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The biomechanics of the quarterback position : a kinematic analysis and integrative approach

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Verduzco, Mario A., M.A.

San Jose State University, 1991

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**THE BIOMECHANICS OF THE QUARTERBACK POSITION:
A KINEMATIC ANALYSIS AND INTEGRATIVE
APPROACH**

A Project Report

Presented to

**The Faculty of the Department of Human Performance
San Jose State University**

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

By

Mario A. Verduzco

December, 1991

APPROVED FOR THE DEPARTMENT OF HUMAN PERFORMANCE

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ABSTRACT

THE BIOMECHANICS OF THE QUARTERBACK POSITION: A KINEMATIC ANALYSIS AND INTEGRATIVE APPROACH

by Mario A. Verduzco

The study analyzed the importance of the quarterback position within the framework of a balanced offensive structure. It identified ethical as well as practical consequences for a philosophical position that aligned itself with the notion that quarterbacks were made and not born. The study identified the ideal teaching techniques based on Schmidt's schema theory and the three stages of motor behavior to accomplish this pedagogical task. The study utilized the sciences of biomechanics and 3-dimensional video taping techniques to identify and visually present the optimal mechanics for the following techniques: passing from a stationary position and passing while on the move (on the move direct, on the move inside right, and on the move inside left). In addition, it presented models for dropping back to pass for the following techniques: five step drop frontside and backside; three step dropback (on time) frontside and backside.

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TABLE OF CONTENTS

ABSTRACT	iii
ACKNOWLEDGEMENTS.....	iv
Chapter I.....	1
Introduction	1
Purpose of the Study.	4
Significance of the Study.....	4
Definitions.....	7
Chapter II.....	8
Review of Literature	8
Introduction.....	8
History of the Passing Game.	8
Philosophy Review	9
Motor Behavior Review	10
General Motor Ability, Transfer, and Specificity.....	11
Schema and General Motor Program Theory.	12
Transfer from a Closed to an Open Environment.....	16
Biomechanics Review	17
Throwing Motion.....	17
Passing Technique.	21
Laws and Principles of Motion.....	27
3-D Video Analysis.	27
Summary	28
CHAPTER III	29
Methodology.....	29

Book Construction	29
Philosophy	29
Motor Behavior	29
Biomechanics	30
Instrumentation	31
Data Analysis.	32
References	34
Appendix A	46
Appendix B	47
Appendix C	48
Appendix D	49
Appendix E	50

Chapter I

Introduction

To date, coaches have taken one of two positions related to quarterback development: quarterbacks are born (White, 1978, 1983) or quarterbacks are made (Stevens, 1988; Walsh, 1986). Biomechanics in part resolved the question since "a coach must understand the biomechanical principles underlying performance in his/her sport before analysis of a technique, and hence coaching directives aimed at improving technique, can take place" (Stothart, 1980, p. 29). The identification of specific biomechanical models of the quarterback position were found to be fundamental to the development of a balanced, flexible, and multiple offensive structure. These models include: (a) dropping back to pass, (b) passing the football, and (c) passing while running (on the move). These models or techniques should be based on the laws of motion. Biomechanics was determined to be the most important variable at this point in time for two reasons: (a) because it will "prevent the blind leading the blind" (Ariel, 1983b, p. 27), and (b) few biomechanical studies have been completed regarding quarterback techniques (Ariel, 1973; Atwater, personal communication, May 1, 1989; Mikszewski, 1968). A coach's knowledge of biomechanics was found to be critical if he wished to improve his quarterback's ability to perform (Ariel, 1983a, 1983b, 1983c, 1984a; Bucher, 1983; Hatze, 1974; Hay & Reid, 1982; Hay 1985; Jensen, Schultz, & Bangerter, 1983; Krieghbaum & Barthels, 1985; Marhold, 1974; McCarthy, 1984; Stothart, 1980). It was suggested that a coach also teach the quarterback the most efficient method of throwing in order for the player to reach his potential, which might lead to offensive balance, multiplicity, and flexibility (Hatz, 1974; Marhold, 1974; Montour, 1979).

Hay (1985), like Cavanaugh, Andrew, Kram, Rodgers, Sanderson, and Hennig (1985), cautioned coaches and athletes against the all too common practice of "copying the

champion." Hay stated, "anyone who blindly copies the technique of a champion copies not only its desirable features but also its undesirable ones" (p. 3). In Hay's opinion a more fruitful method to optimize performance would be through the science of biomechanics, for "it provides the only sound, logical basis upon which to evaluate the various techniques that might be used in a given case and to connect observed effects with their underlying causes...Biomechanics is the science underlying techniques" (pp. 4-5). Ariel (1983a) cited a fine Olympic discus thrower from the United States as one who succumbed to the temptation in that he copied the technique of the East German discus thrower Wolfgang Schmidt. Ariel pointed out that Schmidt's technique, "was a better technique--for the East German not Mac Wilkins...It took him months to get back to where he was before" (p. 79).

Hay (1985), like Stothart (1980), insisted that knowledge in the science of biomechanics was essential to the coach, especially to those at the highest level. He acknowledged the criticism of those who cited examples of successful coaches who possessed little or no knowledge of biomechanics. Nevertheless, he argued that the performance of these coaches' players would be increased if "to all of these coaches' attributes was added a knowledge of biomechanics" (p. 6).

Hay (1985) cited four steps to conduct qualitative analyses.

1. Development of a model (or block diagram) showing the relationships between the results and the factors that produce that result.
2. Observation of the performance and identification of faults.
3. Evaluation of the relative importance of these faults.
4. Instruction of the performer in accord with the conclusions reached in the course of the analysis (p. 244).

The fourth step required knowledge in the field of motor behavior. Motor behavior theory substantiated the understanding that efficient and effective quarterbacks could be developed. Theorists in the discipline pointed out that complex motor acts (models or techniques) must be taught and that success was not dependent upon "all-around" athletic ability (Henry, 1968; Magill, 1983; Sage 1984; Schmidt, 1988). In addition, it was stated that cognitive processes played an important if not a dominant role (Lindquist, 1968, 1971). Summers (1981) suggested that the theory of motor control regarding skilled movement determined the type of practice schedules designed to improve the athlete's psychomotor skills. One of the most comprehensive theories and one that provided a useful framework for the design of practice schedules for discrete ballistic movements was Schmidt's schema theory (Sage, 1984; Schmidt, 1975, 1988; Summers, 1981). Schmidt's schema theory provided a basis for the design of practice schedules for discrete ballistic movements. Schmidt's schema theory removed intuition as the dominant source of coaching practice.

The rationale for the study of biomechanics or motor behavior theory involved questions that authors who wrote books on these two topics were quick to address. The question addressed was: what could the subject matter do for the coach or teacher? Whether teachers or coaches agreed with the rationale and/or followed the advice of the author was found, in part, to be due to their philosophical perspective regarding their responsibilities as educators (Pate, 1984; Ravizza, 1985; Thomas, 1984). In addition, coaches recognized the importance of a specific philosophy. Within the framework of this project these are represented by those subjects that address the specific strategic aspects of the game of football: why passing the football is critical (balance, flexibility, and multiplicity), the nature and function of the keep it simple stupid (KISS) approach, the importance of work ethic, the function of spring and summer practice schedules, the

importance of preparation, the coach's responsibilities to his quarterbacks, the most important position on the field, the important components of the passing game, requirements of an efficient and effective quarterback, and the methods of evaluating and choosing the quarterback. Coaches realized that a sound philosophical position was vital to the guidance of their actions and success on and off the field (Elias, 1978; Hayes, 1970; Holtz, 1978, 1981; Knox, 1985; Paterno, 1988; Teaff, 1984, 1986).

Purpose of the Study. The purpose of the project was to write a book which would provide football coaches with a method for consistently developing effective and efficient quarterbacks for a balanced, flexible, and multiple offensive structure. The method presented was founded on specific biomechanical models or techniques of dropping back to pass and passing on the move, which would provide for balanced, flexible, and multiple offensive structures. Each model was based on the laws and principles of motion inherent in the study of biomechanics, and each was visually presented utilizing three-dimensional video analysis. The rationale for the development of each model was supported by biomechanics and motor behavior research. The method of teaching each technique was grounded on a specific theory of motor control. The rationale which demanded this approach was prompted by the collective research in biomechanics and motor behavior. The approach was integrated with a consistent, coherent, and functionally simple football specific philosophy. The specific football philosophy prompted and supported the proposed approach.

Significance of the Study. The review of literature indicated that no model or technique for dropping back to pass and passing while on the move, based on the laws and principles of motion, had been proposed for a balanced, flexible, and multiple offensive structure. At best, little if any information was available (Ariel, 1973; Atwater, personal communication, May 1, 1989; Mikszewski, 1968).

The lack of biomechanical information related to the quarterback position highlighted the importance of the relationship between the biomechanist and the coach, and the need for an integrative approach (Cavanaugh, 1987; Ravizza, 1985; Sprigings 1988; Stothart, 1980). Stothart specifically pointed out that this relationship was critical to the improvement of the athlete. If the coach was not familiar with the principles of biomechanics it was suggested that he consult a biomechanist, nevertheless, it was suggested that the coach understand, and have the ability to communicate the requirements and parameters of the skill. It was indicated that the biomechanist, on the other hand, should inform the athlete of what he was doing. But more importantly, he should inform the athlete of what he ought to do, "after all, the athlete does not want to be told what he is already doing but what he should do in order to optimize performance" (Hatze, 1974, p. 237). This relationship was deemed critical because the coach was responsible for being the "ultimate decision-maker in training" (Ariel, 1983c, p. 52).

If the coach took it upon himself to do the analysis, it was recommended that he be able to extract and interpret biomechanical data. Understanding the requirements and parameters of the skill coupled with high speed film or video analysis was determined to form the foundation of the coach's knowledge which would allow him to improve the athlete (Ariel, 1983b, 1983c, 1984c; Stothart, 1980).

The review of literature indicated that no biomechanical model or techniques specifically designed for the quarterback position in a balanced, flexible, and multiple offensive structure and based on motor behavior research had been developed. The review indicated that no analytic or speculative effort had been made to point out the philosophical consequences for a belief that quarterbacks were born or an understanding that they were made. Additionally, no attempt was made to integrate the study of biomechanics, motor

behavior, and philosophy in order to provide the coach with a method for quarterback development.

It was determined that an integrative approach which: (a) recognized that biomechanics was the critical foundation and employed it to develop a model for dropping back to pass, and passing while on the move; (b) utilized a specific theory of motor behavior to design practice schedules; and (c) applied a consistent, coherent, and functionally simple philosophy for support and guidance, needed to be formulated. This approach would provide coaches with a method by which they could consistently develop effective and efficient quarterbacks (Ariel, 1984a; Cavanaugh, 1987; Freeman, 1982; Integration, 1989; Sperling, 1989; Sprigings, 1988).

The project and the proposed method for quarterback development was significant for six reasons: (a) it may provide for a balanced, flexible, and multiple offense; (b) it may enable the coach to live up to his responsibilities as an educator; (c) it may enable him to more effectively and efficiently utilize the pool of available talent related to the quarterback position; (d) it may reduce stress on the coach, the quarterback, and the team; (e) it may help the coach to produce more wins than losses, or at the very least fulfill his competitive responsibilities (insure that any game represents the highest quality of a contest; provide his team with the optimum chance for success (Kretchmar, 1975; Thomas, 1984)); (f) it may provide a foundation for further qualitative or quantitative study to determine the optimum technique for dropping back to pass, and passing while on the move.

The book could function as a resource for any coach who may not be familiar with any one, if not all, of the subjects in the book. If the coach understands the biomechanics of dropping back to pass or passing while on the move, but wishes to retrieve motor behavior information specific to the quarterback position in order to design practice schedules, then he need only to refer to that chapter. If he is familiar with these two, the biomechanics and

the motor behavioral aspect of the position, but wishes to gain a different philosophical perspective regarding the game of football and his responsibilities, then he need only to read the chapter on philosophy.

Definitions.

Closed loop was "A control system employing feedback, a reference of correctness, a computation of error, and subsequent correction in order to maintain a desired state; sometimes called a servomechanism or servo" (Schmidt, 1988, p. 184).

Coherency indicated the ability "to give an account of how we know our statements to be true" (Putnam, 1986, p. 132).

Functional simplicity was a philosophy that adheres to its tenets both in spirit and letter (Putnam, 1986).

Open loop was "a control system with preprogrammed instructions to an effector that does not use feedback information and error-detection processes" (Schmidt, 1988, pp. 184-185).

Philosophy was represented in this project by those topics that address the specific principles relating to the strategic aspects of the game of football, including: why passing the football is critical; the nature and function of the KISS approach; the importance of work ethic; the function of spring and summer practice schedules; importance of preparation; the coach's responsibilities to his quarterbacks; the important components of the passing game; the requirements of an efficient and effective quarterback; and the methods of evaluating and choosing the quarterback.

Stages of learning were represented by changes in the learner's movement characteristics over time as he/she acquires a motor skill. The three stages are cognitive, associative, and autonomous (Sage, 1984; Schmidt, 1988).

Chapter II

Review of Literature

Introduction. The subjects reviewed for this study included: history of the passing game; the philosophy of offensive football; motor behavior; the biomechanics of throwing; and the current techniques taught by coaches regarding dropping back to pass, and passing while on the move.

History of the Passing Game. President Theodore Roosevelt and Walter Camp did more to revolutionize the game of football than individuals realized. Walter Camp was instrumental in changing the game in that he sponsored rule changes which impacted the basic structure of the game (away from rugby). Two of those fundamental changes were "the substitution of scrimmage for the rugby scrummage (scrum) and the adoption of the system of downs and yards to gain (first 5, then 10)" (Danzig, 1971, p. 9). With the adoption of the scrimmage line in 1880 the quarterback position first appeared. President Roosevelt's influence was different but no less important. In October, 1906 he instructed the representatives of the Big Three (Yale, Harvard, & Princeton) "to save the game by removing its savagery" (Perrin, 1987, p. 54). American football up to that time had developed into a game of massed plays wherein, "brute force, and slugging was typical of offensive line play" (Perrin, 1987, p. 54). At the end of the year (1906) the Chicago Tribune Times reported 18 deaths and 159 serious injuries (Perrin, 1987). President Roosevelt's October message of 1906 prompted influential individuals associated with the game to formulate the Football Rules Committee. This committee was placed under the direction of the newly formed Intercollegiate Athletic Association of the United States (Perrin, 1987). Between December 1906 and 1912 two major committees were formed and eventually merged; the Football Rules Committee of 1906 and the football rules committee headed by the famous Yale mentor Walter Camp (Perrin, 1987). The merger

formed was named the National Collegiate Athletic Association (NCAA) (Perrin, 1987). Of the rules established in this period of time (prompted by President Roosevelt) the legalization of the forward pass (proposed by Walter Camp and championed by Percy D. Haughton of Harvard, E.K. Hall and Bill Roper) was the most significant in terms of removing "the savagery of the game." It spread the game over a larger portion of the field and reduced its brutality (Danzig, 1971).

The most famous account of the first use of the forward pass and its contribution to winning concerned a little known private Catholic school named Notre Dame. The Fighting Irish defeated a powerful Army team 35-13 in the year 1913. Notre Dame's team featured the passing combination of quarterback Gus Dorais and receiver Knute Rockne (Danzig, 1971; Kohn, 1964). This citation was critical because it was the first account which clearly demonstrated that a physically inferior team like Notre Dame (Perrin, 1987) was not doomed to defeat. Notre Dame compensated for its lack of size and was able to win the game because it had the ability to pass the football. Historic accuracy forced the acknowledgement that the forward pass was used as early as 1906 by Edward B. Cochems (head football coach at St. Louis University) with tremendous success (Danzig, 1971); and "football took a giant step away from Rugby when it added the thrill of the pass to the power of the run and the skill of the toe" (Perrin, 1987, p. 54). The rule change not only reduced the brutality of the game but it signified the starting point for an increase in the specialization of the quarterback position which enabled the game to progress to the point where it is today.

Philosophy Review

It was identified that the sophistication of defensive structures have forced coaches to adopt a specific offensive philosophy (Smith, 1987). These sophisticated defensive structures have forced coaches to demand balance, flexibility, multiplicity in their offensive

structure in general (run/pass) and their pass offense specifically (play pass, straight drop-3, 5, and 7 step and sprint out) (Bicknell, 1984; Dooley, 1987; Edwards, 1983b, 1984, 1985; Osborne, 1984; Tollner, 1983; Walsh, 1983; White, 1983, 1984, 1986). The importance of the passing game and the quarterback within the framework of the type of offensive structure, related to a philosophical perspective, was agreed upon by some professional, college, and high school football coaches (Brodie, 1984; Brown, 1988; Currey, 1979, 1986; Gilman, 1988; Hyder, 1983; Osborne, 1976; Ross, 1983; Schnellenberger, 1984b). Nevertheless, Stevens (1988) insisted that coaches remained unwilling to coach their quarterback's passing mechanics to achieve balance, flexibility, and multiplicity. It was argued that this was because few studies or books concerning the qualitative or quantitative analysis of the forward pass, let alone the major facets of the quarterback position, have been published (Atwater, personal communication, May 1, 1989; Mikszewski, 1968). An approach which forces young quarterbacks to coach themselves and/or copy the techniques of professional quarterbacks was never recommended (Ariel, 1983a; Cavanaugh et al., 1985; Hay, 1985). Consequently, it was suggested that coaches justify their position in the light of what science (biomechanics and motor behavior) provided in terms of research (Pate, 1984).

Motor Behavior Review

A thorough understanding of the principles of motor behavior was determined to be critical to the coach who wished to improve his quarterback's ability to perform.

In the case of physical educators and coaches, a thorough understanding of perception, learning, motivation, and other psychological factors is essential in order to predict and control the behavior of students in the gymnasium, on the playing field, in the swimming pool, and in other areas...The effective physical educator and coach must be

a skilled practitioner in the educational application of motor behavior subject matter (Sage, 1984, p. 12).

It was suggested that an understanding of how quarterbacks processed information was critical to the coach (Lindquist, 1968, 1971, 1973). In addition, it was suggested that the principles of motor behavior, plus the understanding of the component parts of the skill were critical because the coach "must" be both motor diagnostician and movement prescriptor. These collectively formed the foundation for the teaching of motor activities (Sage, 1984). If the coach is deficient in this area, "feedback information will be based on faulty diagnoses and [the coach will] have little chance for promoting learning" (Sage, 1984, p. 381).

General Motor Ability, Transfer, and Specificity. From the research in motor behavior the notion of general motor ability, the "all around athlete," was seriously questioned. "There has been very little evidence reported in the literature to support the General Motor Ability Hypothesis" (Magill, 1983, p. 206). George H. Sage (1984) described this notion as "folklore." Sage stated,

A wealth of information has accumulated over the past twenty-five years that suggests that the notion of general-motor-ability is a myth and that selecting personnel through the use of a motor aptitude test battery is at best ineffective and may be counterproductive (p. 274).

Nevertheless, it was determined that the notion of general motor ability "was probably led by the analogous research of cognitive abilities that was prevalent in the 1930's" (Schmidt, 1988, p. 313). General motor ability came under attack in the 1950's and 1960's, Schmidt continued:

With respect to motor skills, the threat came from essentially two major sources: (a) the work on individual differences conducted by Henry and his students at Berkeley and

(b) the research program related to individual differences in pilotry and similar tasks conducted by Fleishman and his associates through the U.S. Air Force (Schmidt, 1988, p. 313).

Schmidt also illuminated Henry's specificity hypothesis and its subsequent predictions:

Probably the most important prediction of the specificity hypothesis is that two tasks, even if they appear to be quite similar (such as throwing a baseball and throwing a football), will tend to correlate nearly zero with each other. This is because the group of attributes that underlie these two tasks are, according to this view, two distinct collections with nearly no shared abilities. Also, because the collection of abilities for one task and those of another are independent of each other, this leads to the expectation that the correlation among skills should be zero, or at least very low. The evidence tends to support this view (Schmidt, 1982a, p. 401).

With respect to the transfer of skills, Schmidt (1988) utilized Henry, "Generally, the transfer literature supports Henry's hypothesis, showing essentially that motor transfer is generally low and positive" (p. 317). In addition, the research in factor-analytic studies tended to "argue against the general motor ability hypothesis" (Schmidt, 1988, p. 317).

These studies extinguished the notion that an athlete's success in a variety of activities enables the coach to predict that this athlete will be the most qualified quarterback.

Therefore, it was suggested that coaches turn their attention to the information which provided for the understanding that they could teach the required skills inherent in the quarterback position. They could find the basis for this information in Schmidt's schema and general motor program theory (Sage, 1984; Schmidt, 1988).

Schema and General Motor Program Theory. The research identified two basic theories of motor control: (a) closed loop (response chaining), and (b) open loop based (motor

programs). Nevertheless, Summers, (1981), Sage (1984), and Schmidt (1988) argued that each was inadequate when attempts were made to explain a complex ballistic movement.

Schmidt (1975, 1982b, 1988) stated that the closed loop theory answered the questions related to storage but could not answer the question regarding the use of feedback related to time demands in ballistic movements, nor could it solve the degrees of freedom problem. In addition, he determined that the open loop theory required no feedback and could thus answer the question of feedback related to time, but it could not solve the novelty or storage problems adequately. Nevertheless, Schmidt (1982a) dismissed the controversy between closed and open loop theory and stated, "it makes no sense to conclude that 'man is a closed system' or that 'movements are controlled by motor programs', because conclusions about the nature of the control system seem clearly to depend on the kind of task studied" (p. 277). Therefore, Schmidt (1988) determined that it made no sense to view movement as "either a feedback based or motor program based process, for both mechanisms have clear, but different, roles in movement production" (p. 221). Schmidt (1982, 1988) acknowledged that he "borrowed heavily ideas from Adams and others," for the conception of schema theory, "in the hope of keeping the most effective parts and eliminating defective ones" but asserted that it retained "a strong open loop dependency" (Schmidt, 1988, p. 482).

Schmidt developed a schema theory which was based on generalized motor programs, because he felt the closed loop (perceptual trace) and open loop (response chaining and/or motor program) theories were inadequate. The impulse timing, massed spring (equilibrium-point model) theories were also considered by Schmidt to be deficient, and he determined that these theories could not adequately answer the questions posed to them. The massed spring model could not explain why the addition of weight to a movement decreased that movement, and/or why the subtraction of weight from a movement increased

that movement (Schmidt & McGown, 1980). In addition, the massed spring model could only explain simple unidirectional positioning responses (Schmidt, 1988). It was determined that the impulse timing model could not explain the results of experiments which utilized deafferented monkeys (Bizzi, Polit, & Morasso, 1976; Polit & Bizzi, 1978).

Schmidt's schema theory (1975, 1982b, 1988) argued that there were two memory states: (a) recall memory-(movement production), and (b) recognition memory-(response evaluation). Collectively they answered the questions regarding the skill acquisition of ballistic movements. His theory was somewhat related to Lindquist's information processing approach known as the General Serve Problem Solving Model (GSPS) (1968, 1971, 1973).

For rapid, ballistic movements, recall memory is involved with motor programs and parameters, structured in advance to carry out the movement with but minimal involvement from peripheral feedback. Recognition memory, on the other hand, is a sensory system capable of evaluating response-produced feedback after the movement is completed, thereby informing the subject about the amount and direction of errors (Schmidt, 1988, p. 483).

"At the heart of schema theory is the idea of the generalized motor program, structured with phasing and (perhaps) relative force, with parameters being required in order to specify the particular way that the program is to be executed" (Schmidt, 1988, p. 483).

General motor program theory borrowed the notion of invariant features from motor program and impulse timing hypothesis theory (Schmidt, 1988). Those invariant features were order of elements, phasing (time ratio), and muscle force (muscle ratio). General motor program theory solved the storage problem because it required only one program which accommodated a wide variety of movements for a specific skill. It solved the novelty

problem in that only parameters of the movement (duration, force, muscle selection, and spatial parameters) were required for specification (Schmidt, 1988).

Schmidt's schema theory (1982b, 1988) stated that schema learning required the learner to store four variables after an initial trial: (a) initial coordination (body position, weight of the ball, body angles); (b) parameters required (distance, speed, force, and movement size); (c) movement outcome in terms of knowledge of results; (d) how the movement felt, looked, sounded. These four were not stored permanently and thus the storage problem was eliminated, but rather, "stored long enough so that the performer can abstract some relationship among them" (Schmidt, 1988, p. 484).

Schmidt determined that two relationships were theoretically formed, the first of which was the recall schema. Recall schema was concerned with the initiation and the execution of the movement, relationships and not specifics were formed and retained concerning the parameters of movement and their eventual outcome, which solved the novelty problem (Sage, 1984; Schmidt, 1988). The second relationship formed was the recognition schema which was concerned with response evaluation. It provided a background that the senses utilized to determine if the completed trial and its subsequent sensory stimulation matched the expected sensory consequences before a ballistic movement (throwing) was initiated and completed (Sage, 1984; Schmidt, 1982b, 1988). Post ballistic motion errors detected in the recognition schema were fed and incorporated into the recall schema the next time the movement was initiated and executed (Schmidt, 1982b, 1988).

Summers (1981) described the advantages of the schema theory "over the traditional open- and closed-loop models," and stated, "there is no necessity for a separate motor program of references of copies to be stored for each movement that a person makes" (1981, p. 54). In this way flexibility of human skill was accounted for and "furthermore the

model emphasizes the integration between program and feedback in the control of movement" (Sage, 1984, p. 242).

Transfer from a Closed to an Open Environment. Schmidt's schema theory had implications for the manner in which a coach designed practice schedules. It was suggested that the quarterback must be transferred gradually from a closed to an open environment. This transition was analogous to the progress that must be made through the three stages of learning (cognitive, associative, and autonomous). These transitions were required if the quarterback was to become proficient (Magill, 1980; Sage, 1984; Schmidt, 1982, 1988; Shapiro & Schmidt, 1982; Summers, 1981). Summers (1981) argued that the coach must understand that the teaching of motor skills was a "two stage process."

Summers stated:

Initially the teacher or coach must aid the learner in the acquisition of the correct sequence and timing of the movements that comprise the skill...Once the performer is able to perform the skill correctly, the next stage is the development of a motor schema containing all the parameters that are needed to generate a unique movement to meet each situation in which the skill is performed. This can be accomplished by providing the learner with practice in a wide variety of situations that not only allow many variations of a movement to be produced but also require the learner to produce movements that meet the exact environmental demands (p. 64).

Although the environmental requirements in each stage were different the quarterback must pass through the three stages of learning in each. As the quarterback was gradually transferred from the closed to the open environment, and the three stages of learning in each, the principles inherent in general motor program theory, schema theory, practice, motivation, learning, and memory related to skill acquisition remained important in both en-

vironments but functioned in a different manner in each (Summers, 1981; Shapiro & Schmidt, 1982).

Biomechanics Review

The Coach of the Year Clinic Manual was found to be the most comprehensive annual collection of professional, college, and high school coaches' thoughts about the game of football (Duffy Daugherty, personal communication, February, 12, 1982; Bob Troppmann, personal communication, July 17, 1989; Bud Wilkinson, personal communication, February, 13, 1983). Since 1976, up to 1991, the manual presented 589 articles regarding various facets of the game of football. Fifty-two articles addressed various questions and made suggestions for the passing game in general. Fifteen articles addressed the cognitive development of the quarterback, three addressed the sprint out passing game specifically, and none of the articles addressed the problem of applying biomechanics to the quarterback position. The articles did not discuss the motor behavioral aspects and the implications of research in this field of study. There was some philosophical discussion but in general it was restricted to the "style" of offense or defense. The observation made by Mikszewski (1968) was found to be true. He pointed out that there had been studies related to other areas of football but that there had been few completed with respect to the sprint out passing game, the forward pass, or the quarterback in general.

Throwing Motion. Most of the research concerning the throwing pattern of adults was conducted with subjects who threw a baseball or a softball, "it has been primarily evaluated to determine the etiology of injuries" (Montour, 1979, p. 20). The research argued that the utilization of this information as a basis for the study of passing the football was problematic because of the size of the object thrown (Atwater, 1979; Kreighbaum & Barthels, 1985; Pedegana, Elsner, Roberts, Lang, & Farewell, 1982) and the environment in which these two skills were found (Magill, 1983; Sage, 1984; Schmidt, 1988) affected the nature

and the parameters of the skill studied. Nevertheless, the research provided important information which aided: (a) the determination and development of effective training regimens for injury prevention; (b) the identification of efficient methods of injury rehabilitation; (c) the determination of the important muscles and their activation level within the open kinetic link system related to ball speed; and (d) the determination of which factors, genetic or environmental, played a more important role related to throwing ability.

Generally, four phases were defined to separate and analyze the throwing motion: I wind-up; II cocking; III acceleration; IV follow-through (Hinkle, 1979; Jobe, Tibone, Perry, & Moynes, 1983; Jobe, Moynes, Tibone, & Perry, 1984; Montour, 1979; Pappas, Zawacki, & Sullivan, 1985; Yessis, 1984). These phases were determined to take place within a range of motion of about 225 degrees but "the entire excursion is not located entirely within the glenohumeral joint" (Pappas et al., 1985).

The research suggested that the values obtained in throwing studies were impacted by the skill level of the athletes involved (Pappas et al., 1985). Nevertheless, these studies provided a picture of the throwing motion and its inherent factors. It was argued that injury to the throwing arm could be caused by poor mechanics (Atwater, 1979; Montour, 1979). Recent evidence suggested that injuries to the pitching arm could be caused by the amount of pitching and not the type of pitch thrown (Hang, 1981; Sisto, Jobe, Moynes, & Antonelli, 1987). Atwater (1979) stated that pronation rather than supination occurred in all pitches, and Hang (1981) stated that supination tended to create curve ball pitches and pronation tended to create fast-ball pitches. It was suggested that the musculature responsible for the distinct features of these two pitches was not located in the forearm musculature (Sisto et al., 1987). Nevertheless, Sisto et al. (1987) did not extend their electromyographic analysis to the biceps and triceps and instead confined it to the forearm musculature. This was a critical point because Jobe et al. (1983, 1984) found that the

biceps and the triceps functioned as elbow joint muscles and not shoulder joint muscles. Therefore, these two muscles could have been the source of the differences in muscle activation between the two pitches related to the study of Sisto et al. (1987).

Pappas et al. (1985) found that the greatest stress on the elbow occurred during the acceleration and follow-through phases. This was substantiated by Jobe et al. (1983, 1984) who in two reports analyzed the deltoid, supraspinatus, infraspinatus, teres minor, subscapularis, pectoralis major, biceps, triceps, latissimus dorsi, serratus anterior, and the brachialis. They found that the shoulder muscles were activated minimally during acceleration but intensely during follow-through. They also concluded that the biceps and triceps, in addition to functioning primarily as elbow joint muscles, fired intensely from the acceleration phase through the follow-through phase, and the biceps reached peak activity during the follow-through phase.

Atwater (1970, 1979) and Collins (1960) researched movement characteristics of the overarm throw. Atwater's research conflicted with Collins' in that Atwater found wrist flexion to be an insignificant factor related to throwing speed, whereas Collins found otherwise. In addition, Greenisen, Gross, Madhill, and Marshall (1973) suggested that radioulnar pronation caused changes in hand position, not wrist flexion. Collins found no difference in joint angles or range of motion between the throwing motions of overarm and sidearm throws other than that which occurred due to lateral bending of the spine toward the opposite side of the throwing arm.

Sakaris (1978), as well as authors who wrote books on the biomechanics of sport techniques, substantiated the findings (joint angles) by Collins (1960). Sakaris analyzed three right handed University of Florida pitchers and one moderately skilled high school pitcher in order to determine the difference between the overhand and sidearm throws. The conclusions were:

1. minimal difference of take off ball velocity between each type of throw;
2. more torso lean to the left of the vertical axis in the sagittal plane in the overarm throw than the sidearm throw; and
3. greater elbow flexion in the overarm throw than in the sidearm throw.

Toyoshima, Hoshikawa, Goya, and Matsui (1981) studied 18 pairs of twins to determine the extent which, "intrinsic components may account for existing individual differences of the throwing pattern and its performance" (p. 683). They found heredity to be a small factor in determining throwing ability and that training or learning was critical to the effective utilization of trunk and body rotation. This substantiated the research of Leme and Shambes (1978) wherein they found that twisting body movements did not develop naturally. This agreed with Lindquist's (1973) findings wherein she stated, "the belief that the learning of a motor skill is more brawn than brain must be questioned" (p. 80).

Toyoshima, Hoshikawa, Miyashita, and Oguri (1974) found that 46.9% of ball velocity in the overhand throw resulted from the step and body rotation and the remaining 53.1% is due to arm action. They suggested that rapid arm action was due to the physical phenomenon of the neuromuscular system rather than conscious muscle contraction. This confirmed Boucher and Flieger's (1983) observation that with practice of ballistic movements more fast-twitch motor units were recruited.

The research indicated that upper extremity strength (elbow extension, shoulder external rotation, shoulder extension, shoulder flexion, and wrist extension) had a strong relationship to throwing speed, especially wrist extension (Collins, 1960; Pedegana et al., 1982). Pedegana et al. (1982) found a high correlation between wrist extension strength and throwing speed but could not explain this relationship. This conflicted with the studies conducted by Jobe et al. (1983, 1984), Sisto et al. (1987), and Atwater (1970). If these muscles were not intensely activated through the phases of the throwing motion then

strength could not be a factor related to changing joint angles through the entire 255 degree excursion. It could be suggested that upper extremity strength was only a critical variable beginning at acceleration and ending after the follow-through phases.

Collectively, these studies supported the theoretical open kinetic link system. This theory was proposed in books on biomechanics (Jensen, Schultz, & Bangerter, 1983; Krieghbaum & Barthels, 1985). In the review, it was argued that although the muscles changed joint angles at speeds relative to ball speed (Atwater, 1970), the muscles were not activated at an intensity level commensurate with those changes through the entire motion. The theoretical open kinetic link system accounted for this and suggested that the changes in the various joint angles were not abrupt but rather changed in a smooth sequential fashion. Consequently, as each segment proximal to the axis of rotation accelerates, the succeeding distal segment will be initially left behind; as the proximal segment decelerates the succeeding distal segment acquires the speed of the preceding proximal segment (Krieghbaum & Barthels, 1985). The research suggested that the discrepancy between joint angle changes and electromyographic activity could be accounted for in that "the velocity of the distal segments may be so great that the muscle contraction may not be able to apply a torque to accelerate them further" (Krieghbaum & Barthels, 1985, p. 599). The study conducted by Feltner and Dapena (1986) agreed with Krieghbaum and Barthels' (1985) assertion.

Passing Technique. Hinkle (1979) detailed specific laws of physics and their relationship and importance to passing the football. Those specific laws were inertia, continuity of motion, transfer of motion, law of acceleration, center of gravity, and the law of counterforce.

Yessis (1984) stated that there was "one basic pattern of throwing the football" (p. 6), but that there were many variations dependent upon distance, and the speed with which the

ball was thrown (the faster the ball is thrown the greater the number of body parts which need to be involved and the greater their range of motion). He analyzed the throwing motion through five phases: stance, cocking, acceleration, follow-through, and release. He detailed the important muscles utilized in each phase but did not specify their activation level. He also provided specific weight training exercises important to the development of those muscle groups.

Carlson (1962) descriptively analyzed four passers who performed the straight drop, roll-out, jump passes. The quarterbacks involved in the study were from the Northwest: three from Washington State University, and one from the University of Oregon. He utilized game film of the quarterbacks to conduct his study. The focal points of the quarterback's bodies were the feet, hips, shoulders, grip, release of the ball, posture, carriage of the left arm, and body balance. He observed the following characteristics in all four quarterbacks in the straight drop pass: (a) the left foot was the focal point for the direction of the throw; (b) the right foot served as an anchor with slight flexion, and the transfer of weight occurred from the right foot to the left foot during the initiation of motion; (c) action of the right hip was vital and led the right shoulder; (d) the shoulders acted as a base for the throwing arm and were always perpendicular to the target. Passing the football utilizing the roll-out technique produced the same characteristics except that the pass was made off of the right foot. The jump pass produced the same characteristics as the roll-out except that both feet left the ground simultaneously.

Mikszewski (1968) tested six right handed Springfield College quarterbacks in a roll-out technique to determine the difference between throwing accuracy on the move to the left and to the right at three different distances, 6, 12, and 25 yards. He found significant differences in favor of throwing on the move to the right at a depth of 6 yards but no significant differences at 12 and 25 yards.

The research indicated that coaches agreed that the straight dropback passing game could be packaged into three ranges related to receiver route depths of short, medium, and long. The rationale for each was best described by Bill Walsh (1978). The required steps of the quarterback to function in each were as follows: (a) short - 3 steps (some coaches use 1 or 2 steps), (b) medium - 5 steps, or deep - 5 or 7 steps. In conjunction with these step requirements coaches suggested depth, and set and release times although they did not regard them as critical elements. "We don't time our quarterbacks. I don't see this as being of any value. We can always get a 9.3 [s] sprinter to drop back faster than anybody else" (Walsh, 1978, p. 31). Nevertheless, they admitted that "the key to the seven step drop is how fast you can get back" (Walsh, 1978, p. 31). The times suggested were dependent upon the depth requirements determined by the coach in each package (Amedee, 1988; Edwards, 1983a, 1986; Eisaman, 1984; Fry, 1985; Kincaid, 1985; Mallory, 1988; Schnellenberger, 1984a; Sheppard, 1986; Stevens, 1988; Theder, 1981; Trestman, 1986; Walsh, 1978, 1981; White, 1978; Wyche, 1983).

Regardless of dropback times, Pannes (1967) suggested that the technique used to drop back (crossover, sprintback, backpedal) did not impact the length of time required for a specific distance. Nevertheless, Walsh (1981) argued that the coach and quarterback must consider how each technique might impact the quarterback's ability to "get his feet right." In addition, Wyche (1983) stated that the dropback must not inhibit the quarterback's ability to see the backside one third of the defensive display.

