AN ABSTRACT OF THE THESIS OF

Tuula-Maija A. Tyry for the degree of Doctor of Philosophy in Human Performance presented on June 7, 1993.

Title: The Influence of Perceptual Training on Volleyball Performance Among Adolescent Females

Redacted for Privacy

Abstract approved: ______________________________

Dr. Debra Rose

This study investigated the influence of perceptual training on volleyball serve-reception performance. The subjects were ten female high-school volleyball players. Subjects were randomly assigned in equal numbers to a control or an experimental group.

Both groups were tested on two occasions, prior to and following a three-week perceptual training intervention. The pre- and post-training testing sessions consisted of a volleyball serve-reception test and a perceptual-motor test that simulated the serve-reception. At the end of the post-training session, a transfer serve-reception test was conducted.

The results showed a significant positive relationship between years of experience playing competitive volleyball and performance score obtained in the pre-training serve-reception test. No relationship existed between performance score and starting age. Also, no significant relationships were

found between the performance score obtained for the pre-training perceptual-motor test and the amount of competitive playing experience or, starting age.

The results of a 2 x 2 (Time x Group) repeated measures MANOVA, incorporating the dependent variables of mean performance score for the serve-reception test and the standard deviation of the movement time elapsed prior to intercepting the ball, indicated that perceptual training was not significantly related to performance on a serve-reception test. Two separate 2 x 2 (Time x Group) repeated measures ANOVAs, analyzing the performance scores obtained for the pre- and post-training perceptual-motor test under two different viewing conditions (long vs. short) did not reveal any differences between the groups for either viewing condition. The transfer serve-reception test also did not reveal any statistically significant differences between the groups.

In conclusion, the results indicated that the three-week perceptual training-program used in this study did not lead to significant improvements in volleyball serve-reception performance among adolescent female players. In future research, a motor component should be incorporated in the perceptual training-program to allow for the coupling of perception and action. Alternatively, a perceptual-motor adjustment period could be provided to facilitate the recoupling of perception and action following a perceptual training period.

The Influence of Perceptual Training on Volleyball Performance Among Adolescent Females

by

Tuula-Maija A. Tyry

A THESIS

submitted to

Oregon State University

in partial fulfillment of

the requirements for the

degree of

Doctor of Philosophy

Completed June 7, 1993

Commencement June 1994

APPROVED:

Redacted for Privacy

Associate Professor of Exercise and Sport Science in charge of major

Redacted for Privacy

Chair of Department of Exercise and Sport Science

Redacted for Privacy

Dean of College of Health and Human Performance

Redacted for Privacy

Dean of Graduate School

Date thesis is presented June 7, 1993

Typed by Tuula-Maija A. Tyry

Acknowledgements

Upon completing the doctoral program at OSU I would like to express my sincere thanks to all the people who have contributed to this accomplishment. First of all, I am truly grateful to my committee members for them always being available for consultation, even with short notice and long distance. My special thanks to my major professor and advisor Dr. Debbie Rose for her patience and professional guidance especially during the sometimes frustrating writing process.

I am also grateful for the rest of the faculty, staff and graduate students, whose cheerful comments and shared experiences assured me that there was light at the end of the tunnel after all. I am especially grateful for Dr. Christian Zauner and Dr. John Dunn, who not only were extremely helpful before and upon my arrival to US, but also found time to check on my progress through out the program.

I fondly remember the late professor emeritus Art Koski, who always showed great interest in my program and kept challenging me with the tradition of hard working Finns. Since being an "alien" in a foreign country can also provide concerns other than academic, I would also like to extend my thanks to the staff members of Office of International Education at OSU and the regional office of Institute of International Education in San Francisco for their friendly and efficient services.

I would like to share my feeling of pride and joy over this academic achievement with my parents Matti and Hilkka Tyry and the rest of my family, who have never questioned my enterprises and have helped me to realize the value of broad and continuous education. I am also grateful to my friend and husband Dr. Bruce Groll, whose love and support kept me going when I felt "old, beaten and thrown away".

The completion of this study was made possible by a study-grant from The Ministry of Education of Finland, to which I extend my sincere thanks. I am equally grateful for the financial support provided by the Finnish-American Fulbright Commission and the Niemi Foundation during my doctoral program.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES TABLES

THE INFLUENCE OF PERCEPTUAL TRAINING ON VOLLEYBALL PERFORMANCE AMONG ADOLESCENT FEMALES

Introduction

General Introduction

The importance of vision in everyday life is widely recognized. For most people the idea of having to cope without vision is far more frightening than the potential loss of any of the other senses. It is clear that the human species has evolved to rely heavily on vision, even when the use of other senses (i.e., audition, proprioception etc.) might be more appropriate.

The nature of many sports also places high demands on the use of visual information. This is especially true in rapid ball games, such as basketball and tennis, where complex situations arise with moving objects and players. The need to maximize performance in terms of speed and accuracy underscores the importance of visual perception in sport even more than in everyday life. This can be seen in the abundance of popular and scientific literature on the topic of vision in sport. The anecdotes and studies span a whole range from descriptions of legendary performers with supervision to the development of complicated training devices. And yet, the role of vision in sport remains controversial, suggesting the need for further investigation to advance the theoretical understanding of the issue.

The myriad of research findings in the area of visual perception is rather overwhelming and clearly needs some organizing. In an excellent review article on selective attention in fast ball games, Abernethy (1987) used a classification system, first developed by Starkes and Deakin (1984), to categorize previous studies. Two categories of studies were subsequently described; a) those adopting a hardware approach and b) those favoring a software perspective.

The **hardware** category is represented by studies in which the mechanical and optometric properties of the visual system of different skill-level performers is compared. These studies initially measured variables such as static visual acuity, depth perception, inter-pupillary distance, stereoptic vision, and eye-dominance (e.g., Bailey, 1968; Banister & Blackburn, 1931; Miller, 1960). Other variables have recently been added to the repertoire, such as peripheral visual range (Cockerill, 1981), color vision (Mizusawa, Sweeting, & Knouse, 1983) and eye color (Wolf & Landers, 1978). Research findings related to these parameters, however, have lacked consistency.

According to Abernethy (1987), even when multiple measures of several optometric parameters are used, no convincing evidence of expert-novice difference has been provided. Similar equivocal findings were also obtained by Christenson and Winkelstein (1988) who attempted to develop an 11-point sports' vision screening battery. They found athletes to be significantly better than non-athletes in only five of the eleven visual skills tested: vergence ability, speed of saccades, visual reaction time, peripheral awareness, and near-point-of-convergence. For the remaining six parameters, either no significant differences were found or the non-athletes actually performed better. Despite the controversial results, the authors recommended visual training studies to establish whether the superior abilities found could have been the result of training.

Since then, the improvement of optometric parameters has, indeed, been the focus of several visual training studies in sports such as basketball (Darden, 1990), volleyball (Salitsky, 1990), and soccer (McLeod, 1991a). The training regimes used in these studies have ranged from fifteen 15 minute sessions to a total time period of six weeks. The primary objective of the training has been to strengthen and finely tune the muscles that move and direct the eyes. Interestingly enough, these studies have, for the most part, failed to show significant or even consistent benefits from training. Part of the problem could be methodological, as some of the measurements used (i.e., wall-volley test) may not have been suitable for detecting subtle changes in perceptual-motor abilities.

The studies in which the **software approach** has been used, on the other hand, have focused on investigating expert-novice skill-related differences in cognitive processes. These cognitive processes relate to the analyzing, selecting, coding, retrieving, and general handling of visual information, which are all constrained by the physical characteristics of the ocular system (Abernethy, 1987). In other words, these studies have examined differences in the information-processing strategy used.

For instance, experts have been shown to demonstrate better recognition of sport-specific stimuli than the novices. This finding is most evident in the recall of structured game information, such as offensive or defensive patterns in basketball (Allard, Graham & Parsalu, 1980), field hockey (Starkes & Deakin, 1984; Starkes 1987), or volleyball (Borgeaud & Abernethy, 1987).

Another area keenly investigated has been the use of anticipatory cues in rapid ball games. For instance, Abernethy and Russel (1987) showed that expert badminton players can decrease their prediction error about where the serve is aimed at an earlier point in the server's stroke sequence when compared to novice performers.

The importance of vision has been recognized in volleyball as well as in other ball games. Although the speed of the ball is not as great as in games such as tennis or baseball, the relatively small distances involved in game situations in volleyball set high demands on the players' ability to first perceive movement and then react to a moving object quickly and precisely. Several studies (i.e., Allard & Starkes, 1980; Borgeaud & Abernethy, 1987; Ripoll, 1988) have already shown the positive influence of prior knowledge and anticipation on volleyball players' abilities to select correct responses.

Unfortunately, most of these studies have employed paper-and-pencil tests rather than actual motor responses. A more ecologically valid setting would be to have the subjects physically perform a task where perception and action are not separated and where on-line visual perception is available.

Indeed, Abernethy (1987) also pointed to the need for more ecologically valid tests of visual perception which would maintain the contextual cues. He further identified the problems associated with the use of static rather than dynamic perceptual tests. For instance, in a volleyball setting, the expert players' superior recognition of game structures, over that of novice players', only became evident when a filmstrip was shown rather than a series of slides (Allard & Starkes, 1980; Borgeaud & Abernethy, 1987). The expert players were, for instance, better able to detect whether an offensive or a defensive play was being shown.

Although the emphasis of the current literature is still on information-processing approaches, the value of the alternative ecological approach to visual perception has also been discussed (i.e., Colley, 1989; Saltzman & Kelso, 1987; Scully & Newell, 1985). This approach is based on the theory of direct perception. Ecological theorists claim that the invariant nature of the perceptual information obtained from the environment makes it unnecessary for much of the specific detail of past perceptual experiences to be actually stored in memory (Gibson, 1979). In other words, the abundant information provided by the environment is enough, in and of itself, to specify the required action in a given situation.

An example of one available optical property is "tau," that specifies the time left until contact with a moving object. This mathematical relation between optic flow and the actor's movement was first identified by Lee (1976), who defined the optical variable of tau as the inverse of the rate of expansion of the retinal image. This variable is believed to directly specify time-to-contact between an observer and an environmental object of interest. In their catching example, Turvey and Carello (1988) described tau in terms of "...the relative rate of dilation of a closed optical contour generated by the movement of a surface (such as a softball) toward an observation point (such as the eyes of an outfielder) or vice versa" (p. 195).

