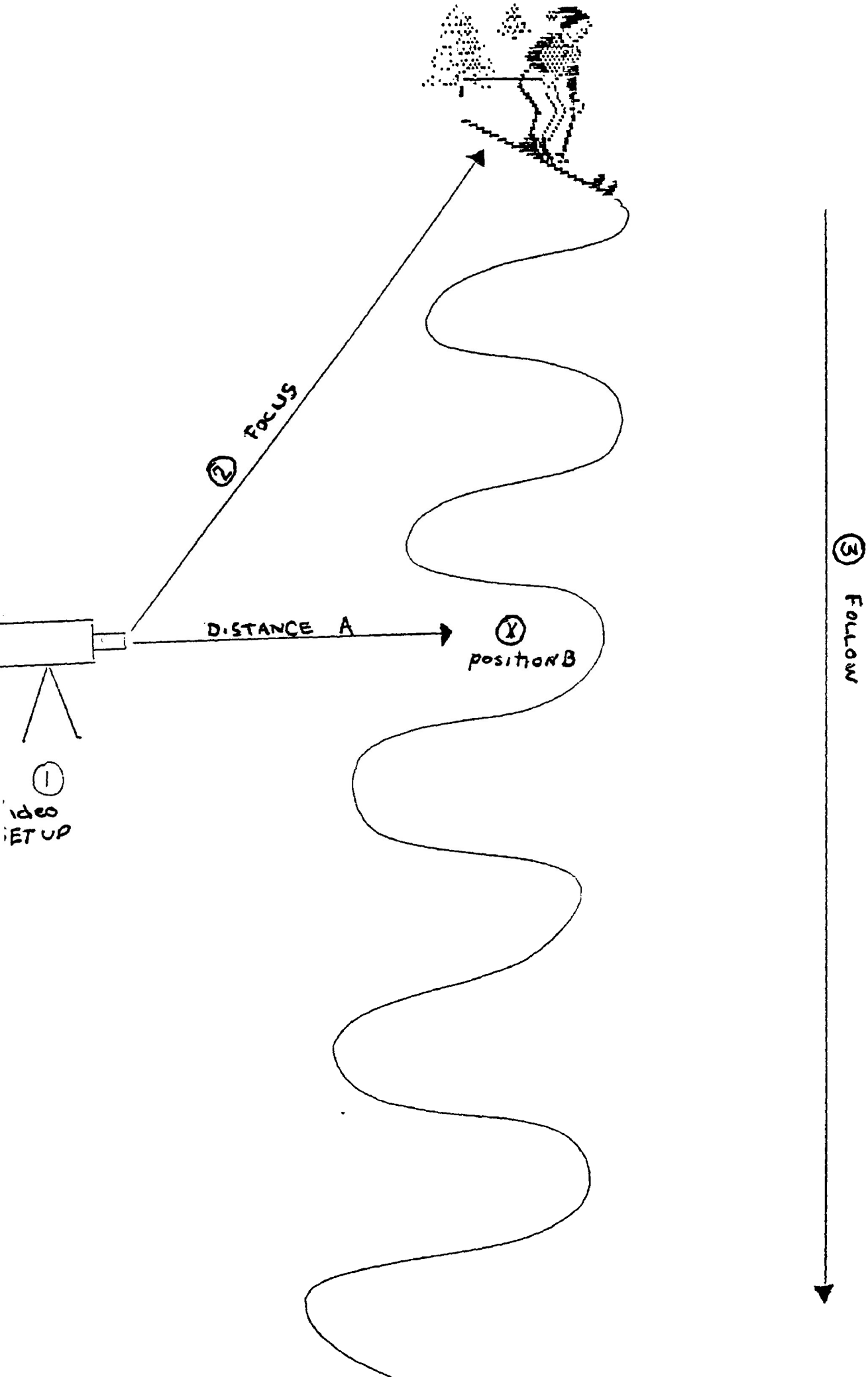
Follow the Action

1. On a signal from you have skier start skiing, Follow the action so that the skier always remains within your field of vision.

2. Do not zoom in on the skier.

3. Record 5 - 7 turns above your filming position and 5 - 7 turns below your filming position (approximately 100 metres above and 100 metres below your filming position).