Stevens (1988) taught his quarterbacks to point their hips and toes at "11 o'clock" toward the backside goal line and at the same time set his shoulders at "right angles to the line of scrimmage" (p. 239). Wyche (1983) disagreed with Stevens (1988), "we want to make sure he is running with a crossover" in order to "find the left one third up the field" (Wyche, 1983, pp. 272-273). Wyche's technique indicated that the quarterback's hips and

toes should point at "9 o'clock" toward the sideline not at "11 o'clock" toward the backside goal line. His technique provided a more efficient posture for getting the shoulders perpendicular to the line of scrimmage. At one time Bill Walsh advocated the "sprintback" technique (also described by Pannes (1967)), and taught his quarterbacks "to get back quick, to completely turn his back the first three steps" (1978, p. 31). Coach Walsh changed his approach to that of Wyche (1983) (Walsh, personal communication, July 21, 1988).

Coaches used many analogies to describe the skills of passing the football which impacted their approach to teaching the skill. The passing motion was likened to a tennis serve (Arians, 1985), or to throwing darts (Bielat, 1986); the stance (distribution of weight) and initial step was compared to the movements of a boxer (Arians, 1985; Sloan, 1984); and the transfer of weight was matched with the mechanics of a golf swing (Arians, 1985; Stevens, 1988). Contrary to Arians' and Sloan's suggestion for equal distribution of weight in the stance phase, other coaches argued that in the stance phase more weight should be distributed on the back foot than on the front foot (Edwards, 1986; Stevens, 1988). Most agreed that the knees should be slightly bent regardless of the style of stance employed (Arians, 1985; Edwards, 1986; Sloan, 1984; Stevens, 1988; Walsh, 1978; Wyche, 1983).

The controversy regarding the distribution of weight was not the only one which existed. Bielat (1986) insisted that the movement of the legs was not important to the production of force on the football in the throwing motion. Others argued that the legs were a critical component (Arians, 1985; Ariel, 1983a; Stevens, 1988; Walsh, 1978; White, 1978; Wyche, 1983). Bielat stated, "try to avoid teaching the quarterback to throw with the lower body" (1986, p. 7). Nevertheless, "if you don't use your legs correctly--the harder you push with your arms--the energy will not go back into the implement, but back

into your legs" (Ariel, 1983a, p. 32). Coaches suggested that a stride length of about shoulder width was the most effective and that the lead step should not cross an imaginary line which connects the cardinal sagittal planes of the quarterback and the receiver (Edwards, 1986; Hinkle, 1979; White, 1978; Wyche, 1983). Coaches asserted that this had an impact on accuracy (White, 1978). Nevertheless, Hay (1985) pointed out that this was not the case, at least in pitching. The opening of the hips was also believed to be a critical factor during the initiation of movement phase of the pass (Arians, 1985; Stevens, 1988).

Some coaches preferred an overarm acceleration pattern to that of a sidearm pattern when passing the football. The reasons cited for this preference included: (a) it reduced stress on the elbow (Albright, Jokl, Shaw, & Albright, 1978; Anderson, 1984; Arians, 1985; Edwards, 1986; Hinkle, 1979; Stevens, 1988); (b) it helped the quarterback pass the football more efficiently (Wyche, 1983; Stevens, 1988); and (c) the elbow should precede the hand and that it should "lead the way" (Edwards, 1986). Atwater (1979) regarded this "lead the way" as a misconception, at least in the case of throwing a softball or baseball. She pointed out that the elbow will lag in back of the hips and shoulder, especially in high velocity attempts. Therefore, Atwater (1979) suggested a better teaching cue would be to instruct the quarterback to lead with his hips and shoulder. This would be facilitated by a suggestion made by Sloan (1984). He suggested that when passing the ball from a stationary position the quarterback's back leg should be lifted off of the ground at the release point.

Coaches agreed on the release pattern and favored pronation over supination (Arians, 1985; Bielat, 1986; Edwards, 1986; Sloan, 1984; Stevens, 1988; Wyche, 1983). This release pattern was also suggested for efficient performance when the quarterback was attempting to pass while he was on the move.

The preceding remarks and/or opinions were descriptions of, and prescriptions for, a passing motion when the quarterback, pitcher, or subject was able to release the implement from a stationary position. In football this would be possible only if the offensive line was successful in executing the pass protection scheme, and thus controlled the environment which surrounded the quarterback (pocket). Tom Moore conducted a study of quarterbacks in the National Football League and found that 43 percent of the time the quarterback was moving while he attempted to pass the football (Bielat, 1986). The technique of passing the football while on the move was rarely discussed by coaches or biomechanists. If it was discussed the analysis was not commensurate with the discussion that was encountered related to throwing from the stationary position. Nevertheless, it was considered by coaches to be an important component which determined quarterback success, and offensive balance, flexibility, and multiplicity. This was especially true in those offensive structures which were based on the quarterback's ability to pass the football while on the move, such as the "Run-And-Shoot" (Ellison, 1984).

Gruniesen (1984) and Sloan (1984) made conflicting recommendations regarding this facet of the quarterback technique. Gruniesen recommended that the football be released with the elbow attaining the shoulder level (sidearm). This would lead to an across the body follow-through pattern. Sloan recommended that the quarterback "does not want to throw across his body" (p. 256), although he provided no technique for insuring that an across the body throwing motion would occur. Gruniesen (1984) and Sloan (1984) agreed with Carlson (1962) that the quarterback should run toward his target with his hips and shoulders square to the target before release and that the right leg should become the plant or load leg from which the football is delivered. Moore's study (Bielat, 1986) suggested that this technique was not always possible for the quarterback, and it certainly is not always the case for the infielder in baseball. The technique of passing the football, or any

implement, while on the move to a receiver who crossed the face of the quarterback, or of a quarterback on the move passing while crossing the face of a stationary receiver in either direction was never addressed in the literature. Nevertheless, these types of passes were determined to be critical because "defenses have become so sophisticated that they force a passer to utilize many different styles" (Anderson, 1984, p. 77).

Laws and Principles of Motion. Regardless of what coaches believed to be important in dropping back and passing the football, and passing while on the move, it was stated that these movements adhered to the laws of motion described by Sir Isaac Newton (Ariel, 1983a, 1983b, 1983c, 1984a, 1984b, 1984c, 1984d; Hay, 1985; Hinkle, 1979; Jensen, Schultz, & Bangerter, 1983; Kreighbaum & Barthels, 1985; Halliday & Resnick, 1988; Yessis, 1984). It was determined that final momentum and final velocity were the "prime factors" in throwing (Atwater, 1979; Jensen et al., 1983).

Jensen et al. (1983) described general principles of force, motion, inertia, and acceleration which could be used to substantiate specific quarterback techniques, clear up uncertainties, and settle some of the disputes and controversies which existed. They are important because as the biomechanist Gideon Ariel (1983a, 1983c, 1984a) pointed out, all bodies involving human movement follow the laws of motion.

3-D Video Analysis. Biomechanists acknowledged the importance of film analysis for improving an athlete's performance. They cited that it should form the foundation of a coach's approach toward improving the athlete, and as Ariel (1983b) stated, it is "better than guessing" (p. 28). It was used to analyze many sports skills in order to explain and improve performance (Pappas et al., 1985) including tennis (David & Burnie, 1985; Elliott & Blanksby, 1986; Elliott, Marsh, & Overheu, 1988), sprinting (Vardaxis & Hoshizaki, 1988), running (Bahlsen & Nigg, 1987; Hinrich, 1987), running equipment (Nigg & Bahlsen, 1988; Vagenas & Hoshizaki, 1988), discus (Gregor, Whiting, & McCoy, 1985),

and the javelin (Paavo & Mero, 1985). The review revealed that no research was published utilizing the Peak Performance system or any other video based 3-D analysis. This was confirmed by Phil Cheetham and Pat Kennedy of Peak Performance Technologies Inc. and Dr. Gary Smith of Oregon State University (personal communication, November 6, 1989).

Summary

The importance of the legalization of the forward pass was evidenced by Notre Dame's strategic thrashing of a physically superior Army team in 1913. The ability to pass the football demonstrated that a physically inferior team was not doomed to defeat (Danzig, 1971; Perrin, 1987). Consequently, the ability to pass the football determined offensive balance, flexibility, and multiplicity. Collectively, these determined the success or failure of a team (Smith, 1987). In addition, the rule change increased the responsibilities and the specialization of the quarterback position (Smith, 1987). The utilizing of the principles of motor behavior allowed the quarterback to progress through the three stages of learning efficiently. The principles of biomechanics in conjunction with the requirements of a quarterback in balanced offensive structure would elicit the most effective quarterback.

CHAPTER III

Methodology

Book Construction

The book contains acknowledgements, a table of contents (outline form), three chapters, references, and an index. Chapter one consists of the philosophy of offensive football; chapter two examines the principles of motor behavior (Schmidt's schema theory) as they specifically applied to the quarterback position. Chapter three proposes biomechanical models of quarterback techniques which settled any disputes found in the review. The proposed models represent the optimal techniques. They provide a balanced, flexible, and multiple offensive structure. The techniques are based on the laws and principles of motion. Each technique is presented with appropriate pictures of the stick figure model generated from the 3-D analysis.

Philosophy

The chapter on philosophy addresses the problems related specifically to the passing game, the quarterback within this phase of the game, and a coach's approach to the teaching and evaluation of his quarterbacks. The chapter identifies the strategic consequences that result from a view that quarterbacks are made or that they are born and the impact that either position had on a coach's view of his responsibilities, his team, and his quarterbacks. Coaching cliches such as: "Keep it simple stupid (KISS)", "there is no 'T' in team" which are employed by coaches to identify their philosophical position are analyzed and re-evaluated.

Motor Behavior

The chapter on motor behavior is divided into three sections. The main resources utilized to write the chapter were Magill (1983), Sage (1984), and Schmidt (1982b, 1988).

The implications of Schmidt's schema and generalized motor program theory and its impact upon the closed and open learning environment of the quarterback are discussed. Schmidt's schema theory was linked with the three stages of learning. Collectively they formed the foundation for specific recommendations regarding the quarterback's gradual transfer from the closed environment to the open environment. Problems related to the training of quarterbacks within this framework are identified and general recommendations are provided.

Biomechanics

Atwater (1970, 1979) pointed out that in throwing activities release was completed in less than one second after initiation of movement. Pannes (1967) and Walsh (1978) compared the dropback patterns to that of running. The speed of the dropback (3 and 5 step drop) was approximately 5.71 yards per second (5.22 meters per second).

Seven techniques were video taped for the 3-D video analysis in the following manner: (a) 5 step frontside dropback (right handed quarterback indicates that the frontside is the right side) with a 35 yard pass, (b) 3 step frontside dropback with a 35 yard pass (see Appendix A), (c) 5 step backside dropback with a 35 yard pass, (d) 3 step backside dropback with a 35 yard pass (see Appendix A), (e) throwing on the move direct with a 35 yard pass, (f) throwing on the move inside right with a 20 yard pass, and g) throwing on the move inside left with a 20 yard pass (see Appendix B). Phil Cheetham of Peak Performance Technologies Inc. suggested that a preliminary check be conducted to determine the optimal camera angles (P. Cheetham, personal communication, November 7, 1989). All passes were caught by a receiver at designated distance. The accuracy of each pass was not a measured variable. However, the receiver did not have to move beyond one meter in any direction to receive the ball.

The subject was marked with black dots, three inches in diameter, at the following areas: (a) proximal phalanx (toe) and calcaneus (heel) of the foot (these marks will be placed over the subject's shoes); (b) approximate lateral, anterior, and posterior greater trochanter of the femur (hip), these marks were painted over bicycle racing shorts of the quarterback; (c) umbilicus (navel) and the approximate corresponding posterior lumbar L4 or L5 vertebrae; (d) lateral, anterior, and posterior aspects of the greater tubercle of the humerus (shoulder); (e) manubrium and the approximate corresponding posterior T1 or T2 vertebrae.

Black bands (Feltner & Depena, 1986) were painted around the following areas: (a) lateral and medial malleolus, and the corresponding posterior and anterior areas of the ankle, the calcaneal tendon and talus respectively (ankle); (b) patella and the corresponding intercondylar fossa, and the lateral and medial epicondyle of the femur (knee); (c) lateral and medial epicondyle of the humerus, and the olecranon of the elbow and the olecranon fossa (elbow); (d) styloid processes of the radius and the ulna, and the anterior and posterior lunate (wrist), and (e) left index finger (see Appendix C, Spatial Model Set Up).

The subject warmed-up in his usual manner (Atwater, 1970). The subject was then marked with the paint. Five trials of each technique were taped (Atwater, 1970) without the shirt (Feltner & Depena, 1986); peds were used to allow a better view of the ankle area, and tight fitted gray lycra bicycle racing shorts were used in place of football shorts. The lycra shorts provided a stable surface for the markers on the hip. The best trial of each technique was determined by the accuracy of the pass in conjunction with a subjective video evaluation of each trial. The best trial was digitized for kinematic analysis. This analysis produced a stick figure that was presented in the book.

Instrumentation. The Peak Performance 3-D Video Analysis System was employed to accomplish the kinematic analysis. Two phase-locked cameras (one Panasonic Camcorder

and one Panasonic D-5000) were used to tape the 3 and 5 step dropback patterns and passing action; passing on the move direct, inside right and inside left (Dillman, Cheetham, & Smith, 1985). The cameras were placed at oblique angles relative to the object space (the area in which the quarterback is restricted to perform the required techniques). In addition, the cameras were positioned at 90° to one another. The distance from the target was approximately 35 meters from the middle of the object space (see Appendix D). Tape speed was set at 60 fields per second and 3/4" VHS video cassette tape was used for taping.

A calibration frame was constructed of plastic tubing. Its dimensions were 6.54 meters on the X axis, 1.829 meters on the Y axis, and .914 meters on the Z axis. Eighteen non-linear control points (black plastic tape-letters A-R), defined specific points and distances on the X, Y, and Z axes (see Appendix E) (P. Cheetham, personal communication, November 7, 1989). Each point was measured by an engineer utilizing standard surveying equipment and procedures. The reliability of each point was checked with the software of the Peak Performance System Technologies software. Phil Cheetham stated that each time a three-dimensional study was conducted a reliability study was completed simultaneously. The calibration frame was videotaped for 3 minutes before the quarterback techniques were taped. Once the calibration frame was taped it was removed. The position of each calibration frame post was marked with a marker used by golfers once they have reached the green on a golf course. Taping was performed at the San Jose State University South Campus.

Data Analysis. Each technique was analyzed with attention directed toward specific events in the movement. The events analyzed in the five step dropback phase were as follows: (a) stance (push and release); (b) first step; (c) second step; (d) third step (stretch); (e) fourth step (cushion); (f) fifth step (set/stance); (g) release (pass). The events of the

dropback phase in the three step are similar to the third, fourth, and fifth events of the five step drop. The events related to the release of the football (pass) were: (a) stance; (b) initiation of movement; (c) acceleration; (d) release/control; (e) follow through. The events related to the techniques which required the quarterback to pass the football while on the move were: (a) sprint phase; (b) control phase; (c) stance; (d) initiation; (e) acceleration; (f) release/control; (g) follow through.

The following anatomical markers and related joint angles were analyzed with respect to time and placement within each event to describe the ideal model and/or technique: toes, knees, hips, torso, shoulders, elbows, hands, fingers, and head. The linear displacement of each drop was recorded. The time required from stance to set, and stance to release was recorded. The velocity of the hand at release for each technique was also recorded. As previously mentioned the proposed models were presented with the intention of settling any disputes found in the review. They serve as proposed optimal quarterback techniques which will provide for a balanced, flexible, and multiple offensive structure.

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Appendix A

Backside Target
X

Frontside Target
X

Point A (0, 0, 0)

Straight dropback passing

Appendix B

Point A (0, 0, 0)

Passing while on the move

SPATIAL MODEL SET UPSpatial Model Name: Bobby

	Label	Connection			
1.	Left Toe	/	1		
2.	Left Heel		2	1	
3.	Left Ankle		3		
4.	Left Knee		4		
5.	Left Hip		5		
6.	Navel		6		
7.	Manubrium		7		
8.	Left Shoulder		8		
9.	Left Elbow		9		
10.	Left Wrist		10		
11.	Right Toe		11		
12.	Right Heel		12	11	
13.	Right Ankle		13		
14.	Right Knee		14	6	
15.	Right Hip		15		
16.	Right Shoulder		16		
17.	Right Elbow		17		
18.	Right Wrist		18		
19.	Right Index Finger		19		
20.	Front Tip Of Ball		20		
21.					
22.					
23.					
24.					
25.					
26.					
27.					
28.					
29.					
30.					
31.					
32.					
33.					
34.					
35.					

Diagram of the Spatial Model:

Appendix E

Project Name: Bobby # of reference point 1
 Stick Figure: Bobby # of coefficients 11
 Standard error X .01
 Y .01
 Z .02
 Frequency cutoff 12-15
 Camera 1: Tape ID number: #1 Panasonic Camcorder Camera 2: Tape ID number: #2 Panasonic D-5000

Control Points (Label: X, Y, Z {meters}):

Point	X	Y	Z
A (Origin)	0	0	0
B	3.27	0	0
C	6.54	0	0
D	0	.914	0
E	3.27	.914	0
F	6.54	.914	0
G	0	1.829	0
H	3.27	1.829	0
I	6.54	1.829	0
J	0	0	1.829
K	3.27	0	1.829
L	6.54	0	1.829
M	0	.914	1.829
N	3.27	.914	1.829
O	6.54	.914	1.829
P	0	1.829	1.829
Q	3.27	1.829	1.829
R	6.54	1.829	1.829

QUARTERBACKS BORN OR MADE? DESTROYING THE MYTH

**The Biomechanics of the Quarterback Position:
An Integrative Approach**

Mario A. Verduzco

This book is dedicated to my wife Cathy.
Without her strength, hard work, and
constant support this book would never have
been started or finished.

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TABLE OF CONTENTS

Acknowledgements	III
THE AIM AND AUDIENCE OF THIS BOOK.....	XIII
Chapter One - Philosophy.....	XIV
Chapter Two - Motor Behavior.....	XIV
Chapter Three - Biomechanics.....	XV
PHILOSOPHY	1
THE PASSING GAME.....	2
The Importance of the Passing Game.....	2
Most Important Position.....	8
Most Important Position. Is it a Question of Function?.....	9
The Democratic Position	10
John Rawls-Two Principles	11
Second Principle-Four Interpretations	12
Methods of Evaluation. Choosing Quarterbacks	13
Leadership.....	14
Leads by Example or Vocal Leader	14
Liberal Equality.....	15
Natural Aristocracy and Natural Liberty.....	17
Democratic Equality and Skill	18
Philosophical Importance of Work Ethic	20
Work Ethic Based System versus Talent Based System.....	20
Ethical Advantage	21
Practical Advantages	22
Spring and Summer Practice Schedules.....	26

The KISS Philosophy	27
Clarity or Simplicity	28
KISS, Talent, and Offensive Structure	29
Ignorance.....	30
The Rationale for Prohibitive Rules.....	31
A Coach's Responsibilities to his Quarterbacks	34
Counselor	35
Teacher	36
MOTOR BEHAVIOR.....	39
GENERAL PRINCIPLES	40
Reasons For Improvement and the Endeavor.....	40
Skill Analysis and the Quarterback Position	42
Schema Theory	44
What is a Motor Program?	45
General Motor Programs	46
Recall and Recognition Schema	49
Recall Schema.	49
Recognition Schema.	50
Specific Generalized Motor Programs	51
Specific Back Pedal	52
General Dropback Patterns.....	52
Specific Throwing Motion	53
General Passing Motion.....	53
CLOSED ENVIRONMENT	54
Continuum and Goals	54

Three Stages of Motor Learning.....	55
Cognitive Stage.....	58
Stage of Frustration	60
Phases within the Cognitive Stage	61
Beginning Cognitive.....	61
Mid Cognitive.....	63
Ending Cognitive.....	63
Associative Stage.....	63
Begin and End Instruction	64
Phases within the Associative Stage	65
Beginning Associative.....	65
Mid Associative.....	66
Ending Associative.....	66
Autonomous Stage	66
Stage of Confusion and Understanding	67
Phases within the Autonomous Stage.....	68
Beginning Autonomous.	68
Mid Autonomous.....	69
Ending Autonomous.....	69
OPEN ENVIRONMENT.....	70
Basic Principles.....	70
Cue-Utilization and Perceptual Narrowing.....	70
Cue-Utilization.....	71
Perceptual Narrowing and Distractibility	74
Three Stages of Motor Learning.....	74

Practice Goals	74
Cognitive	75
Beginning Cognitive	76
Mid Cognitive.....	77
Ending Cognitive	77
Associative	78
Beginning Associative	78
Mid Associative.....	79
Ending Associative.....	79
Autonomous	79
Beginning Autonomous	79
Mid Autonomous.....	79
Ending Autonomous	80
BIOMECHANICS	81
INTRODUCTION	82
Importance of Biomechanics.....	82
Throwing Motion in General. Analysis and Problems.....	87
Injury to the Throwing Arm.....	88
Open Kinetic Link System	89
Video Analysis.....	90
PASSING STATIONARY.....	91
Introduction	91
Progression Analysis	95
Stance Phase	96
Feet.....	97

Knees.....	101
Hips.....	101
Torso.....	101
Shoulders.....	102
Elbows.....	103
Forearms	103
Hands/Wrist (Grip)	103
Head	104
Initiation of Movement Phase.....	105
Feet.....	106
Knees.....	109
Hips.....	109
Torso.....	110
Shoulders.....	111
Elbows.....	111
Forearm.....	112
Hands/Wrist.....	112
Head	114
Acceleration Phase	114
Feet.....	114
Knees.....	115
Hips.....	115
Torso.....	116
Shoulders.....	116
Elbows.....	116

Forearm.....	117
Hands/Wrist.....	117
Head	117
Release/Control.....	117
Feet.....	118
Knees	119
Hips.....	119
Torso.....	119
Shoulders.....	119
Elbows.....	120
Forearm.....	120
Hands/Wrist.....	121
Head	121
Follow Through.....	121
Feet.....	122
Knees	123
Hips.....	123
Torso.....	123
Shoulders.....	123
Elbows.....	124
Forearms	124
Hands/Wrists	124
Head	124
DROPPING BACK TO PASS.....	124
Introduction	124

Five Step Drop Frontside	129
One and Two	130
Three (Stretch).....	130
Four (Cushion).....	131
Five (Set).....	133
Five Step Drop Backside	135
Stretch	135
Four (Cushion).....	135
Five (Set).....	136
Three Step Drop Frontside (throw on time).....	137
One (stretch)	137
Two (Cushion)	137
Three (Set)	137
Three Step Drop Backside (throw on time)	138
One.....	139
Two	139
Three.....	139
Four.....	140
PASSING WHILE ON THE MOVE.....	141
Introduction	141
On the Move Direct	143
Sprint Phase.....	143
Control Phase.....	143
Initiation of Movement Phase.....	144
Acceleration Phase	146

Release/Control Phase	147
Follow-Through Phase	148
On the Move Inside Right	150
Initiation of Movement Phase.....	150
Acceleration Phase	152
Release/Control Phase	153
Follow-Through Phase	153
On the Move Inside Left.....	154
Initiation of Movement Phase.....	154
Acceleration Phase	155
Release/Control Phase	155
Follow-Through Phase	155
Summary	156
References.....	158
Index.....	172
Appendix A	175
Appendix B	176
Appendix C	177
Appendix D	178
Appendix E.....	179
Appendix F.....	180
Appendix G	181
Appendix H.....	182
Appendix I	183
Appendix J.....	184

Appendix K.....	185
Appendix L.....	186
Appendix M.....	187
Appendix N.....	188
Appendix O	189
Appendix P.....	190
Appendix Q	191
Appendix R	192
Appendix S.....	193
Appendix T.....	194
Appendix U.....	195

THE AIM AND AUDIENCE OF THIS BOOK

The task for any coach who is writing a book of this sort is to first decide for whom the book is intended. Next, he/she must decide the aim of the book. The answer to the first problem is short and simple: the book is designed for any coach, at any level, who is looking for a rational scientific method to complement the art of coaching quarterbacks. Consequently, the book is not intended for every coach because some coaches would rather rely on tradition and/or hearsay. However, tradition and/or hearsay may not be the most effective and efficient method: let alone the most rational. Moreover, it is this coach's bias and feeling that a type of coach exists who demands and is thirsting to know the why and wherefore of coaching quarterbacks. This book, at the very least, provides a start in that direction.

The aim of this book is to provide coaches with a method which will enable them to consistently develop effective and efficient quarterbacks. In addition, the book will attempt to answer the question, "are quarterbacks made or born?" However, whether a method of development and/or an answer is even necessary, or that it is important, is dependent upon the variables in the equation of team success which coaches deem critical. The variables in this equation have been defined by many coaches as winning football games, and coaches fulfilling their competitive, educational, and professional responsibilities (hereafter known simply as responsibility or responsibilities). In this coach's opinion this discussion is prerequisite to any rhetoric regarding the need for a method of development and an answer to the question "are quarterbacks made or born?" Therefore, the utility of the research in biomechanics and motor behavior must be tied to coaches' philosophies regarding the importance of the quarterback position and its impact upon their ability to fulfill their responsibilities. The book, however, is not geared to settle the "nature/nurture" argument from a physiological perspective. Rather, it is designed to identify coaches' responsibilities

in teacher-student settings, in relation to the argument, based on the research in biomechanics and motor behavior.

Chapter One - Philosophy

The philosophy chapter will be vital toward gaining an understanding of the best method to formulate a sound passing game and the rationale for doing so. It will attempt to identify the consequences of a position which adheres to the "quarterbacks are born" myth or philosophy. Because after all, myths require their believers to shoulder a certain type and amount of intellectual, spiritual, and psychological baggage (Campbell, 1988). Initially the philosophy chapter will demonstrate why an effective and efficient quarterback is a prerequisite to a balanced offensive structure and why the two (an effective and efficient quarterback and a balanced offense) in lexical order are prerequisites to the goals of winning and coaches assuming their responsibilities. Consequently, the method of development must identify the precise biomechanical models which coaches should utilize to teach their quarterbacks in order to function in a balanced offensive structure (biomechanics). In addition, it must instruct coaches how to teach their quarterbacks these techniques (motor behavior). Therefore, any method of development which enables coaches to consistently develop effective and efficient quarterbacks must be based on the sciences of biomechanics and motor behavior.

Chapter Two - Motor Behavior

Before the problem of the precise biomechanical models can be presented the following criteria must be satisfied:

1. Give evidence to support the notion that a quarterback coach can in fact teach complex motor skills that are inherent in playing the quarterback position. In other words, demonstrate that the drills have an impact and determine whether this is best accomplished through rational thought or scientific experimentation at this point in time.

2. Identify the critical skills (cognitive, psychomotor, affective, and physical) which a quarterback needs to be effective and efficient.

3. Investigate and formulate the best method to teach a complex ballistic motor act.

To accomplish the three tasks, attention must be focused on the study of motor behavior. In the opinion of this coach this field of study can substantiate or invalidate coaches' claims that they can improve the quarterback's learning and performance through the use of drills. Consequently, without an understanding of the principles of motor behavior any biomechanical model identified is doomed to remain confined to the written page.

Coaches seem reluctant to change their attitude and approach toward teaching the necessary skills which are requisite to playing the quarterback position (drills, practice schedules (Stevens, 1988)) in part because they have limited knowledge about motor behavior (Sage, 1984). This ignorance can in turn shape a coach's position regarding the question of whether quarterbacks are born or made and the rationale for a method of development.

Richard A. Schmidt's schema theory, the three stages of motor learning, (cognitive, associative, and autonomous), and various principles in the study of motor behavior will be employed to provide the necessary recommendations. These recommendations will be made within the framework of both the closed and open environments.

Chapter Three - Biomechanics

Because "a coach must understand the biomechanical principles underlying performance in his/her sport before analysis of a technique, and hence coaching directives aimed at improving technique, can take place" (Stothart, 1980, p. 29), biomechanics is the foundation for the method of development and the argument against coaches who assume the talent side of the argument at this point in time. For example, if there are no

biomechanically based models/techniques it follows that there would be no psychomotor skills to be taught. This indicates that there would be no need for an understanding of motor behavior and generalized motor program and schema theory. Because after all, if there were no model or technique to teach, there would be nothing to learn. The critical thing to remember is that to date no models or techniques have been provided for the necessary drop back patterns and/or for passing the football from a stationary or on the move positions. The identification of biomechanical models based on the laws of motion and force play the dominant role in shaping coaches' philosophies related to the formulation of offensive structures. For these reasons biomechanics is the focus of this book but more importantly the book hopefully will "prevent the blind leading the blind" (Ariel, 1983b, p. 27).

Because of the aforementioned comments it is this coach's opinion that an integrative approach must be assumed. This approach recognizes that biomechanics provides the critical foundation for the formulation of this type of approach. It utilizes motor behavior theory and a consistent, coherent, and functionally simple philosophy for support and guidance. Consequently, it will provide coaches with a method by which they may begin to consistently develop effective and efficient quarterbacks (Ariel, 1984a; Integration, 1989; Sperling, 1989). The book will provide information that supports a method of quarterback development which will: (a) provide for a balanced offensive structure; (b) enable coaches to assume their responsibilities; (c) enable them to more effectively and efficiently utilize the pool of available talent related to the quarterback position; (d) reduce stress on themselves, the quarterback, and the team; (e) result in more wins than losses or at the very least insure that any game represents the highest quality of a contest. If you are at all inquisitive with respect to getting this accomplished then by all means read on. If you are of the opinion that quarterbacks are in fact made and not born but do not know how or where to begin the

process then by all means read on. If you know all there is to know about the position and believe otherwise: then God bless your quarterbacks!

"Are quarterbacks made or born and if so how can a coach develop them on a consistent basis?" are questions that will be addressed philosophically in terms of coaches' responsibility and objectively in terms of what the sciences of biomechanics and motor behavior instruct. This being the case, let us begin!

CHAPTER ONE

PHILOSOPHY

**A very popular error: having the courage of one's convictions;
rather it is a matter of having the courage for an attack on
one's convictions!!!**

Friedrich Nietzsche

THE PASSING GAME

The Importance of the Passing Game

If this book is to have any relevance for coaches it must demonstrate that the passing game is critical to the success of the team. Secondly, and more importantly, it must demonstrate that an effective and efficient quarterback is a prerequisite to a balanced offensive structure. If neither of these can be substantiated then any question related to why the quarterback should be trained in any special manner is irrelevant. At the outset, the reader must understand that the word balance indicates multiplicity and flexibility. It also implies an effective and efficient quarterback.

The forward pass was legalized in 1906 (Danzig, 1971; Perrin, 1987). Since that time it has been a simple observation that a football team which has an effective and efficient air attack possess a strategic advantage over an opponent who does not. This is true in modern warfare (Dunnigan, 1982), and it certainly is true in the game of modern football. For example, even teams which employ run oriented offensive structures such as the "veer" or the "bone" or the "I" will be more effective if they have in their arsenal the ability to pass the football effectively and efficiently (DeBerry, 1986; Smith, 1987). However, if the defensive coordinator does not employ specific strategies designed to eliminate the run game then the pass offense of the offensive structure and/or the quarterback's ability to pass the ball will remain unchallenged. Consequently, the offense may not have to rely on the passing game to win. This is not an uncommon mistake; many defensive coordinators have been known to defend teams with strategies that demonstrate respect for either the opponent's passing game or the quarterback's ability to pass (Stevens, 1988). Nevertheless, in those instances wherein the defense eliminates the run game and forces the offense to pass, the effective and efficient utilization of the passing game provides a team with an opportunity to win the competitive game (Dooley, 1987; Stanley, 1987; Stevens,

1988; Walsh, 1978; White, 1978; White, 1984). This was first demonstrated in 1913 with the passing-receiving combination of Gus Dorais to Knute Rockne of Notre Dame. Their collective skill allowed the Fighting Irish to compete with and defeat a physically superior Army team 35-13 (Danzig, 1971; Perrin, 1987). The dramatic example of 1913 demonstrated the strategic advantage of the passing game if offensive coordinators wished to utilize it. In the early 1900's, offensive coordinators had a choice whether to utilize the passing game. Currently, however, sound defensive coaching has forced offenses to abandon a one dimensional approach (Amedee, 1988; Bruce, 1987; Smith, 1987). Consequently, most offensive coordinators have recognized the fact that eventually an offense is, "going to have to throw the ball to win. Defenses force you to throw the ball to win. No longer can people line up and hammer the ball and win...there is a point where the defense shuts down the run. When that happens, you have to be able to control the blitz and throw the ball" (Stanley, 1987, p. 217). The best strategy to control the blitz is to utilize the passing game (Ross, 1983). This is but one advantage of a sound passing game. There are many other advantages as well.

The passing game is an integral part of the offensive structure because it will provide many strategic advantages. The ultimate strategic advantage is that it can provide for a balance between the run and the pass (Brown, 1983; Bruce, 1987; Currey, 1981, 1986; Fry, 1985; Henry, 1986, Jacques, 1983; Nehlen, 1988; Pickett, 1983; Reade, 1983; Sheppard, 1986; Stanley, 1987; Stevens, 1988; Sweeney, 1986; Walsh, 1981). Moreover, balance improves the offensive advantage over the defense (Bicknell, 1984). The reason for this can best be explained by contrasting the run game and the passing game. For example, in order to run the football effectively and efficiently the offensive line must dominate the opponent. On the other hand, the passing game can be successful with a "stalemate" (Trestman, 1986, p. 231). In this manner, the passing game will compensate

for a lack of talent and/or it will allow a team to compete with another team who may have superior talent (Schnellenberger, 1984b; Trestman, 1986; White, 1983). In addition, a balanced offensive attack counteracts modern defensive strategy because it forces the defense to defend the entire field (Schnellenberger, 1984b; Stevens, 1988; Trestman, 1988). Moreover, the defense is kept off balance because it is hard to determine and/or predict when the offense will "pass or run the ball" (Fry, 1985, p. 87). An advantage that is rarely recognized is that the passing game improves defensive play by extending the number of plays the offense will be able to run during a single possession. Extended possession time provides the defense with added rest time (Amedee, 1988). In summary, the rule change in 1906 and Notre Dame's subsequent famous win over Army demonstrated the importance of a balanced (run/pass) offensive structure in modern football. It provides many advantages which have been understood by football coaches at all levels (Currey, 1981, 1986; Dooley, 1987; Henry, 1986; Jacques, 1983; Nehlen, 1983, 1988; Pickett, 1983; Sheppard, 1986; Stevens, 1988; Sweeney, 1986). Nevertheless, a balanced offense is not enough to attain offensive success. Therefore, it is time to identify the importance of offensive multiplicity.

Defensive coaches have forced offensive coaches to recognize the importance of the strategy of multiplicity, and thereby employ it. This is a tactic wherein the offense utilizes multiple formations. A multiple offensive structure forces a reduction in the number fronts and coverages that a defense can employ to attack and/or react to any offensive play that is employed (Bicknell, 1984, 1985; Brown, 1983; Fry, 1984; Hall, 1985; Osborne, 1976). A reduction in the number of fronts allows the offense to better predict what the defensive strategy will be from one play to the next. Therefore, coaches must formulate offensive structures which are balanced (run/pass) and multiple (multiple formations) if they wish to be successful in modern football. Moreover, the qualities of balance and multiplicity will

lead to offensive flexibility and/or diversity. Flexibility and/or diversity indicate that the offense will be able to counteract any defensive strategy employed to limit offensive production (Smith, 1987). However, for the sake of simplicity the word balance will be used to describe the required collective qualities of balance, multiplicity, and flexibility.

The preceding remarks, however, do not answer the more important question of why it is critical to have an effective and efficient quarterback. Therefore, it is important to identify the special role the quarterback plays within the framework of a balanced offensive structure. Nevertheless, it must first be acknowledged that there is more than one approach for achieving offensive balance. For example, many coaches are of the philosophy that a sound running game is a prerequisite to the passing game (Gillman, 1988). Coach Gillman, however, states that this philosophy "is a lot nonsense." Moreover, he states that if an offense is to have a successful run game then it had first "better be able to pass" (Gillman, 1988, p. 120). However, it is this coach's opinion that the lexical order of running in order to pass becomes critical only if this approach fails to train the quarterback to be an effective and efficient passer. The reason for this opinion is clear. Simply stated the position on the team which determines offensive balance is the quarterback position. Specifically, an efficient and effective quarterback is critical because (a) it is difficult to win championships without a quarterback who can pass (Brodie, 1984); (b) a quarterback who can pass will determine the success of the coach (Currey, 1986); (c) "the defense cannot improve without a quarterback" (Hyder, 1983, p. 83); (d) the quarterback determines whether the offense will be able to pass the football (Rogers, 1983); (e) the quarterback handles the football on every play (Sochor, 1983); (f) "the quarterback is the key to the passing game" (White, 1986, p. 255); and (g) the quarterback is the difference between "winning and losing" (Yeoman, 1983, p. 282).

This elevated position has placed more duties and responsibilities on the quarterback, more so than any other position on the field (Shea, 1980; Smith, 1987). "No other position demands such a burden of responsibility" (Shea, 1980, p. 4). Coaches have identified the added duties and responsibilities of an effective and efficient quarterback in a balanced offense. Although not conclusive, the major components can be categorized into the four domains of learning.

1. Affective. The quarterback must be able to effectively communicate with coaches, players, peers, opponents, recruiters, and the media. Leadership, confidence, positive attitude, and the will to prepare are critical components and skills which can be taught and learned (Berndt, 1984; Brown, 1983; Currey, 1986; White, 1984; Wyche, 1983).

2. Cognitive. The quarterback must understand defenses. The ability to read and react to them (pre- and post-snap) quickly are quarterback skills which must be taught (Shea, 1980). These skill are based on intelligence, concentration, and hard work (Brown, 1984; Currey, 1986; Edwards, 1983b; Kush, 1976; Smith, 1987; Theder, 1975; Tollner, 1983; White, 1983, 1984, 1986; Wyche, 1983).