Many authors have recently expressed some interest in a theory of direct perception, especially those authors concerned with visual perception of motion (i.e., Scully & Newell, 1985). For instance, the work of Johansson (1973) has contributed considerably to the theoretical understanding of the perception of biological motion, showing the innate sensitivity of the human visual system to relations between action and visual information of movement.

Another Swedish author, Carl Aurell, has also developed a perceptual model incorporating a direct mode of perception (Aurell, 1984). His model is based on two separate, but interacting, modes of consciousness. The outer mode is produced by the sensory system and the inner mode by the conceptual system. Aurell suggests that the perceptual systems strive to produce the necessary knowledge with minimal use of perceptual effort. This would mean that only the amount of information needed for fulfilling a goal is extracted from the environment with the effort being optimally distributed between active information search and processing of the information. He points out that in perfection of primitive types of automatic behavior, such as babies learning to walk, cognitive intervention is not necessary. This is of particular interest since, phylogenetically, the inner consciousness has emerged only recently in human evolution (Aurell, 1984).

van Wieringen (1988) expressed similar ideas by distinguishing between natural (phylogenetic) and cultural (ontogenetic) skills. He referred to existing coordinative structures, that are comprised of muscles constrained to act together as a functional unit, and suggested that natural skills may exploit these existing units without the need for cognitive involvement. However, in cultural skills such as dance, the existing coordinative structures may have to be overruled. Although most sport skills are cultural skills, many of them consist of components that are natural movements. Intercepting a moving object, for instance, has been identified as a form of natural movement (Lee & Young, 1975).

The use of coordinative structures in natural settings fits in well with the notion of self-organization of musculature in the ecological approach.

According to Michaels and Carello (1981), there is a co-evolution of perception and action that makes them tightly coupled. The organization of musculature into collectives for a particular act calls for regulation by a certain set of information. Similarly, information can constrain specific sets of muscles and joints into collectives for a potential act. An illustrative way to express this co-dependency between perception and action is in the formula derived by Turvey and Carello (1988): "A generates B, B specifies A" (p. 192). For example, visual information of the approaching object can generate an interceptive action or, if the information indicates a too powerful approach, an evasive maneuver. On the other hand, the action of catching specifies a certain set of visual information about the approaching object that has to be present before a particular action is initiated.

The discussion above suggests that human behavior may incorporate both natural perception-action instances and situations in which perception is more cognitively mediated. The shift from one mode of processing to another might reflect the selection of an optimal way to gather information that utilizes either direct or indirect perception or a combination of both. Recent studies (i.e., Burton, 1990) have shown perceptual difficulties to be evident in developmentally delayed children performing tasks involving climbing over, or crawling under, an obstacle. Success in these tasks requires body-scaled information obtained via direct perception. Difficulties in these tasks could indicate a problem in the optimal use of what Aurell

(1984) called, "perceptual effort," as these children may have trouble in transition between different stages of information processing, the gathering versus processing of information.

When looking at the latest advances in research representing either traditional (indirect) or ecological (direct) approaches to perception, it seems evident that the two extremes are gradually converging. Thus, rather than denying the potential of one approach in favor of the other, it appears fruitful to attempt to integrate the two complimentary ideas. Weeks and Proctor (1991), however, have expressed concern with embracing the ideas of the ecological approach prematurely and called for more empirical verification of the theoretical arguments presented thus far. They also cautioned advocates of the ecological approach against dogmatic interpretations of behavior. Rather, the co-existence of alternative approaches should be maintained as an essential component of the advancement of scientific knowledge.

The sport domain lends itself perfectly to such an integrative approach to behavior. The high demands on cognitive processes in terms of complicated actions, technical requirements, and tactical considerations have already been shown to be part of sport-specific expertise. Optimal responses triggered by finely-tuned direct perception could be responsible for efficient functioning in those complicated situations. For instance, consistently relying on the direct mode of perception could help players to automatize the timing aspect of the initiation of their performance. To find out whether this is the case, one must monitor the changes taking place as a result of training.

This approach was taken by Bootsma, Houbiers, Whiting, and van Wieringen (1991) in their study on the effects of static and dynamic environmental conditions in acquisition of an attacking forehand drive in table-tennis. The timing of the initiation of the stroke was examined before and after a four-day training period of novice table-tennis players. The results showed an increase in the consistency of the timing of initiation of the stroke with respect to the time left until contact with the ball. The conclusions of the study thus supported the notion of the use of the optical variable, tau, which specifies the time-to-contact information. The authors suggested that a "funnel-like" type of control is established during acquisition of the skill. First, the players appear to have a certain time and space range available for initiation of the movement. This general purpose timing ability could be a result of transfer from daily activities, in which timing is frequently required. With training, however, the action is gradually adjusted on the basis of the available perceptual information which becomes appropriately constrained for the moment of the contact with the ball.

In the Bootsma et al. (1991) study, the subjects were engaged in actual physical training that proved to be effective. However, given the importance of perceptual information in constraining the movements, one might argue that even a more efficient extraction of information alone could be sufficient to produce the changes in action described, above. Perhaps it is not necessary to actually execute the action to improve the timing. This assumption directly leads to the question of whether perceptual training, by itself, could enhance perceptual-motor performance.

Statement of the Problem

The purpose of this study was to investigate the possible effects of perceptual training on perceptual-motor abilities required in the skill of serve-reception in volleyball.

Justification for the Study

There is scientific evidence that has shown the superiority of elite athletes in certain perceptual abilities, such as dynamic visual acuity, range of peripheral vision and depth perception (Stine, Arterburn, & Stern, 1982). At the same time, however, questions concerning the process by which these important abilities are acquired and then incorporated into the actual motor skill performance have not been adequately addressed.

Although some experiments have already addressed the question of the possible benefit of visual training in sports (i.e., Salitsky, 1990; McLeod, 1991a), no definite answers have been found. These training studies, however, have been conducted according to the hardware approach with the goal of improving optometric properties alone in laboratory settings rather than training the perceptual abilities within a natural context. The more ecologically valid settings provided by the studies employing a software approach represent forward progress. With the testing procedures of the present study, however, the ecological validity is further enhanced by not only maintaining the naturally occurring contextual cues but also coupling perception and action. The use of an ecologically valid research setting is further justified in that methodological problems have been suggested as one possible cause for the failure to show improvements in motor skills as a result of visual training. The use of skill tests which better approximate those performed in the game setting has been recommended (Cohn & Chaplik, 1991; McLeod, 1991b). An extension of this logic would have suggested the coupling of perception and action also in the training process. However, as a first step in an intended series of studies, the training phase in this study was conducted in a purely perceptual domain in order to more precisely identify the source of possible improvement in a perceptual-motor skill.

There is accumulated evidence to show that invariant optic variables obtained via direct perception are being used to guide performance in a variety of motor activities, such as long-jumping (Lee, Lishman, & Thomson, 1982), running (Warren, Young, & Lee, 1986), horseback riding (Laurent, Dinh Phung, & Ripoll, 1989), and table-tennis (Bootsma et al., 1991). There is no reason to assume that this mode of perception could not also be exploited in the game of volleyball. Enhanced ability to directly perceive and predict the flight trajectory of the ball, without conscious cognitive involvement, would allow the performer to allocate attention to other important decisions and observations, providing a definite edge for players at any level. For instance, the locations and movements of the teammates and opponents could be taken into consideration while passing the ball. This advanced information would help the performer prepare for a certain attack pattern and ensuing defense. Also, by relying on a more direct, automatic mode of perception, the performer could possibly avoid sudden lapses of attention, bouts of anxiety, and other fluctuations in performance that are so common in competitive game situations.

The research questions addressed in this study were investigated using the context of the sport of volleyball, more specifically the task of serve reception. This particular task was chosen for two reasons. First, the quality of the serve-reception greatly affects the options and quality of the ensuing attack (Sawula, 1975; McGown, 1974). Any training method that improved serve-reception would positively influence the quality of the first attack. Second, the time frame allowed for the receiver's response has become significantly shorter with new techniques such as jump serving.

This trend emphasizes the importance of rapid perception and action. Assuming the back-row players have a forward movement speed of 250 cm/s, they would need at least one second to cover the edges of their area of responsibility in a typical five-person serve reception formation (Selinger & Ackerman-Blount, 1986). For short serves, this means that receivers have to initiate movement toward the oncoming ball after only 500 ms or less of viewing time of the approximately 700 ms to 1500 ms flight path of the serve.

In some other sports such as racquetball (Abernethy, 1989), experienced players have been shown to use visual cues derived from the movements of the server's upper body and the racket, even before the server actually contacts the ball. In volleyball, especially at the higher skill levels, faking can make this information very deceptive. Moreover, the lack of a racquet or bat as an extension of the arm in the volleyball serving action makes any slight changes in limb position difficult to detect from the other end of the court. Vision is further obscured in volleyball by the intervening net and opposing players. Although anticipation is helpful, to some extent, even in volleyball serve-reception, the ability to act on the basis of on-line visual perception would provide a more solid ground for a consistent performance.

In order to find out whether improved integration of direct and indirect perception could, indeed, enhance the level of performance in volleyball, an ecologically valid experimental setting has to be used--that is, a setting that allows the performers to use both previous experience and the contextual cues naturally available to them. Similarly, the assessment of perception in a natural setting requires coupling perception with the ensuing motor response. These principles have guided the selection of the methods and procedures used in the present study.

Research Hypotheses

1. The performance scores obtained in a pre-training serve-reception and a perceptual-motor test are positively related to years of experience in competitive volleyball.

2. The performance scores obtained in a pre-training serve-reception and a perceptual-motor test are negatively related to the age at which a player first started playing volleyball.

3. The performance score obtained for a pre-training serve-reception test is positively related to the performance score obtained for a pre-training perceptual-motor test.

4. Subjects receiving perceptual training will achieve a significantly greater improvement in post-training performance score for a serve-reception test when compared to subjects who do not receive perceptual training.

5. Perceptual training decreases the variability of the time period elapsing between the onset of the movement towards an oncoming ball and the contact with the ball as measured by a serve-reception test.

6. Subjects receiving perceptual training will achieve a significantly greater improvement in post-training performance score in a perceptual-motor test when compared to subjects who do not receive perceptual training.

7. Subjects receiving perceptual training will achieve a significantly higher post-training performance score in a transfer serve-reception test when compared to subjects who do not receive perceptual training.

8. Perceptual training decreases the variability of the time period elapsing between the onset of the movement towards the oncoming ball and the contact with the ball as measured by a transfer serve-reception test.