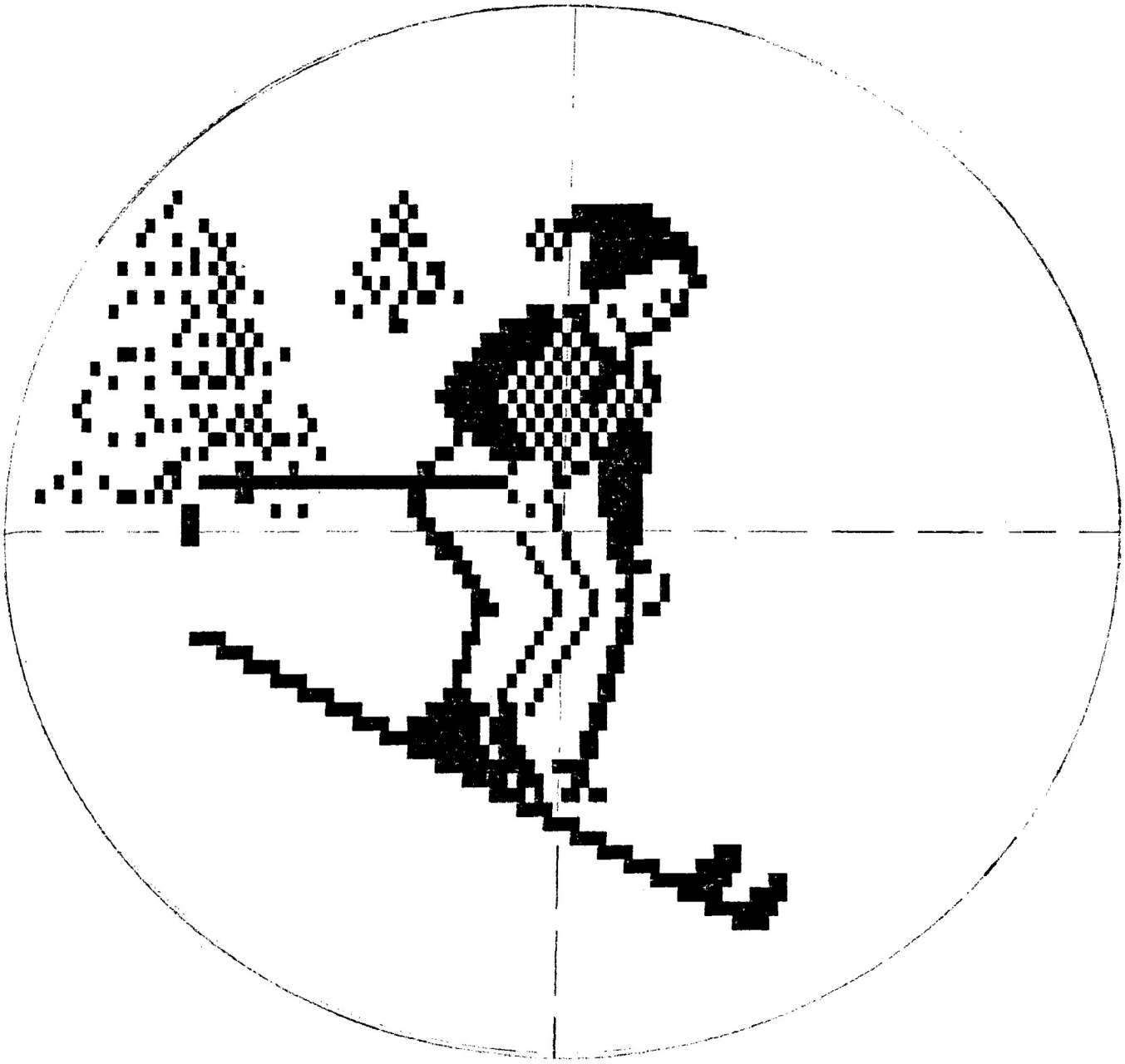
4. Do a trial run to ensure everything is working.