3. Psychomotor. The quarterback must be able to throw specific types of passes and perform specific drops. The ability to move, throw, run, dropback, and set-up are critical as well. In addition, the quarterback must be versatile, and must possess a short stroke, and high release (Currey, 1986; Edwards, 1986; White, 1986; Wyche, 1983).

4. Physical. Gaining strength, power, quickness, and the desired weight can be attained through the proper use of knowledge; these are quarterback skills which must be taught and learned (Brown, 1984; Currey, 1986; Sullivan, 1983).

The quarterback's increased duties and responsibilities have increased his awards, salary, and media attention (in the following sections these will simply be referred to as wealth and position). Consequently, the importance of the passing game, as well as the

development of an efficient and effective quarterback, is of little dispute among professional, college, and high school football coaches (Brown, 1983; Brown, 1988; Currey, 1984, 1986; Dooley, 1987; Edwards, 1983a, 1983b, 1984, 1985; Hyder, 1983; McCartney, 1988; Osborne, 1976; Schnellenberger, 1984a, 1984b; Shea, 1980; Sochor, 1983; Stanley, 1987; Wacker, 1988; Walsh, 1978, 1983; Yeoman, 1983). The previous definition of balance implies an effective and efficient quarterback. Therefore, the word balance and/or the phrase balanced offensive structure or system will imply an effective and efficient quarterback.

Nevertheless, the question of how a balanced offense helps the coach fulfill his responsibilities has not been answered. From a philosophical perspective, it is the responsibility of the coach to equip the players with a chance to win (Kretchmar, 1975; Ravizza, 1985; Thomas, 1983, 1984; Walsh, 1978). A balanced offense yields a philosophical advantage. Bill Walsh (1978) gave one example when stating that it is the responsibility of the coach to develop a passing game because "there is a time in a game when you are behind and it is your obligation as a coach to try and come back and win. The drop back pass is vital" (p. 27). The ability of a coach to develop a balanced offense and an effective and efficient quarterback may affect the approach that the coach would take regarding his evaluation of any game.

The preceding discussion has led many coaches to state, "the quarterback is the most important player on a football team" (Bielat, 1986, p. 4). This elevated position is another ingredient of wealth and position. However, the acknowledgement of this fact may place the coach in an uncomfortable position with the rest of the team. Consequently, an attempt will be made to justify the preceding statement. In addition, it will demonstrate that making this statement is in the best interest of the team and each individual member. John Rawls' (1971) theory of justice will be employed to accomplish this task. It will do so by

reconciling the added duties and responsibilities of the quarterback with his increased wealth and position.

The reason for this justification is not merely to elevate the quarterback position for its own sake. It is hoped that this analysis will relieve the tension between coaches, quarterbacks, and their teammates. In other words, it will match what is overtly stated regarding a team game (that all players are equal in every way) with what is covertly done in practice (the quarterback is the most important position) by providing a fresh and coherent perspective.

Most Important Position

Coaches have at times verbalized what they consider to be the most important position on the playing field. Al Davis, one of finest coaches and owners in the NFL, is of the opinion that a team is built with great corners (Madden, 1984). Many other coaches believe that the foundation of a team begins with the quarterback (Bielat, 1986). One can agree with both opinions if consideration for the rationale which supports a defensive claim is taken into account. The agreement with both philosophies does not indicate an eclectic approach, but it does signify that whether one is speaking about the offensive or defensive side of the ball in part determines position importance. Specific to the offensive structure coaches will suggest that it is either the offensive line or that it is the quarterback who determines team success (Bruce, 1988; Edwards, 1985; Trestman, 1986; White, 1986) and the quarterback (Bielat, 1986; Brown, 1988; White, 1986).

In any event, the justification of position importance cannot be decided by the function of any unit within the offensive structure. Therefore, before a justification is provided for stating that the quarterback is the most important position it is critical to show how the statement cannot be justified.

Most Important Position. Is it a Question of Function?

To see that the question of importance cannot be answered in terms of function, attention must be directed toward the important components of an offensive structure and the passing game specifically. Two questions must be asked: what are the facets of the passing game, and of those facets which is the most important. The second question is directly related to the previous section on the most important position. The components of the passing game can be divided into two groups. Each group is related to the coaches' abilities (see Figure 1).

- I. Coaches ability to teach.
 - A. Passing the football (quarterback position).
 - B. Receiving (all potential receivers).
 - 1. Routes.
 - 2. Alignments.
 - C. Protection (all potential blockers).
- II. Coaches intellect/expertise.
 - A. System (playbook).
 - B. Schemes (keys and reads).
 - C. Attack philosophy (defensive manipulation).
 - D. Commitment.
 - 1. Organization of practice time.
 - a. Passing game development.
 - 1. Consistency.
 - 2. Confidence.

Fig. 1. Components of the Passing Game

A detailed account of each will not be given because each is a subject for another book. Nevertheless, Homer Smith's (1987) book "Football Coach's Complete Offensive Playbook" is a tremendous example of system analysis. The subjects under the heading of roman numeral two (coaches intellect/expertise) are dependent upon the coach's football intellect and his ability to formulate and employ a cohesive, coherent, and functionally simple offensive plan. This is absolutely essential and must be looked at as a given but at the same time can only be developed through research based on diligence and hard work.

The concepts under roman numeral one encompass the techniques, duties, and responsibilities of the specific positions which comprise the passing game. These all have specific inherent difficulties related to efficient and effective performance. These difficulties must be addressed by the coach if the players who play these positions are to be successful. Each, but not all, requires a certain somatotype, speed, and quickness which are in turn dependent upon the style of attack (roman numeral two). Each of these positions (receiver, lineman, quarterback) have specific technical problems yet these are not problematical. As was mentioned earlier the unnatural or natural difficulties inherent in the positions can only be removed by the coach's ability to teach proper mechanics inherent in the requirements of each position (Bullough, 1983, 1984; Knox, 1985).

Coaches acknowledge the fact that "in the pass offense the number one thing is protection. If you can't protect the passer you can't be successful" (Currey, 1986, p. 2). However, a coach could also state that if a team cannot catch the ball then they cannot be successful. Moreover, a coach could state that if a team cannot pass the ball then they cannot be successful. Therefore, it is obvious that the pass offense, from a position standpoint (quarterback, linemen, receivers), requires effectiveness and efficiency in all three positions in order for the pass offense to function and thus create offensive balance. Each position is equally important in this respect. Consequently, the justification for stating that one position is more important than another cannot be answered against the background of position function.

The Democratic Position

The notion that the quarterback is the most important player suggests inequality. However, the phrase all players are equal is an important cliché which identifies a common philosophical position related to the concept of a team. Coaches do not have to avoid the position that players are equal. However, they do have to avoid an approach that suggests

that players are equal in all facets of their existence as team members. So, how is it that coaches can justify that the quarterback is the most important position without cringing at the thought? A rational democratic approach, which recognizes and reconciles inequalities in responsibility and duty with wealth and position is the best method by which to justify the most important position on a team sport. John Rawls' theory of justice in general, and specifically two principles of justice as fairness, will be utilized to accomplish this task.

John Rawls-Two Principles

1st Principle (the principle of equality): "Each person is to have an equal right to the most extensive basic liberty compatible with similar liberty for others" (p. 60).

Application: All players would have the same rights (safe protective equipment, discipline etc.), and liberties (team rules) under the structure of school, societal, and/or coach imposed policy. The parameters of these rules will expand at the professional level relative to high school and college due to the placement and point in life of the professional athlete and the NFL.

2nd Principle (the principle of inequality or the difference principle): "Social and economic inequalities are to be arranged so that they are both (a) to the greatest benefit of the least advantaged, and (b) attached to positions and offices open to all under conditions of fair equality of opportunity" (p. 83). Rawls (1971) further described the "difference principle" wherein he stated, "the higher expectations of those better situated are just, if and only if they work as part of a scheme which improves the expectations of the least advantaged members of society" (p. 75). Application: Inequalities of wealth and position must be to the advantage of the team in general and to the benefit of the least advantaged player on the team specifically. In other words, the increased wealth and position of the quarterback must benefit the third team player. Benefits such as play-off or bowl games (all three levels), championship rings (college and professional), or more money due to

play-off appearances (professional) could be categorized as benefits. In addition, the inequalities can only be seen as just if the assigned duties and responsibilities are commensurate with those inequalities. In other words, in order for the increased wealth and position of the quarterback to be justified he must have a commensurate increase in his duties and responsibilities. Moreover, the opportunity to hold those positions must be open to all players. For example, any player who wishes to compete for the quarterback position must be allowed to do so. In addition, his evaluation must be based on objective criteria. Finally, the two principles must be incorporated and they must operate in "lexical" order. In other words, the first must precede the second. If the quarterback's added duties and responsibilities do not lead to an increase in wealth and position then his treatment is unfair.

Coaches should admit that inequalities exist, cite the parameters of those inequalities, explain why in fact they exist, and explain the rationale for those inequalities. Coaches must not accept the philosophy that suggests that all players are equal in every way. Coaches must, as Vince Lombardi did, treat the players as individuals and yet hold them accountable as team members (O'Brien, 1987).

At this point, the phrase "attached to positions and offices open to all under conditions of fair equality of opportunity" must be examined. This is a critical point because the interpretation of this phrase will determine the method a coach employs to evaluate and choose his quarterbacks.

Second Principle-Four Interpretations

There are four possible interpretations of part (b) of the second principle: "attached to positions open to all under conditions of fair equal opportunity." These interpretations provide a method for determining how it is that individuals on the team are allowed to compete for the quarterback position. In other words, these interpretations provide a

framework for choosing quarterbacks on the team in general and for starting a particular quarterback specifically. However, inequalities of distribution of wealth, income, and social position (which is associated with the quarterback position) cannot be seen as just if the ability to hold those positions is based on any of the following three interpretations.

1. Natural liberty. This interpretation is representative of equality as "careers open to talents" (p. 72). A player's genetic talent and the social position of his family in the community would be the deciding factor.

2. Liberal equality. This interpretation is representative of equality as "fair equality of opportunity" (p. 73). A player's genetic talent but not his social position is the key. Therefore, the arbitrary "natural lottery" of genetic inheritance would be the deciding factor.

3. Natural aristocracy. This interpretation is representative of equality as "careers open to talents" (p.74). A player's social position in the community but not his natural talent would be the deciding factor.

4. Democratic equality. This interpretation utilizes the difference principle and allows for inequalities when those inequalities benefit the least advantaged on the team (second and third team players or lesser advantaged first team players). Inequalities cannot be deemed just if they are based on natural liberty, liberal equality, or natural aristocracy (Rawls, 1971). The specific application and interpretation of each will be detailed in the next section.

Methods of Evaluation. Choosing Quarterbacks

"If the only reason you sprint out is so your quarterback can see, then you are wrong. I can prove you are wrong. You have to teach your quarterback to dropback and read between the trees, regardless of his size...I bring this up because I feel it is a misconception that you have to be tall" (Bicknell, 1984, p. 15). Jack Bicknell's quote points out the fallacy of choosing a quarterback based on height (liberal equality). Providing the

quarterbacks with accurate objective evaluation is a professional obligation (Walsh, 1978). It is critical because "the quarterback (QB) coach must be truthful with his quarterbacks and tell them why they are one, two, or three. The quarterbacks must trust the coach" (Sloan, 1984, p. 255). If the placement of any quarterback on the team's depth chart is justified then it cannot be based on natural liberty, liberal equality, or natural aristocracy. It must be based on accurate objective evaluation of the requisite skills and a system which utilizes the criteria inherent in the principles of equality and inequality (Rawls, 1971, p. 65-83).

Coaches utilize a variety of methods to choose their quarterbacks in general and their starting quarterback specifically. A description of the way in which liberal equality, natural aristocracy, and natural liberty apply to the question of quarterback evaluation will follow. In addition, the method of leadership will also be analyzed. In no way is it suggested that the following list is complete.

Leadership

What is leadership in a quarterback? There are two conceptions that must be addressed because they are common criteria used by coaches for choosing their quarterbacks; in addition, leadership of this sort may impact a final decision. These two are exemplified by the phrases, "he leads by example," and "he is vocal leader." In the next section these two conceptions will be challenged in order to point out the true reason for a quarterback's ability to lead.

Leads by Example or Vocal Leader

We have all heard at one time or another the phrase, he leads by example. A quarterback of this sort has been frequently described as the quiet individual who has little to say but gets the job done. He is either allowed a place on the depth chart and/or he is chosen to be the starting quarterback because of his quiet example. In addition, many coaches have heard of the quarterback who is the vocal leader. He has been described as

the quarterback who prompts his teammates to do better. He vocally demands this of his teammates from Monday until game day.

There has never been one quarterback in the history of the game that has ever led simply by example or simply by his vocal prowess. These statements which describe specific types of quarterbacks disguise the genuine basis which supports the quarterback's competent performance. The quarterback in either case led the team by his performance which was either based on talent or skill (which requires a work ethic to improve the necessary skills). It is impossible for a quarterback to lead by an empty example or simply by his vocal prowess. It is an inexorable fact that a quarterback without effective and efficient performance to support his example or his words could ever lead his team to victory. The genuine reason a quarterback is chosen is due to his effective and efficient performance.

The two previous examples are critical for the following reason. Effective and efficient quarterback performance can be controlled by the teaching of motor skills and therefore, coaches should focus their attention on teaching the precise skills (passing from a stationary position, passing while on the move, dropping back) in the most effective and efficient manner (Sage, 1984; Schmidt, 1988; Walsh, 1986).

Liberal Equality

The liberal equality method of evaluation suggests that coaches choose their quarterbacks based on inherent gifts (all around athlete or physical stature). This does not indicate that it would not be beneficial to the offensive structure to have the best and/or biggest athlete at the quarterback position (Shea, 1980). It does indicate, however, that these attributes in and of themselves will not insure success (Bicknell, 1984; Shea 1980). Moreover, attributes of this sort should not be the sole criteria for the subsequent choice. A liberal equality approach, from a practical perspective, severely restricts the pool of

available players from which a choice can be made, because it eliminates work ethic (this will be detailed in a later section). This approach can force the coach and his system to be dependent upon the whims of talent availability as was earlier described.

Moreover, it is possible that this approach may force coaches to either compromise their principles of a team concept with respect to Rawls' first principle regarding rights and liberties or it may cause them to break the bond of trust between the coach and his players. For example, many coaches have a team rule which in effect states that if anyone transcends the boundaries of this or that rule then that player cannot play and so on. However, if the talented quarterback breaks a rule before a critical game three unacceptable scenarios may occur. First, the quarterback may be punished. His punishment may be to sit out the entire game or at least the first half of the game. He is allowed to play, however, once the second team quarterback demonstrates that he cannot move the team. Second, a vote is taken in a way to express adherence to a democratic principle. This vote is made to take advantage of the team's selfishness in such matters. For example, the players understand that without the first team quarterback they are doomed to failure because the second team quarterback is not prepared to play. However, this is not due to some inherent deficiency in the second team quarterback. Rather it was assumed that because the second team quarterback was 6' 4" or that he was an all around athlete he could get the job done. Third, if the coach decides to adhere to Rawl's first principle of justice regarding rights and liberties and decides to sit the quarterback down for the entire game and play the second team quarterback, then he destroys the trust that the team placed in him to insure the greatest opportunity for success.

There is a another consequence for choosing and/or evaluating quarterbacks based on liberal equality. For example, an entire offensive structure may be eliminated and another one employed in order to harness the talents of a particular quarterback (Brown, 1988).

Coaches will eliminate the "I" formation and instead employ the veer because they have a great athlete at the quarterback position who is an excellent runner. They will emphasize the passing game because they have a quarterback with a strong arm. They will attempt to focus solely on the run game because they have a great tailback and their quarterback cannot throw the ball. They will accept the fact that it is going to be a tough year because they do not have a quarterback who can throw. However, it must be acknowledged that "the same type passing game is not going to be as effective for one quarterback as it is the next" (Walsh, 1978, p. 27). The previous comments do not suggest that coaches should not take advantage of the inherent gifts of their starting quarterback. They do suggest, however, that a system of passing the football should be in place (Smith, 1987).

Nevertheless, even if the coach succeeds in removing all natural contingencies related to evaluation and leaves the position open to all players, potential problems still exist. For example, the coach may not be available to teach his quarterbacks for reasons that will be discussed in the following sections. If this is the case then talent is allowed to play the dominant role in the choice of any one quarterback. In any event, the starting position determines wealth and position. However, "there is no more reason to permit the distribution of income and wealth to be settled by the distribution of natural assets than by historical and social conditions" (Rawls, 1971, p. 74). Therefore, liberal equality is an unacceptable method for choosing the team's quarterbacks.

Natural Aristocracy and Natural Liberty

Because a prospective quarterback's parent may be the superintendent's son, a large fund raiser's son a coach may be inclined to start this quarterback over another for this reason alone (this is not a case for Natural Aristocracy or Natural Liberty but only an interpretation in the football setting). This criteria suggests that if two quarterbacks were

close in production the final benchmark or criteria is the prestige the quarterback's parents might hold in the community not any other justifiable criteria.

The best method by which to choose quarterbacks for the team in general, and the starting quarterback specifically, is based on Rawls' fourth interpretation of the second principle. In other words, the democratic equality.

Democratic Equality and Skill

In order to satisfy the criteria of democratic equality the coach must attempt to remove social and genetic contingencies and he must leave the position open to all. The removal of social factors is problematical because if he is not available to teach, then social contingencies may play a role. For example, quarterbacks with more economic wealth can attend quarterback camps. Depending on the quality of the camps quarterbacks who have the financial ability to attend these camps may gain an advantage. This problem would exist only because the coach is not available to teach. This does not indicate that coaches should be forced to meet with their quarterbacks. However it does indicate that those who wish to should be allowed to do so.

The ability of the coach to remove genetic contingencies is easy. The coach may accomplish this through the teaching of specific skills (Sage, 1984; Walsh, 1986). The most rational teaching method is grounded on the accurate objective and quantitative evaluation of skills which are found in the four domains of learning (cognitive, psychomotor, affective, and physical). Moreover, the only method by which to improve these skills is through a work ethic based performance system. This system acknowledges the importance of skill development. The system's methodology for skill improvement is based on research (Walsh, 1986).

The identification of the psychomotor skills which a quarterback must at least possess to function cognitively in any offense is critical. The requisite skills are dependent upon the

style of attack and the inherent gifts of any one quarterback. However, the ability to pass the football from a variety of strategic positions and the ability to get to those positions is critical for all quarterbacks (Smith, 1987). These skills will be discussed in detail in the chapter on biomechanics. At this point they will only be cited in a general manner. The quarterback must be able to effectively and efficiently throw seven types of passes, inclusive of straight drop and moving passes from three different ranges (short, medium, and long); he must also master four types of drop techniques, both set and timing with release directions, in three different areas (frontside, backside, over the center).

An evaluation process based on skill development provides the coach with rational justifiable criteria to choose the quarterbacks on the team. In addition, it allows him to make an initial choice of the starting quarterback. Moreover, it provides any player with the necessary information to determine whether he would like to compete for a position on the depth chart. The player, in turn, will be confident knowing that the choice will not be based on erroneous information (liberal equality, natural aristocracy, or natural liberty). The information utilized to determine the order of individuals on the depth chart has tangible characteristics. This information is quantifiable and objective. Coaches cannot state that they care for their quarterbacks if they are not willing to accurately evaluate each one of them. How can they? Because they claim honesty? Coaches must transcend honesty. For example, it is not uncommon for the parents of a quarterback to ask the coach to treat their son as honestly and as objectively as the coach would treat his own. That a coach may agree to do so will insure honesty. However, it will not insure objective treatment. As unfortunate as it might be the coach might treat another's son as subjectively as he would his own son. Consequently, a quarterback may be placed at the lower end of the depth chart due to an evaluation process that was based on an arbitrary method.

Nevertheless, coaches must strictly evaluate the methods they use to choose quarterbacks if they wish to be respected as professionals (DeBerry, 1986).

The previous four interpretations may be categorized into two types of development and evaluation systems. The interpretations of liberal equality, natural equality, and natural aristocracy may be categorized under the system entitled "talent based system of quarterback development and evaluation." The fourth interpretation, democratic equality, may be categorized under the system entitled "work ethic based system of quarterback development and evaluation." A definition and description of each system will be provided in the next section. In addition, an analysis of the advantages of a work ethic based system over a talent based system will be presented.

Philosophical Importance of Work Ethic

In the educational setting an individual's work ethic is an important ingredient which will lead to the success of any student (Degler, 1984; Rippa, 1988). Motivation (intrinsic or extrinsic) is important but work ethic as it is used here implies motivation because it doesn't follow that one could work hard without being motivated to do so. This does not indicate that talent is less important, that it should be ignored, that those with talent should be penalized in any way, or that those with talent are a priori lazy. However, it must be admitted that "talent" does not insure work ethic or motivation. Consequently, it is critical to identify the practical as well ethical advantages of work ethic for the coach.

Work Ethic Based System versus Talent Based System

The type of system employed to develop and evaluate quarterbacks in general and to choose the starting quarterback specifically becomes critical to the success of a balanced offense. Two types of systems can be employed to accomplish this goal: a talent based system of quarterback development and evaluation, and a work ethic based system of quarterback development and evaluation. A talent based system indicates that the coach

evaluates and chooses all of his quarterbacks, as well as his starting quarterback, based on the inherent talents or social position of the athlete (liberal equality, natural liberty, natural aristocracy). There is no method of development employed. A work ethic based system indicates that the coach utilizes a method of quarterback development. In addition, the coach evaluates and chooses his quarterbacks based on quantitative, accurate, and objective criteria. For example, the coach would evaluate the quarterbacks' techniques and their ability to read, to key, and react to defensive structures (Shea, 1980). A work ethic based system places the responsibility for the functional efficiency of the offense on the coach's ability to teach.

Ethical Advantage

If a student wished to pursue a professional career in physics or music then it seems to this coach that it is the obligation of the instructors to inform these students of the necessary sacrifices, dedication, skill, and commitment required to achieve such goals. Moreover, the educational system must allow the instructor to teach this type of student if he/she chooses to do so and/or the instructor should be able to direct this type of student to an individual who can provide appropriate instruction. From this perspective, no rules should restrict the work ethic of this type of student or restrict the instructor from teaching this student in any manner. Therefore, if a student wanted to become the finest nuclear physicist, musician, or quarterback that he/she could be then the educational system should not restrict the time that instructors are willing to provide to students who wish to achieve these goals (Rippa, 1988). In this writer's opinion rules should not restrict instruction simply because the instruction may transcend the time demands of the typical classroom. The fact that the football environment is restricted (coaches cannot meet with their players in the off-season), and other areas of education are not, suggests that the football environment is in some way different than the traditional classroom environment.

Moreover, it suggests that the goal of wanting to be a quality quarterback while earning an education may not be a legitimate goal. Nevertheless, if the level of success attained by any student is limited by his/her willingness to work hard and the ability of the teacher to teach, then any rules or philosophies which limit work ethic should be questioned.

Practical Advantages

A talent based system places the responsibility for the functional efficiency of the offense on a young man who may possess some but not all of the skills requisite to a balanced offense. In addition, he may possess none of the requisite skills. More importantly, the skills that he does possess may not have reached the autonomous stage of learning. In other words, the skills have not become second nature. This deficiency will negatively impact his cognitive ability to detect and react to specific cues in the defense which are required if the offense is to function effectively and efficiently (Schmidt, 1988). Collectively, physical and cognitive deficiencies will create more stress in the quarterback and thus diminish his ability to perform (Schmidt, 1988). However, a coach's knowledge of the principles of biomechanics and motor behavior can rectify this problem (Sage, 1984). More importantly, a coach who utilizes a talent based system is dependent upon the availability of a talented quarterback in his immediate area. The absence of this talented quarterback is a potential limiting factor. However, if a coach employs a work ethic based system he may not have to face the above problem. For example, a lack of talent may not be a limiting factor because of another type of athlete. This is the athlete who is not as talented but has a tremendous desire to be a successful quarterback. A strong work ethic, coupled with the coach's work ethic based system of development, will allow a motivated athlete to compensate for a lack of talent. Ultimately, his work ethic may allow him to become a more effective and efficient quarterback than the talented athlete (Walsh, 1986;

Wyche, 1983). Consequently, a coach who utilizes a work ethic based system is not restricted because of a lack of talent.

Perhaps the most important characteristic of a work ethic based system of quarterback development is that it allows a quarterback to be prepared. For example, "the quarterback position is one that can be detailed just as closely as that of a double team block that you teach your linemen. The number of steps he takes, how he practices those steps, who he throws the ball to, how he throws it, all of those things can be categorized to a point where you can be pretty darn sure what is going to happen" (Walsh, 1978, p. 27). Therefore, if the coach understands the requirements necessary to implement a work ethic based system then young quarterbacks will be motivated to attend spring and summer practices and learn the position (Walsh, 1986). In addition, they will not need to be coerced. And because of this they will come to understand what is required to become prepared for any challenge. For example, at a particular point in life most human beings are faced with and challenged by a specific problem and/or a series of problems. The manner in which the individual responds to a crisis may not be as critical as how that individual may have prepared to meet the challenge. It is only through diligent preparation that a person can begin to feel comfortable with, or at least come to some understanding about, potential failure relative to any challenge. It is only through diligent preparation that a person is justified to wake up in the morning, look in the mirror, and state that he/she did the best he/she could. Lack of preparation may lead to excuses for a lack of performance which may then lead to the choice to blame others or events for failure. However, what is worse than the above examples is that individuals (for instance quarterbacks) may be prevented from preparing.

Talented quarterbacks may find themselves faced with the aforementioned problem. For example, during the season a quarterback's "talent" could have led his team to victory in all games except the championship game. However, the reason for a potential loss in

this game may not have anything to do with the quarterback's talent. A possible reason for a loss in this type of game could be the fact that the quarterback was unprepared to meet the challenge of this championship game due to a talent based system of development and evaluation. For example, the quarterback could have been unprepared psychomotorically relative to technique, cognitively relative to defensive recognition (pre- and post-snap keys and reads), and psychologically because he had a false sense of security (his talent would see him through). Nevertheless, some coaches would argue that this analysis is ridiculous because luck has a tremendous amount to do with the result of any game. They would suggest that there are factors over which the coach has no control. There is no question about this, nevertheless, Bill Walsh (1986) was quite correct when he stated that fortune or misfortune should only account for 10-15% of the game's eventual outcome. If coaches state that losses are incurred because of bad luck then it seems that they must also admit that they win because of good luck. However, it must be admitted that a team cannot win if the opponent is superior (Bruce, 1987). Nevertheless, "coaching ultimately makes a difference between winning and losing" (Bruce, 1987, p. 20). Consequently, it is vital to understand "that coaching does make a difference. When everything is equal and all things are considered even, the best coached team is going to win" (Dye, 1987, p. 57). Coaching the quarterback to meet the challenge of the championship game is critical.

At any rate, the loss of the championship game or any game for that matter can be rationalized in one of seven ways, and possibly more:

1. The coaches or players can look for a scapegoat relative to misfortune and the impact of various mistakes.
2. All of the blame can be placed on bad luck.
3. The defense was not playing in a manner commensurate with the opposing defense.

4. Blame can be put on the quarterback for his inability to complete key passes for yardage and/or first downs.

5. Lack of preparation pertinent to game plan consideration due to the incorrect analysis of available information

6. The coach should assume the blame based for two reasons: (a) his failure to prepare the quarterback in the off-season, (b) a lack of pre-game preparation.

7. The loss may be evaluated strategically; the other team was physically and cognitively superior.

Statement number four identifies the quarterback as the cause for a critical loss. It must be admitted that all too often the position that takes the blame for the loss of important games is the quarterback. However, young quarterbacks are many times continually led to believe that their talent will compensate for a lack of preparation. But how is it that the quarterback should take the blame when the method employed to train him was based on the statement, "throw the ball to the man that is open" (Fry, 1985, p. 87). This methodology requires the quarterback to read the entire defense. However, it must be acknowledged that "you can't read the entire defense" (Vermeil, 1981, p. 238). Therefore, it seems that it is the coach and not the quarterback who should assume the blame. On the other hand, if the quarterback has been properly prepared then he and the coach can hold their heads high after a win and after a loss with the knowledge that they have done all that was possible to meet the challenge of the championship game. A loss in this type of game can be evaluated in one of two ways. First, the coach can courageously assume the blame because of a lack of preparation pertinent to the incorrect analysis of available information. For example, the coach could have prepared the offense to attack the wrong defensive structure. Second, provided the team was thoroughly prepared and a work ethic based performance system was implemented, then the loss can be evaluated strategically: the

other team was physically and cognitively superior on that particular day. It must be emphasized that to date there is no conceivable configuration of theoretical knowledge (biomechanics and motor behavior) that will support the notion that a coach can prepare a quarterback's full cognitive ability if he first does not implement a work ethic based system of development and evaluation. Moreover, this method of preparation must be founded on the study of biomechanics and it must be supported by motor behavior theory (Summers, 1981).

A work ethic based system must manifest itself on the field in some specific way. The development of an effective and efficient quarterback in a balanced offense requires time and a solid work ethic on the part of the coach (Bruce, 1987; Teaff, 1986). This indicates that an off-season plan must be employed to develop the quarterbacks in the program (White, 1984). The recommendation for off-season schedules is consistent with the available research related to the development of skills inherent to the quarterback position such as passing from a stationary position and passing while on the move (Magill, 1983; Sage, 1984; Schmidt, 1988).

Spring and Summer Practice Schedules

The legalization of the forward pass was implemented with the intent to reduce the brutality of the game (Danzig, 1971; Perrin, 1987). However, simply legalizing the forward pass will not in and of itself reduce the brutality of the game. In order for that to occur offensive structures must be developed and utilized which will enable a balanced offense to pass the football effectively and efficiently. In addition, an effective and efficient quarterback must be developed because this is a prerequisite to achieving a balanced offensive structure. This objective requires developmental time "during the spring and summer" (White, 1984, p. 305). Moreover, it is difficult if not impossible to develop a balanced offense and avoid implementation of a talent based system of quarterback

development and evaluation without spring and summer practice schedules. Therefore, if education, co-curricular or otherwise, is determined to provide opportunity and success for any student with high professional goals (even those who aspire to be quarterbacks while at the same time earning an education) then it seems that coaches should not be prohibited from meeting with their quarterbacks in the off-season (Rogers, 1983).

Nevertheless, a coach may not be able to implement a work ethic based system of quarterback development and evaluation because he is prohibited from meeting with his quarterbacks in the off-season or the summer. This could be due to external or self imposed restrictions. For example, he could be prohibited from doing so because of conference rules (National Collegiate Athletic Association, 1990; Steve Stearns, personal communication January 17, 1991). On the other hand, the coach may choose not to meet with his quarterbacks because of his adherence to a specific type of philosophy. The merits of a self imposed restriction will be addressed first.

The KISS Philosophy

Many coaches have been reluctant to develop a balanced offense because of adherence to a philosophy embodied in a standard cliché known as "keep it simple stupid" (KISS). It has been suggested that this is due to ignorance, dumbness, and/or laziness (Bullough, 1983, 1984; Montour, 1979; Stevens, 1988; Walsh, 1978). Simplicity, however, could indicate one of two things. First, it could indicate consistency. For example, if simplicity indicated consistency then offensive players would not have to drastically alter their assignments for any one play when attacking the "46" defense as opposed to attacking a "base 50" defense. However, this example is a positive feature of simplicity. Second, it could indicate the elimination of balance as it has been previously described. For example, this type of approach is associated with an elimination or reduction of the passing game and/or a reduction in the number of offensive plays. It is thought that this will a priori

reduce complexity (Ross, 1983). This approach, in the opinion of this writer, is a negative feature of simplicity because in order for an offense to be balanced "it is imperative to have a system with answers for every eventuality...a lot of plays are needed in order to have answers to all problems" (Smith, 1987, p. 165-166). Consequently, some coaches have expanded their offensive structures. They have found that the players enjoy the process of learning a more complex system and consider it a challenge to do so (Ross, 1983). This is especially true for the quarterback in that he must assume more duties and responsibilities (Shea, 1980). For example, to function effectively and efficiently the quarterback within a balanced offensive structure must learn and develop skills over and above those required for a one dimensional run oriented attack. These added responsibilities were identified in the section entitled "Importance of the Passing Game" (section 1, p. 2).

In addition to ignorance and laziness coaches may adhere to the KISS philosophy for three other reasons. First, adherence could be due to a confusion between clarity and simplicity. Second, it may be due to the fact that coaches have had the luxury of adhering to KISS. For example, it may be that the coach has had at his disposal an overabundance of talent which may compensate for a lack of offensive balance. Finally adherence may be due to the fact that the opposition has never strategically challenged the coach's lack of offensive balance.

Clarity or Simplicity. Adherence to the KISS philosophy could be due to the fact that the coach may not be capable of explaining and/or has failed to take the time to clearly explain the theory of the offense and/or any specific play. Advocating the philosophy that one scheme (only the run, or only the pass, or as few plays as possible) is simpler than advocating the use of two or more does not a priori insure simplicity. Nor does it guarantee that the players will understand the offense or their assignment versus various defensive fronts. This approach will place stress in other areas related to performance of

the team in general and the players specifically (Hayes, 1980). An effective coach can explain and/or construct a system which utilizes 20 schemes and achieves tremendous balance without sacrificing simplicity, precision, or execution. Smith (1987) considers balance a prerequisite to offensive success and states, "if an offense is to inspire its players, it must have answers to all possible problems" (Smith, 1987, p. 165). For example, the types of plays (run or pass) that may be successful in attacking a standard seven man defensive front may not be successful against the "46" defense. The construction of an offensive system with answers to all problems requires the coach to possess certain knowledges. In addition, he must be able to clearly explain the theory of the offense and/or any play. Coaches at the lower level tend to use the excuse that they have fewer coaches and/or less time for adherence to the KISS philosophy (Teaff, 1986). Teaff (1986) expressed his disgust for the preceding excuse in the following manner, "our profession has the biggest cry babies in America when it comes to discussing time. I get sick and tired of hearing coaches complaining about how much time it takes to coach...it takes time to do anything, and do it successfully" (p. 213). Consequently, the members of any staff must know the game as well as their opposition (Bullough, 1984). Coaches must take the time to devise an expanded offensive structure. In addition, they must be able to clearly explain the structure of their offense and the reasons specific plays are employed. They must also be familiar with the strategy and theory of the opponent's defense and clearly communicate this to the offensive players (Bullough, 1984).

KISS, Talent, and Offensive Structure. As mentioned above, adherence to the KISS philosophy could be due to the confusion between clarity and simplicity. However, it could also be due to the fact that the coach has had the luxury of doing so because he has superior talent over his opposition on a consistent basis. The following discussion will investigate this possibility.

There are many variables that contribute to and determine the success of a football team. There are two, however, which may compensate for one another: (a) offensive balance (which requires knowledge and work on the part of the coach; and (b) talent. For example, offensive balance may compensate for a lack of "talent" (size, speed, etc.), and talent may compensate for a coach's ignorance or laziness (Stevens, 1988). Lou Holtz's (1981) quote regarding the relationship between talent and coaching is related to this concept. Coach Holtz stated, "I think it is far more important to have good coaches than it is to have great athletes. You cannot win without the athletes, but you sure can lose with them" (p. 7). If a coach fails to research the passing game and settles for a one dimensional run style offensive structure, but has tremendous talent, then this talent may compensate for his lack of offensive balance (Sweeney, 1986). In other words, a coach's adherence could be due to the fact that his team happens to be in a conference wherein they have disproportionately superior talent than their opponents'. This could be due to the fact that they are the largest school in the conference (high school), are able to recruit in a manner not commensurate with the rest of the conference due to legal or illegal considerations (college), or they are willing to spend more money on players and coaches (professional). Nevertheless, an offense structured in this manner will place tremendous stress on the types of players required to insure success (Hayes, 1980). If the coach has enough talent then he and the team may be successful without the advantage of a balanced attack. Nevertheless, as Lou Holtz pointed out, talent alone will not guarantee success. In addition, simplicity may be a philosophy of luxury. It is possible that some coaches adhere to oversimplification because they face opposing coaches who never challenge their ability to pass the football (Stevens, 1988).

Ignorance. In the final analysis, however, and without making an excuse for coaches' possible laziness or ineptness, their adherence to KISS could be due to ignorance (Stevens,

1988). They could be ignorant regarding the development of an effective and efficient quarterback. From this perspective, a one dimensional type of offensive structure may be a result of the coach's inability to consistently develop effective and efficient quarterbacks. This ignorance could be due to a lack of biomechanical and motor behavioral information and/or understanding regarding the development of an effective and efficient quarterback (Hay, 1985; Hay & Reid, 1982; Sage, 1984). However, it also may be a result of the fact that they do not believe that quarterbacks are made in the first place which in turn may be a result of a lack of quality information. Or, if this information was made available coaches may not utilize it due to laziness (Stevens, 1988).

The preceding remarks are not meant to signify that coaches should adhere to a philosophy of offensive construction wherein the players are inundated with so much information that their ability to react is impaired. The above statements are meant to suggest that successful coaches who adhere to a philosophy of oversimplification should inspect the reasons for their success. Accordingly, they should think twice when they choose to promote this philosophy at coaching clinics because the information that they provide is held in great esteem by the coaches who attend. Those who listen may adopt an identical philosophy only because of the reputation of the speaker and not because it is a coherent and/or applicable approach (Stevens, 1988).

In conclusion, adherence to the KISS philosophy restricts the efficiency of the offense because it prohibits quarterback development. It is time to analyze the rationale for the external restrictions which were cited above.