Delimitations of the Study

The present study is delimited to investigation of female subjects only. The rationale for using only one gender is based on different official net heights used for men and women. The different net heights would have prevented the use of identical videotapes for the perceptual-motor test and perceptual training. Females, rather than males, were chosen due to the availability of only girls' teams in local interscholastic sports programs.

To maintain homogeneity in the subject pool, all subjects were high school students. Their ages ranged from 14 to 17 years.

The skill-level of the subjects investigated was that of high school varsity ($n=1$), junior varsity ($n=2$) and freshman ($n=7$) teams ranking in the top 25 percent of all class AAA high schools in the state of Oregon. A sub-elite, rather than elite (inter-collegiate or national team), skill-level was chosen to avoid the risk of possible ceiling effects in perceptual training.

The present study investigated only one aspect of volleyball performance: the serve reception. However, this part of the game was considered an important foundation for creating a good attack and thus warrants further investigation.

Limitations of the Study

As with most experimental designs involving human subjects, this study also faced several practical problems. First of all, the number of subjects remained fairly low ($N = 10$) as a result of attempts to maintain homogeneity in the subject group. Second, due to practical considerations (such as availability of the subjects and facilities), the training period was limited to three weeks. Moreover, it was not deemed reasonable to request volleyball players to refrain from actively training or playing for a longer period of time. Even within this time frame, lack of strict control of other motor activities during the training period may have affected the results, although other motor activities were discouraged. This aspect was monitored via the subjects' daily logs.

Despite attempts to overcome previous methodological shortcomings, some still remained unsolved. The lack of reliable and valid testing instruments was not totally compensated for by the introduction of new measurement tools in the present study. These new instruments will need more validation in the future. The consistency of the degree of difficulty of the serves in the serve reception test remained somewhat difficult to control. However, while the use of a mechanical ball machine rather than a human server would have ensured more consistent serves, it would also have compromised the natural context.

Terminology

Affordances refer to the potential behaviors or adjustments of behavior that a certain environment suggests to an observer.

Attack is a general term used in volleyball to describe the collective offensive efforts of a team as well as the individual offensive efforts of a player to score a point or earn a side-out. The attack phase actually begins when the pass is delivered to the setter and the attackers jump (Selinger et al., 1986).

Attack line is parallel to the volleyball net and located 3 m from the center line. Only front-row players (rotation orders 2, 3, or 4) may spike the ball while in front of the attack line, in the attack zone.

Context is a term used in motor behavior literature to refer to all the conditions surrounding the performance of a movement (Magill, 1993).

Coordinative structures are collectives of muscles and joints that are involved in the control of a specific act.

Depth perception refers to accurate judgement of depth. It encompasses the ability to: a) synthesize two somewhat different retinal images into a three dimensional display; b) determine the distance between two objects at varying distances and, c) detect and interpret object movement towards or away from the observer (Rothstein, 1986).

Dynamic visual acuity refers to the ability of an observer to detect detail of an object when there is relative movement between himself/herself and the object (Burg, 1966).

Ecologically valid is a term used in research literature to describe a research setting that allows more natural behavior than traditional laboratory experiments.

Jump-serve is a newly developed way of serving the ball using an arm swing very similar to the spiking action in volleyball. The server attempts to contact the ball as high as possible by jumping from behind the baseline and reaching up high (Selinger et al., 1986).

Ontogenetic refers to the development or change that takes place during an individual's life history.

Optometric refers to a parameter describing characteristics of the function of the eyes.

Overhand float-serve is the most popular serving technique in North and South America and, Europe. It has little or no spin at all but tends to "float" from side to side. The degree of wobble increases with the horizontal speed of the ball (Selinger et al., 1986).

Perception is defined in cognitive theories as a process by which sensory information is organized, integrated, and interpreted to produce meaning of the incoming sensory information. In contrast to this indirect view of perception, the theory of direct perception, which provides the premises for the ecological approach, assumes that perception is the pick-up of information that already exists in the optical array emanating from the surface layout of the environment. No cognitive processing is deemed necessary for the observer to act.

Perceptual training refers to procedures aimed at either a) enhancing the optometric properties of the eye or b) improving the pick-up and processing of visual information (Abernethy, 1987).

Peripheral vision is the field of vision surrounding the central area of sharp, foveal vision (Seiderman & Schneider, 1983).

Phylogenetic refers to the gradual development taking place during the evolution of a species.

Serve-reception refers to that particular phase of the volleyball-game when a player receives a serve. The term encompasses passing, which is the individual skill used in receiving a serve, as well as serve-reception formation, which is the arrangement of players on the court.

Set refers to the action of delivering a volleyball with a precise trajectory and speed to a particular hitter so that she/he can effectively attack it. Setting is usually done with the fingers of both hands over the head, a technique that allows for sensitive ball handling (Selinger et al., 1986).

Tau is the inverse of the rate of dilation of the retinal image, that is used to specify the time-to-contact with the observer and an environmental object of interest.

Tau-margin refers to the time range available for optimal initiation of a specific movement to contact a moving object (Lee et al., 1985).

Todd number is a ratio of vertical and horizontal tau and indicates whether an oncoming object will land in front of or behind the observer.

Tuning describes the enhanced ability of the observer to extract visual information from the environment.

Review of the Literature

Visual Perception: - The Traditional View

For the past five decades, most motor theorists (i.e., Fitts & Posner, 1967; Magill, 1993; Schmidt, 1977) have made the assumption that visual perception is cognitively mediated. Although theories of perception, in general, have become more sophisticated during that time, the traditional view of indirect perception still reflects the beliefs of the early psychologists (i.e., Fechner, 1860; Helmholtz, 1867; Weber, 1852). According to these indirect theories of perception, visual information from the environment is gathered by sampling the visual layout in a snapshot-like manner. Two-dimensional images of external objects are projected onto the retina of the eye, and cognitive processing interpolates the missing third dimension. The resulting perception is considered to follow the cortical interpretation of the information originally received at the level of the eye. Such variables as past experience, learning, and anticipation are recognized as influencing the perception. Among others, the work of Piaget (e.g., 1954; 1969) has served to establish the notion that perception, in and of itself, plays a relatively small role as opposed to cognitive functions.

The traditional view has, indeed, served to explain many aspects of human perception, especially the role of anticipation and learning in the act of perceiving. However, it has failed to address other questions, ones that were not so frequently addressed in the past. Recent research in cognitive development (i.e., Bower, 1982; Gibson, 1987), for instance, has cast doubt on the role of cognitive mediation in simple actions involving perception. Indeed, the separation of perception from action has been claimed to be artificial and misleading. Subsequently, new attempts have been made to couple perception and action and to provide understanding of areas previously neglected in purely cognitive theories.

One of the challenging perspectives is the ecological approach, whose proponents have argued for a more parsimonious approach to perception. Furthermore, they have claimed that theories of perception should include not only the third spatial dimension but also time as a fourth dimension. The importance of consideration for time has already been shown in several studies. Kellman (1984), for instance, showed that infants of 16 weeks could perceive three-dimensional form from transforming optical projections but not from single or even multiple static views of the same object. Similarly, Kaufmann-Hayoz (1991) provided evidence for the infant's ability to detect rapid movements even during the first month of life. She concluded, that while the visual system in young infants has a relatively low contrast sensitivity and visual acuity, it is highly sensitive to visual motion.

Kaufmann-Hayoz also provided a rationale for this developmental feature. She referred to the role of visual perception in guiding the young infant's actions like object manipulation and locomotion and then pointed out the resulting need for getting information about the layout and the existence of objects. She further suggested that the infant's inability to recognize fine figural details could actually facilitate the detection of fundamental kinematic invariants. These kinematic invariants serve to specify object boundaries, spatial layout, and human facial expression and body movement. Static invariants are detected later and used for perceptual organization. However, Kauffmann-Hayoz also pointed out that "top down" processing starts operating as early as four years of age, making the use of kinematic information more efficient when the object is familiar. She further speculated, that with infant development, internal representations become increasingly important in visual perception. They make "bottom-up" perceptual processing more efficient and precise. Interestingly, the author described as good perceivers those individuals who can use their repertoire of representations to refine their perceptual discriminative abilities, detect new invariants and then use these refined abilities to further enrich their system of representation.

Ecological Approach

The ecological approach has fascinated the minds of psychologists for well over 40 years. The originator of this theory of direct perception was

James Gibson, who carefully described his ideas in several publications (e.g., 1966, 1979). His wife, Eleanor Gibson (1982, 1987), applied the approach to developmental psychology, a research direction keenly investigated ever since. In recent years, the ecological approach has experienced a revival with contemporary theorists (e.g., Lee & Young, 1985; Turvey & Carello, 1988) using more sophisticated methods to explore the issues raised by Gibson. Although, theoretically, the ecological approach also addresses auditory and tactile perceptions as well as vision, most of the research has been done in the area of visual perception (e.g., Lee & Young, 1985). Since the present study limited its investigation to visual perception, the following sections present the key concepts of the ecological approach in terms of visual perception only.

According to Michaels and Carello (1981), the basic premise of the ecological approach is that "...the useful dimensions of an animal's sensitivity are to the structured energy that invariantly specifies properties of the environment of significance to that animal" (p. 156). In other words, the evolution of a specific species has created perceptual instruments that are sensitive to those properties of the environment that are essential for the survival of that particular species. This perceptual tuning to essential properties allows the animal to pick-up meaningful information directly from the environment without having to rely on the mediation of cognitive processing. Michaels and Carello consider lower-level descriptors such as amplitude, momentary retinal form, and wave length to be variant with each one changing as a function of the angle of regard, distance, and/or viewing conditions. On the other hand, there are also structural invariants or energy patterns that relate invariantly to the events that give rise to them. These invariants are believed to form the basis of perceptual constancy.

It must be noted, however, that not all structural invariants are equally important. Energy patterns are termed, "ecologically significant," if they permit or guide adaptive behaviors. These energy patterns are best understood in connection with affordances that are descriptions of the environment with reference to an animal, what the environment means to an animal. According to Michaels and Carello, the affordances of an object, place or event are the behaviors it invites or permits by virtue of its structure, composition, position and the animal's abilities.

The affordances of a given environment may be different for different perceivers or even the same perceiver in different conditions. According to Bakker, Whiting and van der Brug (1990), affordances are different based on the perceiver and his/her goals. They point out that the potential actions are clearly dependent, for instance, on the perceived importance and/or risks of the outcome.