② FOCUS
DISTANCE A
X
position B
③ FOLLOW
① ideo
ET UP

Optimal Size of Skier

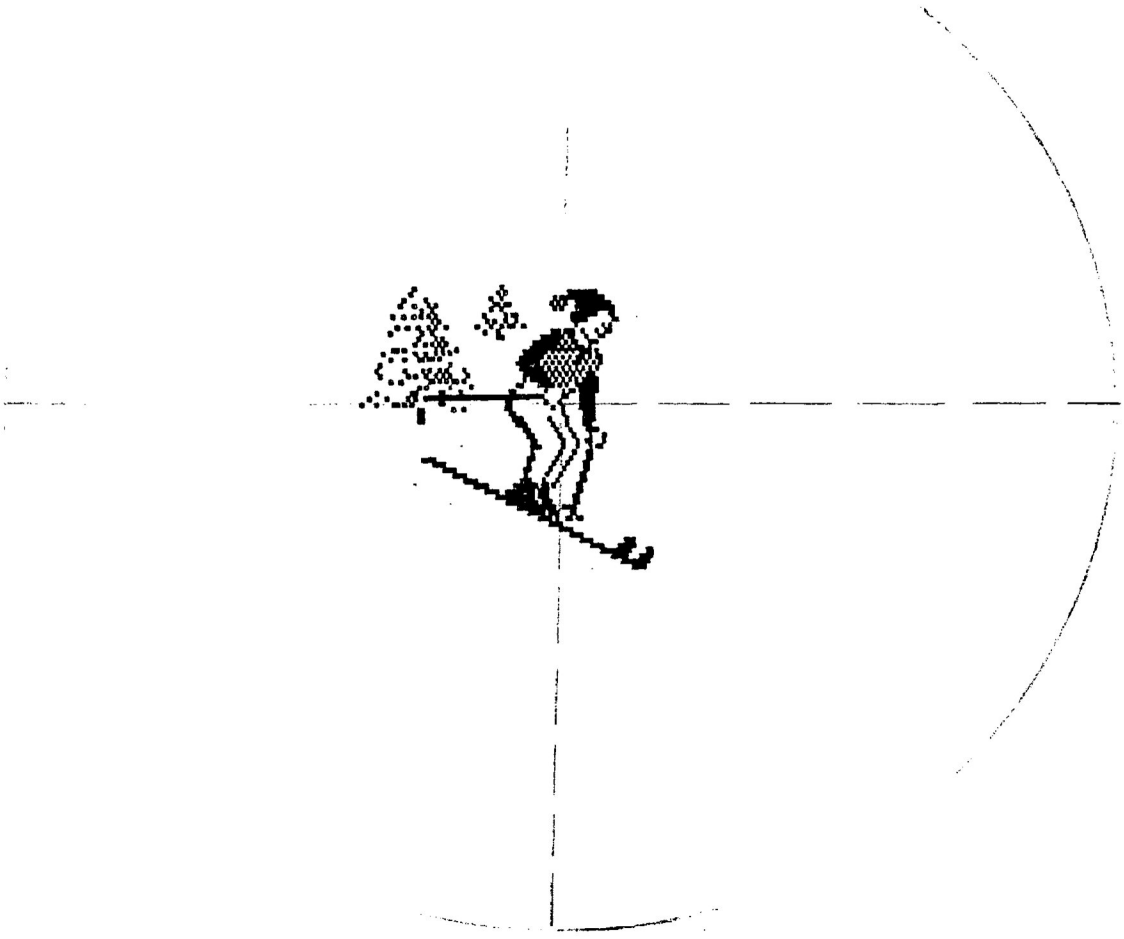
As Seen Through the Video Viewfinder

When the Skier is in Position B.



Skier Image Too Small

For Analysis



ADDITIONAL INFORMATION

Please fill in one of these sheets each time you change video sites. Trail, snow conditions and, trail steepness are all potentially critical to the analysis of the Final Form exams.

1. Coach Name_____

Address_____

Tel No (_____) - _____ - _____

2. Mountain where filming took place _____

Mountain's phone number (_____) - _____ - _____

3. Name of trail where filming took place _____

Trail rating: Green _____ Blue _____ Black_____

Trail steepness (degrees or %) if available _____

Level(s) tested _____

Snow Conditions

Powder_____

Packed powder_____

Packed powder over icy based _____

Hard packed _____

Man-made _____

Ice _____

Other _____

Trail Conditions Temperature _____

Freshly groomed _____

Bumps _____

Crud _____

Other _____

Performance Grading Sheets

As a back-up to the audio on the videotape. Please indicate each performer's bib number and beside it, whether the performance was a "pass" , "fail" or a "test" performance. The sequence of performers on the video should correspond to the sequence on the sheet.

BIB NUMBER	PASS/FAIL/TEST

Appendix C

Pilot Study

To: Pilot Study Participants

Fm: Kim Kubeck

Thank you for agreeing to take part in this pilot study. The purpose of this study is:

1. Determine if the standardized videotaping procedures (see attached) produce high quality recordings.

2. Determine if the instructions are easy to understand and apply.

3. Determine if consistent recordings are produced by different persons using the same procedures.

In order to duplicate the setting in which these instructions will be used, you will not receive any verbal instruction to help use these procedures. Please keep track of any questions (write them down if possible) which enter your mind when you are trying to decipher these instructions.

You will be provided with a video camera and skiers for the practical application of these procedures. These subjects know nothing of this study and will be expecting instructions from you. Again keep track of any problems or good questions which come to mind (have someone record your comments as they come to mind).

After applying the instructions, you will be interviewed by the investigator and asked to comment on the video procedures. A copy of the questions to be asked has been included for your benefit.

POST INTERVIEW - PILOT STUDY

1. Were there any problems understanding the vocabulary or the grammar structure of the written instructions?

2. Were the instructions clear? Explain any ambiguity.

3. Were there any problems in the set up phase?

4. Were there any problems in the focus phase?

5. Were there any problems following the action?

6. Did you encounter any mechanical problems with the camera?

7. Was there any additional information which you would include in the instructions?

8. Did the diagram help to explain the written instructions?

9. Approximate setup and filming time _____

Standardized Video Instructions

To: Katarina Siska (for information to:)
Nancy Greene Coaches
Skill Award Program Conductors
Nancy Greene Chairpersons

Fm: Kim Kubeck, Lakehead University

Because of your involvement with the Skill Awards Program, you are being asked to participate in a nationwide study of the Final Form exams of this Alpine Canada program. The purpose of this study, is to determine whether the critical features of a giant slalom ski turn are being tested through the final form exams. If they are, then the investigator hopes to compile a list to describe precisely how each of the critical features are manifested at each of the 8 final form levels. For example, if balance is a critical feature of skiing, then what does the skier do differently to maintain balance at the power plow level when compared with short radius turn level?

To accomplish this goal, the investigator needs a great deal of data to analyze. Katarina Siska, an Alpine Canada representative along with the investigator have chosen your club as a participant. As such, she will need to videotape your youngsters performing the Final Form exams from the Skill Awards Program.

The quality of the analysis is dependant upon the quality of video recordings. The investigator has therefore included standardized videotaping procedures. Following these instructions will decrease the amount of perspective error and distortion so please, follow them VERY carefully. If you have any questions concerning these instructions please contact Katarina.