The Rationale for Prohibitive Rules

As was mentioned earlier the coach may be prohibited from meeting with his quarterbacks because of conference rules (National Collegiate Athletic Association, 1990; Steve Stearns, personal communication, January, 17, 1991). It was suggested that the

rationale for the implementation of these prohibitive rules was to prevent coaches from coercing athletes into making an off-season commitment, and/or because off-season work interferes with the ability of an athlete to compete in other sports (Pat Lovelle, personal communication, January 15, 1991). The two are linked in a special way. For example, if the coach requires off-season work, and/or at least makes himself available, then athletes who wish to play other sports may feel coerced into making an off-season commitment. The possibility of this will be discussed in the next sections.

First, prohibitive rules have been established to prevent coaches from coercing their quarterbacks into making an off-season commitment. It must be admitted that sometimes this occurs. For example, coaches may inform their quarterbacks that "if they are not willing to work extra they should consider playing another position" (Brodie, 1984, p. 19). This statement in and of itself is not negative because it acknowledges the facts related to the available research regarding skill development. For example, the skills necessary for effective and efficient performance require time to reach the autonomous stage of learning (Magill, 1983; Sage, 1984; Schmidt, 1988). Even if the athlete is not willing to put in the extra time he must, nevertheless, be allowed to compete for the position (Rawls, 1971). Therefore, when explaining the necessary responsibilities and commitment of playing the quarterback position the coach should not prevent the young man from competing for the position if he chooses not to follow the the training regimen. If this were the scenario then this would amount to coercion. On the contrary, any player who wishes to compete for the position is welcome to do so. Moreover, his placement on the depth chart would be determined by accurate objective evaluation. However, athletes must be made aware of the reality of the situation. For example, if he is a "talented all-around athlete," with no knowledge of specific principles in the field of motor behavior such as "specificity of skill," then he may see himself as being capable of overcoming

serious skill deficiencies. This would be the case simply because he views himself as a "talented all-around athlete." Keep in mind that, his talent will not insure that he will be capable of performing effectively and efficiently the required skills in a pressurized game situation (Sage, 1984; Shea, 1980).

The other rationale for prohibitive rules suggests that the intent of the rules are to provide athletes the opportunity for a broad based athletic experience. Coaches and administrators suggest that young athletes who would like to play quarterback should be comfortable with the decision to play as many sports as they would like (Pat Lovelle, personal communication, January 15, 1991). Whether the decision to play other sports conflicts with his ability to adequately prepare to play the quarterback position is deemed irrelevant.

There is no question that athletes should be allowed the opportunity to compete in as many sports as they would like. However, this should not be the standard by which athletes competing for specific positions in co-curricular sports are developed and/or evaluated. This is especially true with regard to the quarterback position which requires an off-season commitment in order to learn the position (Shea, 1980; White, 1984). There is nothing in the educational system which suggests that educators are obliged to formulate a philosophy aimed at the promotion of mediocrity (Rippa, 1988). However, there is something in the educational system which suggests that educators and students are limited only by their imagination and work ethic (Degler, 1984). But if quarterbacks are prevented from meeting with their coaches in the off-season simply because other athletes cannot meet because they play other sports, then two things are evident. First, mediocrity will result. Second, the challenge facing the quarterback position will be misrepresented. Coaches must not misrepresent the challenges of the quarterback position. Nor should any educator misrepresent the challenge facing any student regarding that student's career

goals. Moreover, any adult misrepresenting the challenge of the quarterback position should experience the stress and anxiety an unprepared quarterback feels when confronted with a 3rd and 10 situation, let alone pre-game jitters. Those individuals who misrepresent the challenge of the quarterback position are often times the parents who advocate both a broad based athletic experience and a balanced offense. These parents sit in the stands and goad the coach to throw the football with a quarterback who is unprepared. Ironically, the reason that he is unprepared is in part due to their support of talent based system of development and evaluation. For example, if the coach wants to implement a work ethic based system he may encounter obstacles not only from parents but athletic directors, administrators, and/or conference officials. These individuals may apply pressures which force the coach to abandon this type of system or the educational setting altogether. If this type of coach decides not to leave this setting, and if he decides not to abandon a work ethic based approach, he is deemed a cheater and a rogue for working with his quarterbacks in the off-season. From this perspective the system needs more cheaters and rogues and fewer "famous wise men" because "although the famous wise have wrapped themselves in the Lion's skin, that skin covers the spirit of an ass harnessed to the people's wagon" (Lampert, 1986, p. 102). In other words, sometimes those in positions of authority do not act in the best interest of the students but only in a way to satisfy the whims of the general public.

The previous discussion suggests that the coach has specific responsibilities. Therefore it is critical to determine what those responsibilities might be.

A Coach's Responsibilities to his Quarterbacks

"The key in coaching is not to criticize what you have, but to improve what you have. That's all you have and if you go in with a constructive plan to improve him, he'll

improve" (White, 1978, p. 108). The preceding quote suggests that the coach has a certain amount of responsibility to his team and quarterbacks.

There are many responsibilities which a coach must fulfill if he is to be successful. The coach must communicate with players, staff, and administration in an appropriate and effective manner (Bicknell, 1984; Currey, 1986; Dooley, 1987; Edwards, 1986; Sheppard, 1986; Sloan, 1984). He must be able to effectively promote the football program (Claiborne, 1985) and his ability to organize is critical (Bicknell, 1985; Edwards, 1983a; Knox, 1985). He is responsible for insuring that his players have the opportunity to graduate (DeBerry, 1986; Hayes, 1981; Nehlen, 1983; Osborne, 1984; Sweeney, 1986) and he is responsible for abiding by correct recruiting procedures (Hayes, 1980; Nehlen, 1983; Osborne, 1984; Sweeney, 1986; Walsh, 1978). In addition, he must possess effective teaching skills (Brodie, 1984; Burton, 1985; Dye, 1987; Knox, 1985; Novak, 1983; Sullivan, 1983; Walsh, 1986).

The coach has certain responsibilities to the quarterbacks on the team. Within a work ethic based system of development and evaluation two questions must be asked, (a) what are the coach's responsibilities to his quarterbacks, and (b) when do they begin? The latter is easily answered. They begin as soon as an identification is made with those individuals who want to be quarterbacks. This identification should be made ideally in the spring or summer. The "what" of those responsibilities is more detailed.

Counselor

The coach has the professional obligation to counsel the quarterback regarding the added duties, responsibilities, and the work ethic necessary to prepare and function effectively and efficiently in a balanced offensive structure. For a coach to provide information to the contrary or none at all would be to seriously misrepresent the challenge (Bruce, 1987; Tollner, 1987). The duties and responsibilities of the quarterback position

are immense and a negative experience, due to lack of preparation, would be counter-productive at any level (Sage, 1971, 1977, 1984).

Teacher

Regarding the passing game, the coach is ultimately responsible for "having a method of coaching it, having a method of practicing it and at some point, being able to use it in a game" (Walsh, 1978, p. 27). Moreover, the most important thing about the passing game is that the coach must be able to predict what will happen on any specific play. Consequently, this is "the key for the young quarterback or any quarterback" (Walsh, 1978, p. 27). The coach is also responsible for properly evaluating his quarterbacks, which will be discussed later. Coaches spend hours teaching the correct techniques for other positions but for the quarterback position some are of the opinion that a quarterback cannot be developed (White, 1986). Nevertheless, Walsh (1978) believes that "the quarterback position is one that can be detailed just as closely" as that of a double team block that coaches teach their linemen. The components of the quarterback skills can be taught. For example, "the number of steps he takes, how he practices those steps, who he throws the ball to, how he throws it, all of those things can be categorized to a point where [the coach] can be pretty darn sure what is going to happen" (p. 27). "Developing individual skills is critical at all three levels [high school, college, and professional]" (Walsh, 1986, p. 1). It is the coach's responsibility to locate, isolate, and develop a method to teach the requisite skills (Walsh, 1986). In addition, the coach must take a positive approach to his teaching rather than a negative one. If this takes place, "a young man on a high school junior varsity team can enjoy and get [as much] fulfillment from the game, as a ten-year veteran in the NFL" (Walsh, 1986, p. 1). Joe Montana provided some insight related to the importance of quality teaching from a coach like Bill Walsh. Joe stated,

I wouldn't be wearing these three [Super Bowl] rings if it weren't for Bill...He instilled confidence in me right from the start. The other guys [Guy Benjamin, Steve DeBerg, Dan Fouts, Ken Anderson, Virgil Carter, Greg Cook, Steve Dils, and Sam Wyche] have talked about how much he helped them, but I'm the only one lucky enough to have had his coaching for 10 years (Dickey, 1989).

This does not suggest that Joe is an average athlete. However, it does suggest that only under coach Walsh's tutelage and his system could Joe have accomplished what he did. Accordingly, one need only check coach Walsh's success record with quarterbacks to understand that he does not rely solely on natural talent to develop excellence at the position. That coach Walsh had the luxury of the draft may be conceded. However, this only serves to point out the importance of a philosophy that aligns itself with quarterback development based on instruction and skill development because in the NFL everybody has the luxury of the draft. Consequently, coaches should not use the fact that coach Walsh had the luxury of the draft to support their position and misunderstanding that quarterbacks are born and not made. Coaches must understand that the only method by which to tap a quarterback's cognitive skills (reading defenses etc.) is through the teaching of biomechanically precise psychomotor skills. In addition, these skills must become automatic by utilizing the principles of motor behavior. That these skills can be learned is a principle rooted in the research in the field of motor behavior (discussed in chapter two). Consequently, Joe Montana's quote points out the importance of quality teaching. However, the methodology which determines this type of development is non-existent (Atwater, personal communication, May 1, 1989). The coach also has the responsibility to reconcile the quarterback's added duties and responsibilities in balanced offensive structure with his increased wealth and position on the team. This was detailed in the section related to Rawls' Theory of Justice.

In summary, coaches must become the great integrators, the superior physical educators, the epitome of education. It is their duty and professional obligation. The players count on their quarterbacks, quarterbacks count on their coaches, and coaches must count on themselves. It is not enough to have the courage of one's convictions, rather, coaches must have the courage for an attack on their convictions. Coaches are obligated to assume the commitment of the profession and to know all that there is to know about the fundamental principles of teaching motor based activities. Why? Because as Vince Lombardi stated, "you don't do things right once in a while, you do them right all the time." Most importantly, coaches must become who they are, who they have chosen to be. Vince asked an even more important question, one that every individual must ask, "Unless a man believes in himself and makes a total commitment to his career and puts everything he has into it, his mind, his body, and his heart what is life worth to him"?

Moreover, a philosophy which adheres to a work ethic based system of quarterback development solves many philosophical and strategical problems for the coach, the team, and each individual quarterback. The philosophy of systematic quarterback development requires knowledge in the field of motor behavior and biomechanics. This commitment involves not only the identification of specific skills (biomechanics), but also the understanding of how these skills can be most efficiently and effectively taught (motor behavior).

CHAPTER TWO

MOTOR

BEHAVIOR

Probably the most important prediction of the specificity hypothesis is that two tasks, even if they appear to be quite similar (such as throwing a baseball and throwing a football), will tend to correlate nearly zero with each other.

Richard A. Schmidt

The information provided in this chapter will be presented in the following manner. The first section will consist of the general principles of motor behavior. This will provide a foundation for the specific coaching recommendations made in section one: quarterback skills-closed environment; and section two quarterback skills-open environment. If the general principles are understood then the reader may choose to skip section one or two. Moreover, if the general principles in each of these sections are understood then the reader may choose to read the recommendations found under the sub-heading Three Stages of Learning in each section.

GENERAL PRINCIPLES

Reasons For Improvement and the Endeavor

"Complex motor behavior consists of a variety of movements, and these movement patterns must be learned" (Sage, 1977, p. 163). However, there are many reasons why a quarterback will improve his skills over time. Attention and maturation alone will elicit improvement. If left to his own devices a quarterback can incorrectly practice and improve his performance. On the other hand, he can work extremely hard and never show any improvement (Schneider, 1985). However, in either case, it will be difficult for the quarterback to reach an optimal level of performance based on what a balanced offensive structure might demand. To justify the position that drills improve the athlete's learning and performance one can employ a rational approach or scientific experimentation. In this coach's opinion, the problems involved in designing an ethical experiment are insurmountable. However, at this point the tension between doing so and not doing so has only served to confound and stagnate any formulation of a rational method with which to develop and evaluate quarterbacks. The problem becomes more complex when this tension is coupled with the fact that no identification of precise biomechanical models has been provided to test a method of teaching (drills) in the first place. Consequently, the most

advantageous method, which will also stimulate thought about the problem of quarterback development and evaluation, is based on the scientific principles inherent in the study of motor behavior. More importantly, the field of motor behavior provides information which supports the position that quarterbacks are made and not born. In addition, it provides information which enables coaches to formulate and implement a method to develop and evaluate their quarterbacks.

The principles of motor behavior and any prescribed drills must be guided by a theory of motor control which adequately describes and accounts for the various mechanisms of how it is that a quarterback controls his body in a precise manner in a game environment (Schmidt, 1988). Moreover, because a quarterback can learn and perform any specific motor skill through the programming of his central processing unit (his brain), the task is to determine the precise biomechanical models and couple them with the most efficient method of programming based on the most comprehensive theory of motor control. The theory of motor control used for this book is Richard A. Schmidt's Schema Theory (1982b, 1988).

The assumption that coaches can teach the requisite quarterback skills through motor programming infers that the quarterback must learn and duplicate specific skills. This must take place in a controlled and closed environment initially, and in an uncontrolled open (game) environment eventually (Summers, 1981). However, the amount of learning that takes place may only be inferred. The intensity and quality of this inference is dependent upon the level of performance. Moreover, the variables that may improve performance may have a detrimental effect on learning (Schmidt, 1988). Nevertheless, many coaches do not appreciate the fact that these skills can be learned (Sage, 1984). It is not difficult to understand why coaches align themselves with the notion that quarterbacks are born and not made when it is acknowledged that "one of the most persistent bits of folklore of physical education and coaching is the notion of a...natural athlete...an all-around athlete"

(Sage, 1984, p. 274). Coaches should acknowledge that, "the collection of abilities for one task and those for another task are independent of each other" (Schmidt, 1982a, p. 401). For example, because it is known that skills are specific and transfer is low-positive then it follows that an effective and efficient passing game does not require "an all around athlete" at the quarterback position. Premature judgements about an athlete's potential to play the quarterback position based on his performance in other sports may be tenuous at best (Sage, 1984). For example, because the athlete can throw a baseball 90 mph does not indicate that he can throw the variety of passes required to function in a balanced offensive structure. Because he can backpedal in basketball does not insure that he can step behind the center and execute any of the various dropback patterns in an effective and efficient manner. Because he can hit a baseball consistently is no assurance that he can anticipate the "break" of a receiver versus man coverage with consistency commensurate with the environment. Nor does it indicate that he could predict, read, and react to the various stimuli in the defensive display. What is to follow in this section is the theoretical base which will, it is hoped, stimulate coaches to take up the endeavor. Because as Lindquist (1968, 1971, 1972) suggested, coaches must understand how it is that the athlete processes information.

Skill Analysis and the Quarterback Position

Up to this point, reference has been made to the skills which make up the quarterback position. First, it is critical to define the word skill. Skills are "acts or tasks that require movement and must be learned in order to be properly performed" (Magill, 1983, p. 11). Additionally, skill has been described as proficient performance. For example, H. W. Johnson described it this way, "Skill = speed x accuracy x form x adaptability" (Magill, 1983, p. 15). In summary, skills are, "movements that are dependent on practice and

experience for their execution, as opposed to being genetically defined" (Schmidt, 1982a, p. 20).

The categorization of the skills that comprise the quarterback position is critical because the design of practice schedules, coupled with the recommendations of schema theory, are dependent upon this type of categorization. The dropback is easier to categorize than the passing motion. The dropback is essentially gross motor. Consequently, it requires the use of large muscle groups over larger distances of space and time. The passing motion (stationary, or on the move), however, is not as easily defined. The skill can be defined as a gross motor act providing the analysis is confined to the overall scope of the movement. However, it also has fine motor qualities if the analysis includes the release mechanics of the wrist, hand, and fingers. These require dexterity and synergy if the quarterback is to impart any spin on the football to keep it on line. In no way does this suggest that it is a fine motor movement to the degree of a concert violinist's finger movements. The dropback and passing motion are discrete, that is, they have a definite beginning and a definite end. The passing motion, in terms of time, takes approximately one reaction time (150 milliseconds) from initiation of motion to follow-through. This indicates that feedback cannot play a role in the correction of errors, in other words it is an open-loop system. Consequently, the open-loop system of motor control is best explained by Schmidt's schema theory. The dropback patterns require longer amounts of time to complete and are essentially closed-loop. This indicates that feedback can play a role for the correction of errors. Nevertheless, the performer can make a conscious choice whether they are to be controlled by closed-loop processes or open-loop processes. Therefore, they can be explained by schema theory as well. Moreover, the choice for utilizing feedback processes is an advantage during the learning process but once learned it is best that these

dropback patterns are controlled by open-loop processes which do not require the use of feedback (Schmidt, 1988).

Schema Theory

Schmidt (1975, 1982a, 1982b, 1988) theorized the existence of generalized motor programs and developed a schema theory because the closed-loop (perceptual trace), open-loop (response chaining and/or motor program), massed spring, and impulse timing theories were inadequate (Schmidt, 1988). Schmidt (1982a, 1988) acknowledged that he "borrowed heavily ideas from Adams and others," for the conception of schema theory, "in the hope of keeping the most effective parts and eliminating defective ones" (1988, p. 482). Schmidt (1988) asserted that it retained "a strong open-loop dependency" unlike Adams' closed-loop theory (p. 482). In addition, "at the heart of schema theory is the idea of the generalized motor program" (Schmidt, 1988, p. 483). Summer's (1981) described the advantages of the schema theory "over the traditional open- and closed-loop models" and stated,

there is no necessity for a separate motor program of references of copies to be stored for each movement that a person makes. By applying various response specifications to a generalized motor program a large number of movements can be generated for this abstract representation. In this way the tremendous flexibility evident in human skills can be achieved. Furthermore, the model emphasizes the interaction between program and feedback in the control of movement (p. 54).

Consequently, Schmidt's schema theory (recall memory - movement production; and recognition memory - response evaluation) solves the problems regarding novelty, storage, and the skill acquisition of ballistic movements. This is a critical point because other theories of motor control cannot. It solves the novelty problem in that only "parameters of the movement" need to be specified (Schmidt, 1988, p. 240). For example, once the

quarterback learns how to pass the football from a stationary position in a biomechanically precise manner he can then apply it to passing while on the move. More importantly, he can adjust this precise passing motion to fit the requirements of the environment which may require him to alter it in one way or another while attempting to pass from either a stationary position or passing while on the move. Once the quarterback learns the cushion and set phase of the dropback pattern he can apply it to the one, three, five, or seven step dropback patterns. Schmidt's schema theory solves the storage problem, because one program can accommodate a wide variety of movements for a specific quarterback skill. For example, once the quarterback learns the basic biomechanical model for passing from a stationary position he can apply it to passing while on the move direct, on the move inside right, or on the move inside left. In addition, schema theory solves the problem of skill acquisition due to the formulation of recall and recognition schemas. Although it has limitations, "for the time being schema theory provides a useful framework for attempting to understand this complex subject" (Sage, 1984, p. 244).

Although motor program theory alone cannot explain the acquisition of complex skills it is critical to Schmidt's schema theory (general motor programs). It is critical because the notion of generalized motor programs includes the notion of motor programs. Therefore, it would be wise to answer the upcoming question.

What is a Motor Program?

The motor program is an abstract representation that when activated produces movement without regard to sensory information indicating errors in selection. Once the program has been initiated, the pattern of action is carried out for at least one RT [reaction time] even if the environmental information indicates that an error in selection has been made. Yet, during the program's execution, countless corrections for minor

errors can be executed that serve to ensure that the movement is carried out faithfully (Schmidt, 1988, p. 237).

The above definition suggests that the upper hierarchy of motor control, the executive level (the quarterback's brain), is responsible for the "ballpark" goal of the movement. It is responsible for response selection and any errors therein. The lower hierarchy of motor control, the motor program, is responsible for the specifics of the movement, it is responsible for response execution and any errors therein. For example, the quarterback selects the program and runs it off, and once started it cannot be stopped. This is consistent with the comments made by quarterbacks wherein they state that as the ball left their hand they knew it was the wrong decision or that they knew it was a touchdown. These types of comments seem to be manifestations of generalized motor theory. They demonstrate the importance of cognitive skill development related to attention, cue utilization, perceptual narrowing, and arousal theory which will be discussed in the next section regarding quarterback skill development in an open environment.

General Motor Programs

In order to understand general motor program theory "it is sometimes helpful"...to consider a model with many of the same features as the theory" (Schmidt, 1988, p. 246). Schmidt's "favorite model for the generalized motor program is the standard phonograph record....On the record, structured as invariant features are three things" (Schmidt, 1988, p. 246):

1. Order of elements. Analogy: "specifying that the drum beat comes before the guitar and so on" (Schmidt, 1988, pp. 244-246). For example, the left foot must move forward and it must precede the forward arm stroke of the right arm for a right handed quarterback whether he is passing the ball stationary or while on the move.

2. Phasing-time ratio. Analogy: "Think of phasing as a kind of rhythm, so that the time between any two events on the record divided by the total record time is constant. For phonograph records, the ratios between the time of occurrence, or the durations, of any two events on the record are always fixed" (Schmidt, 1988, pp. 244-246). Angular acceleration of joint angles near the axis of rotation are proportional to those that occur at the most distal joints whether the pass is hard or soft.

3. Relative force. Analogy: "the relative force is fixed. That is, the first drum beat is always twice as loud as the second" (Schmidt, 1988, pp. 245-246). Passing the football ten yards as opposed to thirty yards requires less force production in the required musculature. Nevertheless, the ratio between any two muscles will remain the same.

These invariant features represent a code on the record that can be played at different speeds, with varying amounts of volume, treble, bass, or speaker selection. Schmidt (1988) termed these variables parameters. Nevertheless, the manipulation of these superficial characteristics does not change the invariant features. In terms of movement, Schmidt (1988) cited these parameters as well.

1. Overall duration parameter. Analogy: "The basic idea is that the motor program contains phasing and sequencing information, but this sequence can be run off slowly or rapidly by assigning a different overall duration parameter, just as increasing the speed of the phonograph turntable speeds up the entire sequence of sounds as a unit" (Schmidt, 1988, p. 246). The difference in the duration of the passing action from initiation of movement to follow-through between passing the ball ten yards versus 30 yards will be slower. Nevertheless, the ratio of time between the sequence of movements in any two muscles will remain the same.

2. Overall force parameter. Analogy: "The overall force parameter can be thought of as the volume control, whereby the same pattern of action can be produced either loudly or

softly" (Schmidt, 1988, p. 255). Passing the football thirty yards as opposed to ten yards requires more force production from the participating musculature albeit the ratio of force between the participating muscles will not change.

"The selection of the force and speed parameters are not independent, as the particular value of the force parameter will depend heavily on the particular duration parameter chosen" (Schmidt, 1988, p. 254). For example, "if the force parameter is too large, the movement will go too far in the proper time; if the force parameter is too small, the movement will not go far enough" (Schmidt, 1988, p. 254).

3. Muscle selection. Analogy: This parameter is "analogous to the operation of the speakers" (Schmidt, 1988, pp. 254-255). Although the sequencing of movements in the non-dominant passing arm is not as smooth as those in the dominant arm the passing motion can be completed nonetheless.

4. Spatial parameters. "Consider throwing a ball overarm versus sidearm. It is possible that the patterning of activity (phasing and relative force) is the same for these two actions, but that they differ only in terms of the angle of the arm with respect to the torso" (Schmidt, 1988, p. 255).

In a general sense, and in addition to his phonograph analogy, Schmidt utilized a computer analogy to describe the general motor program. From this analogy coaches can draw the conclusion that the quarterback represents the computer and the biomechanical model or technique of dropping back to pass and passing on the move represents the software (Schmidt, 1988). Accordingly, coaches can understand that, "the idea of a generalized motor program is that a motor program for a particular class of action is stored in memory and that a unique pattern of activity will result if the program is executed" (Schmidt, 1988, p. 240). According to Schmidt's schema theory (1982a, 1988), schema learning requires the learner to store four variables after an initial trial: (a) initial

coordination (body position, weight of the ball, body angles); (b) parameters required (distance, speed, force, and movement size); (c) movement outcome in terms of knowledge of results; (d) how the movement felt, looked, sounded (Schmidt, 1988). These four are not stored permanently, which eliminates the storage problem, but rather are, "stored long enough so that the performer can abstract some relationship among them" (Schmidt, 1988, p. 484).

Recall and Recognition Schema

With repeated trials two relationships are formed. They are formed in the closed and open environment and the general recommendations related to the recall and recognition schemas are applicable to both environments.

Recall Schema. Recall schema is concerned with the initiation and the execution of the specific biomechanical models for dropping back and passing from either a stationary position or while on the move. Moreover, it represents the quarterback's estimation of the movement parameters required for the initial trial of a specific biomechanical model which is based on prior dropback, throwing, and/or passing experiences. Relationships, not specifics, are formed and retained concerning the parameters of these movements and their eventual outcome. This solves the novelty problem (Sage, 1984; Schmidt, 1988). In other words, the quarterback compares the new movements of dropping back or passing with past experience in the same class of movements (Sage, 1984). In this way the parameters (distance, speed, force, and movement size) are applied to a generalized motor program (past dropping back or passing movements) to produce the desired specific biomechanical action. If there is an error, mistake, and/or miscalculation the recall schema will be updated. After each trial the quarterback compares and evaluates (a) the relationship between the parameters that were chosen to produce the movement, (b) the outcome of the movement within, and (c) the context of the initial conditions. With successive attempts

these three form a product in that, "the stored data [four aforementioned variables] is 'thrown away,' so that all that remains is the rule, called the recall schema" (Schmidt, 1988, p. 485).

Recognition Schema. The second relationship formed is the recognition schema which is concerned with evaluating the specific biomechanical models for dropping back or passing from either a stationary position or while on the move. It provides a description of the background that the quarterback's senses utilize to determine if the completed trial and its subsequent sensory stimulation match the expected sensory description and background before a drop back or passing motion was initiated and completed (Sage, 1984; Schmidt, 1988). The recall schema is formed and utilized in much the same manner as the recognition schema. However, for its formulation, recall schema (unlike recognition schema) depends upon the evaluation of and a comparison between the selection of parameters coupled with initial conditions and movement outcomes. Recognition schema, on the other hand, utilizes sensory consequences instead of the selection of parameters for its formulation. For example before the movement is initiated, the quarterback with the aid of the recall schema,

selects a movement outcome and determines the initial conditions. Then, with the recognition schema, the individual can estimate the sensory consequences that will occur if that movement outcome is produced. These are called expected sensory consequences...and serve as a basis for movement evaluation (Schmidt, 1988, p. 486).

Consequently, the quarterback, in terms of the specific biomechanical models for dropping back and passing, compares what he thinks will happen and how it will feel with what was done and how the completed trial felt (Schmidt, 1988). The sensory information from the moving body parts is compared with what was expected and any differences between the two represent errors. Drop back or passing errors detected in the recognition schema are

fed and incorporated into the recall schema the next time the movement is initiated and executed (Schmidt, 1988). This is a critical juncture and one where the coach's knowledge and instruction is vital (Sage, 1984; Schmidt, 1988). For example, in addition to the subjective evaluation of the error information, the quarterback must receive objective extrinsic feedback from the coach. Therefore, the coach compares the quarterback's movement with the precise biomechanical model.

Specific Generalized Motor Programs

The schemas are derived from general motor programs which are in part dependent upon the quarterback's past experiences with passing the football and dropping back to pass specifically and/or throwing and back-pedaling/running-sideways in general (Schmidt, 1988). For example, running backwards, sideways or whatever on the street or playground would help formulate a general motor program for dropping back to pass. In addition, throwing rocks or baseballs would contribute to the formulation of a general motor program for passing. However, there are specific types of throwing motions each with similar general characteristics. Throwing a baseball and throwing a football could be categorized as such. Nevertheless, efficiency in one does not guarantee efficiency in the other (specificity of skill [Henry, 1968]). Moreover, the distinction in skills within the sport where these skills function may also become more fine. For example, because a player can throw the baseball from first base to second base effectively and efficiently is no indication that he could pitch a baseball in a commensurate manner. Conversely, because the player can throw the football 100 yards is no indication that he could pass the football in a balanced offensive structure. Even within a particular sport, skills are specific. However, the skills which are performed in an open environment must become generalized as the next section will clarify. Therefore, in the closed environment, and throughout the

stages of learning with each specific skill, coaches must be concerned with formulating a specific generalized motor program (SGMP).

Specific Back Pedal

Before the passing motion is executed it must be preceded by an effective and efficient dropback technique. The function of the dropback is to remove the quarterback from the line of scrimmage in adequate time, with adequate distance. The drop back patterns are skills that are one third shuffle, one third carioca, and one third running. Although the skill operates in an open environment the steps of the drop must be initially programmed in a closed environment (Summers, 1981). This will allow the quarterback to consistently attain a certain depth in a specific time (the importance of this will be discussed in the next chapter). These dropback patterns are based on precise biomechanical models and form the foundation for future variety but each must first reach the autonomous stage of learning in the closed environment (Summers, 1981).

General Dropback Patterns

The specific dropback patterns must become generalized within the framework of the position and the eventual open environment. For example, because there are different ranges of passes, dictated by down and distance strategy, there are different types of dropback patterns that must be learned and executed when called upon to do so in pressure situations during the game. The variety of dropback patterns must be practiced. Coaches must not assume that because the quarterback can perform one or two of the drop back patterns that he can perform them all. In addition, there are times when the sequence of the drop may become disrupted by a defensive lineman or a blitzing linebacker. This is true regarding each individual technique and especially the five and seven step drop. Consequently, the quarterback will have to change his drop. He may have to pass the ball before the dropback pattern has been completed in a precise manner by utilizing quicker

steps and/or reducing the number of steps. Moreover, he may have to get out of the pocket before he has completed the drop.

Specific Throwing Motion

Passing the football is a specific type of throwing motion. It exists in an open environment wherein the target is usually moving, and like pitching, passing requires fine motor control of the wrist, hand, and fingers. However, unlike pitching, passing the football must sometimes be executed while on the move and, as previously mentioned, must be executed in an open environment. These passing techniques (stationary and on the move) are based on specific biomechanical models. In addition, they form the foundation for future variety (Summers, 1981). Each individual skill, however, must first reach the autonomous stage of learning in the closed environment (Summers, 1981). Moreover, all skills which function in an open environment must be taught in this manner. Once the skill has been developed in the closed environment it must be practiced to function in an open environment.

General Passing Motion

The specific passing motion must become generalized within the framework of the position and the eventual open environment. For example, within this framework there are required skills that impact the precise biomechanical model of passing: (a) range of the pass (short, medium, and deep); (b) the type of drop which precedes the pass (3, 5, or 7 step); and (c) the release technique (set and throw; set, hitch and throw; set, hitch, set and throw). The precise biomechanical passing model must be fused into these different dropback techniques. Nevertheless, game situations occasionally prevent the execution of the precise biomechanical models (Bielat, 1986). For example, the quarterback may be flushed from the pocket and may have to throw the ball while on the move, he may get a hand in his face by a defensive lineman and have to throw the ball slightly sidearm, or he

may be hit as he releases or begins to release the ball. In any event these situations will alter his technique in one way or another.

The variety of passes and dropback patterns, planned and unexpected, require a practice regimen that takes this into account. Consequently practice variability is essential (Schmidt, 1988). However, early in practice, this variability must take place in an environment wherein the quarterback knows what specific variation to expect and execute (Summers, 1981). In this manner the environment should remain closed.

In the next section (Closed Environment) the quarterback's skills will be described as they progress through the three stages of motor learning in the closed environment. Specific and general problems will be identified and discussed. The general design of drills will be provided along with the specific number of sets and repetitions.

CLOSED ENVIRONMENT

Continuum and Goals

"The teaching of motor skills can be viewed as a 'two stage' process. Initially the teacher or coach must aid the learner in the acquisition of the correct sequence and timing of the movements that comprise the skill" (Summers, 1981, p. 64). Consequently, in the closed environment the coach begins the development of general motor programs, and the recall and recognition schemas for precise biomechanical quarterback skills through the use of specific drills. In addition, the development of general motor programs and the recall and recognition schemas are dependent upon intrinsic and extrinsic feedback (Schmidt, 1988). As the quote by Summers pointed out, there are continuums of environments (closed to open) that a quarterback must progress through in order to be prepared and perform effectively and efficiently in a game situation. In the closed environment the quarterback's arousal level must be kept at a minimum level (Oxendine, 1970; Sage, 1984; Schmidt, 1988). There are few if any stimuli presented to which the quarterback must react

in the closed environment. The work in this environment is designed to perfect the precise biomechanical skills (Summers, 1981). This will allow for future practice variability (Schmidt, 1988; Summers, 1981). The precise skills coupled with practice variability will ultimately allow the coach the opportunity to tap the quarterback's cognitive abilities, which is necessary in a balanced offensive structure. Moreover, precise skills coupled with variable practice will systematically prepare the quarterback for the competitive game situation.

The information that is programmed into the computer (the quarterback's brain) are the correct biomechanical models (the software). Although these models will be presented in the next chapter, they are programmed in the computer through the use of specific drills. The types of drills employed are dependent upon the coach's ability to identify and diagnose specific biomechanical problems (Sage, 1984). In addition, they are dependent upon his imagination in utilizing schema theory and the principles of motor behavior coupled with his understanding of the correct biomechanical model (Sage, 1984). This would allow him to design and prescribe specific drills for specific problems. This indicates that in each stage of motor learning there are basic drills that must be employed to teach the techniques. Nevertheless, quarterbacks will differ in the manner which they process information (their kinesthetic language) and in the motor behavior problems they display relative to the precise biomechanical model. Consequently, no two drills or solutions to those problems will be, or should be, the same. Ultimately, individual problems will require individual solutions (Lindquist, 1971; Sage, 1984).

Three Stages of Motor Learning

There are three stages of motor learning through which the quarterback must progress during the course of instruction in the closed and open environments (cognitive, associative, and autonomous). The process, however, is dynamic (Sage, 1984). This

suggests that there are no specific markers or indicators which signify that one stage has ended and another has begun. However, this does not indicate that progress cannot be observed. Moreover, within each stage of learning for a specific skill (dropping back or passing), and/or combinations of skills (dropping back to pass or passing while on the move) there are three phases within each stage: beginning, mid, and ending. "Each phase presents particular problems and challenges to learners and each has unique implications for the employment of instructional strategies" (Sage, 1984, p. 376). Moreover,

the following two phenomena are often quite evident to those working with students:

- (1) a learner's concept of what he is doing and what he is actually doing are often quite different;
- (2) when a suggestion is given for improvement, the student appears to ignore the suggestion and continues with his own plan of attack (Lindquist, 1971, p. 1).

Consequently, there are two goals of which a quarterback must be made aware in this environment. They are called the "goals in motor responding" (Schmidt, 1982a, pp. 292-293). The two goals which are critical in this environment are process and product. For every trial, the quarterback must be made aware of the importance of the relationship between these two and he must be made aware of the fact that one takes precedent over the other in this environment. The process goal may be described as the movements which are performed by the quarterback and the correctness of those movements relative to the precise biomechanical model of dropping back and passing the football from a stationary position or while on the move. The product goal would manifest itself as the tight spiral of the football when passing the ball. On the other hand, it would manifest itself as a balanced stance the quarterback would or would not experience once any of the dropback patterns are complete and he is set. Most young quarterbacks can accomplish each with some measure of success. Nevertheless, the quarterback must be able to perform them

effectively and efficiently in a game situation under extreme pressure while his attention is focused on offensive strategy and the defensive display. During these pressure situations he must not concentrate on the dropback pattern or the passing motion. In addition, the quarterback must utilize the proper mechanics in order to maximize his full mechanical potential. In other words, these skills must be biomechanically precise and they must become automatic. If these skills are not developed, and generally these skills are not, then the quarterback must be convinced that it is the process and not the product goal that is critical during the early stages of learning. For example, the quarterback must understand that spirals and/or how fast or deep he can get back on his drops at this point is meaningless.

As practice progresses, parts of a specific skill will progress and regress through the three stages until the specific skill in total has reached the autonomous stage (Schmidt, 1988). Learning how to pass the football from a stationary position requires tremendous coordination between the necessary body parts. Once passing the football from a stationary position has reached the autonomous stage the motor program for that specific skill can be run off efficiently and effectively without thought. This, however, merely represents the ending phase of the cognitive stage and the beginning of the associative stage, because the quarterback must now learn how to drop back and then pass the football. In other words, the quarterback does not perform the required skills separately in a game environment. Moreover, when the array of requisite skills has reached the overall autonomous stage in the closed environment this only represents half of the equation. The quarterback must again go through a similar, albeit quicker process, wherein the requisite skills are placed in an open environment. In addition, he must be acclimated to the open environment in order that he may develop the requisite cognitive skills.

Cognitive Stage

This stage is characterized by the quarterback's inability to attend to few if any stimuli outside of that which is taking place in his body. His concentration is centered on the skill or skills which he is attempting to perform. This is not abnormal but rather a general characteristic of this stage of learning (Sage, 1984). Consequently, the quarterback should not be required to concentrate on any other stimuli nor should he be required to react to any stimuli. He should focus his attention on the mechanics of the skills that he is attempting to perfect. Dependent upon the skill level of the player, the motor program is practically non-existent. The quickness of its development is dependent upon past throwing experiences and the ability of the coach to teach (Sage, 1984; Schmidt, 1988). As a result, the quarterback may look very awkward, he may feel awkward, and he will demonstrate gross errors with respect to the precise biomechanical model (Magill, 1983; Sage, 1984; Schmidt, 1988). The reasons for this are simple. The quarterback will be asked to perform in a manner which is foreign to his past experience. In addition, he may be required to utilize muscle groups to perform the required skills which he may never have used. For example, he may have never used any torso rotation to throw the ball. He may have never thrown the ball while on the move. This technique requires a delivery off of the right foot, for a right handed quarterback, and not the left which is required while passing from a stationary position.