Some of the optical properties that have been shown to be of value for human observers are body-scaled dimensions and an optical variable called "tau." Body scaling refers to the fact that humans and animals tend to use their own body measures (i.e., eye height) as the unit of measurement when defining which actions are feasible in a given environment. Indeed, finding the lawful relationships between the environmental information and responses have been identified as one of the main goals in this area of research (Turvey & Carello, 1988).

Tau is an optical variable indicating the time that is left until collision with a moving object. This variable is based on the rate of expansion of the retinal image of a moving object. It has been shown that higher levels of information are being extracted from the optical flow of information than was previously thought (Todd, 1981). Rather than gathering separate information on angles of approach, speed, and distance, combinations of these parameters seem to be available. This information does not need to be further processed in order for the animal to act. The possibility of such high-level information being used at an early phase of visual processing has prompted some theorists to refer to the visual apparatus as a smart perceptual instrument (Runeson, 1977).

The enthusiasm surrounding the concept of smart perceptual instruments waned, however, after it was discovered that the direct perception observed in lower animals was not evident in humans to the same degree. The specialized receptor cells at the retinal level of lower animals have their correspondents at the cortical level in humans. The more radical form of the ecological approach, however, still claims that cortical structures are not necessary in perception because there is no central representation of movements stored in the brain. This rigid argument has long hindered any collaboration between proponents of direct perception and motor theorists supporting the information-processing, or indirect view of perception.

In more moderate discussions on direct perception, however, the concept of central representation of movement patterns is recognized. Turvey (1977) suggested that there exists an abstract entity called an "action concept" that subserves motor constancy. Colley (1989) has more recently described it as "an operator which can modify and relate coordinative structures" (p. 169).

Empirical Evidence for Direct Perception

Several studies have shown that optical properties of the environment are used as action boundaries that suggest potential behavior in a given situation. Using terminology derived from the ecological approach, these optical properties define what the environment affords the person (see Turvey & Carello, 1988). For instance, people have been shown to perceive the surface layout in body scale units in: a) stair-climbing (Warren, 1984), b) estimating seat height (Mark, 1987), and c) walking through apertures

(Warren & Whang, 1987). These studies have further shown that manipulating the eye-height of the observer by having him/her wear 10 cm block-shoes or by lifting the level of the floor in the room where the subject is looking tends to distort the estimation of whether the stairs are climbable, the chair is too high for sitting on or the opening of the door is wide enough to walk through. Interestingly, Mark (1987) reported some experiments where his subjects were allowed to walk around in their block shoes between trials. These subjects were able to adjust their body-scaling to the new eye-height after about ten trials.

Concurrently with the studies investigating the use of body-scale units, another line of research has focused on the optical variable tau. During the past ten years a considerable amount of new data on the use of tau as a predictor of time-to-contact has been reported. One of the earliest discoveries of the use of tau in the sport domain was illustrated in a study conducted by Lee, Lishman, and Thomson (1982) using long-jumping. They showed that rather than estimating speed and distance to the take-off board, long-jumpers relied on optical patterns to predict time-to-contact with the take-off board and adjusted the length of their last six strides accordingly.

Warren, Young, and Lee (1986) subsequently provided support for the use of tau in running over uneven terrain. They concluded that the vertical impulse of a step is modulated by the change in tau that specifies the time interval the runner has to bridge two targets.

The Use of Tau in Object Interception

Turvey and Carello (1988) provided an illustrative example of the use of optical properties in ball games. They described the problem of a softball outfielder who has to decide whether to move to catch the oncoming fly ball or move to cut it off after it bounces. They referred to the mathematical work of Todd (1981) and concluded that "...there is a dimension-less, macroscopic optical property available to a point of observation that specifies where a ball will land relative to that point of observation" (p. 195). This optical property, the Todd Number, could drive action in a situation like that described above.

The Todd Number is built from a ratio of two taus, one specifying the ball's vertical drop and the other specifying the ball's horizontal traverse. If these two taus are equal, the ratio thus being 1, the ball will meet the point of observation. Logically, if the ratio is grater than 1, the ball will land behind the point of observation and if the ratio is less than 1, the ball will land in front of the point of observation. The Todd Number thus specifies the appropriate action, whether it is retreating, advancing or staying still (Todd, 1981; Turvey & Carello, 1988).

Todd reported the results of a series of four experiments in which computer simulation of two approaching objects was used. The experiments were designed to show that there is visual information available to an observer about a moving object's angle of approach, changes in velocity and acceleration and their direction, its time to collision with vertical and horizontal axes and whether it will land in front or behind the observer. The results indicated that human observers can benefit from many abstract properties of visual stimulation but are not sensitive to all potential information. For instance, the subjects did not benefit from being able to see the ball at the highest point of its trajectory, although mathematically this piece of visual information would be very helpful (Todd, 1981).

Rosengren, Pick and von Hofsten (1988) have shown that the presence of a minimal visual frame, as compared to a darkened environment, appears to aid performance. Since the use of computer simulation is bound to neglect the surrounding visual environment, the results of Todd's (1981) experiments should not be applied to real-life situations without further investigation. Intuitively, however, one would assume that with the natural surroundings the environmental optics could be utilized even better than in computer simulations.

Perceptual Tuning

According to Eleanor Gibson (1982), perceptual learning involves finely tuning the perceptual system to detect perceptual invariants. In childhood, perception improves through differentiation of distinctive and important features of sensory information. In other words, the child more readily selects and attends to relevant information in the environment and detects those invariant perceptual relationships that signify specific objects and events. It is important to note that, according to this differentiation theory, the information has always been in the environment--the child has simply not been attending to those affordances. Perceptual learning therefore occurs as a function of increasing specificity of perceptual information, improved attention and more economical and efficient acquisition of perceptual information.

In an extensive discussion of research findings related to infant responses to optical information for collision, Yonas (1981) also suggested that the development of spatial perception may not be the result of pure maturation or associative learning. Instead, it could be the result of increasing specificity of discrimination. With regard to sensitivity-to-collision information, some spatial sensitivity may be present at birth, but experience in a visual world may be required for differentiation to occur.

The above-mentioned authors did not specify either how much or what kind of experiences are important for normal development, not to mention maximizing performance. However, in the extreme forms of children's athletic training, the potential benefit has been recognized. For example, Israel (1976) argued that, for sport-specific purposes, specific visual training would be beneficial from as early as two years of age. Brandt (1979) also recommended specific training for development of visual orientation ability in volleyball. He claimed that, for players under 16 years, the development of coordination abilities, especially the visual orientation ability, should be the major concern rather than a technically correct performance. A strong background of visual training will later allow the players to deal simultaneously with the technical details and tactical considerations.

While the effectiveness of extensive training, or tuning of the perceptual apparatus, has not yet been determined, it is of interest to acknowledge the possible benefits of early exposure to sport-specific perceptions. Docherty and Boyd (1982) have reported results indicating the importance of experience in prediction of performance in volleyball, badminton, and tennis among adolescents. In their study, experience was evaluated on a seven-point scale ranging from non-players to experienced competitive players. Based on a step-wise multiple regression analysis, they concluded that previous involvement in volleyball accounted for 56 percent of the variance in performance.

Vision in Ball Games

A long line of research has been completed on the role of vision in catching a ball. According to Williams (1988), about 20 papers and theses on ball skills and related topics were produced between 1967 and 1977 by a group led by John Whiting at the University of Leeds. Since then, further work has been conducted by this group and others providing an extensive body of knowledge concerning the effects of partial occlusion of the visual tracking of a ball on subsequent catching performance (e.g., Lamb & Burwitz, 1988; Whiting, Gill & Stephenson, 1970; Whiting & Sharp, 1974).

One general conclusion of these studies is that an early accurate visual appraisal of a ball's flight path is characteristic of skilled ball catching. Although it is not necessary for a catcher to attend closely to the whole duration of the flight path, some viewing time must be allowed prior to contact for the appropriate timing of the motor actions associated with catching.

Jeannerod (1981) discovered that lack of vision of the hand just prior to contact adversely influenced hand positioning. He suggested that the function of vision in this latter stage is either to assist the performer appropriately position the catching hand prior to contact and/or to facilitate the timing of the grasp. Similar results have been reported by Whiting, Alderson and Sanderson (1973), who also found that performance in dark conditions deteriorated as the trials progressed. These results support the conclusions of Smyth and Marriott (1982) that proprioceptive information, alone, is not adequate to determine the location of a limb and that the proprioceptive system needs to be constantly recalibrated by the visual system to remain reasonably accurate.

Fischman and Schneider (1985), however, argued that the accuracy with which articular proprioception can guide limb position is a function of skill level. Their results provided support for this hypothesis in that the skilled catchers experienced difficulties only in the grasping phase of the catching action and not in the spatial placement of the hand prior to the catch when vision was occluded.

Unfortunately, no findings have been published on analogous experiments in volleyball. However, since no grasping action is required when performing the volleyball forearm pass and the larger contact surface provides a greater margin of error, it might well be that expert volleyball players also rely primarily on early visual information in predicting where to contact the ball in space. In this way, any additional visual information usually available prior to contact could be directed toward refining the associated body and arm movements. Since it has been shown that novice players tend to be less able to attend to and utilize early visual information (e.g., Abernethy & Russel, 1987), they could benefit from a type of training where they learn to extract enough early flight information on which to base an accurate prediction of the ball's flight path.

The ecological approach to ball catching is based on a holistic interpretation of the catching action. Lee and Young (1985) proposed that when performing an interceptive act such as catching a ball, the visual system, alone, enables finely-timed action. This is achieved by using the looming effect of the oncoming object as an indication of the time remaining to contact. Yonas (1983), referring to the ability of infants and even dogs to intercept a moving object, concluded that the interceptive action is not cognitively mediated.

Although the concept of direct perception has been present for several decades, it is only recently that it has been applied to ball games. Most of the earlier research literature related to the role of vision in ball games was based on the indirect view of perception. While this has limited the nature of the experimental settings used, it has also provided an extensive knowledge base related to the cognitive aspects of perception. Some examples are provided below.

Abernethy (1989) found that both novice and expert badminton players tended to use visual cues to determine the direction of the opponent's serve. The time period beginning 83 ms before racket-shuttle contact and lasting 83 ms after the contact was deemed particularly crucial for extracting useful information. Abernethy concluded that the more experienced players have an advantage over novices in terms of their ability to utilize early and proximal cues provided by the actions of the opponent.