Thank you for taking part in this study and good luck with your teams.

EQUIPMENT NEEDED

One VHS camera
One VHS videotape
One Tripod (recommended)
Markers - to indicate start and finish of filming area for skiers
Numbered bibs for all participants

Video Procedures for Skill Awards Program

Camera Set up

* Refer the visual diagram on the following page.

1. Place (use a tripod if possible or hold steady) the camera half way down the filming run (100 metres down the run).

2. Make sure you have an unobstructed view of the entire filming area

3. Place the camera so that no skier will pass closer than 10 metres at the nearest point (See distance A on figure).

4. Mark out the track for the skiers to use (i.e. a start and finish) using gates or dye so that they may pass at right angles to the camera.

5. Keep the camera level and still during the filming.

Focus

1. Turn on the camera as per the manufacturers' instructions.

2. Zoom in on a skier at the top of the run and focus. The focus need not be touched again

3. Have a skier stand at position B (see figure) and zoom out so that the entire skier will be filmed but, the surroundings are not. Make allowances for flexion and extension movements of the skiers.

4. Film at that zoom and focus position for the entire session.

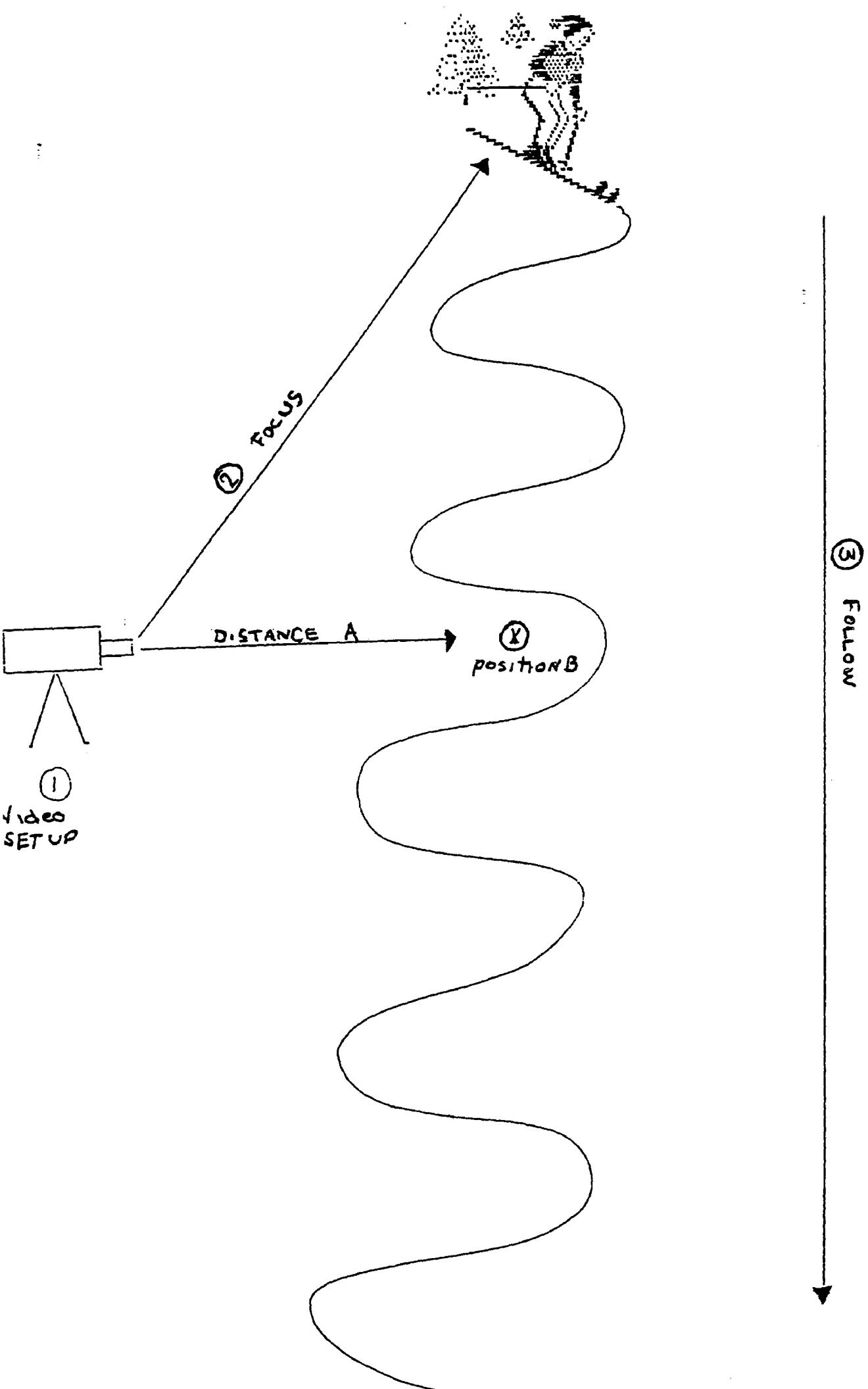
Follow the Action

1. On a signal from you have skier start skiing, Follow the action so that the skier always remains within your field of vision.