The method by which coaches teach and guide each quarterback through this stage is as varied as the genetic make-up of each quarterback. No two quarterbacks process the verbal or visual instructions, provided by the coach, in the same manner. This is a fundamental reason why teaching skills of this sort is so difficult (Lindquist, 1968). Moreover, the only common factors between the coach and each quarterback are the precise biomechanical models for each specific skill. However, this does not suggest that each quarterback will

look identical with respect to the biomechanical models. Each quarterback will look different in some way or another if for no other reason than differences in body structure, lever lengths, etc. Nevertheless, this should not be an excuse for not teaching and or attempting to teach the correct biomechanical model. Nor should this observation be the foundation for the argument that quarterbacks are made because no two look the same. The challenge for the coach, in the cognitive stage of learning, comes in identifying how it is that the novice quarterback processes the corrective instructions (visual or verbal) that are provided. These corrections are based on what the coach observes (what the quarterback is doing) and what the quarterback thinks he is doing. The corrective instructions must make sense to the novice in order for him to act upon them. To accomplish this, the novice quarterback must use his ability to interpret visual and verbal instruction from the coach, and kinesthetic feedback from his body to learn and perform the new skills and/or correct specific problems (Magill, 1983).

In the initial trials, depending on the problems the quarterback may exhibit, he should be instructed to focus his attention on those areas of the biomechanical model beginning at the feet progressing up to the head or the hand. Many times novice quarterbacks will experience problems passing the football simply due to poor positioning of the lower body and the feet specifically. In addition, these problems are easy to correct. Moreover, this procedure allows the quarterback to selectively attend (visually and kinesthetically) to specific parts of the model. It is here that problems begin between vision and kinesthetic perception. In other words, between what he sees, what he perceives his movement to be, and his actual movement. A common kinesthetic language between coach and quarterback is vital. The use of vision, can only be seen as the initial step (Magill, 1983). The coach must attempt to translate into words, to the quarterback, what it feels like to pass the football effectively, efficiently, and smoothly with the proper sequencing of motion.

However, what it may feel like to the coach and how he may interpret and verbally express his kinesthetic awareness may not be the same language that the novice would utilize.

Similarly, there would be differences between two novice quarterbacks. The excitement for the coach comes when it is apparent that the instructions given are put into action by the quarterback. This demonstrates that at the very least the quarterback understands the instructions.

Stage of Frustration

This stage is a stumbling block relative to the teaching of the precise biomechanical models for the quarterback position. For example, the coach may be attempting to teach a well coordinated athlete how to pass the football while he is on the move. However, the moment he attempts to improve the quarterback's technique to maximize the quarterback's full mechanical and psychomotor potential the athlete exhibits the motor patterns of an uncoordinated athlete. Consequently, the solution for some coaches is to throw their hands up into the air and say to the quarterback "do it your way!" Which is essentially what happens (Lindquist, 1968, 1971, 1973). Or coaches attribute the problems to "paralysis by analysis." This phrase is another way of identifying overcoaching and will be discussed in the autonomous stage of learning where it is applicable. Furthermore, it is not paralysis by analysis, it is just the time lag due to the processing (translation and interpretation) of information. Working with computers may provide a useful analogy. For example, when the Macintosh Plus computer attempts to designate page breaks in a large document it takes more time than the Macintosh SE. Nevertheless, coaches should not make the mistake of thinking that instruction represents the smaller or larger documents (the less I give the better etc.). Rather, it is that each quarterback represents the slower or faster computers (some quarterbacks can process more information more quickly than others). When the quarterback begins to act on the instruction provided (proper sequencing etc.) and states

that he understands the instruction, it is one of the greatest feelings in the teaching profession.

Phases within the Cognitive Stage

Beginning Cognitive. Before stepping on the field the quarterback should view a video of an accurate model in the company of a coach who can point out the critical details that are important for the first practice session (Magill, 1983; Sage, 1984; Schmidt, 1988). Of the two major skills (passing and the dropback), the passing motion should be analyzed first. Work on the dropback patterns should follow the session on passing. In addition, these two skills should not be combined at this point.

The quarterback should play catch with an accurate model. This could be the coach or another quarterback whose skills are representative of the correct models (Sage, 1984). In either case, the coach should be present. The quarterback should be allowed to complete 10-20 repetitions with no instruction aimed at correcting whatever problems that may be noticed (Schmidt, 1988). This procedure will provide the coach with information about what the quarterback perceives to be the composition of a precise model regarding the 5 phases of the passing motion: stance, initiation of motion, acceleration, release, and follow-through; and the 7 phases of the dropback: release, open step, crossover step, stretch step (5 and 7 step drops), cushion, set, and stance.

The practice structure during the cognitive stage of learning will be massed and blocked. This indicates that the passing motion will not be preceded by any dropback pattern. In addition, the skill of passing the football while in a stationary position will not be practiced in conjunction with learning how to pass the football while on the move. Moreover, the quarterback will be asked to duplicate the precise model. Dependent upon the problems that the quarterback exhibits, the particular skill may have to be broken down into parts (Astrand & Rodahl, 1986). Consequently, the knowledge about random and part

practice and their affinity for promoting learning must be tempered with the knowledge about blocked and whole practice and their affinity for promoting performance and motivation. This is due in part to the task complexity of dropping back and passing. At this point, the coach is concerned with the development of the three invariant features of each skill (order of elements, phasing, relative force). In addition, the rules or schemas are in the developmental stage.

Once the initial trials are completed instruction begins with the proper passing motion in general and the stance phase specifically. Any problems that are noticed with the passing motion are generally caused by problems located in the foundation. For example, problems with the passing motion could be due to the fact that the quarterback's stance is incorrect. These problems are easily corrected because they are position problems that require little thought, attention, and/or movement by the quarterback. Along with the importance of intrinsic feedback relative to the starting position, this is the reason instruction begins with proper stance. Coaches tend to focus on the upper body and the passing arm movement specifically (Ariel, 1983a). However, this is not the place to begin in order to rectify problems. Once the passing motion can be performed somewhat effectively and efficiently, the coach can begin to teach the cushion and set phases of the dropback pattern. However, the two skills must not be combined.

This is a difficult period for the quarterback because he is attempting to resolve many problems at once. For example, as one part may be fixed within the framework of a specific skill (dropback or passing) another part may be impacted negatively. Consequently, this new problem, which was not a problem earlier, may regress to the cognitive stage while the older previous problem progresses unaffected to the autonomous stage. For example, when the quarterback's feet are corrected the passing arm may begin to do things that it did not do previous to the feet being corrected. The coach must force the

quarterback to concentrate on specific problems and to convince him that this is the nature of this phase of learning.

Mid Cognitive. At this point the quarterback is able to perform each skill separately with little trouble. For example, he may be able to pass the football and he may be able to perform the cushions and set phases of the dropback pattern. However, it may remain difficult for him to drop back to pass. The invariant features seem well developed, and the sequence of movements with respect to each skill is smooth.

Ending Cognitive. Once the cushion and set phase of the dropback pattern and the passing motion can be performed at a slow speed with little trouble, and the invariant features of each are secured, it is time to combine the two. It is desirable to combine these two as soon as possible. The ability to do so, however, is dependent upon the quarterback's ability to comfortably execute the cushion and set phases of the dropback pattern. The problem at this point is that the passing skill or the dropback skill that was thought to have been solidified before they were combined may each regress to a point beyond recognition. This indicates that the skills were not strong enough before they were combined. This is simply due to the fact that combining skills forms one new skill. At any rate, one will negatively impact the other. The coach may have to regress and work on each skill separately if there are too many problems.

Associative Stage

This stage is characterized by the quarterback's ability to sequence the skills into smoother patterns of movement. Gross errors are all but eliminated and the quarterback no longer has to concentrate as hard on the skill as he had to in the cognitive stage. The quarterback begins to concentrate "on how to do the particular pattern, rather than on which pattern of action should be produced" (Schmidt, 1988, p. 460). In many ways this is a more difficult stage than the cognitive stage because specific problems are hard to diagnose

and many times harder to rectify. It is here that the commonality of kinesthetic language between coach and quarterback and the coach's expertise and creativity become critical (Sage, 1984). The coach must understand the biomechanics of the skill and he must be able to detect and prescribe solutions for specific errors. Failure in either area will inhibit if not prevent learning (Sage, 1984).

Begin and End Instruction

This is the stage of learning where many coaches begin the instruction of their quarterbacks if their method of development and evaluation is talent based. For example, only athletes with at least this amount of talent can even begin to compete for the quarterback position. The quarterbacks that do have this ability may have it for no more of a reason than because of past experience (Magill, 1983; Schmidt, 1988). When coaches acknowledge the evidence relative to the notion of the prediction of a quarterback's later skill or performance based on skill or performance at this stage they will realize that prediction is impossible (Schmidt, 1988). To think otherwise and/or to act upon this misconception may be counter-productive (Sage, 1984).

This is the stage of learning where many coaches end the instruction of their quarterbacks. For example, because the quarterback looks somewhat comfortable performing a few skills, the coach assumes that all of the required skills are comparable and/or that all of the requisite skills have reached the autonomous stage of learning. Consequently, coaches make five erroneous assumptions. First, the coach assumes that the quarterback needs no further instruction. Secondly, the coach assumes that the quarterback can utilize pre-snap precues, and post-snap cues (cue-utilization). However, because the quarterback cannot utilize the cues provided, which is evident because he continues to demonstrate that he cannot find the open receiver, it leads to the third erroneous conclusion. The coach assumes that it is not possible to employ a balanced

offensive structure which requires these types of cues because the quarterback has consistently demonstrated that it is not possible to act upon them. This leads to the fourth assumption wherein the coach assumes that a balanced offensive structure is not possible without a talented quarterback who cannot be developed. The coach therefore assumes that a better offensive structure is one that aligns itself with the philosophy evidenced by the cliché: "keep it simple stupid" (KISS). This is an unfortunate situation especially when one takes into consideration that the foundation for this philosophy is due only to the fact that the collection of required quarterback skills has not reached the third stage of learning.

Phases within the Associative Stage

Beginning Associative. The coach can begin to focus more on knowledge of results (KR), in other words, the product (the speed and depth of the drops and/or the spirals of the passes). This does not indicate that knowledge of process (KP) is not important but it does suggest that the depth and speed of the drops are critical to the effectiveness and the efficiency of the offense and the spirals are an indicator of the proper biomechanics of the passing motion. In any event, this will become clear in the chapter on biomechanics.

The quarterback's stance (the set phase) after each dropback must look identical to his stance if he was passing with no drop. It is useful, at this point, to force the quarterback to think in terms of drop and then pass as if they were two separate skills which were not connected in any way. The reason for this is that quarterbacks at this point will tend to think of passing the ball before they are set to do so. This will destroy the proper sequencing of motion, reduce accuracy, and reduce power. Before he passes the ball the quarterback must be totally comfortable, balanced, and he must not pass the ball until he is so. If this means he must re-adjust his feet before passing then the back foot should always be adjusted to the front. In other words, the odd step will be adjusted to the even step. The rationale for this will become clear in the next chapter. If this problem persists

then its origin is usually located in the cushion and set phase of the dropback and may have to be analyzed and treated separately. In any event, the coach may have to regress and work on the two separately.

Mid Associative. As practice continues the quarterback will be able to perform each skill separately with little trouble. In addition, a variety of observations can be made: the problems exhibited by the quarterback will be reduced, the quarterback will be able to comfortably perform the combination of skills at a reduced speed, and he will no longer have to think of the skills separately. For example, the dropback will not interrupt passing efficiency and visa versa. Moreover, the invariant features between the skills and those that fuse the skills will become solidified.

Ending Associative. Once the combination of skills can be performed effectively and efficiently it is time to change the duration parameter, that is, to speed up the movements. Schema theory informs us that the invariant features of the skill will not change as the overall duration parameter is changed (Schmidt, 1988). However, in order for this new duration parameter not to change the invariant features, practice at this new speed must take place. This is the purpose of the rapid fire drill. In any event, the coach may have to regress and slow down the duration parameter if the problems are too many or too pronounced.

Autonomous Stage

Unlike continuous skills such as running, swimming, and riding a bike, discrete skills such as dropping back to pass a football in an open environment require constant practice in order that they retain their integrity (Schmidt, 1988).

This stage is characterized by effortless performance. It may take many months or years to reach this stage. Progress is dependent upon the quarterback's past experience, ability to process information, and the coach's ability to teach (Schmidt, 1988). When the

quarterback reaches this stage he does not have to attend to the skill or skills which he is performing. Consequently, he can concentrate on, process information about, and react to the defensive display without any degradation of skill (Magill, 1983; Sage, 1984; Schmidt, 1988). In other words, the skills have become automatic or second nature and as a result they require no attention. For example, just as the quarterback can walk and react to stimuli in a crowded shopping mall without thinking about walking he can now perform effectively and efficiently all of the required skills while his attention is focused on the defensive display.

Stage of Confusion and Understanding

This stage is confused with the other two stages of learning because of the apparent similarity of problems experienced in each. For example, when the skills have become automatic, "conscious introspection about the component parts of the pattern during this phase of learning often results in the 'paralysis from analysis' phenomenon" (Sage, 1984, p. 383). Consequently, this phenomenon is confused with the problems found in the first two stages for two reasons. First, many coaches confuse the "paralysis by analysis phenomenon" with the lack of a common kinesthetic language between themselves and their quarterbacks. Second, the "paralysis by analysis phenomenon" is confused with the quarterback's slow information processing time. For example, the paralysis which is usually observed in the early stages is not due to conscious introspection but rather it is due to the fact that the quarterback is attempting to process a tremendous amount of information. These misconceptions may form the foundation for the erroneous argument that a quarterback's inherent skills should not be tampered with or the position that only serious problems should be corrected.

This is the stage of learning that coaches understand best if their method of quarterback development and evaluation is talent based. For example, occasionally a coach will have

the good fortune to coach a quarterback that is genetically wired up to play the position within the framework of his system. This type of quarterback can play the game with little or no coaching. He then becomes the norm. He shapes a philosophy best expressed by statements such as, "if you have a quarterback who can throw the ball, don't screw around with him" (White, 1983, p. 97)...**"THE MOST OVER COACHED POSITION IS QUARTERBACK...I think you get good quarterbacks because they are born...this business of having to do it this way or that way is baloney"** (White, 1986, p. 257).

Phases within the Autonomous Stage

Beginning Autonomous. The increased speed of performance no longer creates a problem for the quarterback and if there are any problems they are minimal. It is now time to vary the practice regimen in the closed environment. For example, there are a variety of types of dropback patterns and passes which must be performed in a game situation. Moreover, their motor programs must be run off effectively and efficiently in pressure situations during a game. Consequently, these variations and a variety of situations must be practiced (Schmidt, 1988).

When the cushion and set phases of the dropback pattern can be performed effortlessly in conjunction with the passing motion, then the job of the coach at this point becomes more simple. The coach at this point needs only to preface the passing motion with the various types of dropback patterns (three, five, and seven step drop) that will be discussed in the biomechanics chapter.

Each of these dropback patterns which precedes the passing motion should be worked on separately in three to four rounds of three to four sets of seven repetitions with a 20 second rest between sets and a 90 second rest between each round. For example, the following practice schedule would be utilized: the three step dropback frontside pass, seven repetitions (20 second rest); three step dropback backside pass, seven repetitions

(20 second rest); five step dropback frontside pass seven repetitions (20 second rest); five step backside pass (90 second rest). This procedure is equal to one round. The other dropback and passing skills would be practiced in a similar manner until four rounds were completed. The split and depths of the stationary receiver would be dependent upon the arm strength of the quarterback. The goal for the quarterback would be the maximum splits and depths required for the specific offensive structure. In addition, KR may be given more frequently. In any event, the coach may have to regress and separate the two, and/or slow them down if the problems are too many or too pronounced.

Mid Autonomous. The quarterback is able to perform all of the drops which precede the passing motion with minor problems in each at full speed or with no problems at reduced speed. At this point the practice variability should be increased. For example, the following practice schedule would be utilized: three step frontside pass, five step backside pass, five step frontside pass, three step backside pass, passing on the move direct, three step frontside pass, seven step backside pass (20 second rest). This would equal one set. Three more similar sets would be employed. This would equal one round. The fourth set would be followed by a 90 second rest. With increased practice the skills become smoother and the quarterback will become more confident.

Ending Autonomous. The quarterback has no problem with any of the drops at any speed. In any event, the coach will have to regress because now the process that serves to acclimate the quarterback to the open environment must be started.

The fundamental difference between the closed and open environment is that in the closed environment the quarterback was not required to react to external stimuli. In the open environment he must be trained to do so.

OPEN ENVIRONMENT

Basic Principles

Once the psychomotor skills of the quarterback have reached the autonomous stage of learning in the closed environment he must become acclimated to the open environment in a similar manner (Anderson, 1984; Schmidt, 1988; Summers, 1981).

This can be accomplished by providing the learner with practice in a wide variety of situations that not only allow many variations of the movement to be produced but also require the learner to produce movements that meet the exact environmental demands (Summer, 1981, p. 64).

To place the quarterback in a game environment after he has reached the autonomous stage in the closed environment without providing any training in the open environment would be counter-productive. In the open environment the coach is concerned with the development of cognitive skills. The development of the cognitive skills are dependent upon the psychomotor skills reaching the autonomous stage of learning in the closed environment. This will allow the quarterback to identify, process information about, and react to the defensive movements. Consequently, the role of arousal theory in this environment relative to cue-utilization, and perceptual narrowing needs to be addressed. These two are critical components because they can impact the level of performance of any quarterback.

Cue-Utilization and Perceptual Narrowing

There are two theories which are related to the theories of arousal and motivation, and each is related to motivation and stress. In addition, each is related to the other. The two are J. A. Eastbrook's (1959) Cue-Utilization Hypothesis, and D. Kahneman's (1973) idea of perceptual narrowing.

Cue-Utilization

Each time the quarterback approaches the line of scrimmage (LOS) and is asked to change the play, drop back or sprint out to pass the ball he is involved in a choice stimulus and choice reaction situation. Consequently, Eastbrook's theory demands coaches to understand that the quarterback needs and relies on cues from the environment to make the proper choices effectively and efficiently in the required amount of time. Such cues might be the movements of opponents or teammates, the specific play that was called in the huddle, or the time remaining in the game (Schmidt, 1988). Without relevant cues the quarterback's performance will deteriorate (Schmidt, 1988). The quarterback's skill in making the correct decision efficiently and effectively in the shortest amount of time is dependent upon two characteristics. First, the psychomotor skill level of the quarterback will determine his decision making capabilities. For example, if the quarterback's skills have not reached the autonomous stage of learning then this will have a detrimental effect on his performance (Schmidt, 1988). Second, his ability to make the correct decisions is dependent upon the decision making strategies required by the offensive structure.

There are three distinct strategies that coaches employ to teach their quarterbacks to make correct post-snap decisions: (a) no cues (Fry, 1984); (b) utilize the receiver as a post-snap cue to determine if that receiver is open, termed fixes (Smith, 1987); and (c) utilize pre-snap precues which determine post-snap cues each of which are derived from the defensive display (Gillman, 1981; Kush, 1976; Stevens, 1988; Vermeil, 1981; Walsh, 1978; White, 1983). The research related to precues and cues does not support a "no cue" approach because it causes tremendous uncertainty and indecision. For example, the search time to localize the necessary information is dependent upon the number of elements in the display and especially so when the elements in the display are similar (Butler, 1980; Estes, 1972). Consequently, the ability of the quarterback to make a correct decision is

dependent upon his ability to find the appropriate stimulus or cue and then react to it if necessary. Therefore, it is inappropriate to instruct the quarterback to see the entire field by instructing him to throw the ball to the open man. Furthermore, with this "no cue" strategy the quarterback must remember every situation for every play. In addition, the research does not support the "utilize the receiver as a cue" approach because this strategy requires the quarterback to process one more "bit" of information than that of a pre-snap precue post-snap cue strategy (Hick, 1952). For example, if the pass play selected employed three receivers down field the receiver cue strategy would require the quarterback to process information relative to three post-snap choices. In addition, these strategies require the quarterback to memorize every defensive situation for every play or different series of plays. Consequently, it is not hard to see that the quarterback may become cognitively paralyzed in any situation with this strategy. This observation is analogous to the storage problem inherent in the open-loop theory which attempts to describe modes of motor control (Schmidt, 1982a, 1988). Therefore, the way in which the quarterback is taught to make correct decisions is critical. The upcoming discussion is an attempt to describe the strategy wherein the quarterback utilizes pre-snap precues and post-snap cues to make appropriate decisions.

In the game of football the quarterback relies on a variety of stimuli, precues, and cues in order to make the correct decisions. A stimulus is synonymous with the appropriate pre-snap precue. In other words, the quarterback focuses his attention on a specific defensive player before the ball is snapped. This stimulus enables the quarterback to determine on which defensive player or players he should focus his attention once the football is snapped. For example, Gillman (1981) and Vermeil (1981) determined this stimulus by the alignment of the strong safety, the free safety and their collective relationship to the wide receiver. They termed this safety the "best located safety" (Vermeil, 1981, p. 238).

In any event, this stimulus would indicate the proper cue which is identical to the correct post-snap cue. This would be a defensive player or a series of players which the quarterback would focus his attention upon once the ball was snapped. This post-snap cue is dependent upon the type of pass play employed. The appropriate post-snap cue, for example the free safety, due to his post-snap movement, would provide the information that would allow the quarterback to make a correct response. The correct response simply indicates that with practice the quarterback, because of the previous two cues, would be able to consistently pass the football to the proper receiver in the required time (Welford, 1986).

This strategy reduces the stimulus-response alternatives which in turn reduces uncertainty, reaction time, cognitive training time, and the arousal level of the quarterback (Schmidt, 1988). However, merely providing the quarterback with cues is not adequate. In accordance with the available research, the cues must be tied to a specific action, or in keeping with Schmidt (1988), a specific general action. In addition, the quarterback must be informed of the relationship between the two (Estes, 1972; Gumenik, 1979). The research suggests that it is best to provide specific cues but the features of the cue should be general. For example, if a specific pre-snap precue is the alignment of the strong safety then the quarterback should not focus on the exact depth of the strong safety's alignment but rather the general alignment and the differences between three or four strong safety alignments (Butler, 1980; Gumenik, 1979; Lambert & Hockey, 1986). In addition, the coach must be careful to provide the quarterback with cues that are relevant and informative, otherwise learning and/or choice reaction time will remain too slow for the environmental requirements (Acosta, 1982; Harvey, 1980). Another potential problem involves the compatibility between the cue and the stimulus. Incompatibility (matching a defender's movement with a receiver across the field as opposed to matching a defender's

movements with a receiver in the immediate area of the defender) causes longer choice reaction times (Hendrix, 1986). In summary, cuing has been shown to reduce choice reaction times (Butler, 1980; Goodman & Kelso, 1980; Gumenik, 1979; Harvey, 1980; Hendrix, 1986; Lambert & Hockey, 1986; Rosenbaum, 1980).

Perceptual Narrowing and Distractibility

Kahneman (1973) suggested that as performers are removed from the controlled environment (closed environment) to a more "game-like" situation (open environment) they are less likely to utilize and/or be able to detect "peripheral" information (not necessarily peripheral vision but rather important events). This increase in arousal merely due to change in environment narrows the focus of attention to a point where it is a detriment to performance. In addition, "high levels of arousal are likely to cause the individual to direct attention to many different sources from moment to moment, with some of these sources providing irrelevant information and causing the relevant signals to be missed" (Schmidt, 1988, p. 133). Schmidt labeled this phenomenon "distractibility." Moreover, the use of cues is critical to the reduction of perceptual narrowing (Schmidt, 1988). Therefore, it is critical that coaches provide the quarterback with appropriate pre-snap precues and post-snap cues. This will reduce choice reaction time, increase the quarterback's consistency in choosing the correct receiver, and it will allow him to focus on the correct cues without narrowing his perception.

Three Stages of Motor Learning

Practice Goals

In the closed environment the quarterback's psychomotor skills were gradually transferred from the cognitive to the autonomous stage of learning (dropping back to pass, and/or passing on the move--direct, inside right and inside left). Essentially his goal was to perform those skills without thought or attention. The task of the coach in the open envi-

ronment is to insure that these skills are gradually incorporated into, and not negatively impacted by, the stimulus response requirements inherent in this environment.

Effective and efficient performance in a game situation is determined by the quarterback's skill in identifying and reacting to specific stimuli in the defensive display. In the initial stages of learning, as the quarterback is first presented with stimuli that demand quick reactions, his arousal level will be extremely high. This elevated arousal level will cause the skills that were developed in the closed environment to regress. However, the regression of these skills will only be temporary if the quarterback is properly guided through each stage of learning in the open environment. Moreover, if there is no attempt to transfer the psychomotor skills to the autonomous stage in both environments then it is impossible to utilize with any consistency the pre-snap and post-snap keys and reads that are critical to a balanced offense .

Cognitive

The quarterback is presented with a stimulus that requires a response. In this stage the stimulus is provided by a stationary receiver which reduces information processing time of the quarterback (Schmidt, 1988). Therefore, the two are extremely compatible because they are one and the same. Nevertheless, his arousal level will reach a point that negatively impacts the required response. Consequently, the developed skills will regress only because of the unfamiliarity with the requirements of this environment. The environment that surrounds the quarterback remains closed or at least semi-closed. Any drills that are employed to disrupt the quarterback's attention and reaction to the stimulus are not utilized. In the closed environment the quarterback was instructed not to pass the ball until he was set and he was not required to react to any stimulus. In this environment he must react to a stimulus that is presented at different times but must do so only when he is set. In this way the two environments are different. This does not indicate ignorance of the fact that there

are times in the game when the quarterback must pass the ball when he is not set and/or that this fact will not play a role in drill design. However, it does suggest that the quarterback must first build a foundation for the practice variability that will take place in the later stages of learning in this environment.

Beginning Cognitive

The types of drills used in this phase are designed to remove the quarterback's high arousal level upon the presentation of a stimulus. For example, a stationary receiver stands approximately 15 yards from the quarterback. The quarterback performs a dropback pattern and then receives a signal from the coach (two hands up) to pass the ball. The drills are designed to get the quarterback to relax and react to the stimulus. He should not anticipate when the stimulus will be presented. This is critical, because this type of anticipation and/or arousal causes the quarterback to lean into his stance. In other words, the quarterback will place too much pressure on the front leg. This problem will destroy the proper sequencing of the passing motion. In this phase the quarterback is provided with advanced information of what the stimulus is to be and the proper response (spatial/event anticipation). Consequently, the only variable that will remain unpredictable is the time in which the stimulus will be presented (temporal anticipation). Temporal anticipation (the time in which the stimulus will be presented) is controlled by the coach. Because of this advanced information the response selection stage is all but bypassed (Schmidt, 1988). In other words, the quarterback does not have to decide what the appropriate response might be. Nevertheless, the quarterback will experience problems running off the appropriate motor program because of the unpredictable signal related to time (Schmidt, 1988). The time deficit between getting set and passing the football (upon reception of the stimulus) will initially be large. This indicates that the processing time is taking too long. However, as practice continues, this time deficit will decrease somewhat.

When the quarterback's back foot contacts the ground (three, five or seven step drop) and the stimulus is presented, the quarterback will have no problem releasing the ball effectively and efficiently. The environment which surrounds the quarterback will not be disrupted in any way.

Mid Cognitive

In this phase the quarterback will be unaware of when the stimulus is to be presented, which is a general characteristic of the game environment. This drill is similar to the common hitch drill but the quarterback will be informed of what stimulus he will see. The quarterback must remain relaxed and he must react to and not anticipate what the stimulus will do.

Ending Cognitive

In this phase the quarterback is required to read and react to stimuli in different locations. He will not know when and/or which stimulus will be presented. This particular drill is called a hitch drill. A hitch indicates that the quarterback must re-set his stance arrow and then pass the ball when the appropriate stimulus is presented. For example, if stationary receiver A indicates that he is closed (one hand up), then the quarterback must now hitch to stationary receiver B and receive a stimulus from that receiver. If receiver B indicates that he is open (two hands up) then the quarterback will pass him the ball. On the other hand, if receiver B indicates that he is closed than the quarterback must hitch back to receiver A. If receiver A indicates that he is open then the quarterback must pass him the ball. However, if receiver A indicates that he is closed then the quarterback is instructed beforehand to either throw the ball away or to run and pass the ball while on the move. The split between the two receivers and their depth depends on the arm strength of the quarterback and/or the requirements of the offensive structure. The total time elapsed for three hitches should be 3.0 seconds.

Associative

In the associative stage the stimulus and the receiver become more incompatible in that they are no longer one and the same. For example, the stimulus which is meant to represent a linebacker or a secondary defender will be employed. This stimulus will move toward one of two receivers. As the stimulus commits to covering one of the receivers the quarterback must pass the ball to the other receiver. However, the receivers at this point remain stationary. The number of receivers and/or stimuli presented are dependent upon the type of pass play to be simulated and the stage of learning. The environment that surrounds the quarterback can remain closed or it can become semi-open. Consequently, drills used to simulate a semi-open environment would be employed. For example, a coach or another quarterback would allow the quarterback to dropback. However, once the quarterback releases the ball the coach would hit the quarterback with a hand carried blocking bag. This forces the quarterback to concentrate and focus his attention on the receiver and not the hit.

Beginning Associative

The types of drills utilized in this phase are made up of two stationary receivers and one stimulus which represents a specific undercoverage or secondary defender. In this phase the quarterback is aware of what the stimulus will do. However, he will not be aware of when the stimulus will do it. For example, the quarterback will know that the simulated defender will cover receiver A or receiver B. However, he will not be aware of the time during the dropback that the simulated defender will commit to covering receiver A or receiver B. Consequently, the quarterback must concentrate on the defender as he drops back to pass. He may have to refix his sights and pass the ball to the appropriate stationary receiver.

Mid Associative

This phase is identical to the beginning associative phase. The difference is that the stimulus is now unpredictable in terms of which receiver will be chosen and at what time during the drop or set the choice is made.

Ending Associative

This phase is exactly the same as the mid cognitive phase except that the stimuli and responses become multiple. For example, instead of a choice between two receivers (located at the same depth) based on one stimulus, this phase requires the quarterback to pass the ball to one of three or four receivers each at different depths. His decision is based on two or three stimuli which he must read and react to in a sequence.

Autonomous

This stage like the other three has three phases and represents the environments where coaches sometimes prematurely place their quarterbacks. This is done either because no preparation had taken place in the closed environment or because no coaching had taken place to prepare him for this stage of learning. Coaches are familiar with the activities in this phase and so they will not be discussed in detail.

Beginning Autonomous

The first type of drill in this stage is the 7 on 7 drill or the pass skeleton type drills. These drills are meant to acclimate the quarterback to the specific strategies employed by the defense to defend the specific types of passing structures.

Mid Autonomous

Scrimmages consisting of a full offensive team versus a full defensive team represent the drills of this stage. They require the quarterback to react to the specific cues in the defensive display. The quarterback is sometimes protected from being tackled in these types of scrimmages.

Ending Autonomous

The final stage and environment is the competitive game situation. All of the work that was done in the previous environments, stages, and phases are put to the test at this point.

In summary, if coaches wish to employ a balanced offensive structure, which relies on the quarterbacks' ability to key and read defenses, it is critical for coaches to understand that the skills of their quarterbacks must reach the autonomous stage of learning in the open environment. If the quarterback does not achieve this stage of learning he will not be as effective and efficient as could be. However, coaches must remember that practice does not make perfect. They must acknowledge that only perfect practice makes perfect. Consequently, attention must be focused on the biomechanics of the quarterback position.

CHAPTER **THREE** **BIOMECHANICS**

Biomechanics provides the only sound, logical basis upon which to evaluate the various techniques that might be used in a given case and to connect observed effects with their underlying causes... Biomechanics is the science underlying techniques (pp. 4-5).

James G. Hay, 1985

INTRODUCTION

Importance of Biomechanics

Ultimately, "the improvement of skill technique can become an efficient organized process through the application of biomechanical information and methods, or it can remain the trial and error act that it has been. Certainly, there is a choice. Coach it's up to you" (Stothart, 1981, p. 31). Moreover, the research in biomechanics, like the research in motor behavior, can help decide whether quarterbacks are born (White, 1978, 1983) or made (Stevens, 1988; Walsh, 1986). If and when coaches recognize that 46.9% of ball velocity in the overhand throw results from lower body rotation (Toyoshima, Miyashita, & Oguri, 1974), and that these lower body movements do not develop naturally (Leme & Shambes, 1978; Toyoshima, Hoshikawa, Goya, & Matsui, 1981), then they will understand that quarterbacks are made and a method of development is urgent. Ultimately, the coach's knowledge of biomechanics is critical if he wishes to improve the quarterback's ability to perform (Ariel, 1983a, 1983b, 1983c, 1984; Bucher, 1983; Hatze, 1974; Hinkle, 1979; McCarthy, 1984; Marhold, 1974; Pate, 1984). Consequently, "a coach must understand the biomechanical principles underlying performance in his/her sport before analysis of a technique, and hence coaching directives aimed at improving technique, can take place" (Stothart, 1980, p. 29). More importantly, the identification of a biomechanically based technique for the requisite skills in a balanced offense is critical because it will "prevent the blind leading the blind" (Ariel, 1983b, p. 27). Coaches should teach the quarterback the most effective and efficient method of dropping back and passing in order for the player to reach his potential, which will lead to offensive balance (Frederick, 1985; Hatze, 1974; Marhold, 1974; Montour, 1979).

The reason why research in biomechanics is critical is in part due to the fact that the research, which could provide a coach with a picture of a biomechanically based technique,

is essentially non existent (Atwater, personal communication, May 1, 1989; Mikszewski, 1968). Mikszewski (1968) pointed out that there have been studies related to other areas of football but that there had been few attempted with respect to the sprint out passing game, the forward pass, or the quarterback in general. Atwater stated that even if there was any information it would be obscure at best. This is true of professional journals as well. In addition, the information provided by expert coaches is absent. For example, The Coach of the Year Clinic Manual, which is the most comprehensive annual collection of professional, college, and high school coaches' thoughts about the game of football, has had few articles about the quarterback position. Since 1976 the manual has presented 589 articles regarding various facets of the game of football; 52 addressed various questions and made suggestions for the passing game in general, 15 articles dealt with the cognitive development of the quarterback, 3 dealt with the sprint out game specifically, and none of the articles addressed the question of quarterback biomechanics in any capacity. This is not meant to suggest that the clinic and/or the manual have been derelict in their duty. On the contrary, the clinic and the manual do a tremendous job. Nor is it meant to suggest that the manual has not presented coaches' opinions regarding how it is the quarterback should drop back or pass. However, it is meant to signify that it is difficult if not impossible for coaches to retrieve quality information about the techniques of the position which will settle existing disputes related to quarterback mechanics. This lack of information highlights the importance of the relationship between the biomechanist and the coach. For example, if coaches are not familiar with the principles of biomechanics then they can consult a biomechanist regarding the specific quarterback problems. Stothart (1980) pointed out that this relationship is critical to the improvement of the athlete. But if the relationship is to be fruitful then the coach, at the very least, must have some conception and understanding of the requirements and parameters of the skills that make up the quarterback position, and he

must communicate these to the biomechanist (Stothart, 1980). The biomechanist, on the other hand, must not only inform the athlete and/or the coach of what the quarterback is doing but what he ought to do. Because, "after all the athlete does not want to be told what he is already doing but what he should do in order to optimize performance" (Hatze, 1974, p. 237). Understanding the requirements and parameters of the skill coupled with high speed film analysis may form the foundation of the coach's knowledge which allows him to improve the athlete (Ariel, 1983b, 1983c, 1984; Stothart, 1980). This is critical because the coach has the responsibility of being the "ultimate decision-maker in training" (Ariel, 1983c, p. 52).

As previously mentioned, some research has been published which has helped to shed some light regarding the biomechanics of the quarterback position. Hinkle (1979) detailed specific laws of physics and their relationship and importance to passing the football. Those specific laws were the law of inertia, law of continuity of motion, law of transfer of motion, law of acceleration, law of center of gravity, and the law of counterforce. In addition, Yessis (1984) stated that there is "one basic pattern of throwing the football" (p. 6), and that there are many variations based on this basic pattern. He suggested that these variations were dependent upon distance, and the speed with which the ball was thrown (the faster the ball is thrown the greater the number of body parts which need to be involved and the greater their range of motion). In addition, Yessis analyzed the throwing motion through five phases: stance, cocking, acceleration, follow-through, and release. He detailed the important muscles utilized in each phase but did not specify their activation level through any phase. He also provided specific weight training exercises important to the development of those muscle groups.

Carlson (1962), descriptively analyzed four passers performing three different passes including straight drop, roll-out, and the jump pass. The quarterbacks involved in the

study were from the Northwest: three from Washington State University, and one from the University of Oregon. He utilized game film of the quarterbacks to conduct his study. The focal points of the quarterback's body were the feet, hips, shoulders, grip, release of the ball, posture, carriage of the left arm, and body balance. He reported the following characteristics in all four quarterbacks in the straight drop pass:

1. The left foot is the focal point for the direction of the throw.
2. The right foot serves as an anchor with slight flexion, and the transfer of weight occurs from the right foot to the left foot during the initiation of motion.
3. The action of the right hip is vital and leads the right shoulder.
4. The shoulders act as a base for the throwing arm and are always perpendicular to the target.

Passing the football utilizing the roll-out technique produced the same characteristics except that the pass was made off of the right foot. The jump pass produced the same characteristics as the roll-out except that both feet left the ground simultaneously.

Mikszewski (1968) tested six right handed Springfield College quarterbacks in a roll-out technique to determine the difference between throwing accuracy on the move to the left and to the right at three different distances; 6, 12, and 25 yards. He found significant differences in favor of throwing on the move to the right at a depth of 6 yards but no significant differences at 12 and 25 yards. Aside from Pannes' (1967) thesis, regarding the differences of various dropback techniques, the preceding is essentially all that has been done to present a picture of the best technique to pass the football.