McLeod (1991a) reported the results of an "Eyerobics" visual skill training program in soccer. The videotaped program consisted of six exercises organized into 12 sessions, each lasting between 18 to 38 minutes. The objective of the exercises was to strengthen and refine the muscles that move and direct the eyes. Both the experimental and control group, each consisting of nine experienced female players, were tested prior to and after the intervention. Results indicated a significant training effect in balance and hand-eye and foot-eye coordination as measured by a dribble test but failed to show a training effect using a wall-volley test. The validity of the tests used to detect improvement, however, were subject to criticism from both the author and others as well (McLeod, 1991b; Cohn & Chaplik, 1991). It was concluded that the wall-volley test may not have been ideal for testing soccer playing ability and that the conclusion of a training benefit was justified only to the extent that visual control is assumed to affect dribbling.

Burroughs (1984) reported benefits for a visual training program incorporating a cognitive learning strategy. He investigated the possible benefits of visual simulation training in baseball batting. Thirty six collegiate baseball players attended from four to six 45 minute training sessions, during which they viewed a film of oncoming baseball pitches, as seen by a player in the batter's box. Their task was two-fold. First, the subjects watched only the release phase of the pitch and reported the type of pitch and where it would land on a grid behind the home plate. Second, the subjects watched the same pitch again, but this time the viewing time was not restricted at all. Again, the type of the pitch and estimated landing location of the pitch were to be reported. This procedure was repeated for a total of 20 pitches.

The level of performance of each of the players was measured before and after the training using a specific test. In this test the player was standing in the batter's box ready to swing. He was wearing a special helmet that would automatically occlude his vision after a fixed time interval following release of the ball from the pitcher's hand. The player was expected to call out the pitch location with reference to the grid behind the home plate. The results showed significant improvement in the test scores for both a sub-group who viewed slow-motion film and, a sub-group exposed to regular speed film. The training benefit was still evident in a follow-up test conducted six weeks later. Although these results are encouraging, it is important to note that the authors did not report whether any improvement in the actual motor skill of batting was observed.

The present study differs from that of Burroughs (1984) in several aspects. In addition to including an actual motor-skill test to better evaluate the effectiveness of the perceptual training period, the present study was also designed to investigate the possible benefit of perceptual training from a more ecological approach as compared to the design used by Burroughs. While the subjects in that study were instructed to use a cognitive learning strategy to guide their predictions, the present study exposed the subjects to perceptual tuning without the emphasis on cognitive reasoning in the form of verbal instructions. Also, in the perceptual-motor testing procedures, an actual real-time motor response was required rather than simply a verbal prediction, thus providing a better opportunity for the subjects to act based ondirect perception in addition to or instead of relying only on cognitive mediation.

Role of Vision in Volleyball

In the former Soviet Union and other Eastern Block countries, the importance of perceptual training in volleyball has been emphasized for decades (Belyaev, 1983a; 1983b; Sawula & Maxwell, 1982). According to Sawula and Maxwell (1982), 90 percent of the information obtained by a player in volleyball comes via peripheral vision and should, therefore, be one of the major areas of conditioning. Depth perception is another important area, as the perception of approaching and departing objects is crucial for timing of the set and attack as well as for defensive actions. Although the Soviet view seems to emphasize the cognitive and psychological aspects of visual training, it also focuses on the automatization of responses. Rather than having players anticipate and reason out the nature of an attack or serve, certain drills are designed to eliminate the early cues and to force the player to act using direct perception. An example of such training was to have players involved in a game where the net was covered with a sheet. Both teams would have to react to the serve or an attack without seeing the ball until it emerges from behind the net. According to Belyaev (1983a) and Sawula and Maxwell (1982), this type of training can be used to force the players to react rapidly.

The members of the 1984 Olympics Gold Medal U.S. Men's volleyball team reportedly participated in visual skill enhancement training prior to the Olympic Games (Kluka, 1987). With the help of an optometrist working on their visual skills, the players were able to improve their blocking, passing, and digging skills. The training regime followed the hardware approach that focused on the improvement of the optometric properties of the visual system. No reports have been published on perceptual training programs in volleyball incorporating a software approach.

Summary

A growing body of literature has provided support for the use of a direct mode of perception in a wide variety of tasks. As opposed to the strictly ecological approach to perception, the more contemporary interpretations of direct perception have recognized the role of an action concept as a form of central representation of the movement. This compromise has made it possible to integrate some of the premises of the ecological approach with the views of proponents of the indirect view. For instance, the developmental aspects of perception can be better accounted for by combining the body of literature provided by the two approaches.

The role of vision in ball games has been primarily studied in the context of information-processing theory. This body of research has provided a solid base for understanding the role of prior knowledge and anticipation in tasks involving prediction of ball flight. However, recent studies have indicated that incorporating the direct mode of perception by linking perception to action rather than to purely cognitive processes can provide a more comprehensive description of the movement behavior. Further research in ecologically valid settings, however, is needed to identify the suggested mechanisms underlying the perceptual-motor behavior.

Methods and Procedures

Introduction

The purpose of the study was to examine the effectiveness of a three week perceptual training program on the performance of a volleyball serve-reception task. The following sections describe the subjects, apparatus and, methods and procedures used.

Subjects

The subjects were ten female volleyball players from class AAA high school varsity ($n = 1$), junior-varsity ($n = 2$) and freshman ($n = 7$) volleyball teams. The average age of the subjects was 15.5 years (SD = 1.0). The players' participation in the experiment was voluntary and fully supported by their coach.

Prior to the study, the subjects were asked to complete a two-page questionnaire (see Appendix A) concerning their previous experience in volleyball. Parental consent for their participation was also obtained as well as approval from the principal of the high-school and school district (see Appendix B).

Methods

The experimental schedule is presented in flow-chart form in Figure 1. All subjects were required to keep a daily log of their ball-game related activities both during the three-week training period and one week before the start of the training period. This was done in order to detect possible changes in participation levels that could confound the results of the study.

Subjects in both testing groups were encouraged not to engage in the playing of ball games during the training period (see Appendices C and D). One subject who was concurrently involved in an interscholastic softball program, however, was allowed to complete her last week of playing and training, but only to the extent required by her coach.

Preparation of testing and training videotapes. Two videotapes were prepared for use in the study. Both of them pictured a female player serving overhead float serves to the left half of an official volleyball court as seen from the receiver's viewpoint (see Figure 2). The net-height was 224 cm which is the official height for women's games. A video-camera (Hitachi VM, model 3000A HQ), mounted on a tripod, was placed 6 m behind the baseline and 2.25 m to the right of the left sideline. The camera lens was directed towards the server standing behind the baseline in the service area. The height of the lens was 1.4 m above the ground, which approximates the

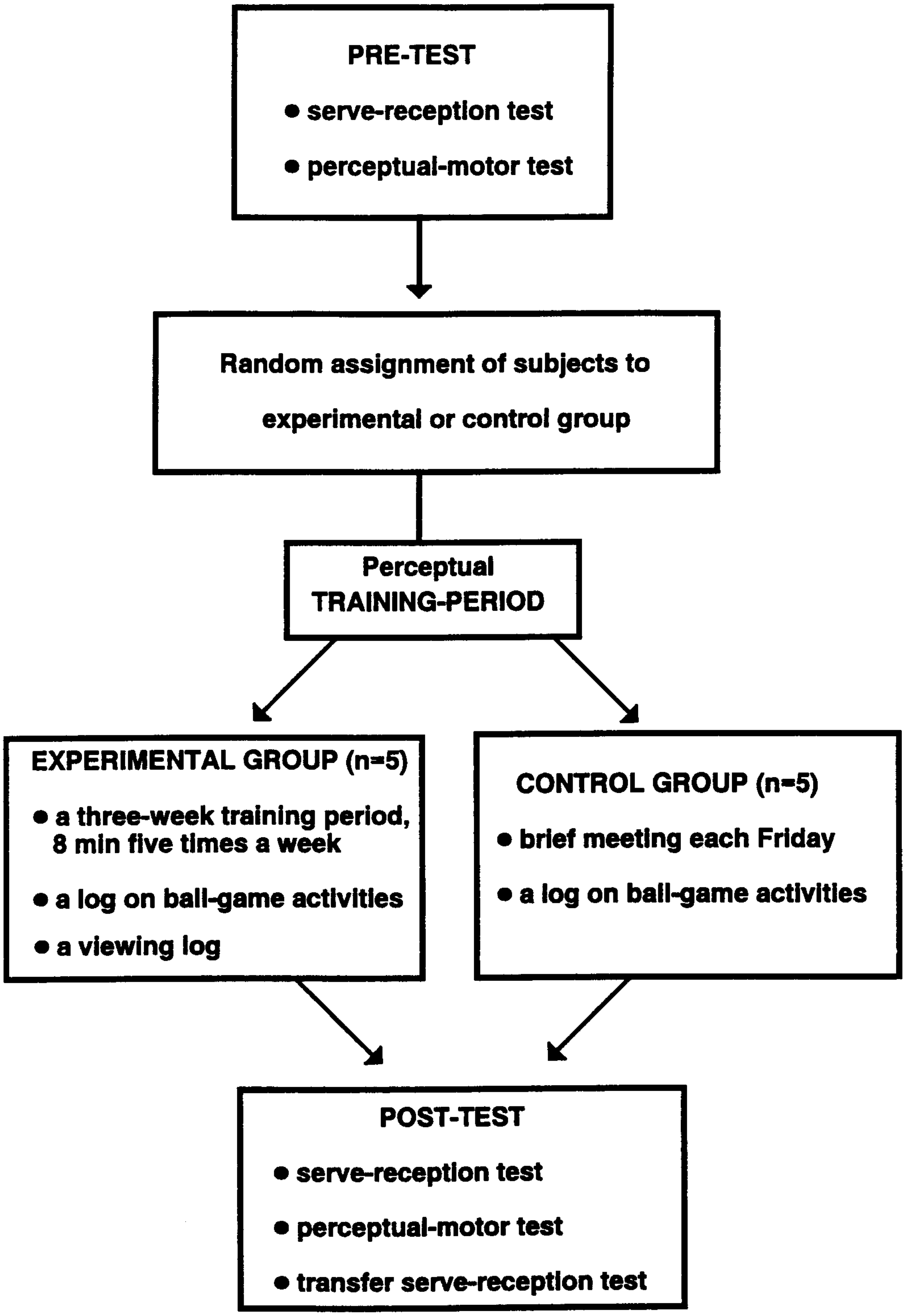

Figure 1. Experimental schedule.