2. Do not zoom in on the skier.

3. Record 5 - 7 turns above your filming position and 5 - 7 turns below your filming position (approximately 100 metres above and 100 metres below your filming position).

4. Do a trial run to ensure everything is working.


② FOCUS
DISTANCE A
(X)
position B
(1)
Video
SET UP
③ FOLLOW

ADDITIONAL INFORMATION

Please fill in one of these sheets each time you change video sites. Trail, snow conditions and, trail steepness are all potentially critical to the analysis of the Final Form exams.

1. Coach Name_____

Address_____

Tel No (_____) - _____ - _____

2. Mountain where filming took place _____

Mountain's phone number (_____) - _____ - _____

3. Name of trail where filming took place _____

Trail rating: Green _____ Blue _____ Black_____

Trail steepness (degrees or %) if available _____

Level(s) tested _____

Snow Conditions

Powder_____

Packed powder_____

Packed powder over icy based _____

Hard packed _____

Man-made _____

Ice _____

Other _____

Trail Conditions Temperature _____

Freshly groomed _____

Bumps _____

Crud _____

Other _____

Appendix D

Raw Data

Critical feature 1 - upper limb position close to side.

A. Upper limb slightly abducted, slightly flexed at elbow, hands held at or below hip level, close to body. (yes)
B. Upper limb hangs loosely at side, elbows slightly flexed, hands held like kangaroo. (yes)
C. Upper limb abducted at shoulder, elbow flexed, arms rotated medially, hands held like kangaroo. (yes)
D. Upper limb abducted at shoulder, flexed at elbow, hands held away from body about rib cage height. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	7	0	1	0	0	1	0	0	9
%	36.8	0	5.9	0	0	5.9	0	0	14.5%
B	1	1	1	0	0	0	0	0	3
%	5.3	16.6	5.9	0	0	0	0	0	4.8
C	2	0	1	0	0	0	0	0	3
%	10.5	0	5.9	0	0	0	0	0	4.8
D	9	5	13	6	2	4	4	3	46
%	47.4	83.3	76.5	100	100	80	100	100	74.2

Critical feature 2 - rounded shoulders, flexed at hip and trunk.

A. Hip flexed, trunk flexed, shoulders rounded. (yes)
B. Hip flexed, trunk slightly flexed, shoulders rounded. (yes)
C. Hip flexed, trunk upright. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	1	3	12	4	0	5	2	3	31
%	5.3	50	70.6	66.6	0	100	50	100	50.8
B	7	2	4	1	1	0	2	0	17
%	36.8	33.3	23.5	16.7	100	0	50	0	27.9
C	11	1	1	1	0	0	0	0	14
%	57.9	16.7	5.9	16.7	0	0	0	0	22.9
Not Observed	0	0	0	0	1	0	0	0	1

Critical feature 3 - shoulders in-line with trunk.

A. Shoulders remain in-line with trunk throughout the turn. (yes)
B. Some rotation at the start of the turn. (no)
C. Shoulders rotate slightly uphill. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	17	6	14	5	2	4	4	1	53
%	89.5	100	82.4	83.3	100	80	100	33.3	85.5
B	1	0	1	0	0	0	0	0	2
%	5.3	0	5.9	0	0	0	0	0	3.2
C	1	0	2	1	0	1	0	2	7
%	5.3	0	11.8	16.7	0	20	0	66.6	11.3

Critical feature 4 - upper and lower body separation.

* This critical feature is best described through the analysis of critical features 14, 17 and 28.

Critical feature 5 - shoulders forward of hips.

A. yes. (yes)
B. shoulders even, or forward of hips. (yes)
C. shoulders even but, not forward of hips. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	15	6	17	6	2	5	4	3	58
%	78.9	100	100	100	100	100	100	100	95.1
B	2	0	0	0	0	0	0	0	2
%	10.5	0	0	0	0	0	0	0	3.3
C	1	0	0	0	0	0	0	0	1
%	5.3	0	0	0	0	0	0	0	1.6
Not Observed	1	0	0	0	0	0	0	0	1

Critical feature 6 - leg independence.

A. legs work independently of one another. (yes)
B. legs are struck close together. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	19	6	16	6	2	5	4	3	61
%	100	100	94.1	100	100	100	100	100	98.4
B	0	0	1	0	0	0	0	0	1
%	0	0	5.9	0	0	0	0	0	1.6

Critical feature 7 - extension of hip and knees.

* Was tallied as critical feature 25.

Critical feature 8 - retraction of legs.

A. Legs were flexed and passed under the body while the weight was shifted to the new ski. (yes)
B. No retraction observed. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	0	0	1	0	0	0	0	0	1
%	0	0	5.9	0	0	0	0	0	1.6
B	19	6	16	6	2	5	4	3	61
%	100	100	94.1	100	100	100	100	100	98.4

Critical feature 9 - Movement perpendicular to slope

* Was calculated as critical feature 25.

Critical feature 10 - body inclination.

A. Yes, during the preparation phase. (yes)
B. No visible inclination. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	0	0	17	6	1	5	4	3	36
%	0	0	100	100	50	100	100	100	60.0
B	17	6	0	0	1	0	0	0	24
%	100	100	0	0	50	0	0	0	40.0
Not Observed	2	0	0	0	0	0	0	0	2

Critical feature 11 - ankle angulation.