If a more comprehensive approach is not taken then coaches as well as their quarterbacks may be left to copying the techniques of successful performers. For example, "anyone who blindly copies the technique of a champion copies not only its desirable features but also its undesirable ones" (Hay, 1985, p. 3). Ariel (1983a) cited a fine Olympic

discus thrower from the United States as one who succumbed to the temptation of copying the East German discus thrower Wolfgang Schmidt. Ariel pointed out that Schmidt's technique, "was a better technique--for the East German not Mac Wilkins...It took him [Wilkins] months to get back to where he was before" (p. 79). For football coaches in general and quarterback coaches specifically

it is important to understand that some performance techniques may have evolved from performers who have been successful in spite of the use of unsound techniques.

Furthermore, at times performers are convinced they do something in a certain way when actually it is done quite differently (Jensen, Schultz, & Bangerter, 1983, p. 210).

Nevertheless, a more fruitful method to optimize performance would be with the aid of the science of biomechanics because "it provides the only sound, logical basis upon which to evaluate the various techniques that might be used in a given case and to connect observed effects with their underlying causes...Biomechanics is the science underlying techniques" (Hay, 1985, pp. 4-5). Stothart (1980), like Hay (1985), stated that knowledge in the science of biomechanics was essential to coaches, especially to those at the highest level. Hay (1985), however, acknowledged the criticism of this point of view by those who have cited the examples of the successful coaches who possess little or no knowledge of biomechanics. Nevertheless, he asserted that the performance of these coaches' players would be increased if "to all of these coaches' attributes was added a knowledge of biomechanics" (p. 6).

The preceding information forces coaches to understand that because any highly successful quarterback passes the football with a particular motion does not indicate that they should force their quarterbacks to utilize that motion. Moreover, it suggests that because there are a multitude of styles does not indicate that basic and even specific features of the dropback and passing motion should not be taught. Coaches should be interested in

optimizing the performance of their quarterbacks at the lowest and highest levels of play. Most importantly, the study of biomechanics can help settle disputes and provide guidance for the coach regarding the best technique of passing the football in a balanced offensive structure.

Throwing Motion in General. Analysis and Problems

The open kinetic link system which has been utilized to describe the throwing motion suggests that throwing in general

involves the sequential action of body segments progressing from the larger, slow-moving trunk actions to the faster, distal actions of the relatively smaller arm and hand segments. Depending upon the demands of the sport, both speed and accuracy in varying combinations constitute the goals of the throw (Atwater, 1979, p. 43).

Moreover, the research on throwing has provided information which can be applied to the passing motion in a general way. This research has helped to determine the development of effective training regimens for injury prevention; identify efficient methods of injury rehabilitation; determine the important muscles and their activation level within the kinetic link system related to ball speed; and determine which factors, genetic or environmental, play a more important role related to throwing skills. These in part provide guidance to the endeavor of training and developing effective and efficient quarterbacks. However, utilizing this information as a basis for providing specific prescriptions of passing the football is problematic in that the size of the object thrown, the environment in which these two skills operate, and the skill level of the athletes involved affect the nature and the parameters of the skill (Kreighbaum & Barthels, 1985; Magill, 1983; Pappas, Zawacki, & Sullivan, 1985; Pedegana, Elsner, Roberts, Lang, & Farewell, 1982; Sage, 1984; Schmidt, 1982a, 1988). This is a critical point because all too often books on biomechanics suggest that passing the football "is nearly the same as the overarm baseball

throw" (Jensen et al., 1983). Consequently, all that is devoted to the mechanics of this type of throwing motion is a paragraph and/or a page at the most.

Generally four phases have been defined to separate and analyze the throwing motion: I wind-up; II cocking; III acceleration; IV follow-through (Jobe, Tibone, Perry, and Moynes, 1983; Jobe, Moynes, Tibone, and Perry, 1984). These phases take place within a range of motion of about 225 degrees but "the entire excursion is not located entirely within the glenohumeral joint" (Pappas et al., 1985). Most of the research concerning the throwing pattern of adults has been conducted with subjects throwing a baseball or a softball, "it has been primarily evaluated to determine the etiology of injuries" (Montour, 1979, p. 20). This was substantiated by Atwater (1979).

Although the above research cannot be used to make specific recommendations, it can provide a general picture of the throwing motion. At the very least, it can provide a starting point.

Injury to the Throwing Arm

Injury to the throwing arm can be caused by poor mechanics (Atwater, 1979; Montour, 1979). In addition, recent evidence suggests that injuries to the pitching arm are caused by the amount of pitching and not the type of pitch thrown (Hang, 1981; Sisto, Jobe, Moynes, & Antonelli, 1987). Moreover, Albright, Jokl, Shaw, and Albright (1978) found that a sidearm release pattern was associated with more throwing arm disability than that of an overarm pattern. Although supination tends to create curve ball pitches and pronation tends to create fast-ball pitches (Hang, 1981), the musculature responsible for the distinct features of these two pitches is not located in the forearm musculature (Sisto et al., 1987). Nevertheless, Sisto et al. (1987) did not extend their electromyographic analysis to the biceps and triceps but instead confined it to the forearm musculature. However, Jobe et al. (1983, 1984) found that the biceps and the triceps function as elbow joint muscles and not

shoulder joint muscles. Consequently, these two muscles could be the source of the differences in muscle activation between the two pitches.

Pappas et al. (1985) found that the greatest stress on the elbow occurred during the acceleration and follow-through phases. This was substantiated by Jobe et al. (1983, 1984) who in two reports analyzed the deltoid, supraspinatus, infraspinatus, teres minor, subscapularis, pectoralis major, biceps, triceps, latissimus dorsi, serratus anterior, and the brachialis. They found that the shoulder muscles were activated minimally during acceleration but intensely during follow-through. They also concluded that the biceps and triceps along with functioning primarily as elbow joint muscles fire intensely from the acceleration phase through the follow-through with the biceps reaching peak activity during the follow-through phase.

This information has practical applications. For example, if the quarterback complains of a sore elbow but has not done much passing it could be due to the fact that he has poor mechanics in general and/or that he has a side-arm release specifically. On the other hand, if he has thrown quite a bit it could be due to the same reasons cited above, his work out sessions are too long, and/or that he does not have enough strength in his biceps to decelerate the passing motion through the follow-through phase.

Open Kinetic Link System

These studies together support the theoretical open kinetic link system describing the throwing motion proposed by books on biomechanics (Jensen et al., 1983; Krieghbaum & Barthels, 1985). Although the muscles change joint angles at speeds relative to ball speed (Atwater, 1970), the muscles are not activated at an intensity level commensurate with those changes through the entire motion. In addition, the changes in the various joint angles are not abrupt but rather change in smooth sequential fashion. As each segment proximal to the axis of rotation accelerates, the succeeding distal segment is initially left behind;

as the proximal segment begins to decelerate the succeeding distal segment acquires the speed of the preceding proximal segment (Krieghbaum & Barthels, 1985). Seen in this light coaches can account for the discrepancy between joint angle changes and electromyographic activity in that "the velocity of the distal segments may be so great that the muscle contraction may not be able to apply a torque to accelerate them further" (Krieghbaum and Barthels, 1985, p. 599).

Video Analysis

Biomechanists acknowledge the importance of high speed film or video analysis for the coach toward the goal of improving his athlete (Ariel, 1983b). They cite that it should form the foundation of his approach toward improving the athlete and as Ariel (1983b) pointed out it is "better than guessing" (p. 28). It has been used to analyze many sports skills in order to explain and improve performance. Very little analysis of this sort has been done with respect to the quarterback position although Anderson (1984) utilized it to demonstrate hand-off techniques, the throwing motion, and the dropback. Because of the development of the VHS or Beta video systems and their proliferation, the ability for coaches to do analysis of this sort has been made easier.

The Peak Performance's 3-Dimensional Video Analysis System was used to provide the images in this book. The system provides the coach and/or biomechanist with the ability to perform 2- or 3-dimensional video analysis. The fact that this system may not be at the disposal of coaches does not indicate that anything short of this system is useless. A tremendous amount of information can be retrieved from simple video analysis. For the coach who is new at coaching quarterbacks video analysis is vital, for coaches who are familiar with it, video is a blessing. The more quarterbacks a coach sees and coaches, the more problems and glitches in proper mechanics he will see as well. For the unfamiliar coach, these mechanical problems are hard to diagnose and even harder to correct. This

can be very frustrating. However, video analysis coupled with knowledge of and experience with implementing biomechanical principles can make the task of coaching quarterbacks an exciting challenge.

PASSING STATIONARY

Introduction

"My philosophy has been more toward controlling the ball with the forward pass...The drop back pass will control the ball" (Walsh, 1981, p. 86). Consequently, passing the football from a stationary position is critical to this approach. However, before the models are presented it is important to gain some frame of reference related to how coaches have understood and/or have viewed the mechanics/techniques of the quarterback position. This will at the very least provide a foundation from which to start the analysis. In addition, it will illuminate some of the misunderstanding which may have led to improper instruction.

Coaches have used many analogies to describe the skills of passing the football:

1. Stroke: tennis serve (Arians, 1985), throwing darts (Bielat, 1986).
2. Stance (distribution of weight) and initial step: boxer (Arians, 1985; Sloan, 1984).
3. Transfer of weight: golf swing (Arians, 1985; Stevens, 1988).

Coaches believe that in the stance phase the back foot should handle more weight than the front foot (Edwards, 1986; Stevens, 1988). On the other hand, other coaches believe that the weight should be equally distributed (Edwards, 1986). Most agree that the knees should be slightly bent regardless of the stance (Arians, 1985; Edwards, 1986; Sloan, 1984).

The controversy regarding the distribution of weight is not the only one which exists. For example, Bielat (1986) stated, "try to avoid teaching the quarterback to throw with the lower body" (p. 7). Nevertheless, "if you don't use your legs correctly--the harder you push with your arms--the energy will not go back into the implement, but back into your

legs" (Ariel, 1983a, p. 32). Consequently, other coaches understand that the legs are a critical component (Arians, 1985; Hackett, 1990). However, in all fairness to Bielat it must be understood that he was merely attempting to point out that it was not always possible for the quarterback to pass the football from the pocket. And in his study at least, he "found out that the QB WAS NOT throwing the ball from the spot he was supposed to be throwing it from" (p. 5). In addition, his research demonstrated that "the [quarterback] QB throws the ball with the ARM; NOT the feet" (p. 5). This led him to conclude that "the feet is [sic] really not that important" and question,

if this is the situation, why are we teaching the QB to throw the ball under perfect conditions? We need to change our coaching techniques. So I went back to some old scramble drills and old movement drills we used to use (p. 5).

However, imagine a young coach sitting in the audience during a coaching clinic attentively listening to and writing down every word Larry Bielat, the quarterback coach from Michigan State University, had to say. That this young impressionable coach would begin the instruction of his quarterbacks with scramble drills (variable practice) without first teaching them the importance of the proper mechanical use of the feet represents poor coaching. The question of teaching is related to the chapter on motor behavior and so the rationale for this criticism can be found in that chapter. But because coach Bielat's recommendations were related to a biomechanical principle it needs to be discussed here as well and will be in the rest of the chapter. This serves to point out the relationship between motor behavior and biomechanics. In connection with the argument, coaches must acknowledge that 46.9% of ball velocity in the overhand throw results from step and body rotation and the remaining 53.1% is due to arm action (Toyoshima, Miyashita, and Oguri, 1974). In addition, these authors as well as Komi (1986) suggested that rapid arm action is due to the physical phenomenon of the neuromuscular system rather than conscious muscle

contraction. This confirmed Boucher and Flieger's (1983) observation that with practice of ballistic movements more fast-twitch motor units are recruited.

This does not suggest that the upper body is not important. On the contrary, research has demonstrated that upper extremity strength (elbow extension, shoulder external rotation, shoulder extension, shoulder flexion, and wrist extension) have a strong relationship to throwing speed, especially wrist extension (Collins, 1960; Pedegana et al., 1982). Pedegana et al. (1982) found a high correlation between wrist extension strength and throwing speed but they could not explain this relationship. It could be to enhance stiffness regulation and thus provide a base of support at release (Komi, 1986). Their findings, however, conflict with the studies conducted by Jobe et al. (1983, 1984), Sisto et al. (1987), and Atwater (1970). For example, if these muscles are not intensely activated through the phases of the throwing motion then strength cannot be a factor. Therefore, strength may not be a factor related to changing joint angles through the entire 255 degree excursion. Strength may only be a critical variable during acceleration and the follow-through phases.

Coaches suggest that a stride length of about shoulder width is the most effective. In addition they suggest that the lead step should not cross an imaginary line which connects the cardinal sagittal planes of the quarterback and the receiver (Edwards, 1986; Hinkle, 1979; White, 1978; Wyche, 1983). It has been suggested that the forward distance of the lead step has an impact on accuracy (White, 1978). However, Hay (1985) pointed out that, at least in pitching, this was not the case. The opening of the hips was also believed to be a critical factor during the initiation phase of the pass (Arians, 1985; Stevens, 1988).

Some coaches preferred an overarm acceleration pattern to that of a sidearm pattern when passing the football. First, it was suggested that an overarm throwing motion would reduce stress on the elbow (Anderson, 1984; Arians, 1985; Edwards, 1986; Hinkle, 1979;

Stevens, 1988). Second, it was indicated that this type of motion would help the quarterback pass the football more efficiently (Stevens, 1988; Wyche, 1983). Third, it was suggested that it would reduce injury to the throwing arm (Albright et al., 1978). Atwater (1970) and Collins (1960) researched movement characteristics of the overarm throw. Atwater's research conflicted with Collins' in that Atwater found that wrist flexion was not a significant contributor to throwing speed. Collins found no difference in joint angles or range of motion between the throwing motions of overarm and sidearm throws except in the lateral bending of the spine away from the throwing arm. Sakaris (1978) substantiated the findings by Collins (1960). He analyzed four right handed pitchers in order to determine the difference between the overhand and sidearm throws. The conclusions were as follows:

1. There was minimal difference of take off ball velocity between each type of throw.
2. There was more torso lean to the left of the vertical axis in the sagittal plane in the overarm throw than the sidearm throw.
3. There was greater elbow flexion in the overarm throw than in the sidearm throw.

The rationale for an overarm passing motion as opposed to a sidearm motion has practical implications. An over the top motion creates less mechanical problems for the quarterback when he attempts to pass the ball while he is on the move. This will be discussed in the section that addresses the models for passing the football while the quarterback is on the move.

Coaches believe that the elbow should precede the hand and that it should "lead the way" (Edwards, 1986). This is in line with Bielat's (1986) comparison of passing the football to throwing darts. Atwater (1979), however, considered this to be a total misconception. Coaches agree on the release pattern and favor pronation over supination for passing from a stationary position and while on the move (Arians, 1985; Bielat, 1986;

Edwards, 1986; Sloan, 1984; Stevens, 1988; Wyche, 1983). Coaches suggest that when passing the ball from a stationary position the back leg should be lifted off of the ground at the release point (Sloan, 1984). The following analysis will attempt to affirm or refute the assertions made by coaches.

Progression Analysis

As mentioned earlier final velocity is critical to passing the football. The stance presented here allows the passer to exert more muscular forces responsible for rotating the hips, shoulders, arms, and the ball forward over a longer distance in a short period of time (Hay, 1985). This serves to properly direct the application of force, maximize the constant application of force, and increase the distance of force application. Consequently, the final linear velocity of the football will be increased which leads to increased power (Jensen et al., 1983; Kreighbaum, & Barthels, 1985). For example, power (P) is equal to force (F) times distance (D) over time (T): $P = F \times D / T$. Of the three variables on the right side of the equation two, (D) and (T) can be improved with proper technique. In this case by simply utilizing a proper stance. Force can be improved through proper strength training.

In order to provide some frame of reference the face of two clocks and three axes will be utilized to describe the quarterback's motion in the sagittal, frontal, and transverse planes. In addition, these reference clocks will move with the quarterback as he drops back to pass. The quarterback will always be in the center of the clocks and the target will always be at 12 o'clock (see Appendix A).

It is critical to understand that the models provided represent the foundation for all practice variability. The types of passes required in a balanced offense under ideal and chaotic situations require a starting point. In other words, a specific general motor program. These models are software programs with which the quarterback's computer (his brain) must be programmed.

Stance Phase

The stance is critical because as was mentioned in chapter two it is important for the quarterback to begin right, in order to move right, in order to end right. In addition, it provides a foundation for later practice variability, and the foundation for the mechanical efficiency of the passing motion. The stance described in the upcoming section is a closed stance (for 3-dimensional image see Appendix B). The quarterback must be absolutely comfortable in this position. This, however, does not indicate that he must be allowed to get in the most comfortable position simply because the correct position is uncomfortable (the discomfort could be due to the fact that he is unfamiliar with it). However, it does indicate that there will be some variation from one quarterback to another. Nevertheless, with any one quarterback, the stance must not vary from one repetition to another in the cognitive and beginning stages of learning. Furthermore, once the quarterback hits the second and third step in a three step drop, fourth and fifth step in the five step drop, or the sixth and seventh step in the seven step drop, the placement of the feet must not change in order to attain his proper stance. All too often quarterbacks must do a tap dance or hitch step before they are prepared to throw the football. This not only destroys the proper sequencing of motion but it also takes too much time for the type of passing structures which require the quarterback to pass the ball once his last step contacts the ground (Gillman, 1981). This does not indicate that there are not passing structures which require a hitch step technique but it does indicate that if the quarterback must hitch step in order to set his feet to pass the ball then he will be late with the delivery of the ball for those structures that require a quick release. The only variable that will change once this last step hits the ground will be the quarterback's center of gravity which will be shifted from the even step (2, 4, or 6) to the backward odd step (3, 5 or 7). In addition, he should be able to stay in this stance indefinitely. This is the only way the quarterback will ever be ready to

throw accurately and consistently on the final step without resetting (Gillman, 1981).

Coaches must coach the stance if they wish to accomplish the following:

1. Use pass packages which require this type of precise timing.
2. Develop a quarterback who can throw a variety of passes.

This stance position must reach the autonomous stage of learning. It is only when this happens that a variety of passes can be taught and utilized.

Feet

The lower body generates almost 46.9% of the passing power (Boucher & Flieger, 1981; Toyoshima et al., 1974). Consequently, the position of the feet is critical to the proper alignment of the quarterback which will impact the final velocity and momentum of the pass. Effective and efficient movement of the lower body is dependent upon the following descriptions which serve as anatomical markers for a right handed quarterback. These markers allow the coach to check the quarterback's stance.

An imaginary horizontal line (the X axis) always extends from and through the right arch of the quarterback to the target. (for a visual reference to the following description see Appendix C). In addition, there is an imaginary line which extends from and out of the back foot. It is termed the "stance arrow." This imaginary stance arrow extends out of the arch and is perpendicular to the longitudinal axis which connects the heel and the toe. The longitudinal axis is termed the R line. The R line extends down the Z axis (yard line) toward 3 o'clock. Consequently, the stance arrow extends out from the arch of the right foot on the X axis toward the target (12 o'clock) and backwards from the quarterback as well (6 o'clock). As a result, the back foot is labeled the direction foot in the stance. The backward position on the X axis at 6 o'clock is 0° while the forward position at 12 o'clock is 180° . The stance arrow and the line that connects the quarterback and the receiver, the X axis, should be lined up one on top of the other. As one can see the X axis will not change

in relationship to any target. However, the stance arrow can. The X axis lies in the sagittal plane, it is perpendicular to the frontal plane, and parallel to the transverse plane (Hay & Reid, 1982).

One of the goals of passing the football is to maximize the distance the right hip and shoulder and the ball travel from initiation of movement phase (at 6 o'clock) to release (at 3 o'clock), in the shortest amount of time about their respective longitudinal axes. This will "contribute to an increase in the amount of work that can be done on the ball and to the magnitude of the velocity with which it can leave the [quarterback's] hand" (Hay, 1985, p. 193). In addition, the quarterback should create as long a lever from the axis of rotation, the ankle (the most proximal segment), to the ball (the most distal segment). Technically, the goal is to increase the radius of rotation from the axis of rotation (left ankle) to the most distal segment or implement (ball), and from the left hip to the right hip, and from the left shoulder to the right shoulder (Kreighbaum & Barthels, 1985; Yessis, 1984). In addition, the quarterback should move the most distal point from the axis of rotation (the football) through the range of motion over the shortest period of time. However, the overall goal to create the longest lever does not exclude the utilization of wheel-axle arrangements where appropriate (Kreighbaum & Barthels, 1985). The longest lever coupled with wheel-axle arrangements will collectively serve to maximize final velocity if and when final velocity is critical to the success of the pass play. This point is critical because there are times when "touch" is more critical than final velocity. Nevertheless, if the quarterback can learn how to maximize final velocity he can learn how to utilize "touch." The reverse of this is not always true.

In relation to the X axis in the sagittal/transverse planes, the maximum distance that the ball can travel is 90°. Therefore, the quarterback's toes should be pointed toward the sideline down the Z axis (pointed to 3 o'clock). As previously mentioned, the stance arrow

and the X axis should be lined up with one another. As a result, the R line, which is pointed to the sideline, should form a 90° angle with the X axis which connects the quarterback to the receiver (see Appendix D, Closed Stance). These points are critical because they provide the coach and the quarterback with anatomical markers and coaching guides. For example, if the stance arrow is pointed to the left of the forward extending X axis (at 10 or 11 o'clock instead of 12 o'clock) with the toes pointed forward at 1 or 2 o'clock instead of 3 o'clock then this indicates that the stance is rotated forward (see Appendix D, Open Stance). This open stance, however, rotates the hips, torso, and shoulders forward and around toward the target (1 or 2 o'clock) about the longitudinal axis of the right foot. However, due to the transverse flexibility at the knees, hips, and torso it is possible for the hips and shoulders to be closed while the feet are in an open position. Nevertheless, once the left leg is lifted to begin the transfer of weight from the right leg to the left leg (initiation of movement), the hips, torso, and shoulders automatically open up. Consequently, the distance over which the right hip and shoulder can travel in the transverse plane about their respective longitudinal axes will be reduced. In other words, the radius of rotation will be reduced. This, in addition, reduces the distance the ball is allowed to travel within the 90° on the X axis within the sagittal/transverse plane from initiation of motion to release. With respect to the imaginary transverse clock, the ball, with this open stance, starts its motion forward at 5 or even 4 o'clock instead of 6 o'clock.

On the other hand, if the stance arrow is pointed to the right of the target at 2 or 3 o'clock with the toes pointed backward away from the target at 4 or 5 o'clock then this causes the hips, torso, and shoulders to be closed (see Appendix D, Hyper Closed Stance). This increases the distance over which the right hip, shoulder, and the ball can travel, which alone may not be a disadvantage, however, it also increases the time over which the ball must travel. In addition, this closed stance increases the distance that the lead leg must

travel to be properly set. Furthermore, if this was a pitching motion in a closed environment then this added distance would not be a severe problem and could possibly contribute to increased final velocity if the time remained constant. However, the potential for increased power is outweighed by the time demands of the open environment. Finally, it inhibits the external rotation of the right femur at the hip during the initiation of motion. This makes it more difficult for the quarterback to open his hips during this phase which destroys the proper sequencing of motion and the proper direction of force application.

Most of the pressure should be placed on the back foot in general and on the outside midsole of the foot specifically. In other words, the quarterback should be flat footed. This will serve to increase the surface area which is a requirement when the set step contacts the ground at the end of the drop back phase. If there is too much weight placed on the front foot then the back leg will be extended. As it is for the batter in baseball, this knee extension will reduce the force of hip rotation which the quarterback can produce (Hay, 1985). The quarterback does not want to be on the toes or completely on the heel of this foot. In addition, the toe of the front foot should be aligned with the arch of the back foot. In other words, the front toe will be aligned on the stance arrow of the back foot. This will decrease the lead step movement time to the outside and it will aid the quarterback's balance over the right foot. The toes of the front foot, where the phalanges meet the metatarsals, should be the major parts of the foot that touch the ground. The distance between the feet should be approximately shoulder width.

Coaching Point: The quarterback should be able to tap his front foot on the ground without drastically changing his center of gravity and thus the stance. If, when the quarterback taps his foot, there is a noticeable shift backward toward 6 o'clock then this indicates that he has placed too much pressure on his front foot which can create severe problems. For example, when the quarterback initiates his movement to throw the ball (the

second phase) he must first change his center of mass backwards in order to pick his left foot up to step forward. This takes time and time is critical to a quarterback's performance and survival. On the other hand, if the quarterback's weight is placed on the back foot then he does not have to change his center of mass before stepping forward.

Knees

The knees are slightly bent. This serves to increase the "stretch of the extensor muscles and adds to the force of their extension" (Jensen et al., 1983, p. 230). The patella of each knee should point in the same direction as the toes of the feet--down the Z axis (3 o'clock). If the toes are pointed in the correct direction but the hips are slightly open this is generally due to the fact that the left knee is pointed slightly downfield (1 or 2 o'clock).

Hips

The hips should be closed. In other words, the transverse axis which connects each hip should point in the same direction as that of the stance arrow of the back foot down the X axis (12 o'clock). A direction arrow extends out from the left hip toward the target. Therefore, when standing in front of the quarterback the coach should not be able to see the frontal plane of the hips. In simple terms, the coach should not be able to see any zipper. Due to the flexibility of the ankle, knee, and hip joints, it is possible for the hips to be open while the feet and knees remain closed. However, if the hips are open then it is not possible for the quarterback to take advantage of the right hip's full 90° rotation in the transverse plane over the longitudinal axis at the left ankle.

Torso

The torso should be in a slightly backward leaning position. However, this lean is ever so slight. The center of gravity should be directly over the the back foot down the longitudinal axis of the right foot. The chest should point in the same direction as the toes,

patellas, knees, and hips--the Z axis (3 o'clock). In addition, the torso should remain closed in the same manner as the hips for the same reason.

Shoulders

From a strategic perspective the shoulders are critical because they provide clues regarding the depth of the throw. For example, if the left shoulder is tilted upward then this indicates that the pass will be deep. On the other hand, if it is level with the right shoulder the pass will be intermediate or short. This provides information advantageous to the defense in general and secondary players specifically. In any event this information is detrimental to the offense. Some coaches suggest that one need only coach the quarterback to do the opposite. For example,

if we are going to throw the ball long, we want the QB to put the shoulder Down....If we are going to throw the ball short, we want the shoulder UP....We do the opposite of what the defense expects (Bielat, 1986, p. 7).

This strategy still provides a consistent clue for the defense and the solution to this problem is simple. For example, it is possible to pass the ball to the intermediate or short zones with the shoulders tilted slightly upward without losing power or time. Therefore, it is advisable to have the quarterback tilt his shoulders upward about 5° in order to disguise the intentions of the offense.

In addition, the transverse axis which connects the shoulder joints should point down the X axis toward the target (12 o'clock). In other words, a direction arrow extends out of the left shoulder toward the target. In this manner the shoulders should remain closed like the hips. The coach should not be able to see any jersey numbers or writing on the chest. However, because of the flexibility at the torso it is possible for the hips to be closed yet the shoulders remain in an open position. If this is the case then the coach should first

check the lower body. If the lower body is in good position then the coach should merely have the quarterback close his shoulders.

Elbows

The elbows should be pointed downward, although the left elbow will not be pointed in this direction as severely as the right. It should, however, point in the same direction as the direction arrow of the stance--down the X axis (12 o'clock). This will insure that the shoulders are relaxed.

Forearms

The left forearm should be in line with the seam opposite the laces and close to the ball. The right forearm should be almost perpendicular with the ground and perpendicular to the bottom seam of the football.

Hands/Wrist (Grip)

The wrist of the passing hand should be in a hyperextended position. At the very least it should not be in a neutral or flexed position. This will allow for pronation at release which will be discussed in the upcoming sections. Consequently, the angle between the carpal/metacarpal (back of the hand) and the radius/ulna (top of the forearm) should be about 40°, with the palm of the passing hand pointing upward. An arrow (direction arrow) extends out perpendicular from the flat part of the forward part of the passing wrist. This direction arrow is lined up with the stance arrow and the X axis (12 o'clock). If this and the other positions are in place then the front point of the ball will be pointed to the right of the target (1 o'clock). In addition, the seams of the ball will be parallel with the ground. The left wrist should be in a neutral or slightly flexed position. The position of the ball, due to the forearms and the hands, helps to protect the ball in a potentially violent environment.

The football should be held with the fingers. Passing a football "without the fingers is like taking a flat-footed jump" Jensen et al., 1983, p. 337). More importantly, "failure to use these levers limits the opportunity to develop maximum velocity. In order to use the fingers effectively, the performer must hold the ball by the fingers, not in the palm of the hand" (Jensen et al., 1983, p. 337).

Head

The head and nose should point straight down field toward the target. However, in order to get a jump on the ball before it is thrown, many defensive coaches teach their undercoverage and secondary players to key the quarterback's eyes or face mask. Consequently, the head can be a key for the defense or an instrument of deception for the offense. It is critical that the quarterback learns to play a "game with the defense."

It is A Game Of Deception! It is a game of not allowing the defenders to read his [the quarterback's] intentions until it is too late for them to react efficiently enough to defense the play. He does not want to give the defense a head start in diagnosing what he plans to do. This happens when the QB telegraphs his intentions....The discipline of maintaining [a] good focal point downfield is critical...We want everyone on defense on the snap of the ball to go where the coach told them to get in the pattern coverage. We don't want people getting out of their pattern or coverage and reading our eyes (Gillman, 1981, p. 50).

Note: Aside from the obvious gross differences between passing from a stationary position and passing while on the move (direct, inside right, and inside left) the details of each phase related to each technique are identical. Any differences will be identified in the passing while on the move section.

Initiation of Movement Phase

This phase is characterized in general by the body's forward movement down the stance arrow and the X axis in the sagittal plane, towards the target over the left foot. It has also been termed the cocking phase (Hinkle, 1979; Jobe et al., 1983, 1984; Montour, 1979; Pappas et al., 1985; Yessis, 1984). In addition, the initiation of movement phase can be divided into two phases: first phase and second phase. The first phase begins the moment the back foot starts to push against the ground through knee extension and the lead step is lifted and moves forward. This takes place in conjunction with the ball being put in motion backwards (towards 6 o'clock) by the passing arm (see Appendix E, frames 1-18). The first phase ends the moment the lead step hits the ground (see Appendix E, frame 18). The second phase begins the moment the lead step hits the ground and ends the moment the ball is accelerated forward by the passing arm (see Appendices E & F, frames 19-25). This distinction is made because in the second stage the ball will begin to move forward due only to the forward translatory movement of the lower body and the torso not because of any rotary movement of the passing arm (Jensen et al., 1983). The initiation of movement phase may be characterized by the forward initiation of movement (acceleration) of the ball by all body parts except the passing arm which, simultaneously, moves the ball backwards in the early phase. This backward movement serves to increase the initial muscular tension of the musculature required for acceleration of the ball (Jensen et al., 1983).

The initiation of movement phase begins the transfer of weight from the back foot to the front foot which serves to move "the proximal segment [the lower body] out from under the distal segment [the ball] in which case it is described as inertial lag" (Kreighbaum & Barthels, 1985, p. 595). Once the lead foot makes contact with the ground the ankle becomes the new axis of rotation and all reference points that were associated with the right foot are transferred to the left foot. For the sake of brevity the two phases will be

combined and distinguished only when appropriate (for a 3-dimensional visual reference of the following description see Appendices E & F, frames 1-25).

Feet

The right foot (back foot) marks the beginning of the first phase of the initiation of movement phase. It pushes against the ground and as a result the pressure is transferred from the back of the right foot to the sesmoid bones of the big toe. Eventually the right heel will be lifted off of the ground. At this point, however, the back foot will not lose contact with the ground until the moment before release which will be discussed later.

The transfer of weight from the back right foot to the front left foot is an example of a principle related to the law of inertia in general and specifically to the principle of combining translatory and rotary motions (Jensen et al., 1983). It is identified by the, "linear motion of the total body combined with the rotary motion of the body segments" (Jensen et al., p. 213).

The placement of the left foot, the lead step, is critical to the effectiveness and efficiency of the pass, both in relation to the quarterback's mechanics and to his accuracy in hitting the target. Consequently, it becomes the direction foot for motion. The placement is forward toward the target at 12 o'clock and lateral toward the left sideline at 10 o'clock. In addition, it should be quick and decisive. It should be placed approximately 12 inches to the left of the quarterback. This outside lateral placement is critical because it will compensate for the leftward shift of the quarterback's center of mass due to the lateral bending of the spine which is required by an over the top motion (Atwater, 1970; Collins, 1960; Sakaris, 1978). This outside placement of the left foot provides a new base of support in general (Halliday & Resnick, 1988; Hay, 1985; Jensen et al., 1983) and rotary stability specifically (Kreighbaum & Barthels, 1985). In this way the lead step provides "a new base for the forward moving CG [center of gravity]" (Kreighbaum & Barthels, 1985,

p. 513). Moreover, "this off-line placement of the striding foot permits the hips to be more completely rotated to the front than if the foot were placed on line" (Hay, 1985, p. 195) and it "permits a greater distance over which to apply the force which serves to increase final velocity" (Jensen et al., 1983, pp. 226-227). Accordingly, failure to step to the outside in this manner will cause the quarterback to lose his balance outside to the left. Consequently, this will destroy the proper sequencing of motion required for an effective and efficient throwing motion.

The heel to toe relationship of the lead step should be toe in and heel out. Therefore, the longitudinal axis which connects the left heel with the left toe (L line) should point inward toward the center of the target. This will insure that all forces applied to the football by the body will be "applied as directly as possible in line with the intended motion. Forces applied in other directions either retard motion in the desired direction or result in wasted energy" (Jensen et al., 1983, p. 227). This is a specific principle of force known as direction of force application. The quarterback should be taught to step to the outside hip of the receiver. His toes, however, should point inward toward the middle of the receiver. Consequently, the L line of the lead step will point inward across the X axis in the transverse plane toward the middle of the target. This lead foot alignment acts like an outside wall, and this wall is perpendicular to the ground. In addition, it extends from the outer most edge of the lead step to the receiver. Consequently, this wall directs the force, which is accumulated from the moment of release through the follow-through, toward the middle of the target. In this manner it compensates for the outward movement of the lead step.

The quarterback must simultaneously step approximately 12-24 inches forward toward the target (also known as stride length) for the same reasons cited above for the lateral placement. This distance will change depending on the depth and intensity of the pass.

However, the forward placement of the lead step should not be so great where it changes the angle of the left femur in relation to the pelvis to a point where it will inhibit and reduce the lateral bending of the spine. If this occurs it will inhibit an effectively and efficiently sequenced release and follow-through. A large forward lead step is usually due to the fact that the quarterback is uncomfortable using a curvilinear motion, throwlike pattern (serving a tennis ball) and opts rather for a rectilinear motion, pushlike pattern (throwing darts) which serves to flatten the path of the ball. However, a curvilinear path "is used for generating high linear velocity to the distal end of a series of links [the ball]" (Kreighbaum & Barthels, 1985, p. 604). Whereas the rectilinear path is used for accuracy. This, however, does not indicate that the quarterback cannot employ a curvilinear motion and at the same time be very accurate. To read the research in this manner would be a mistake. If the stride length is too long it can be corrected by having the quarterback place added weight on the ball of his lead step in conjunction with merely shortening up the stride length. Failure to use a rectilinear path instead of a curvilinear path is a bad habit sometimes related to past throwing experience in baseball. It can also be related to the fact that the young quarterback is uncomfortable throwing a heavier and bigger football rather than a lighter smaller baseball (Kreighbaum & Barthels, 1985).

At this point the quarterback transfers his weight from his right foot to his left. The left foot should absorb the weight primarily on the outside portion of the foot from the heel to the ball of the toe. In addition, the quarterback should not be allowed to place any weight on the heel until he learns how to place it on the ball and outside portion of the foot. The reason for this is that if the quarterback attempts to contact the ground with his heel this tends to extend his stride length. Nevertheless, if the quarterback can do this without over extending his stride then he should be allowed to do so. In any event, the goal is to

increase the surface area and thus the counterforce that the ground produces on the quarterback's body (Jensen et al., 1983).

Knees

In the early phase, the extension of the right knee in conjunction with the push of the right foot, initiates the forward motion of the body while the torso, shoulder, and the passing arm move the ball backward. At the end of the second stage the knee is nearly straight and the patella should be pointing toward the target.

Through the first phase the left knee is flexed and points toward the target (12 o'clock). At the end of the first phase, when the left foot makes contact, and at the beginning of the second phase, the knee will be flexed 70-75°. However, in the second phase it will begin to extend and thus accelerate the hips, torso, shoulders, and the ball forward before the ball is accelerated by the passing arm. The prime movers for extension of the left knee will be identified in the acceleration phase. For the most part, these movements will proceed naturally. However, sometimes problems will arise in these areas and it is best that the coach understands the sequence of events, related to the open kinetic link system, in order to provide accurate solutions.

Hips

The hips lag behind the forward position of the left foot and knee but lead and precede the torso by a slight margin (Kreighbaum & Barthels, 1985). Through the first phase the transverse axis of the hips will remain, for the most part, pointed toward the target (12 o'clock). In other words, they will remain in a closed position. At the start of the second phase the left hip becomes locked in the sagittal plane about the longitudinal axis of the left ankle. As the left hip begins to move forward in the sagittal plane over the new axis of rotation (the left ankle) the right hip, simultaneously, begins to move through the transverse plane counter clockwise about the longitudinal axis of the left hip toward the target, and

forward about the axis of rotation of the left ankle toward the target. The prime movers will be described in the acceleration phase. By the end of the second phase the right hip will have rotated forward and the transverse axis which connects the hips will be at 90° in relation to the X axis (right hip pointed at 3 o'clock and the left hip pointed at 9 o'clock). In other words, the hips will be in a fully open position toward the target. Nevertheless, they will continue to move forward about the axis of rotation at the left ankle.