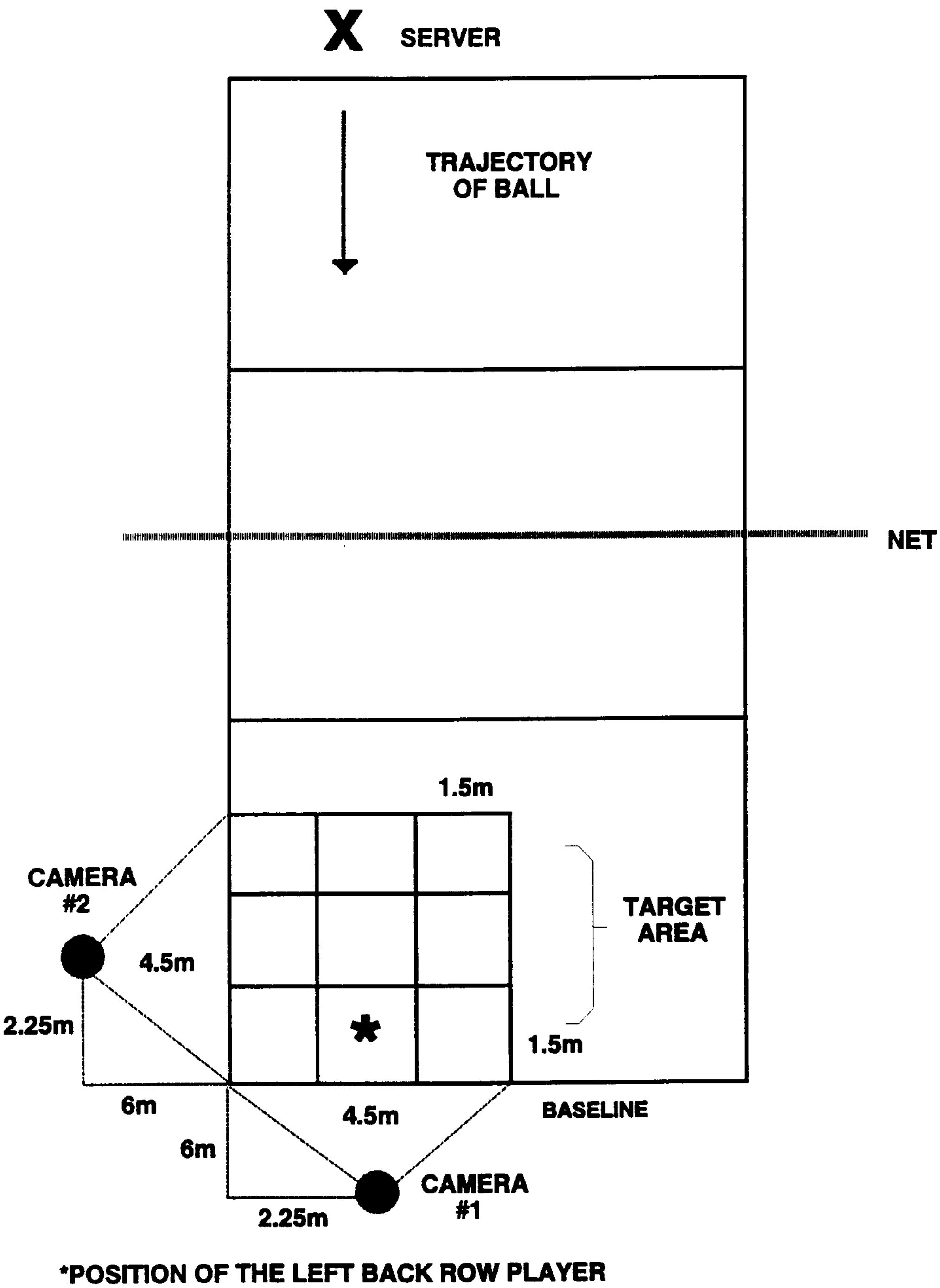

Figure 2. Preparation of testing and training videotapes.

eye-height of a female player in a ready position waiting for a serve. The camera lens was zoomed to simulate the view obtained when standing in the left back row position. For the purpose of the study, this position was defined as being between 1.5 m and 3 m to the right of the left sideline and no more than 1.5 m in front of the baseline. Positioning the camera behind the baseline was considered necessary in order to provide a wide enough visual angle to simulate the receiver's visual field. On-court placement of the camera would also have obscured the final phase of the ball's flight in the case of longer serves.

Six sets of 15 serves were filmed, resulting in 90 serves projected into or just beyond a 4.5 m x 4.5 m target area in the left half of the back court. This target area was further divided into nine 1.5 m x 1.5 m squares with 3/4" wide masking tape. A second video-camera (Hitachi, model VM 3000A HQ), mounted on a tripod, was placed 6 m to the left of the left sideline, 2.25 m in front of the baseline and at a lens height of 1.5 m to record the exact landing location of each serve.

All filmed serves were subsequently reviewed using both video tapes to determine where each of the serves landed with respect to the marked target area. Only those serves which clearly landed in the middle of a square were retained. The remaining serves were labeled ambiguous if: a) the served ball landed on a line bordering two squares or b) the landing location of the served ball, combined with the angle of approach of the ball, made it difficult to determine where players of different height, using different technique and/or style, would have to position themselves in order to pass the ball. The frame-by-frame function (accuracy of 1/30 s) on the VCR was then used to measure the elapsed time from the ball's contact with the server's hand until it touched the floor following completion of the serve. All serves with a flight time longer than 50 frames (1700 ms) or less than 38 frames (1140 ms) were discarded. The flight pattern of these serves was clearly different from the remaining serves.

A total of 26 unambiguous serves (mean flight time 1,448 ms, SD 117 ms) were included on the test tape, six to be shown during practice trials and 20 to be presented during the test trials. Only two serves landing in each of the nine squares were included in the 20 test trials. The remaining two serves exceeded the court boundaries and were therefore considered to be "out-of-bounds." The practice trials consisted of one out-of-bounds serve and five serves to different squares. The 26 serves to be presented on the test tape were randomly ordered.

The first part of the tape consisted of 10 serves, one serve per square and one out-of-bounds, edited to show only the first 830 ms of the ball's flight. This time represented the first 52 to 59 percent of the ball's overall flight time, depending on the speed and trajectory of each serve. Greater accuracy in calculating flight-time percentages was not feasible with the editing facilities available (cut-off accuracy of +/- four frames). Blank tape was inserted between each serve to create a frequency of one serve per 10 s. This time interval simulates the actual rhythm of a server performing a similar serving drill. The second set of 10 serves to be presented was edited in a similar manner, but using different serves in a different randomized order and showing only the first 500 ms of the ball's flight, which corresponded to the first 30 to 39 percent of the ball's flight time.

The six practice trials were placed at the beginning of the test tape. The first three were examples of the longer exposure time (830 ms); the last three represented the shorter viewing time (500 ms). The longer, as opposed to shorter, viewing time was shown first to all subjects to avoid discouraging the subjects. A 15-second strip of blank tape was placed between the practice and test trials as well as between the two sets of test trials to provide time for the subjects to relax and refocus their attention.

The training tape was edited using the remainder of the serves, including ambiguous ones. The whole flight of the ball was shown, including the landing. Five sets of 20 serves were recorded on a master tape with a frequency of one serve per five seconds. A 10-second strip of blank tape was inserted between the sets. Each set consisted of 20 serves with two serves landing in each of the nine squares and two going out-of-bounds. The serves were presented in a different randomized order in each of the five sets. This master tape was then used to create four additional tapes in which the five sets of 20 serves were randomly ordered. These five training tapes were to be used during the training period in a different order each week to decrease the monotony of viewing and to prevent the subjects from memorizing the order of the serves.

Pre-training test. Baseline measurements for the serve-reception and the perceptual-motor tests were obtained during the course of one day. All testing was conducted on a regulation volleyball court in a high school gymnasium. Each subject was tested individually. The total time spent in testing was about 25 minutes per subject.

Upon arrival, the subjects were instructed by their coach and the experimenter to engage in a routine warm-up procedure in a separate gymnasium and to spend at least 10 minutes passing and receiving the ball with a partner.

The first test performed was the serve-reception test. This test consisted of receiving and passing an official volleyball on a regulation volleyball court. This test was followed by a perceptual-motor test which required similar subject responses. In this second test, however, the subject viewed a projected image of the oncoming ball rather than an actual serve. The subject was to execute the most appropriate motor response, despite the absence of the ball.

<u>The serve-reception test</u>. For the serve-reception test, a 4.5 m x 4.5 m area, divided into nine equal squares and covering the left half of the back court, was marked with 3/4" wide masking tape. A 3 m x 2 m target area for passing was marked immediately in front of the net line and 4.5 m to the right of the left sideline. A larger rectangular area (4 m x 3 m) surrounded the smaller target area, starting 3.5 m from the left sideline (see Figure 3). The smaller target area represented the area in which the setter should receive the pass in order for her to have several tactical options for the subsequent setting action. The larger target area was marked for scoring purposes.

The subjects were required to receive and pass a total of 24 serves executed by two female volleyball players. Each server alternated after serving the ball for three consecutive serves. After two sets of three serves had been completed by both servers (a total of 12 serves), a two minute interval was inserted for the purpose of ball collection. A second series of 12 serves was then executed by the same servers. These procedures were followed to minimize the fatigue of the servers and therefore maximize the consistency and accuracy of the serves. The use of multiple servers was also more consistent with an actual game situation.