* Not observable through video analysis techniques

Critical feature 12 - tall stance.

A. Yes, skier entered turn fully extended (within equipment constraints). (yes)
B. Hips were high but, the knees remained flexed. (no)
C. Hips remained slightly flexed. (no)
D. No. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	9	6	12	4	1	2	1	1	36
%	47.4	100	70.6	66.6	50	40	25	33.3	58.1
B	1	0	0	0	0	0	0	0	1
%	5.3	0	0	0	0	0	0	0	1.6
C	8	0	4	0	1	3	3	0	19
%	42.1	0	23.5	0	50	60	75	0	30.6
D	1	0	1	2	0	0	0	2	6
%	5.3	0	5.9	33.3	0	0	0	66.6	9.7

Critical feature 13 - steering of the foot of the turning ski

A. Yes, the skis were steered by pivoting the turning foot.(yes)
B. Yes, right into next phase. (yes)
C. Very little. (yes)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	14	4	14	5	1	2	2	3	45
%	73.7	66.6	87.5	83.3	50	66.6	50	100	75.0
B	5	2	2	0	0	0	2	0	11
%	26.3	33.3	12.5	0	0	0	50	0	18.3
C	0	0	0	1	1	1	0	0	4
%	0	0	0	16.7	50	33.3	0	0	6.6
Not Observed	0	0	1	0	0	1	0	0	2

Critical feature 14 - projection of the upper body towards the fall-line.

A. Yes, during the preparation or pre-execution phase. (yes)
B. Slightly. (yes)
C. Extreme. (yes)
D. No, the upper body moved with the hips. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	6	4	13	5	2	4	4	3	41
%	31.6	66.6	81.3	83.3	100	80	100	100	67.2
B	2	1	2	1	0	1	0	0	7
%	10.5	16.7	12.5	16.7	0	20	0	0	11.5
C	0	0	1	0	0	0	0	0	1
%	0	0	6.2	0	0	0	0	0	1.6
D	11	1	0	0	0	0	0	0	12
%	57.9	16.7	0	0	0	0	0	0	19.7
Not Observed	0	0	1	0	0	0	0	0	1

Critical feature 15 - knee angulation.

A. Yes, initiated during the pre-execution phase. (yes)
B. Yes, as the phase neared completion, or as pivoting neared completion. (yes)
C. Small amount. (yes)
D. Yes, simultaneously with the hip. (yes)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	13	4	11	5	2	3	3	2	43
%	72.2	66.6	64.7	80	100	60	75	66.6	70.5
B	3	0	1	1	0	0	0	0	5
%	16.7	0	5.9	20	0	0	0	0	8.2
C	2	1	1	0	0	1	1	1	7
%	11.1	16.7	5.9	0	0	20	25	33.3	11.5
D	0	1	4	0	0	1	0	0	6
%	0	16.7	23.5	0	0	20	0	0	9.8
Not Observed	1	0	0	0	0	0	0	0	1

Critical feature 16 - hip angulation.

A. Yes, during the pre-execution phase. (yes)
B. Small amount of hip angulation near the end of the phase. (yes)
C. Hips remained high and uninvolved. (no)
D. No. (no)
E. Hip was isometrically adducted but not angulated. (no)
F. Simultaneously with the knee. (yes)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	2	1	2	0	0	1	2	3	11
%	11.8	16.7	12.5	0	0	20	50	100	19.0
B	0	2	10	4	2	3	2	0	23
%	0	33.3	62.5	80	100	60	50	0	39.7
C	7	1	0	1	0	0	0	0	9
%	41.2	16.7	0	20	0	0	0	0	15.5
D	2	0	0	0	0	0	0	0	2
%	11.8	0	0	0	0	0	0	0	3.2
E	6	1	0	0	0	0	0	0	7
%	35.8	16.7	0	0	0	0	0	0	12.1
F	0	1	4	0	0	1	0	0	6
	0	16.7	25	0	0	20	0	0	10.3
Not Observed	2	0	1	1	0	0	0	0	4

Critical feature 17 - upper body movement.

A. Shoulders in-line with trunk, trunk moved with skis, remainder as per stance phase (i.e. very static). (no)
B. Trunk became more flexed and/or arms more ab/adduct, remainder as per stance. (yes)
C. Trunk in anticipation, increased flexion, outside arm abducted, inside arm may adduct. (yes)
D. Arms were closer to trunk than in stance, trunk was anticipated. (yes)
E. Upper body over rotates. (yes)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	9	2	0	0	0	0	0	0	11
%	47.4	33.3	0	0	0	0	0	0	17.7
B	10	3	4	0	0	0	0	0	17
%	52.6	50	23.5	0	0	0	0	0	27.4
C	0	1	10	3	2	4	3	3	26
%	0	16.7	58.9	50	100	80	75	100	41.9
D	0	0	3	3	0	0	1	0	7
%	0	0	17.6	50	0	0	25	0	11.3
E	0	0	0	0	0	1	0	0	1
%	0	0	0	0	0	20	0	0	1.6

Critical feature 18 - movement of the hips towards the snow.