Torso

The torso follows the motion of the hips through the first phase, that is, it remains closed. In addition, lateral bending of the spine begins at the start of the second phase. At the end of the second phase (the instant before the passing arm begins to accelerate the ball forward) the chest is expanded and thrust outward and forward which places the rectus abdominus on stretch. This increases the initial muscular tension by putting the muscles on stretch (Jensen et al., 1983). At this point the spine is maximally bent laterally toward the side opposite the passing arm. This places the right external obliques on stretch (Yessis, 1984). The torso is a wheel-axle arrangement. In other words, the spine acts like an axle and the external and internal obliques act like a wheel (Jensen et al., 1983). At this point the speed of rotation at the trunk is high. Consequently, it is assumed that "the spinal rotator muscles contract applying force to the spine (axle), thus causing the wheel [the obliques] to turn" (Jensen et al., 1983, p. 202). Moreover,

the vertebral movements function not only to contribute force for the movement but also to position and reposition the extremities, particularly the upper extremity...the vertebral column transverse rotation works with pelvic medial rotation to initiate the acceleration of the dominant arm. The transverse rotation has been shown to play a major role in producing high velocity of the hand in throwing and striking skills (Jensen et al., 1983, p. 271).

Because, "transverse rotation is the base upon which acceleration of the upper extremity takes place, it deserves much time in the training of athletes performing throwing and striking skills" (Jensen et al., 1983, p. 271).

Shoulders

Through the first phase the transverse axis of the shoulders remains pointed toward the target, that is the shoulders remain closed. However, in terms of forward rotation in the sagittal/transverse plane, the right shoulder will lag behind the hips and torso. Through the first phase the right shoulder will remain slightly higher than the left shoulder. However, in the second stage, as a result of the lateral bending of the spine, the difference in height between the two will increase. This should be facilitated by depression of the left shoulder due to contraction of the trapezius, and elevation and rotation of the right shoulder because of contraction of the trapezius and levator scapulae. In addition, the shoulders are retracted (military posture) because of the contraction of the rhomboids and trapezius. This places the pectoralis group and the serratus anterior on stretch which increases the initial muscle tension (Jensen et al., 1983). In other words, they are cocked and readied for action in order to impart force on the football. Through the second phase the right shoulder is accelerated forward and around about the longitudinal axis of the left shoulder. However, the left shoulder does not become locked and stabilized over the left hip and foot until the beginning of the acceleration phase. As previously mentioned, it lags behind the hips and torso. However, it will precede the elbow, wrist, hand, and ball.

Elbows

Through the first phase the passing elbow will point backward (6 o'clock) and the off elbow will point forward (12 o'clock). Consequently, the elbow of each will be shoulder height and the humerus of each arm will be parallel to the ground. However, at the beginning of and through the second phase, in order to facilitate and not inhibit the lateral

bending of the spine, the left elbow should point downward (this will occur with the aid of left forearm movement). If it is allowed to remain at shoulder height and pointing out to the side, through the second phase, this will prevent the depression of the left shoulder which will inhibit lateral bending of the spine toward the left side.

At the beginning of and through the second phase the right elbow will move forward. This, however, will not be due to any movement at the glenohumeral joint (horizontal adduction, extension, adduction). Rather, it will be due to the forward movement of the right shoulder about the longitudinal axis of the left shoulder and the forward movement of the hips, and the lower body through the sagittal plane about the axis of rotation of the left ankle. Consequently, the left elbow continues to move backward and/or it will at least remain locked in relation to the left shoulder from the second stage to the beginning of the acceleration phase.

Forearm

Through the first phase the forearms of both arms will move from their stance positions to positions perpendicular to the ground. The right forearm will attain this position due to humeral external rotation. At the moment the chest is expanded and the spine begins to laterally bend (beginning of the second stage), the forearm of the passing arm will become parallel with the ground. The position of the right forearm indicates that the right humerus is maximally externally rotated which places the supraspinatus on stretch. Nevertheless, this is due to a wind up and not inertial lag (Kreighbaum & Barthels, 1985).

Hands/Wrist

At the beginning of the first phase, and as the lead step is taken, the left hand separates from the ball. However, the separation should be due to the right hand moving the ball backward and not the left hand moving forward. This is critical because it indicates that the shoulders are remaining closed until the proper time when forward movement takes place

(this will facilitate proper sequencing). If the left hand is moving forward it could be due to the shoulders moving the hand or the fact that the hand is being thrust forward too soon. This would indicate that the hand is creating the sequencing problem. At any rate, the movement of the left hand allows the coach to detect and correct a sequencing problem with the shoulders. If the shoulders prematurely open before the lower body (proximal segments) has had a chance to decelerate, creating a base of support, then this will reduce potential power (Kreighbaum & Barthels, 1985; Yessis, 1984). By the second phase the left hand is nose high and sweeping across the face of the quarterback. It remains an extension of the left shoulder and any movement seen in the left hand aside from that which is caused by humeral external rotation should be minimal.

The right hand with the football begins to move backwards. It is critical that this backward motion of the ball takes place at the same horizontal level from which it began. In other words, the ball should not be lowered as it retreats. This is a bad habit that only serves to slow down the passing motion and provide the defense with an edge. In addition, at the time the lead foot contacts the ground the ball should be head high in the transverse plane.

The right wrist should remain in a neutral or semi extended position. It should not be flexed. If it becomes flexed too soon then it will inhibit an efficient sequencing of movement at release and follow-through (Pedegana et al., 1982). As the ball is moved backward the palm of the right hand and/or the direction arrow of the wrist point toward the sideline (2-3 o'clock). Consequently, the front point of the ball will point backward (4-5 o'clock). This is due to horizontal abduction at the glenohumeral joint and not radioulnar pronation. By the end of the second phase the seams of the ball will be perpendicular to the ground. This is due to horizontal adduction of the humerus and not pronation of the

forearm. The left hand, in relation to the left elbow, should remain in a superior position. This, in any event, is opposite to that of the pitching motion.

Head

During this phase the lateral bending of the spine will cause the quarterback's head to be tilted to the left. Consequently, the quarterback must tilt his head to the right side to keep his eyes level.

Acceleration Phase

The acceleration phase begins the moment the football begins to be accelerated by the passing arm and it ends with the release of the football. Of the 210° multi planar excursion, the acceleration phase, takes up approximately 70° on the X axis in the sagittal/transverse planes and is completed in less than 1/10 of a second (for a 3-dimensional visual reference to the following descriptions see Appendix F, frames 26-29). Muscular activity in the rotator cuff muscles (infraspinatus, supraspinatus, teres minor, and subscapularis) in this stage is minimal (Jobe et al., 1983, 1984). The greatest stress on the elbow occurs during the acceleration and follow-through phases (Pappas et al., 1985). The analysis of the deltoid, supraspinatus, infraspinatus, teres minor, subscapularis, pectoralis major, biceps, triceps, latissimus dorsi, serratus anterior, and the brachialis demonstrates that the biceps and triceps function primarily as elbow joint muscles. In addition, they fire intensely from the acceleration phase through the follow-through with the biceps reaching peak activity during the follow-through phase (Jobe et al., 1983, 1984).

Feet

The position of the feet remains unchanged through the initial stage of this phase of the passing motion. As previously mentioned the ankle of the left foot provides the new axis of rotation. However, at the moment before the end of this phase and the moment before release of the football the right foot loses contact with the ground. This allows for total and

maximum constant application of force in the proper direction over the greatest distance (Jensen et al. 1983).

Knees

The lead knee begins this phase at 130° of extension. It extends to nearly 180° of full extension at the point of release. This is accomplished by the contraction of the quadriceps muscles. Consequently, the right knee is nearly fully extended at this point. However, as the right knee passes forward it will be flexed. This reduces the moment of inertia at the right hip (the length of the radius from the right hip to the right toe) which allows the knee to pass quickly and efficiently forward through the acceleration phase in the sagittal plane, without destroying the proper sequencing of events. In addition, the right knee should pass through this phase at a width no greater than the shoulders. This will reduce the moment of inertia of the hips (the length of the radius from the left hip to the toe of the right leg) in the transverse plane.

Hips

"During throwing and striking activities, the movement of the pelvis at the hip joint plays an important role as the pelvis medially rotates around the supporting extremity" (Kreighbaum & Barthels, 1985, p. 223). Consequently, the hip joint in this case acts like a wheel-axle arrangement geared for speed. The right hip lags behind the left hip by $5-10^{\circ}$. Through internal rotation of the left femur the right hip at release achieves a position even with the left hip; a full facing position. The muscles responsible for internal rotation of the left femur at the left hip are the gluteus medius, gluteus minimus, gracilis, adductor magnus, tensor fasciae latae, semitendinosus, and the semimembranosus (Jensen et al., 1983). The angle between the femur of the left leg and the torso begins at 120° and at release the hip is flexed to 110° . The muscles responsible for this extension are the

semimembranosus, semitendinosus, biceps femoris, and the gluteus maximus (Jensen et al., 1983).

Torso

The torso, like the hips, begins this phase offset from a full open position by 5-10°. In addition, the torso remains laterally bent. It attains an open position at release due to the contraction of the right external obliques that were previously put on stretch. It is moved forward through the sagittal/transverse plane in the X axis, during the acceleration phase, 30° toward the target. This is critical to the total application of force.

Shoulders

The right shoulder lags in back of the left shoulder, hips, and torso. The left foot, left shoulder, and left hip provide an anchor and a base of support for the right shoulder and the passing arm. The right shoulder should not begin to move forward through the sagittal/transverse plane about the longitudinal axis of the left shoulder until the hips attain a front facing position. The rotator cuff muscles of the right shoulder that were wound up tightly during the initiation of movement phase unwind rapidly through the acceleration phase. As a result, the humerus is internally rotated. In addition, it is also horizontally rotated by the contraction of the anterior and medial deltoid.

Elbows

The left elbow remains pointed downward through this phase. In addition, as it moves backward, it should not pass the vertical alignment of the left shoulder in the frontal plane. This backward movement contributes to the rotation of the trunk (Hay, 1985). The right elbow begins its acceleration forward through the sagittal/transverse plane but only when the transverse axis of the shoulders becomes perpendicular to the sagittal plane. That is, the shoulders attain a front facing position. At the beginning of the acceleration phase the right elbow was flexed at 80-90°, however, at the end of the acceleration phase and at

release it is extended to 175° . Nevertheless, elbow extension does not contribute significantly to force production (Pappas et al., 1985).

Forearm

The left forearm remains perpendicular to the ground. In addition, the right forearm remains nearly perpendicular to the ground.

Hands/Wrist

The wrist of the right hand should be in a neutral or a slightly extended position. It should not be in a flexed position. The palm of the right hand, or the direction arrow of the right wrist, which began the acceleration phase pointed up to the sky, finishes this stage pointed 45° left of the target.

Head

The position of the head should remain in nearly the same position as the previous stage. The head remains erect and the eyes should be level.

Release/Control

The release is the explosive manifestation of the previously prepared and stored energy. Any and all of the muscles that were put on stretch in the previous stages have been releasing their energy in a sequential fashion from bottom (ankle) to top (wrist). The total stored and sequentially released energy culminates in the explosive release of the football. However, when the quarterback first learns to pass the football, the previous phases ending in the release must not be uncontrolled. The quarterback must learn how to control the spin of the football with his passing arm in general and the wrist and hand specifically. For example,

when it is traveling nose first, a football presents a smaller cross-sectional area and a more streamlined shape than when it is traveling broadside; the drag is roughly 10 times larger in the broadside orientation. This fact determines the best technique for throwing

a football; namely, it should be 'spiraled' or thrown nose first with a substantial spin about its long axis. (The spin gives the ball angular momentum, which stabilizes the orientation of the spin axis in flight). Launching the football with its long axis angled laterally to its path will shorten its range considerably (Halliday & Resnick, 1988, p. E6-5).

The most advantageous method for accomplishing this task and one that contributes to the most effective, efficient, and total application of force is humeral external rotation coupled with radioulnar pronation (for a 3-dimensional visual reference of the following descriptions see Appendix F, frames 30-31).

Feet

The right foot remains unchanged through this phase of the passing motion. However, occasionally the direction arrow of the left foot will move to the left about the longitudinal axis. This opens up the outside wall, created when the foot was planted, and disperses the built up energy over a larger area. This redirects the application of force which in turn reduces final velocity (Hay, 1985; Jensen et al., 1983; Kreighbaum & Barthels, 1985). An analogy may prove helpful in pointing out the problem. When the nozzle of a car wash hose is tightened the water is channeled into a smaller area "signaling an increase in the fluid velocity" (Halliday & Resnick, 1985, p. 374). Consequently, the water can travel a greater distance. On the other hand, if the nozzle is loosened the water is dispersed over a larger area which serves to reduce the fluid velocity. The water, at any rate, cannot travel as far as if the nozzle were tight. More accurately, this problem is associated with the concept of angular velocity. Angular velocity is identical with angular speed in this case because the body is rotating "through an angle equal to or less than 180° " and in "one direction" (Hay, 1985, p. 47). Angular velocity (w) is equal to angular displacement (O) divided by time (T) or $w = O / T$. Opening the left foot previous to and/or at the moment of

release increases the angular distance over the same amount of time (and/or more) thus reducing angular velocity and thus final velocity of the ball. This opening of the left foot is associated with a side arm motion because of the forces associated with this motion in the transverse plane. Specifically, it is due to the fact that the right foot may not have been lifted off of the ground before or at the moment of release. This type of error also serves to reduce the maximum distance and constant application of force.

Knees

The left knee is nearly fully extended approximately 175° and the patella is pointed toward the target. The right knee, which was extended 175° at the beginning of acceleration, is flexed to 140° at release (for the reasons that were previously mentioned).

Hips

The hips are in a front facing position. Consequently, the transverse axis is perpendicular to the flight of the ball. This position provides the longest force arm for the hips (Yessis, 1984). In addition, the hips are locked in position in the transverse plane. In other words, the right hip has decelerated about the transverse axis of the left hip at the instant of release. This is consistent with the theoretical open kinetic link system.

Torso

Through this phase the torso is in a front facing position. It should attain this position for the same reasons that were previously provided regarding the hips.

Shoulders

The shoulders, in this phase, are in a front facing position (Yessis, 1984). This is a characteristic of all the models that will be discussed in this chapter. The transverse axis of the shoulders is perpendicular to the flight of the ball. In addition, the shoulders are locked in a position in the transverse plane. In other words, the right shoulder has decelerated about the transverse axis of the left shoulder at the instant of release. Because the

longitudinal axis for transverse planar rotation of the right shoulder is through the left shoulder this front facing position provides the longest force arm at release (Yessis, 1984). If the left shoulder were allowed to move backward as the right shoulder pivoted around it the potential force would be reduced because there would be a shorter force arm and some of the force would be redirected to the rear. Consequently, this would cancel some of the forward force. This would also reduce the distance of force application and the ball's potential final velocity (Yessis, 1984).

Elbows

The left elbow remains unchanged: it points downward. The right elbow joint at release is extended to 170° and it points toward the sideline. However, according to the open kinetic link system the elbow should be extended a full 180° . The bent elbow at this point creates a wheel-axle arrangement between the forearm and the humerus as opposed to a lever arrangement which would be a result if the elbow were straightened to 180° . This wheel-axle arrangement is an advantage because "the greater acceleration in the wheel-axle system gives this system two and one half times the linear velocity of the lever system, although the lever system has a larger radius of rotation" (Kreighbaum & Barthels, 1985, p. 602). This is due to the fact that "the smaller rotational inertia of the wheel-axle mechanism allows a five times greater angular acceleration and thus greater angular velocity" (Kreighbaum & Barthels, 1985, p. 602).

Forearm

The direction arrow of the right forearm at the instant before the right index finger loses contact with the football (release) will be pointing toward the target. This indicates that the radius and the ulna have imparted their full 45° range of radioulnar pronation. The left forearm will be in the same perpendicular position.

Hands/Wrist

The right wrist remains stabilized. It should be in a neutral position (Atwater, 1971, 1979). The extensors as well as the flexors of the wrist are activated. However, the function of this activation, aside from contributing to ball speed, is not clear (Pedegana et al., 1982). It could be that they, in conjunction with the firing of the flexors, provide a stable foundation for the built up energy of all body parts at the explosive point of release. The right palm will be facing the target at the instant the index finger loses contact with the football.

Head

The head remains in the same position. This will enable the quarterback to remain focused on the target.

Follow Through

Although a correct follow-through imparts no force on the ball it eliminates the tendency to decelerate the passing motion before release is initiated and/or completed. In addition, a correct follow-through helps the quarterback maintain his balance, and it helps him to reduce stress by gradual deceleration of the joints, muscles, and the connective tissue that were activated during the passing motion (Jensen et al., 1983). The distance from release to the end of follow-through in the sagittal/transverse plane is 105°. This is nearly one half of the entire passing motion. From the coach's perspective, related to teaching, the follow-through is critical because it provides clues with respect to what the quarterback did during the motion phases of the pass. For the novice quarterback coach the passing motion is initiated and completed too quickly to analyze specific details without the aid of film analysis. However, with practice coupled with on the spot analysis of the follow-through, coaches can accurately describe and diagnose specific problems, and subsequently prescribe specific solutions. In the cognitive stage of learning the quarterback

should not be allowed to come out of his follow-through before instructed to do so. The rationale for this is twofold: (a) the coach needs to analyze the quarterback's final position, (b) the quarterback must be able to maintain his balance after the follow-through and the coach must be able to see this. If he cannot maintain his balance then there is a problem with foot placement in the stance or the initiation of movement phases. These problems will negatively affect the efficiency of the pass. In the subsequent analysis only the final position will be analyzed (for a 3-dimensional visual reference of the following descriptions see Appendices F & G, frames 32-66).

The follow-through utilized when passing the football from a stationary position is termed a far knee release (it is different than the near knee release utilized when passing the football while on the move, which will be discussed later). Newton's laws of motion, consistent with angular motion, are related to and dependent upon a specific axis of rotation. Consequently, the passing hand of the quarterback (which represents the end point of the radius from the axis of rotation) should end at the origin of rotation and stability. This end point is the left foot. A far knee release will increase the distance of force application over which each phase can take place. In addition, the maximum force generated between one object rotating around another is a direct line between the two and oppositely directed (Halliday & Resnick, 1988). The direct line is generated from the right hand to the left foot.

Feet

The left foot should finish in the same position as it started in the initiation of movement phase. The heel to toe line should be somewhat parallel with the X axis. The right foot should have travelled forward in the transverse plane to a point across from, at the very least, the arch of the left foot. In other words, it is lined up with the left arch on the Z axis. The R line of the right foot should be pointing approximately 45° across the face of the X

axis. The toe of the right foot should be all that is touching the ground. The distance between the two feet should be approximately shoulder width and it should have very little weight on it.

If the right toe remains in contact with the ground and/or if it should remain in a position behind the left foot this will cause premature deceleration of (a) the right hip in the transverse plane about the longitudinal axis of the left hip, (b) the right shoulder in the transverse plane about the longitudinal axis of the left shoulder, and (c) the entire body in the sagittal plane about the axis of rotation of the left ankle. If the right toe is lifted off of the ground before the moment of release and it is able to come through as described then the rest of the follow-through will proceed efficiently, effectively, and smoothly.

Knees

The patella of the left knee should be pointed toward the target and the knee could be slightly bent or fully extended. The right knee should be flexed 145° and the patella of the right knee should be pointed in the same direction as that of the right toe (10 o'clock). The direction with which the right knee is pointed in conjunction with the right toe will insure complete follow-through of the hips.

Hips

The hips should be pointed in the same direction as the right toe and knee. The zipper should not be facing the target but rather should be pointed toward 10 o'clock.

Torso

The chest should be facing in the same position as the right toe, the right knee, and the hips. The torso should be in a fairly erect position and should not be bent at the torso like a pitcher after release.

Shoulders

The shoulders should be facing in the same position as the right toe, right knee, hips, and chest. Consequently, they will be facing to the left of the target.

Elbows

The elbows at the point of maximum deceleration will be extended to 150°. The right elbow should be pointed toward the sideline 90° perpendicular to the line of flight of the ball. This indicates that the humerus has been maximally decelerated and has completed maximal internal rotation. The left elbow is extended which increases the moment of inertia at the shoulder girdle. This helps to slow the rotation at the torso.

Forearms

The forearms are basically perpendicular to the ground. The difference is that the wrists are below the elbows.

Hands/Wrists

The palm of the right hand and the direction arrow of the right wrist should be pointed in the same direction as the right elbow (the sideline). This indicates that the radius and the ulna have completed radioulnar pronation.

Head

The eyes should be directed at the target. The head may be tilted but ideally the eyes should be level.

DROPPING BACK TO PASS

Introduction

Before the quarterback has the opportunity to pass the football he must drop back (retreat from behind the center) to a depth determined by play selection. This is a requirement provided that the shotgun formation, or a play pass has not been selected. Nevertheless, the requirements of the quarterback in the shotgun formation or the play pass

are not problematical as they are in the straight drop passing game where "the quarterback has to get back cleanly, under full, balanced control" (Walsh, 1978, p. 31).

Coaches agree that the straight dropback passing game can be packaged into three ranges related to receiver route depths: short, medium, and long. The rationale for each has best been described by Bill Walsh (1978). The required steps of the quarterback to function in each is as follows: short - 3 steps (some coaches use 1 or 2 steps); medium - 5 steps; deep - 5 or 7 steps. In conjunction with these step requirements coaches have suggested depth, set and release times. However, they do not regard them as critical, "we don't time our quarterbacks. I don't see this as being of any value. We can always get a 9.3 sprinter to drop back faster than anybody else" (Walsh, 1978, p. 31). Nevertheless, they will admit that "the key to the seven step drop is how fast you can get back" (Walsh, 1978, p. 31). The times suggested are dependent upon the depth requirements determined by the coach in each package.

1. 3 step drop: depth - 3 to 5 yards, set time - 1.1 to 1.3 seconds, release time - 1.3 to 1.5 seconds;
2. 5 step drop: depth - 5 to 7 yards, set time - 1.3 to 1.5 seconds, release time - 1.4 to 2.2 seconds;
3. 7 step drop: depth - 9 to 10 yards, set time - 1.7 to 1.8 seconds, release time - 2.3 to 2.4 seconds (Amedee, 1988; Edwards, 1983a, 1986; Eisaman, 1984; Fry, 1985; Kincaid, 1985; Mallory, 1988; Schnellenberger, 1984b; Sheppard, 1986; Trestman, 1986; Walsh, 1978, 1981).

Regardless of times Pannes (1967) suggested that the technique used to drop back (crossover, sprintback, backpedal) did not impact the length of time required for a specific distance. However, Walsh (1979) suggested that the coach and quarterback must consider how each technique might impact the quarterback's ability to "get his feet right" (p. 91). In

addition, Wyche (1983) stated that the drop must not inhibit the quarterback's ability to find the backside one third of the defensive display.

Stevens (1988) taught his quarterbacks to point their hips and toes at "11 o'clock" toward the backside goal line and at the same time set his shoulders at "right angles to the line of scrimmage" (p. 239). Wyche (1983) disagreed with Stevens (1988), and stated, "we want to make sure he is running with a crossover" in order to "find the left one third up the field" (pp. 272-273). At one time Bill Walsh advocated the "sprintback" technique (also described by Pannes (1967)), and taught his quarterbacks "to get back quick, to completely turn his back the first three steps" (1978, p. 31). Coach Walsh has since changed his approach to that of Wyche (1983).

It is difficult for an offensive line coach to teach his linemen to pass protect for quarterbacks who are inconsistent with depth and time. Inconsistent dropback depths and times change the attack angle of the defensive linemen relative to the depth of the quarterback in a commensurate manner (Gillman, 1981). This serves to change the offensive linemen's protection angle relative to these two variables which is compounded by the fact that the defensive linemen can see the quarterback and the offensive linemen cannot. Consequently, if the quarterback's depth is too shallow and the offensive lineman sets at his normal protection depth then the defensive lineman has the opportunity to gain a sack or a flush through an inside pass rush lane. In any event, this inconsistency causes more sacks which are erroneously blamed on the offensive linemen. This is a major reason that consistent dropback depths and times are critical (Gillman, 1981).

There are three types of passes which can follow a particular dropback pattern and are immediately employed once the last step contacts the ground. Each is impacted by the drop that is employed: (a) set and throw on time; (b) set, read, and throw; (c) hitch and throw; (d) hitch, set, read, and throw; (e) hitch, set, hitch, and throw. There are three variables

which determine the type of technique utilized: the type of pass play, the pre-snap defensive alignment which may or may not be impacted by the third variable, the post-snap defensive movement which is required versus a disguised coverage. Because the use of disguised coverages will be determined by the philosophy of the defensive coordinator and/or the level of play, this last variable may not be a concern. For example, if the defense does not use disguised coverages then the technique utilized may be determined by the pre-snap alignment of the defense. On the other hand, if the defense utilizes disguised coverages then the technique employed will need to be decided upon as the quarterback is dropping back to pass (Gillman, 1981). Toward the end of the drop the quarterback must cushion his built up momentum, set his feet, and maintain his balance. These attributes will collectively prepare him to pass the football effectively and efficiently.

As was mentioned earlier the most difficult of these techniques to teach and learn is the one which requires the quarterback to throw the football once his last step (3, 5, or 7) contacts the ground without any extraneous foot movement (Gillman, 1981). In other words, to set and throw on time. In order to accomplish this the quarterback must be coached to stop his backward momentum with his next to last step (2, 4, or 6). This will allow the quarterback to achieve a stance that is identical to the one employed when he is not dropping back to pass (see the previous section on the stance phase). This will be discussed in more detail in the following sections.

Only the three and five step drops will be analyzed. In addition, the five step drop described employs a stretch step (Hackett, 1981, 1990). The one step drop is fairly easy to teach and the three step drop is a reduction of the five step drop and the seven step drop is merely an extension of the five step drop. Consequently, the most efficient method for teaching the three, five, and seven step drops is to base all techniques on the five step drop. For example, the three step drop consists of the last three steps of the five step drop and the

seven step drop is merely preceded by two quick steps before a five step drop. To begin with, the five step drop is described to the quarterback in the following manner: one, two, s-t-r-e-t-c-h, four, five. Consequently, the three step drop is merely stretch, four, five of the five step drop and the seven step drop is preceded by two quick steps and is described as quick, quick, one, two, stretch, four, five. For these reasons the five step drop will be discussed first. Coaches must keep in mind that the word "stretch" may negatively impact the quarterback's ability to perform the drop. The reason for this is not clear but it may be a potential problem. Some quarterback's feel more comfortable thinking of the stretch step as "three" and not "stretch."

Three coaching points should be mentioned at the outset as they are applicable for all the following models. First, the initial step of the quarterback away from the center should not pass beyond an imaginary line which begins at the left heel and is perpendicular to the line of scrimmage (LOS) (drop axis). In other words, the line of the quarterback away from the LOS should be perpendicular to the LOS beginning at the left foot and/or it should be directed to the right of the drop axis (see Appendix H). This will serve to increase the distance the quarterback can travel over time and it will keep him away from a backside rush which he cannot see. Second, as a general rule the quarterback should point his toes toward the sideline as he is dropping back. The quarterback should be coached to lead with his ankles and not with his toes. If he leads with his toes then the transverse axes of his hips and shoulders will not be perpendicular to the LOS. Consequently, he will have trouble finding the backside one third of the defense because the range of motion of his torso, shoulders, and head will be restricted. In addition, leading with his toes will prevent the fifth step and the direction arrow from being properly placed. This is especially critical when a pass over the middle or backside is required. Third, the initial contact point of the drop steps should be the balls of the feet. The exceptions are the set steps of the frontside

and backside five step drops and the set step of the three step frontside drop. The set step of the three step backside drop will contact the ground on the balls of the foot.

No detailed analysis will be provided regarding the stance behind the center. However, this does not indicate that this part of the quarterback's mechanics should not be coached. This part of his technique is critical because if he cannot receive the ball from the center then there can be no play. In addition, this part of the quarterback's mechanics must achieve the autonomous stage of learning. The quarterback must have no concern about receiving the ball from the center. While under the center the quarterback should be comfortable and relaxed. His elbows should be bent as should his knees and hips. His feet should be shoulder width apart and the toes of his left foot should be in line with the heel and/or at least the arch of his right foot. In addition to removing him from the LOS for the purpose of distance, the toe to arch alignment will serve to further clear his body from the LOS and out of the way of the offensive line more so than if his feet were positioned toe to toe (see Appendix H). More importantly, it will allow him to do so without any added movement. Some coaches teach their quarterbacks to stand toe to toe and to then take a short jab step backwards with the left foot as a means to remove them from the LOS before their first step back with the right foot. For a quality explanation of this part of quarterback mechanics see Hackett (1981).

Five Step Drop Frontside

The five step drop can be described as one, two, stretch....., four, five (the notation (.....) indicates a delay). Moreover, the fifth step will contact the ground quickly after the fourth step. Because the rhythm of the drop is critical (Hackett, 1981) it is helpful to have the quarterback clap the rhythm. Aside from the number of steps, the major difference between the three and five step drop is the use and placement of the arms. The reason for movement of the arms is very similar to that of running. For a detailed analysis see Hay

(1985, pp. 411-412). The difference, however, is that the arms move across the body in opposition to the legs which are moving the quarterback away from the LOS with a series of cross over steps. This, obviously, is different from the mechanics of running. The main purpose of the arms is to "cancel out the contrary alternating angular momentum of the legs" (Hay, 1985, p. 412).

One and Two

The quarterback initiates the first step by simply sitting down. This forces his center of gravity to fall backward of his base of support and thus a loss of balance in the desired direction. Consequently, "the gravity line is taken as far away as support friction permits from the base edge in the direction of motion" (Kreighbaum & Barthels, 1985, p. 519). In addition, the quarterback must push and pivot with the left foot while under the center and simultaneously angling his torso backward. The backward angle of the body for the first two steps is similar to that of the first step of the three step drop although the angle of the torso here will be more severe over time and space (see Appendix I, frames 1-20). The purpose of the second step will be to change the angle of the torso to an upright position by providing a base of support for the stretch step as it is opened up and thrust backward (see Appendices I & J, frames 22-41).

Three (Stretch)

As the stretch step is thrust backward the toe should point toward the sideline and the aiming point for contact of the stretch step should be the line of the drop axis or a point to the right of the drop axis. This will insure that the transverse axes of the shoulders and the hips remain perpendicular to the LOS. This will enable the quarterback to view any part of the defensive display while he is dropping back to pass. In addition, it will insure that the maximum distance can be achieved by the stretch step. However, if a pre- or post- snap read dictates a frontside release then this is not critical. In any event, this is determined by

the type of route package employed. For example, the present description is that of a five step frontside dropback. Consequently, the quarterback's right toe may point toward four or five o'clock (see Appendix J, frames 34-42). At any rate, the push of the third step serves several purposes: create distance which would not be possible with a normal drop step (Hackett, 1981); prepare the body for deceleration by changing the backward lean of the torso to an upright position; rotate the torso, stance arrow (set step) the direction arrows, and the X axis to the right of the drop axis. When the stretch step makes contact with the ground it provides a base of support for the fourth step which is a crossover step (see Appendix J, frames 42-58).

Coaching point: Through the first three steps the vigorous movement of the arms is a critical component. This is especially true in the first two stages of learning. In addition, during the early stages of learning the quarterback should exaggerate the vertical component of the stretch step. However, as he progresses through the three stages of motor learning he should exaggerate the horizontal component.

Four (Cushion)

The main purpose of the fourth step is to stop the quarterback's built up momentum (see Appendix J & K, frames 59-78). For example, in order to decelerate the built up momentum generated from the first three steps the fourth step must be

planted ahead of the line of gravity, causing resistive ground friction and a weight torque that tends to rotate the CG [center of gravity] backward and downward about the foot base. The friction impulse provides some resistive force to slow the forward body momentum, which tends to carry the body forward [in this case backward] over the foot (Kreighbaum & Barthels, 1985, p. 520).

Nevertheless,

if too much lean is created for deceleration or reversal, the feet become unweighted to the extent that the ground friction is insufficient to secure the foot, the base of support slides out from under the body, and the body slides linearly in the direction of the existing momentum (Kreighbaum & Barthels, 1985, p. 521).

Therefore, it is critical that the quarterback find the optimal degree of torso lean. This is in part determined by the surface of the playing field and his drop speed. In addition, he must bend at the knees and hips in order to lower his center of gravity which will help decelerate his built up momentum over a longer period of time (Kreighbaum & Barthels, 1985). In other words, the fourth step acts like a shock absorber, it cushions the abrupt shock. For example, when jumping off of a table it is critical that one bends at the knees and at the waist if balance is to be maintained, let alone to prevent injury to the joints in the lower extremities. Moreover, a properly executed cushion step will allow the quarterback to place his fifth step down efficiently with the stance arrow pointing in the proper direction. In the present description the proper direction is frontside. In addition, it will allow the quarterback to control the width of the stance. Without a cushion step the quarterback will not be able to set and throw quickly. Moreover, any pass package that requires this sort of precise timing and/or environmental condition which forces the quarterback to pass the ball quickly off of his set step without resetting will always be late. For example, if he does not lean into the LOS and cushion on the fourth step then he will have no recourse but to transfer the built up momentum to the fifth step which will cause the fourth and fifth steps to be separated by a large distance. In order to pass the ball from this extended position one of two corrections can be made. The quarterback can hitch the fifth step forward toward the fourth step or he can pull his fourth step back toward his fifth step in order to attain a proper stance position. In any event, each of these corrections takes time. The

result is that the pass will be late and tipped or intercepted, or the quarterback will be sacked. In addition, it will be difficult for the quarterback to control the position of the fifth step in a manner which will enable him to pass the ball to the backside. Nevertheless, if the quarterback has to read a defensive player and/or wait for a receiver to clear a zone or a defender and is not able to pass the ball on time then this foot would remain in contact with the ground until the initiation of the movement phase.

Because of the torque created by the push of the stretch step, the toes of the fourth and fifth steps at contact will point towards 5 o'clock. The fourth step, however, will be placed to the right of the drop axis while the fifth step will be placed on the drop axis. All of the direction arrows described in the stance phase will be pointed to the frontside target.

Five (Set)

The fifth or set step is synonymous with the stance arrow. Consequently, the quarterback's ability to pass the ball to any receiver quickly, effectively, and efficiently off of his fifth step is dependent upon his ability to point the stance arrow toward the target once the fifth step makes contact with the ground (see Appendix K, frames 97-99). In addition, this technique will allow him to do so without hitching and/or resetting his feet. Once the fifth step is set all of the recommendations that were made earlier regarding the stance phase of the passing motion are applicable here. Moreover, the fifth step acts like a wall from which the quarterback's momentum is deflected. For example, if the quarterback was required to pass the ball directly over the middle then the stance arrow would need to be pointed perpendicular to the LOS. Consequently, the transferred momentum from the fourth step, albeit a small amount, would be reflected at a line perpendicular to the R line of the fifth step (see Appendix L, Dropback: Down the middle of the field). In this case the quarterback would be able to regain his balance while he attained a set position quickly and efficiently because "the base of support" is "enlarged in the direction of momentum and in

the direction of intended deceleration" otherwise known as the balance principle (Kreighbaum & Barthels, 1985, p. 521). On the other hand, when the quarterback must pass the ball to the frontside the balance principle cited above is violated. For example, the transferred momentum is reflected off the wall in the direction of the toes, in a forward direction, causing the quarterback to lose his balance in the forward direction toward 5 o'clock (see Appendix L, Dropback: Frontside). Conversely, the backside technique will cause the stance arrow to the backside and the toes of the fifth step will point to 1 or 2 o'clock. The transferred momentum in this technique, however, will be reflected in the direction toward seven o'clock. In other words, the quarterback will lose his balance backward (see Appendix L, Dropback: Backside). Nevertheless, the frontside technique is not as problematic as the backside one because with the frontside technique the quarterback can at the very least employ dorsi flexion of the feet to counteract the forward loss of balance. With the backside technique, however, the quarterback cannot utilize dorsi flexion of the feet to counteract a leftward and/or backward loss of balance. Nevertheless, this is an easy problem to correct. His only recourse to compensate for a leftward and/or backward loss of balance is to simply exaggerate the cushion and set steps of the drop. This is a critical point because all too often this technique will not be taught simply because of this problem and a valuable technique which enables the quarterback to be more effective and efficient is eliminated because of a seemingly difficult problem which is easy to correct.

If the quarterback is experiencing a problem executing the cushion and set technique a coaching point may prove helpful. The coach should ask the quarterback to hit his fourth step, maintain his balance, and not place his fifth step on the ground until the coach directs him to do so. This can be preceded by the first three steps or by the stretch step only. This will force the quarterback to sit down and cushion his momentum. In any event, it will provide the recall and recognition schema with concrete experience of how it should feel to

hit his fourth step hard in order to stop his momentum and not rely on the fifth step to accomplish this task. He will experience the feeling of leaning back into the LOS.

Five Step Drop Backside

The differences between the frontside and backside drops are centered in the stretch, cushion, and set steps of the drop. Therefore, the first two steps will not be detailed here. Moreover, the differences in the stretch step are few and will be detailed briefly.

Stretch

The difference between the stretch step in the backside drop and the frontside drop is twofold: (a) the direction that the toes point as the step is thrust backwards, and (b) the intent when the foot pushes off of the ground during the third step. With the backside technique the toes must point toward the sideline (see Appendix M, frame 8).

Instead of pushing and creating a torque which serves to rotate the fourth step and point the direction arrows to the right of the drop axis the stretch step must not create a torque. Moreover, the quarterback must insure that his third step, when it contacts the ground, is aligned with the drop axis. If this is accomplished then the transverse axes of the hips and shoulders will remain parallel with the drop axis and the sideline and perpendicular to the LOS. This allows the quarterback full view of the defensive display. If, on the other hand, this is not accomplished it will be difficult for the quarterback to find the backside one third of the defense. At first glance this appears to be a simple technique. However, it is a technique that requires much practice.