The subjects were responsible for defending the left half of the back court only. They were required to pass the served balls to the setter's target area as accurately as possible and with a high enough trajectory to

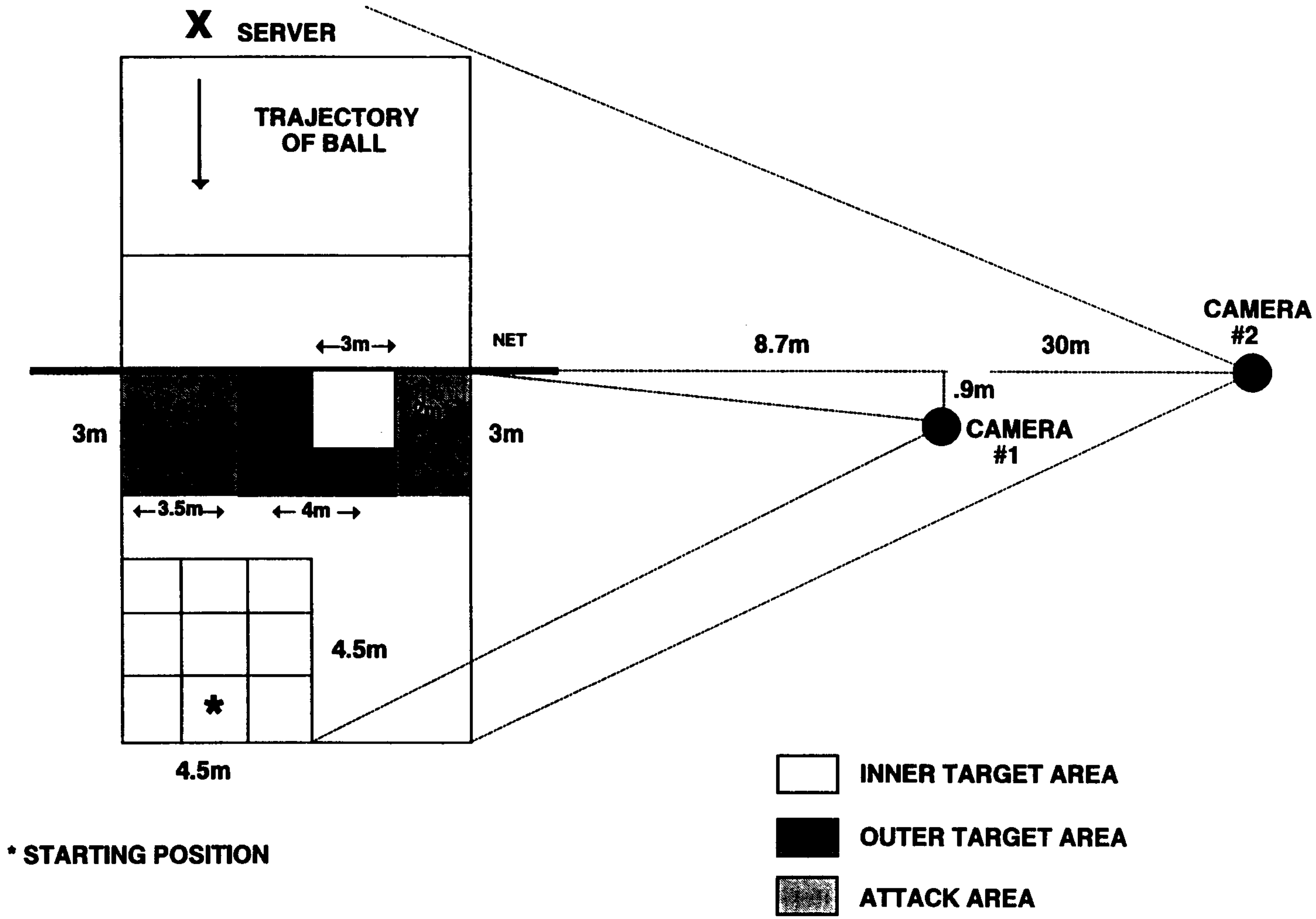

Figure 3. Court lay-out and camera positions for serve-reception test

allow an imaginary setter in the target area to set the ball with an overhead motion. Subjects were required to return to the same starting position (the middle back row square) after completing each pass. The subjects were required to call "out" if the serve appeared to be going out-of-bounds. The out-of-bounds serves were repeated to provide a total of 24 legal serves.

Each server was instructed to direct her serves, if possible, to each one of the nine squares during their turn at serve. The servers were using a well-practiced overhand float serve. They were also requested to adopt a serving pattern and speed that they were able to maintain with reasonable consistency in the past.

The subjects received three practice serves from each of the two servers prior to the start of the test trials. Any serve contacting the net or, landing on the court but outside the designated reception area was repeated, regardless of whether the receiver touched the ball. The out-of-bounds serves were repeated only if the subjects did not attempt to touch the ball.

The performance of each subject was videotaped using a tripod-mounted video-camera (Panasonic, model AG170) positioned 8.7 m to the right of the right sideline and 60 cm from the centerline at a lens height of 2.15 m. The videotaped responses were used to score the quality of the reception and subsequent pass. A second video-camera (Hitachi VM, model 3000A HQ) was mounted on a tripod and positioned on the center line 30 m to the right of the right sideline. Its lens was at a height of 1.5 m and pointing to the sideline at a 90 degree angle. This camera was used to record the speed and distribution of the serves. This allowed for later omission of serves that did not meet the established criteria for speed and trajectory. The remaining serves were classified into four groups based on landing location (left or right, front or back). For the final analysis, a total of 16 serves were randomly selected, four from each sub-group.

The performance score was based on the quality and accuracy of the pass according to predetermined criteria. Five points were scored if a pass landed in the inner target area, four points if it landed in the outer target area and three points if the ball landed within the attack area. All passes were required to reach the height of the net at some point during the ball's trajectory in order to qualify for any of the points described. Two points were scored for any pass considered by independent judges as playable by any other team member. Finally, one point was scored if contact with the ball was achieved, but the pass was not playable by anyone on the team. Failure to contact a ball landing within the boundaries resulted in zero points. The maximum score for the 16 trials comprising the test was 80 points. The scoring of the videotaped test performances was completed independently by three qualified judges who had experience in playing and coaching volleyball at the high-school and collegiate levels. Pearson's correlation coefficients were calculated to measure inter-rater reliability during each of the two testing sessions. Since the correlations were relatively high (between .94 and .97) for all three judges in each session, the mean of the three judge's scores was used for later analysis.

The test-retest reliability of the serve-reception test had been assessed earlier using a smaller sample of college students (N = 4). The Pearson correlation coefficient obtained for scores obtained in two testing sessions completed one hour apart was .98. The validity of the test was based on the logical validity achieved by using a game-like design. The scoring criteria was a modification of a recently published volleyball passing test (Bartlett, Smith, Davis & Peel, 1991) and based on consultations with five knowledgeable volleyball coaches, three of whom later served as independent judges in the actual scoring process.

The perceptual-motor test. The perceptual-motor test was designed to measure the subjects' ability to utilize early visual information of the ball's flight trajectory to predict where the oncoming ball would land. A game-like situation was created to allow for the coupling of the motor response with visual perception.

The perceptual-motor test was administered on a regulation volleyball court adjacent to the one on which the serve reception test was conducted. In place of the net, a 1.2 m x 1.5 m portable screen was placed on the center line 2.25 m from the left sideline and facing the serve-reception area (see Figure 4).

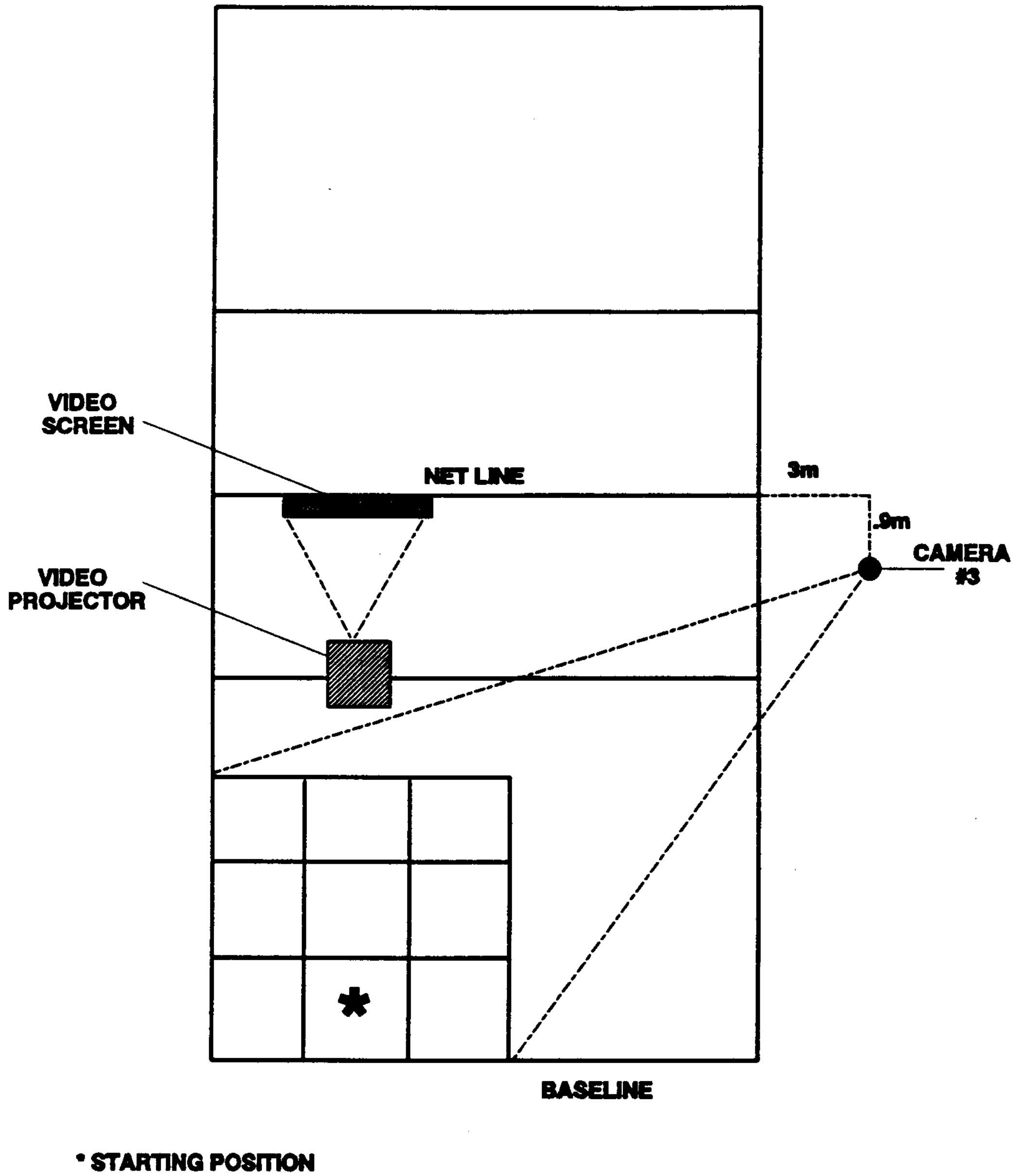

Figure 4. Court lay-out and camera position for perceptual-motor test.