A. Movement downwards and externally rotated, as in angulation, (yes)
B. Down slightly to finish the turn. (yes)
C. Movement inwards. (yes)
D. High, uninvolved, static. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	1	2	14	6	1	5	4	3	36
%	5.3	33.3	82.4	100	50	100	100	100	58.1
B	1	1	3	0	0	0	0	0	5
%	5.3	16.7	17.6	0	0	0	0	0	8.1
C	1	0	0	0	0	0	0	0	1
%	5.3	0	0	0	0	0	0	0	1.6
D	16	3	0	0	1	0	0	0	20
%	84.2	50	0	0	50	0	0	0	32.3

Critical feature 19 - regulation of turning through angulation.

A. Angulation at the knee. (yes)
B. Angulation at the hip. (yes)
C. Steering as well as angulation at the knee or hip. (yes)
D. Steering and isometric adduction at the hip. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	8	0	0	0	0	0	0	0	8
%	42.1	0	0	0	0	0	0	0	12.9
B	0	2	16	6	1	5	4	1	35
%	0	33.3	94.1	100	50	100	100	33.3	56.5
C	1	3	1	0	1	0	0	2	8
%	5.3	50	5.9	0	50	0	0	66.6	12.9
D	10	1	0	0	0	0	0	0	11
%	52.6	16.7	0	0	0	0	0	0	17.7

Critical feature 20 - progressive turning.

A. Yes, turns were linked, complete, gradual with no excess pressure exerted anywhere through the phase. (yes)
B. Pressure distribution through the turn was uneven resulting in a shaky turn. (no)
C. Too much pressure at the beginning of the turn. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	17	6	11	6	2	5	3	3	53
%	94.4	100	64.7	100	100	100	100	100	88.3
B	1	0	0	0	0	0	0	0	1
%	5.5	0	0	0	0	0	0	0	1.6
C	0	0	6	0	0	0	0	0	6
%	0	0	35.3	0	0	0	0	0	10.0
Not Observed	1	0	0	0	0	0	1	0	2

Critical feature 21 - weight on one ski.

A. Yes, turn was controlled through the movements of one ski. (yes)
B. weight placed well back on the ski as well. (yes)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	18	5	16	5	2	5	4	3	58
%	94.7	83.3	100	100	100	100	100	100	96.6
B	1	1	0	0	0	0	0	0	2
%	5.3	16.7	0	0	0	0	0	0	3.2
Not Observed	0	0	1	1	0	0	0	0	2

Critical feature 22 - constant lower limb length.

A. Yes, leg does not flex at the knee or hip during the execution phase. (yes)
B. Bum drops at the end of the phase causing hip flexion. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	19	6	17	6	2	3	4	3	60
%	100	100	100	100	100	60	100	100	96.8
B	0	0	0	0	0	2	0	0	2
%	0	0	0	0	0	40	0	0	3.2

Critical feature 23 - turn progression through one arc.

A. Smooth, continuous arc from start to finish. (yes)
B. Arc changes because of uneven pressure throughout the turn. (no)
C. Arc changes because steering was used at the end of the turn. (no)
D. Arc changes because constant lower limb length was not maintained. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	18	5	17	5	2	3	4	3	57
	94.7	83.3	100	100	100	60	100	100	93.6
B	1	0	0	0	0	0	0	0	1
	5.3	0	0	0	0	0	0	0	1.6
C	0	1	0	0	0	0	0	0	1
	0	16.7	0	0	0	0	0	0	1.6
D	0	0	0	0	0	2	0	0	2
	0	0	0	0	0	40	0	0	3.2
Not Observed	0	0	0	1	0	0	0	0	1

Critical feature 24 - extension of hips and knees of the pressured ski.

A. Extension forward and upwards but, incomplete. (yes)
B. Complete extension, forward and upwards. (yes)
C. Hips extended fully, knees remained bent. (yes)
D. hips remained slightly flexed. (yes)
E. Not extension, a movement back to stance, relaxation of the muscles of the lower limb and hip. (no)
F. No extension, movement of the hips forward. (no)
G. Retraction of limb. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	1	0	4	2	0	1	1	2	11
	5.3	0	23.5	40	0	20	25	66.6	18.0
B	3	2	6	3	1	3	2	1	21
	15.8	33.3	35.3	60	50	60	50	33.3	34.4
C	0	0	3	0	1	0	0	0	4
	0	0	17.6	0	50	0	0	0	6.6
D	0	0	3	0	0	1	1	0	5
	0	0	17.6	0	0	20	25	0	8.2
E	13	4	0	0	0	0	0	0	17
	68.4	66.6	0	0	0	0	0	0	27.9
F	2	0	0	0	0	0	0	0	2
	10.5	0	0	0	0	0	0	0	3.2
G	0	0	1	0	0	0	0	0	1
	0	0	5.9	0	0	0	0	0	1.6
Not Observed	0	0	0	1	0	0	0	0	1

Critical feature 25 - extension perpendicular to the slope.