Four (Cushion)

Unlike the frontside cushion step, the backside cushion step will remain in line with the drop axis once it makes contact with the ground. Nevertheless, as the quarterback becomes familiar with this technique it is possible that the cushion step may be rotated to the left of

the drop axis. The toes of the left foot will point toward the sideline (see Appendix M, frame 22). In addition, the R line will be almost parallel with the LOS.

Coaching point: This step might need to be exaggerated if the quarterback is not familiar with this technique. In other words, the quarterback may have to exaggerate the bend in the knees and the hips to perform this technique correctly. In any event, this step is critical because the center of gravity must be lowered in order to compensate for the fact that the balance principle is violated as described in the frontside technique.

Five (Set)

When the fifth step makes contact with the ground the transverse axes of the hips and shoulders will be perpendicular to the LOS and not pointed in the direction of the stance arrow. Moreover, instead of the toes of the fifth step pointing in the same direction as the fourth step they will point towards 2 o'clock. As a result, the stance arrow will point toward the backside target but the direction arrow of the hips and shoulders will be pointed toward the middle of the field (see Appendix M & N, frames 28-44). The recommendations made in the stance phase of the passing motion are applicable once the initiation of motion is started and the fourth step loses contact with the ground. Once the initiation of movement is started the transverse axes of the hips and the shoulders will point toward the target.

Coaching point: If the stance arrow is not pointed to the backside target then the quarterback will have difficulty executing a proper lead step. This will cause mechanical problems which will in turn cause functional problems related to accuracy and velocity (for a detailed analysis see the section Initiation of Motion). Functionally, the velocity of the ball will be reduced and the quarterback will tend to pass the ball behind a receiver that is running a route into the sideline.

Three Step Drop Frontside (throw on time)

One (stretch)

The technique for the frontside model is similar to the backside model in that it is described as throw on time. It is not described as set, read, and throw. The reason for this is due to the fact that these techniques do not include a set step such as there is with the set, read, and throw technique.

The frontside three step drop should be explained to the quarterback as stretch....., four, five. The stretch step is the largest of the three in time and space. During the stretch step the ball should be carried at the chest or jaw bone level. Therefore, there will not be much arm motion. The purpose and intent of the stretch step is similar to that of the five step technique. Consequently, the quarterback's body will remain in a more upright position as he moves away from the center as opposed to a backward leaning position with the first step in the five step drop (see Appendix O, frames 1-21).

Two (Cushion)

The purpose of this step is identical to that of the five step drop. The forward angle will not be as pronounced as required in the five or seven step drop because there is not as much momentum built up in the three step drop (see Appendix O, frames 21-31). If there is no cushion then the quarterback will not be able to control his set step. As a result the set step in relation to the cushion step will be too wide, there will be too much pressure placed on the front foot in the stance, and the direction arrow will be placed improperly.

Three (Set)

The direction arrow of the set step should be pointed at the target. This will insure that the stance will be closed for reasons that were explained in the "Passing-Stationary" section (see Appendix O, frames 32-44). Once the transfer of weight to the set step is complete the initiation of motion phase of the throwing motion will begin.

Three Step Drop Backside (throw on time)

The backside technique is similar to the frontside technique in that they both require the quarterback to pass the ball on time. However, the backside technique is different than the frontside model in that the steps are more evenly dispersed over space and time (aside from the first step). It can also be described as a four step technique because of the absence of a true set step. Therefore, it can be described simply as one.....two, three, four with the fourth step representing the lead step of the initiation of movement phase.

Obviously, the execution of this technique is determined by the style of the defense and/or the pre-snap read. For example, if the opposition's style is one wherein they do not employ disguised coverages then this is an effective and efficient technique. On the other hand, if the opposition's style of defense is one wherein it disguises its coverages then the quarterback will not be able to rely on pre-snap reads to determine whether the backside receiver will be open. The pre-snap read could indicate that the corner would be responsible for the deep third which provides a free area for a short pass and catch type route to be run into this area but upon the snap of the ball the corner would roll up and cover any short routes. With this technique, the quarterback would throw into coverage and suffer either an interception which turns the ball over to the opposition and/or the ball would be batted down which is identical to wasting a down. If this is the case then the question is as follows: what is the best technique to combat this defensive strategy? The answer is simple, all that is required is the implementation of the last three steps of the five step backside technique. In other words, stretch....., four, five of the backside drop. And like the three step frontside drop, the quarterback's torso will remain upright. In any event, this technique will allow the quarterback to check the backside coverage before his motion is initiated. In other words, set, read, and throw. Nevertheless, because this technique is a combination of the three step frontside and the five step backside drop it will

not be presented. Moreover, the backside technique presented is the more difficult of the two to teach and learn.

One

The first step of the backside technique is similar to the frontside model except that it does not cover quite as much distance. Therefore, it is not termed a stretch step (see Appendix P, frames 1-20).

Two

This step does not have to absorb as much force as it did in the frontside technique because the built up momentum will instead be transferred quickly to the third step. In addition, there will not be as much torso lean back into the LOS when this step hits the ground. For these reasons step two is not termed a cushion step (see Appendix P, frames 21- 31).

Three

The distance between the second and third step is greater than the distance between the last two steps of the frontside technique. In this way a quarterback can compensate for the shorter first step associated with this drop technique. Once the third step contacts the ground the direction arrow should point toward the backside target (see Appendix O, frame 33). In other words, the toe of the third step will point toward 1 o'clock. In addition, the second step should lose contact with the ground once the weight is transferred to the third step (see Appendix O, frames 37 & 38). This is different from the techniques which require the quarterback to set, read, and throw. For example, when the quarterback must set, read, and throw the cushion step will remain in contact with the ground while the quarterback's center of gravity is shifted over the cushion step to the set step. Moreover, it will remain in contact with the ground until the initiation of motion phase of the passing motion. This is critical because if the quarterback is required to pass the ball on time to the

backside and the second step remains in contact with the ground then the quarterback will not be able to rotate his hips, torso, and shoulders to the backside. All of the problems related to the improper placement of the lead step are applicable here as well. Therefore, it is critical that the quarterback understand that once his weight is transferred to the third step his second step should immediately lose contact with the ground and it should start moving in the transverse plane backside toward his target.

Four

The fourth step is the initiation of movement lead step (see Appendix O, frames 36-44), so all of the recommendations provided in the section regarding passing the ball from a stationary position are applicable. Nevertheless, the difference between those recommendations and the technique here is that the quarterback is not initiating his movement from a stationary stance. The effective and efficient execution of this technique has two requirements. First, the stance arrow must be pointed to the backside. Second, the fourth step must move in the transverse plane toward the backside across the drop axis and contact the ground in a manner consistent with the recommendations provided in the section initiation of motion phase (step of the midline) (see Appendix O, frames 32-44). The problem is that these two requirements will cause the quarterback to lose his balance to his left. Nevertheless, the quarterback must not pass the ball on the X axis toward the target and yet let his center of mass fall to the left of the line of the flight of the ball. To compensate for this problem the quarterback must (a) cushion on three; (b) actively push himself toward the target off the third step; (c) step to the left of the target with four; (d) and pull himself toward the target during the initiation of movement and through the release and control phases of the passing motion. In other words, the quarterback should be coached and told to "step to the outside and push and pull your motion toward the receiver." The

quarterback should chase the ball down its flight path toward the receiver. However, it will not be done to the same degree as passing the ball while on the move.

PASSING WHILE ON THE MOVE

Introduction

The preceding descriptions and prescriptions are related to the passing motion while the quarterback is stationary. However, he will be able to throw from this stationary position only if the offensive line has been successful executing the pass protection scheme thus controlling the environment which surrounds the quarterback. This small environment is known as the pocket. Tom Moore conducted a study of quarterbacks in the National Football League and found that 43 percent of the time the quarterback is moving while he is attempting to pass the football (Bielat, 1986). Moreover,

there are a couple of advantages for moving outside [to pass]. One certainly is to avoid the inside pass rush. For a drop back passing team we will sprint, or waggle as we call it, outside to avoid blitzers who approach straight up the field on us. The other advantage is to bring yourself closer to the potential receiver (Walsh, 1981, p. 86).

However, the technique of passing the football while on the move is rarely discussed by coaches or biomechanists, and if discussed, it is done in a very superficial manner. Regardless, it is an important component which determines quarterback success. This is especially true in those offensive structures which are based on the skill of the quarterback to pass the football while on the move such as the "Run-And-Shoot" (Ellison, 1984) and or any offensive structure which is designed to be truly balanced.

Gruniesen (1984) and Sloan (1984) made conflicting recommendations regarding this quarterback technique. Gruniesen recommended that the football be released with the elbow attaining shoulder level (sidearm). This would lead to an across the body follow-through pattern. Sloan, however, recommended that the quarterback "does not want to

throw across his body" (p. 256) but he provided no technique for insuring that an across the body follow-through pattern succeeded release. Each agreed with Carlson (1962) that the quarterback should run toward his target with his hips and shoulders square to the target before release and that the right leg and not the left becomes the plant or load leg from which the football is delivered for a right handed quarterback. Although the analysis regarding the plant leg is consistent for all models of passing the ball while on the move, the alignment of the hips with the shoulders is not always possible. This is true for the infielder in baseball, and certainly the quarterback. However, the technique of passing the football while on the move to a receiver which is crossing the face of the quarterback is never addressed in the literature. These types of passes or styles of passing are critical because "defenses have become so sophisticated that they force a passer to utilize many different styles" (Anderson, 1984, p. 77).

This is one of the most important components of this book. This topic ties the science of biomechanics to the chapters of philosophy and motor behavior. For example, with respect to the philosophy chapter, if the offensive philosophy is to be truly balanced in order to provide the players with a chance to win the competitive game then the quarterback must be able to pass the ball from a stationary position and he must be able to pass the ball while on the move. Therefore, it must be determined which type of arm motion (over the top or sidearm) is more effective and efficient for accomplishing this task. In terms of the motor behavior chapter, there must be some understanding of how the quarterback can be trained to master the technique of passing the ball while he is on the move. The goal must then be to program the computer (the quarterback's brain) utilizing specific computer language (Schmidt's schema theory) with software (correct biomechanical models) that will enable the quarterback to effectively and efficiently employ the specific type of passing motion in an open environment. For this chapter the following section will provide

objective rationale identifying why an over the top motion is more effective and efficient than a side arm motion for throwing the necessary passes in a balanced offensive structure. In addition, the recommendations and descriptions that were provided regarding the passing motion from a stationary position are applicable. An analogous detailed analysis will not be presented. Nevertheless, there are differences and where necessary they will be pointed out.

On the Move Direct

Sprint Phase

The sprint phase is characterized by the normal body lean of the quarterback while he is running. The major difference is the action of the arms. While running under normal conditions the arms should pass forward and backward in the sagittal plane and there should be very little rotation of the shoulders in the transverse plane (Hay, 1985). However, because the quarterback is carrying a football the arms will pass across his body in the transverse plane and the shoulders will rotate in this plane as well. Nevertheless, for all intents and purposes the quarterback's running motion will be the same.

Control Phase

The control phase is characterized by a sharp change in the quarterback's posture. At this point there should be no forward body lean and the ball should be prepared for release and placed in a similar position to that of the stationary technique. There will be no movement with the arms. Moreover, the quarterback's body must be under control. This will allow him to pass the ball in an effective and efficient manner. This phase is somewhat analogous to the stance phase because it is here that the ball will be set. The obvious difference between the two is the nature of the stance. For example, when passing the ball from a stationary position the stance is closed. That is, all of the direction arrows are

pointed toward the target. When passing while on the move the quarterback's stance is open.

As the quarterback becomes more familiar with this technique he will be able to eliminate the control phase altogether if the environment dictates that there is no time to pass through a control phase. This does not indicate that he will be able to lean into the pass as much as if he were running but it does indicate that the posture may not have to change as drastically nor will the ball have to be set in order to pass the ball while on the move in an effective and efficient manner.

Initiation of Movement Phase

This phase is divided into two phases. The first stage begins the moment before the left foot contacts the ground (see Appendix Q, frame 1) and ends the moment the right foot contacts the ground (see Appendix Q, frame 15). The second phase begins the moment the right foot contacts the ground and it ends the moment the ball is put in forward motion by the right arm (see Appendix Q, frame 15). Obviously, one of the biggest difference between passing stationary and on the move is the fact that while passing on the move the quarterback is in an open position. Nevertheless, it is critical that the quarterback at some point close his "stance." In other words, the quarterback must point the direction arrow of his left shoulder toward the target. It is during the initiation of motion phase that the quarterback must get this accomplished (see Appendix Q, frames 11-13). This phase in general is characterized by the rotation of the torso and shoulders in a clockwise direction about the longitudinal axis of the spine in conjunction with the passing arm and ball being cocked while at the same time the hips remain in an open position. This action initiates inertial lag. Inertial lag helps to stretch the upper body musculature. This increases the amount of force they can generate during the passing motion.

The lack of movement of the arms and shoulders, the placement of the ball during the control phase, and the movement of the arm in the first phase of the initiation of movement phase creates a glitch in the rhythm of running. For example, when running with a normal pattern, the motion of the legs and arms is opposed contralaterally. That is,

as the athlete's left knee is swung forward and upward, the right arm is swung forward and upward and the left arm backward and upward, to balance the leg action. Then as the left foot is lowered and the right leg starts to move forward, the actions of the arms are reversed (Hay, 1985, p. 411)

In addition, when running, the transverse axis of the shoulders should remain perpendicular to the intended path. In other words, the shoulders should not rotate forward and backward (Hay, 1985). Nevertheless, this principle is first violated in the sprint phase because the arms are swinging across the quarterback's body. It will also be violated in this phase because the quarterback has to rotate his torso and shoulders in a clockwise direction about the longitudinal axis of the spine to pass the football. In addition, during the first phase when passing while on the move as the left leg is planted the left arm and shoulder will be moving forward instead of backward and the right arm will be moving backward instead of forward. This may cause the quarterback to initially feel uncomfortable, but this type of rhythm is critical to the effective and efficient execution of the pass.

The second phase begins the moment the right foot contacts the ground. The right foot becomes the direction foot for motion when passing on the move in an identical way that the left foot was when passing from a stationary position. The right toe must point toward the designated target (See Appendix O, frame 15). The second stage is characterized by the left leg being thrust forward while at the same time the torso, shoulders, and passing arm are rotating clockwise about the longitudinal axis of the spine (see Appendix O, frames 14-

22). This is a characteristic that is consistent with the open kinetic link system and inertial lag. At this point the rhythm of the running pattern is momentarily resumed. For example, as the right leg is moving forward and contacts the ground the left arm will be moving forward and the right arm, in addition to the torso and shoulders, will be rotated clockwise to its furthestmost position. In this manner the direction arrow of the left shoulder will point toward the target. This is a critical point. Because of the quarterback's open position when running, he will tend to be lazy with, what can be termed, "getting his shoulders around." If this occurs and his shoulders remain in a front facing position at this point then he will not be able to generate any force with the shoulders or the torso, and he will be passing the ball with only his arm. The recommendations that were provided in the section for passing the ball from a stationary position (Initiation of Movement Phase) are applicable here.

Acceleration Phase

The acceleration phase begins the moment the passing arm is thrust forward by the glenohumeral joint and it ends once the ball is released (see Appendix R, frames 23-27). As previously mentioned, the beginning of this phase is consistent with the left leg's forward and upward thrust. Nevertheless, the left leg will have completed half of its forward movement when this phase begins. In addition, it is at this point that any lateral bending of the spine will occur. In general, the acceleration phase can be characterized as a movement which "consists of transverse rotation of the trunk about the vertebral column axis" (Kreighbaum & Barthels, 1985, p. 540). However, "since there is no momentum about the longitudinal axis, the lower part of the body must 'react' with an equal and opposite momentum to keep the angular momentum at zero" (Kreighbaum & Barthels, 1985, p. 540). The forward and upward thrust of the left leg serves to "increase the radius of gyration about the lower body's longitudinal axis. This decreases the lower body's reaction to the upper body's rotation around the longitudinal axis during the [passing]

movement" (Kreighbaum & Barthels, 1985, p. 541). Therefore, the forward and upward movement of the left leg provides a stable foundation which allows the hips, torso, and shoulders to act as a base of support by maintaining a full facing position which is critical to an effective and efficient passing motion (Yessis, 1984). The forward and upward thrust of the leg should be in line with the intended direction which is the flight of the ball toward the target. Therefore, the movement of the left leg must be directed toward the target and not sideways to the left or right.

Release/Control Phase

As the ball is released the left leg will attain its highest thrust forward and upward. It should do so in line with the flight of the ball toward the target. It should not come across the body (see Appendix R, frames 28-29). However, if a far knee release is employed then this principle related to the proper direction of force application will be violated. For all intents and purposes the ball is released while the quarterback is in the air and the rhythm of the release is similar to the up beat of duple meter. For example, when tapping a rhythm with the foot the first down beat would be "one" and the second down beat would be "two." The rhythm could be described as "one, two, one, two" etc. Furthermore, one could substitute the word "right" for the word "one" and the word "left" for the word "two." In this manner, the rhythm would be "right, left, right, left" etc. If, however, the up beat were counted without reducing the speed then the rhythm would be described as "right and, left and, right and," etc. Similar to the manner in which military personnel march to a specific cadence. In this case, however, the "right" signifies the step of the right leg before the ball is released and the "left" signifies the step of the left leg after the ball is released. The "and" signifies the release of the ball during the flight phase of the running pattern. Although the left foot contacts the ground a little later than the rhythm would suggest, it is that simple.

It is critical that the quarterback not be in contact with the ground as the ball is released. If this occurs then "the radius of gyration about the lower body's longitudinal axis" will be decreased instead of increased because the right foot would act like an axis of rotation which would force the left leg downward and backward. There would be no base of support for the forward and downward moving right arm and the sequence of motion and the rhythm of the passing action would be destroyed.

Follow-Through Phase

The follow-through phase begins once the ball is released and ends once the left leg makes contact with the ground. This does not indicate that the quarterback should abruptly stop. The quarterback should continue his running motion if possible down the line of the flight path of the ball. The follow-through, as previously mentioned, imparts no force on the ball. It does, however, provide clues to the nature of the passing mechanics. The follow-through mechanics when passing the ball from a stationary position were described as a far knee release (see section Follow-Through). The mechanics for passing while on the move are described as a near knee release (see Appendix R frames 30-44). The reasons for this type of release are identical to those provided in that previous section.

As originally stated, the passing hand of the quarterback (which represents the end point of the radius from the axis of rotation) should end at the origin of rotation and stability (see Appendix R, frame 41). Because this end point when passing while on the move is the right foot, a near knee release will increase the distance of force application over which each phase can take place. In addition, the maximum force generated between one object rotating around another is a direct line between the two and oppositely directed (Halliday & Resnick, 1988). In this case the direct line is generated from the right hand to the right foot.

The internal forces which activate a far knee release are inefficient for passing the ball while on the move. For example, the forces utilized to pass the football, from the initiation of motion through the follow-through phase, should be directed in line toward the target in the sagittal plane. A near knee release will insure that the applied forces are directed in the proper direction. However, when utilizing a far knee release the forces used to direct the ball are functioning in the transverse plane. The forces which activate a far knee release serve to "retard motion in the desired direction or result in wasted energy" (Jensen et al., 1983). This far knee release pattern is exactly what takes place when the quarterback's specific general motor program for passing the football is a side arm motion. Moreover, a sidearm motion has even greater consequences when the quarterback must pass the ball while on the move to a receiver who is moving across his face and/or when he is moving across the face of a stationary receiver (on the move inside right or on the move inside left). This does not indicate that there are some successful quarterbacks who utilize a sidearm motion while passing on the move. It does indicate that their ability to do so may be for no other reason than sheer strength, which is a variable in the equation that most young quarterbacks do not possess. More importantly, this coach would suggest that those quarterbacks who employ an over the top motion are on the average more accurate than those who use a side arm motion. Which in turn will determine the amount of offensive balance. In addition, a far knee release requires a larger angle in the arm pit (between the humerus and the rib cage). This is one instance where the over the top motion will be created by the forces of the glenohumeral joint and not solely lateral bending of the spine.

The quarterback should not stop his motion toward the target once the ball has been released. As a result, he should be coached to chase the ball down its flight path.

On the Move Inside Right

As it was previously mentioned, the ability of the quarterback to pass the football while he is running directly toward the target is not always possible. For example, the famous pass and catch from Joe Montana to Dwight Clark, known as "the catch," was essentially an on the move inside right technique. Moreover, Joe's career is littered with examples of this type of pass. Whether Joe Montana's ability to execute this type of pass is a genetic quality has little to do with the fact that this type of technique is easy to teach. Moreover, passing the football in this manner is essentially no different than passing while on the move directly. However, there are critical differences which could stem from one of two possibilities. The receiver could be crossing the quarterback's face while the quarterback is approaching the receiver or the quarterback may be crossing the face of a stationary receiver. The technique analyzed here is the most severe of cases. That is, the receiver is at a 90° angle in relationship to the quarterback's running path at the moment he passes the ball. There is no difference in the sprint or control phase between the inside and the direct techniques, therefore, they will not be detailed. In addition, all of the distinctions which separate one phase from another and/or stages within phases are identical.

Initiation of Movement Phase

Obviously, one of the biggest differences between the direct and the inside right technique is that with the direct technique the quarterback is in an open position whereas with the inside right technique he is in a closed one (see Appendix S, frames 1 & 2). And although this closed position is similar to passing while stationary the difference is that the quarterback's momentum is moving across the face of the receiver from left to right. On one hand this closed stance is a positive attribute because the quarterback does not have to work to close his shoulders as he did with the on the move direct technique. On the other hand, it is a detriment because at some point he must open his hips in order to begin the

inertial lag of the open kinetic link system. It is during the initiation of movement phase that the quarterback must get this accomplished. Consequently, this phase in general is characterized by the counter clockwise rotation of the feet, legs, and hips about the longitudinal axis of the spine in conjunction with the shoulders, passing arm, and the ball remaining in a closed and cocked position. The push of the left foot at the end of the first stage of the initiation of motion phase will begin to rotate the legs and the hips counter clockwise toward the target (see Appendix S, frames 6-16).

At the beginning of the second phase when the right foot contacts the ground the toe should be pointed toward the target (see Appendix S, frames 16-20). Turning the right toe at this point creates some problems related to the direction of force application when running (Jensen et al., 1983). Nevertheless, it is essential for passing the football on the move inside right for the same reasons that it is a detriment for running. For example, pointing the toes toward the target allows the quarterback to direct his forces "straight ahead" toward the target (Jensen et al., 1982, p. 227).

The latter part of the second phase with the inside right technique is different from the direct technique. For example, with the direct technique the left leg is thrust forward and upward in the direction opposite of the quarterback's momentum and passing action, and the left toe is naturally pointed toward the target. In this way the force of the left leg is directed toward the target. With the inside right technique the left leg is thrust across the quarterback's body (see Appendix S, frames 18-20). Moreover, it is not natural for the left toe to point toward the target in this case. Nevertheless, each is a characteristic that is consistent with the open kinetic link system and inertial lag. The recommendations that were provided in the section for passing the ball on the move direct (Initiation of Motion Phase) are applicable here.

Acceleration Phase

All of the characteristics related to the direct technique are similar. Nevertheless, there are a few critical differences. As was pointed out earlier with the direct technique the left leg is thrust forward and upward to increase the radius of gyration of the lower body to oppose the general momentum of the quarterback's body and the forward and downward thrust of the passing arm. The purpose here is exactly the same (see Appendix S, frames 21-25). However, because the left leg is moving across the quarterback's body in the transverse plane (inside right technique) and not forward and upward in the sagittal plane (direct technique) it does not appear to be analogous. Nevertheless, the purpose and the effects of the left leg's motion must be viewed in reference to the total movement in relationship to the ground and not the specific movement itself. For example, the total movement and momentum of the quarterback is from right to left. At some point the passing arm will have to oppose this right to left momentum in order to pass the ball back inside at a 90° angle to the direction in which the quarterback is running in both the sagittal and transverse planes. For example, in the sagittal plane this is evident if the analysis of the skill excludes the fact the quarterback is running over ground. In other words, the quarterback is an isolated system. In this case, the passing arm is moving forward and downward in the sagittal plane. In addition, it will accomplish this in the transverse plane if the analysis of the skill includes the fact that the quarterback is running. In other words, the total movement and momentum of the quarterback is considered. In this case the passing arm is moving from left to right in relationship to the total movement. Therefore, the movement of the left leg must be directed toward the target and sideways from right to left to oppose the transverse planar action of the arm which is moving from left to right. Moreover, the toe of the left foot must be pointed toward the target for reasons that will be identified in the next phase.

Release/Control Phase

As the ball is released the left leg will attain its greatest thrust from left to right. It should do so in line with the flight of the ball toward the target. In other words, it should not cross the midline of the quarterback's body (see Appendix S, frames 26-28). At the point of release, for all models, it is critical that the hips, torso, and shoulders are in a stable front facing position. Moreover, the toe of the left foot should point toward the target from the beginning of the second stage of the initiation of movement phase through the release/control and follow-through phases. If this does not occur during the second stage of the initiation of motion or release/control phases and instead the left toe is pointed in the direction the quarterback is running then it will be impossible for the quarterback to attain a front facing position at the point of release. In addition, if the toe points in this wrong direction during the follow-through phase then this will suggest that during the previous two critical stages and/or phases his hips were in the process of being closed. This will destroy the proper sequence of events.

Follow-Through Phase

Because of the near release for passing while on the move the quarterback will maintain an open position in relationship to the target in order to achieve an effective and efficient follow-through position (see Appendix S, frames 29-44). For example, the position of the body in the follow-through phase for passing on the move direct was an open position in relationship to the target. Therefore, the transverse axis of the hips and shoulders remained perpendicular to the flight of the ball. In addition, the toes remained pointed toward the target. This must occur with the inside right technique as well. The transverse axis of the hips and shoulders must remain perpendicular to the line of the flight of the ball and the toes must remain pointed toward the target as the follow-through phase ends. In other

words, the quarterback's shoulders and hips, with the inside right or left technique, should point back inside toward the target once the ball is released (See Appendix S, frames 38-44).

On the Move Inside Left

Passing the football in this manner is essentially no different than passing inside direct. But because it is an awkward technique for the quarterback to learn and for the coach to teach, many coaches do not believe that it is possible for the quarterback to do so effectively and efficiently. There is no difference in the sprint or control phase between the inside right and the inside left techniques, therefore, they will not be detailed. In addition, all of the distinctions which separate one phase from another and/or stages within phases are identical.

Initiation of Movement Phase

The inside left technique is similar to the inside right technique. Obviously, one of the big differences between the two is that with the inside left technique both the hips and the shoulders are closed (see Appendix T). At some point he must open his hips and shoulders in order to begin the inertial lag of the kinetic link system and it is during the initiation of motion phase that the quarterback must get this accomplished. This phase in general is characterized by the clockwise rotation of the quarterback's body in order to open the hips and close and cock the shoulders and the passing arm. The push of the left foot at the end of the first stage of the initiation of motion phase will begin to rotate the legs and the hips clockwise toward the target (see Appendix T, frames 1-14).

At the beginning of the second stage when the right foot contacts the ground the toe should be pointing toward the target. The hips will attain their full facing position but the shoulders and the passing arm will continue to move clockwise until they are fully cocked (see Appendix T, frames 15-25).

The latter part of the second stage with the inside left technique is different than the inside right technique. For example, with the inside right technique the left leg is thrust across the quarterback's body from right to left in order to oppose the movement of the passing arm which is thrust from left to right. It is similar to a cross over step. With the inside left technique the reverse situation must occur. For example, instead of the left leg creating a cross over step the left leg opens up (see Appendix T, frames 17-33). The recommendations that were provided in the section for passing the ball on the move direct (Initiation of Motion Phase) are applicable here.

Acceleration Phase

The purpose and the effects of the left leg's motion must be viewed in relationship to the total movement and not the specific movement itself. Therefore, the movement of the left leg must be directed toward the target and sideways from left to oppose the transverse planar action of the arm which is moving from right to left. Moreover, the toe of the left foot must be pointed toward the target for reasons that will be identified in the next phase.

Release/Control Phase

As the ball is released the left leg will attain its furthest thrust from right to left (see Appendix T, frames 30-31). At the point of release, for all models, it is critical that the hips, torso, and shoulders are in a stable front facing position. Moreover, the toe of the left foot should point toward the target from the beginning of the second stage of the initiation of movement phase through the release/control and follow-through phases. The consequences for this not taking place are identical to those with the inside right technique.

Follow-Through Phase

Because of the near release for passing while on the move the quarterback will maintain an open position in relationship to the target in order to achieve an effective and efficient follow-through position (see Appendix T, frames 32-44). For example, the position of the

body in the follow-through phase for passing on the move direct was an open position in relationship to the target. Therefore, the transverse axis of the hips and shoulders remained perpendicular to the flight of the ball. In addition, the toes remained pointed toward the target. This must occur with the inside right technique as well. Consequently, the transverse axis of the hips and shoulders must remain perpendicular to the line of the flight of the ball and the toes must remain pointed toward the target as the follow-through phase ends. In other words, the quarterback's shoulders and hips, with the inside right or left technique, should point back inside toward the target once the ball is released.

In order to see that the models for passing the ball are based on a specific generalized motor program see Appendix U. Except for small differences the model for each type of pass the posture of the body at the release and control phase is similar.

Summary

Coaching quarterbacks is a tremendous responsibility because of their importance within the framework of a balanced offensive structure. It can provide any coach with one of the most exciting and gratifying experiences. It is this writer's opinion that a quality quarterback coach must possess specialized knowledge. This does not indicate that coaches need to be scientists in the strictest sense but it does indicate that coaches must rely on scientific principles and not tradition or hearsay to coach their quarterbacks.

The recommendations made in this book are a result of 15 years of practice and study. Due to the parameters of this study the subdiscipline of physiology was omitted leading to a sketch of the next book. It will serve as a companion to this book in that it will utilize the principles of motor behavior and biomechanics and combine them with physiology in order to detail a quarterback specific workout. The writer knows from experience the difficulty associated with attacking one's convictions regarding the teaching of quarterbacks. It is difficult to accept the fact that what one may have been teaching for a period time is totally

antithetical to research and reality. It is even more difficult to accept the fact that the reason that one may adhere to a specific technique or methodology is due to what one's mentor or former coach stated to be correct. However, the principles of motor behavior do not adhere to this approach. More importantly, the laws of physics in general and those of force certainly do not. It was the intent of this book to provide some guidance for teaching quarterbacks.

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A
 all around athlete
 myth 42
 angular acceleration 120
 angular velocity 118, 120
 Ariel
 "blind leading the blind XVI

B
 balance principle 133
 biomechanics
 importance of, 82
 biomechanist and the coach 83

C
 Campbell XIV
 championship game 25
 closed environment
 associative stage 65
 autonomous stage 68
 closed stance 99
 Coach of the Year Clinic Manual 83
 coach's responsibilities
 to his quarterbacks 35
 to the team 35
 coach's responsibility
 passing game 36
 Cue-Utilization Hypothesis 70
 curvilinear path 108

D
 democratic approach
 most important position 11
 direction arrow 117, 144
 disguised coverages 127, 138
 drop axis 128, 130
 dropback
 depths, set and release times 125
 dropping back to pass 124

F
 far knee 149
 far knee release 148
 rationale 122
 five step drop
 verbal description of, 127
 five step drop backside 135
 fifth step (set) 136
 fourth step (cushion) 135
 third step (stretch) 135
 five step drop frontside 129
 fifth step (set) 133

Index

first two steps 130
 fourth step (cushion) 131
 third step (stretch) 130
 force application
 constant 115, 119
 direction of, 107
 distance of 120, 148
 maximum distance 119
 total 116
 forward pass
 legalization of 2

G
 general motor program
 invariant features
 order of elements 46
 phasing-time ratio 47
 relative force 47
 parameters
 duration 47
 force 48
 muscle selection 48
 spatial 48
 phonograph analogy 46
 general motor programs
 closed environment 54
 generalized motor programs 44

H
 head and eyes
 "Game Of Deception" 104

I / J
 inertial lag 112, 144, 151, 154
 injury
 throwing arm 88

K
 KISS
 and excuses 29

L
 L line 107
 lateral bending of the spine 106, 111
 law of inertia 106

M
 most important position 8
 quarterback 8
 question of function 10

N
 near knee release 148
 Nietzsche
 popular error 1

O

- on the move direct 143
 - acceleration phase 146
 - control phase 143
 - follow-through phase 148
 - initiation of movement phase 144
 - release/control phase 147
 - sprint phase 143
- on the move inside left 154
 - acceleration phase 155
 - follow-through phase 155
 - initiation of movement phase 154
 - release/control phase 155
- on the move inside right 150
 - acceleration phase 152
 - follow-through phase 153
 - initiation of movement phase 150
 - release/control phase 153
- open environment
 - autonomous stage 79
- open environment
 - associative stage 78
 - cognitive stage 75
 - goals 70
- open kinetic link system 87, 89, 119, 120, 151
- open stance 99

P

- passing game
 - components 9
 - philosophical advantage 7
 - strategic advantages 3
- passing the football
 - goals of, 98
- passing while on the move 141
- passing-stationary 91
 - acceleration phase 114
 - follow-through 121
 - initiation of movement phase 105
 - stance phase 96
- perceptual narrowing 70, 74
- power 95
- preparation 23
- process goal 56
- product goal 56

Q

- quarterback evaluation
 - democratic equality and skill 18
 - he leads by example 14
 - liberal equality 15

vocal leader 14

- quarterback position
 - importance of 5
 - what type of skill 43
- quarterback skills
 - affective 6
 - cognitive 6
 - open environment 70
 - physical 6
 - psychomotor 6

R

- R line 97, 99, 133
- radioulnar pronation 120, 124
- radius of gyration 148
- radius of rotation 98
- recognition schema
 - closed environment 50
- rectilinear path 108
- release/control 117
- rotator cuff 114, 116

S

- schema theory 41, 44
 - advantages 44
 - recognition schema 50
- set and throw on time 127
- seven step
 - verbal description of, 128
- shoulders
 - strategic perspective 102
- simplicity
 - consequences for, 30
- skill
 - defined 43
- specific generalized motor program (SGMP) 52
- specificity of skill 32
- spin of the football 117
- stages of motor learning 131
 - associative 63
 - open environment 75
 - phases within 66
- stance arrow 97, 99, 133, 134, 136, 140
- stretch step 128
- stride length 107

T

- Theory of Justice
 - principle of inequality
 - four interpretations
 - liberal equality 13
 - two principles

- principle of equality 11
- three step drop
 - verbal description of, 127
- three step drop backside 138
 - four 140
 - three 139
 - two 139
- three step drop frontside 137
 - first step (stretch) 137
 - second step (cushion) 137
 - third step (set) 137
- throwing motion
 - research 87
- translatory and rotary motions 106
- V/W/X/Z**
- video analysis 90
- wheel-axle 98, 110, 115, 120
- winning and losing
 - the championship game
 - six rationalizations 24
- work ethic
 - luck 24
 - philosophical importance of, 20
- work ethic based system of development and evaluation 35
- X axis 97, 98, 99, 105, 107, 110, 122, 140
- X axis, 116
- Z axis 97, 122

Appendix A
QUARTERBACK POSITIONING

Stance

Appendix B

Front
Side Front
Facing

Back

Back
Side

Appendix C

L LINE, R LINE, AND STANCE ARROW

Left Foot

L Line

Right Foot

R Line

Appendix D

STANCE ARROW AND STANCE

Appendix E

Passing Stationary

Initiation of Motion: First Phase

Front View

Front View

Appendix F

Passing Stationary

Follow-Through

Appendix G

Passing Stationary

Follow-Through

Follow-Through

Front View

Appendix H

DROP AXIS

Appendix I

Five Step Dropback: Frontside

Appendix J

Five Step Dropback: Frontside

Three (Stretch)

Side View

Side View

Four (Cushion)

Side View

Appendix K

Five Step Dropback: Frontside

Side View

Side View

Side View

Appendix L

SET STEP AND BALANCE

Dropback: Down the middle of the field

Dropback: Frontside

Dropback: Backside

Appendix M

Five Step Dropback: Backside

Three (Stretch)

Side View

Four (Cushion)

Side View

Five (Set)

Side View

Appendix N

Five Step Dropback: Backside

Side View

Side View

Appendix O

Three Step Dropback: Frontside

One

11

10

9

8

7

6

5

4

3

2

1

Side View

Two

22

21

20

19

18

17

16

15

14

13

12

Side View

Three

33

32

31

30

29

28

27

26

25

24

23

Side View

Initiation of Motion

44

43

42

41

40

39

38

37

36

35

34

Side View

Appendix P

Three Step Dropback: Backside

Side View

Side View

Side View

Side View

Appendix Q

On The Move Direct

Appendix R

On The Move Direct

Release/
Control

Front View

Acceleration

Follow-Through

Side View

Front View

Side View

Appendix S

On The Move Inside Right

Front View

Initiation of Motion: First Phase

11 10 9 8 7 6 5 4 3 2 1

Front View

22 21 20 19 18 17 16 15 14 13 12

Follow-Through Release/Control

Front View

33 32 31 30 29 28 27 26 25 24 23

Front View

44 43 42 41 40 39 38 37 36 35 34

Front View

On The Move Inside Left Appendix T

Initiation of Motion: First Phase

Front View

Second Phase

Front View

Acceleration

Release/
Control

Front View

Follow-Through

Front View

Front View

Appendix U

Specific Generalized Motor Program

<p>Side View</p>
<p>Front View</p>
<p>Release/Control Passing Stationary</p>	<p>Release/Control Passing On The Move Direct</p>	<p>Release/Control Passing On The Move Inside Right</p>	<p>Release/Control Passing On The Move Inside Left</p>