A. Extension perpendicular or slightly back. (yes)
B. Extension perpendicular or slightly forward. (yes)
C. Yes, extension was perpendicular when releasing the pressured ski. (yes)
D. Extension perpendicular or, slightly back or forward. (yes)
E. Extension back from perpendicular. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	2	0	1	1	0	0	0	0	4
%	10.5	0	5.9	16.7	0	0	0	0	7.3
B	0	1	3	1	1	2	0	0	8
%	0	16.7	17.6	16.7	50	40	0	0	14.5
C	10	4	13	3	1	3	3	3	39
%	76.6	66.6	76.5	50	50	60	100	100	70.9
D	0	1	0	0	0	0	0	0	1
%	0	16.7	0	0	0	0	0	0	1.8
E	1	0	0	1	0	0	0	0	2
%	5.3	0	0	16.7	0	0	0	0	3.6
Not Observed	6	0	0	0	0	0	1	0	7

Critical feature 26 - explosively through the range of motion.

A. Yes, the extension was completed quickly. (yes)
B. Extension was gradual. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	6	1	7	0	2	5	4	3	28
%	31.6	16.7	41.1	0	100	100	100	100	45.9
B	13	5	10	5	0	0	0	0	33
%	68.4	83.3	58.9	100	0	0	0	0	54.1
Not Observed	0	0	0	1	0	0	0	0	1

Critical feature 27 - return of the hip and lower limb to the stance position.

A. Both the hip and lower limb returned to stance prior to subsequent turns. (yes)
B. Body passed through the stance position. (no)
C. Lower limb returned to stance position but, hip did not. (no)
D. Neither the hip or lower limb returned to the stance position. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	19	6	8	2	0	1	2	0	38
%	100	100	47.1	33.3	0	20	50	0	61.3
B	0	0	9	3	1	4	2	3	22
%	0	0	52.9	50	50	80	50	100	35.5
C	0	0	0	0	1	0	0	0	1
%	0	0	0	0	50	0	0	0	1.6
D	0	0	0	1	0	0	0	0	1
%	0	0	0	16.7	0	0	0	0	1.6

Critical feature 28 - upper body in anticipation.

A. At the end of the turn,the upper body was in anticipation. (yes)
B. At the end of the turn,the body was in very slight anticipation. (yes)
C. At the end of the turn, the upper body was moving with the skis. (no)
D. At the end of the turn, the upper body was rotated slightly uphill. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	1	0	12	3	1	3	4	3	27
%	5.9	0	70.6	50	50	60	100	100	45.0
B	0	0	2	1	0	1	0	0	4
%	0	0	11.8	16.7	0	20	0	0	6.6
C	16	6	2	1	1	0	0	0	26
%	94.1	100	11.8	16.7	50	0	0	0	43.3
D	0	0	1	1	0	1	0	0	3
%	0	0	5.9	16.7	0	20	0	0	5.0
Not Observed	2	0	0	0	0	0	0	0	2

Critical feature 29 - movement of the arms, trunk and hips back to the stance position.*

A. Yes, corrected excess lateral movement. (yes)
B. Yes, corrected excess rotation. (yes)
C. Yes, corrected excess forward-backward movement. (yes)
D. No recovery required. (no)

Descriptor/Level	1	2	3	4	5	6	7	8	Total
A	2	0	1	0	0	0	0	0	3
%	10.5	0	5.9	0	0	0	0	0	4.8
B	0	0	1	0	0	0	0	2	3
%	0	0	5.9	0	0	0	0	66.6	4.8
C	0	0	0	0	0	0	1	0	1
%	0	0	0	0	0	0	25	0	1.6
D	17	6	15	6	2	5	3	1	55
%	89.5	100	88.2	100	100	100	75	33.3	88.7

* Calculated on a per turn basis, not observed throughout an entire performance.

Appendix E

Consent Form

My signature on this sheet indicates that I will allow my child to participate in a study by Kim Kubeck on ANALYSIS OF THE FINAL FORM EXAMS FROM THE SKILL AWARDS PROGRAM and indicates that I understand the following:

1. My son/daughter is a volunteer and can withdraw at any time from the study.
2. I have received explanations about the nature of the study, its purpose, and procedures.
3. There is no physical or psychological harm.
4. The data provided by my son/daughter will be confidential.
5. I will receive a summary of the project, upon request, following the completion of the project.
6. The videotapes will be destroyed following the completion of the analysis.

PARENT'S OR GUARDIAN'S SIGNATURE_____

DATE_____

School of Physical Education and Athletics
Lakehead University
Thunder Bay, Ontario
P7B 5E1

January 10, 1989

Dear Parent,

We are conducting a study to investigate the technique of alpine skiing from all levels of the National Skill Awards program. The purpose of the study is to develop national standards at each of the eight levels.

In order to accomplish this goal, Katarina Siska, an Alpine Canada representative, will be videotaping your child during a Skill Awards program testing session. Analysis of the videotaped performances will allow us to better understand and describe the ski technique demonstrated in each of the eight levels.

All videotapes will be sent to Lakehead University for analysis. All information provided will remain confidential. Only the research team will be allowed to view the videotapes. The findings of the completed project will be made available to you at your request.

Thank you for your cooperation.

Kim Kubeck