The serve reception area was divided into nine squares using 3/4" masking tape in the same way as in the serve reception test. A video-projector was placed 2.1 m in front of the screen (2.4 m in front of the serve reception area) at a height of 80 cm. The upper edge of the screen projecting the video image was at a height of 2.40 m above the floor. The subjects were instructed to adopt a ready position in the middle back row square and to respond to the image of the oncoming ball on the screen as if it were an actual serve. This was the same ready position used in the previous serve-reception test. The subjects were encouraged to mimic the complete action of a serve reception and then return quickly to the starting position. They were encouraged to call "out" if the serve appeared to be going out-of-bounds. Six practice trials were presented to all subjects in the same order; those serves providing a longer viewing time were presented first. However, in subsequent trials the order of presenting the two sets of ten trials with different viewing times was counter-balanced.

The movements of the subjects were videotaped for later scoring using a video-camera (Hitachi VM, model 3000A HQ) mounted on a tripod and positioned 3 m to the right of the right sideline, on the same side of the "net," 90 cm from the center line and at a height of 2 m. The lens of the camera was zoomed to provide a full view of the 4.5 m x 4.5 m serve reception area. This camera malfunctioned during the pre-training trials and was replaced with a second camera (Panasonic, model AG170) in the post-training testing. The total score for the test consisted of one point for each response to the correct direction and an additional two points for each response with correct estimation of depth. The rationale for awarding more points for correct movements in the backward and forward dimension as compared to movements to the right or left reflected the corresponding difficulty of the estimation. Three points were also awarded for a correct response to the out-of-bounds serves. Thus, the maximum score for each set of ten serves (longer and shorter viewing condition) was 30 points. For scoring purposes, the subject's reception location was determined by the placement of the front foot relative to the direction of the movement. The scoring of the video-taped performances was completed by an outside judge. The intra-rater reliability was assessed for two scorings one week apart and resulted in a Pearson's correlation coefficient of $r = .70$ for the pre-training test and $r = .98$ for the post-training test. The difference between the pre- and post-training reliabilities was possibly due to the better quality of the post-training videotapes. During the pre-training testing the malfunctioning video-camera made it more difficult to accurately detect some of the ambiguous moves where the subject was on the border between two squares. The malfunctioning video-camera was replaced with a second camera in the post-training testing session. Since it was justified to assume that the judge was more accurate in her scoring as a result of having already scored all the trials once, only the second round was used for later analyses.

Training. After completion of the two pre-training tests, subjects were randomly assigned to either the experimental or control group. Subjects were contacted two days after the pre-testing session. All subjects in the experimental and control group were reminded to keep a daily log of ball-game related activities and to return the form to the coach or the experimenter at the end of the week. They would then receive a new form from the experimenter. This procedure was repeated in each of the next two weeks as a means of minimizing disinterest among the control group subjects.

The subjects in the experimental group were provided with information on the procedures for gaining access to the VCR in the athletic department of their high school during their study hall hour. A student assistant supervising the facilities during study-hall hours gave them a different copy of the training tape each school day of the week and in different order each week. This was done to minimize the chances of subjects learning the order of the serves.

Each subject was requested to sit by herself in front of the 13" TV screen located in a quiet room and concentrate on the viewing, trying to predict as soon and as accurately as possible where the served ball should be received. Since the flight of the serves on the training tapes was not occluded, subjects were able to view the actual landing position of the ball. No motor responses were required but the importance of maintaining attention was emphasized. The subjects were advised to use the 10-second intervals between the five sets of 20 serves to rest their eyes. The subjects were allowed to watch the videotape only once during each session and were required to return it to the student assistant immediately following the viewing session. The students were required to view the tape each school day for three weeks (only 14 days due to Memorial Day). At the completion of the training period, each subject should have viewed a total of 1400 serves.

Due to changes in their academic schedule, field trips, exams and the like, three subjects were unable to attend the 14 sessions as scheduled. Make-up sessions were subsequently arranged for these three subjects. After make-up sessions, their attendance record was 12, 12 and 10, respectively.

Post-training test. The post-training test was administered one or two days after the completion of the three week training period. A second day was required because four subjects were unable to attend on day one. The post-training test measurement procedures were identical to those used during the pre-training test with all subjects completing both the serve-reception and perceptual-motor tests. An additional test to measure possible transfer of learning effects was also administered at the end of each subject's post-training testing session. This was done to determine whether the possible benefits of perceptual training were limited to the original task presented (serve-reception in the left back row position) or whether the benefits, if any, of the perceptual training could be transferred to a slightly different task.

Transfer serve-reception test. The transfer serve-reception test was identical to the serve-reception test described earlier except for the placement of the marked serve reception area. In the transfer serve-reception test, the subject received the volleyball in the right, instead of the left, half of the back court, which was also divided into nine squares. The serves came diagonally from across the court but the target area for the pass was at the same location by the net as in the earlier test. The subjects received six practice trials prior to the test trials. These trials consisted of two sets of 12 serves executed by the same two servers used in the pre-training testing session.

The overall duration of the post-training testing session was about 45 minutes per subject. All tests were presented in the same order, starting with the serve-reception test, followed by the perceptual-motor test and, finally, the transfer serve-reception test. A 10-minute rest interval was provided between each test to allow for subject recovery and the completion of technical operations (e.g., collection of balls, checking the cameras).

Data Analysis

Videotape recordings were used to score the performance of the subjects in the serve-reception test and the perceptual-motor test. In the serve-reception test the scoring was limited to 16 serves only, excluding those serves in which the flight times were either too short (i.e., < 1330 ms) or, too long (i.e., > 1660 ms). If the flight time was within an acceptable range (i.e., 1330 ms - 1660 ms) for more than the number of serves required, all serves were first classified by location and then 16 serves that evenly represented the reception area were randomly selected. This criterion was followed to ensure objectivity in selection of the serves for subsequent analyses. The 16 selected serve receptions were scored by three independent judges according to the criteria described earlier in the chapter.

The subject's mean performance score in the pre- and post-training serve-reception test constituted the first dependent variable. The maximum possible score was five points. The second dependent variable associated with this test was derived from the performer's movement time, that is, the time elapsing between the onset of the subject's movement toward the oncoming ball and the actual contact with the ball. The standard deviation associated with this time period reflected the player's movement variability and constituted the second dependent variable. The values for these timing variables were calculated by using the frame-by-frame function on the VCR. The criteria used to identify the onset of movement was the elevation of either of the heels from the floor immediately prior to the movement towards the served ball. The time of contact with the ball was defined as the last frame before a pass where the direction of the ball's flight remained unchanged by contact with the player's arms.

The transfer serve-reception test was scored in a similar manner to the pre- and post-test serve-reception tests, and two similar dependent variables (i.e., mean performance score and the standard deviation of movement time) were also obtained from this post-training performance. These two measures constituted the third and fourth dependent variables.

The fifth and sixth dependent variable were the performance scores obtained in the pre- and post-training perceptual-motor test for both long and short viewing times, respectively. The maximum score for each of these two remaining variables was 30 points.

Statistical Analysis

Descriptive methods (i.e., mean, standard deviation) were used to conduct a qualitative analysis of the information obtained from the questionnaires, weekly logs and viewing logs. Subjects' responses to questions two (i.e., number of years in competitive volleyball) and three (i.e., age at the time of starting volleyball) in the questionnaire were used to investigate the possible relationship between past exposure to volleyball and subjects' performance scores in the pre-training serve-reception and perceptual-motor tests. Pearson product-moment correlation coefficients were calculated in order to investigate the possible relationships between these variables. Number of years in competitive rather than recreational settings was used as a dependent variable, since it was deemed to more precisely indicate the amount and nature of the players' exposure to the game of volleyball. The relationships of competitive experience and starting age to consistency of the movement time during the serve-reception test were not analyzed in this study, since no prior data was available for testing these hypotheses. A second Pearson product-moment correlation analysis was conducted to examine the possible relationship between pre-training performance scores obtained for the serve-reception and the perceptual-motor test.

The possible effects of perceptual training, as measured by a serve-reception test, were analyzed using a 2 x 2 (Group x Time) multivariate repeated measures MANOVA (Schutz and Gessaroli, 1987). The dependent variables analyzed were the mean performance score and the standard deviation of the subject's movement time recorded during pre- and post-training performances of this test. A multivariate approach was chosen to maintain the natural interrelationship of these two dependent variables derived from the same test. A priori calculation of multivariate statistical power was based on the results obtained from a pilot study. One point per serve or, 16 points out of a possible 80 points in the total test score, was chosen as the level of expected difference. This difference score, combined with an expected standard deviation of eight points in the total performance score yielded an effect size of two. Since such a large effect size could be expected for at least one of the two dependent variables in MANOVA, the performance score, the table for large overall effect was consulted (Stevens, 1980). This table suggested a minimum group size of 15 for a .95 power at an alpha-level of .05. Since this level of power was unnecessarily high, a more conservative group size of ten was set as a more realistic goal for recruitment of subjects.

The effectiveness of perceptual training, as measured by a post-training perceptual-motor test, was also to be analyzed using a 2 x 2 (Group x Time) multivariate repeated measures MANOVA (Schutz and Gessaroli, 1987). The dependent variables were the performance scores obtained in each of the two viewing conditions (i.e. long and short viewing time) presented during the pre- and post-training perceptual-motor tests. The use of viewing-condition as an additional factor was not appropriate however, due to the small sample size (Schutz and Gessaroli, 1987). Follow-up univariate analyses were conducted if the omnibus F-test indicated significant differences ($p < .05$) between the groups.

The possible learning effects, as measured by the transfer serve-reception test, were analyzed using a MANOVA procedure with group (experimental/control) as the independent variable. The dependent variables were the mean performance score and the mean standard deviation of the subject's movement time for the transfer serve-reception test.

Results

Descriptive Results

The questionnaires indicated that, on average, the subjects tested had played competitive volleyball for a mean of 3.3 years (SD = 1.73). Subjects assigned to the experimental group had played for a mean of 3.0 years (SD = 1.87), while the subjects assigned to the control group had played for a mean of 3.6 years (SD = 1.95). The mean starting age for any type of volleyball playing was 11.0 years (SD = 2.41). Subjects assigned to the experimental group started playing at 10.6 years (SD = 2.88), while subjects in the control group started at 11.4 years (SD = 2.41). On a scale from zero to five, subjects rated their own serve-reception skill from two to four ($\bar{M}$ = 3.2, SD = .64). The mean serve-reception rating for subjects assigned to the experimental group was 3.0 (SD = .64), while the mean rating for subjects in the control group was 3.4 (SD = .49). Descriptive data obtained for each subject are presented in Table E-1 (see Appendix E).

In addition to requesting that all subjects refrain from participating in ball-related games during the course of the experiment, daily logs were also required from both groups. Unfortunately, five subjects failed to complete and return the daily logs indicating the extent to which they participated in ball game related activities during the course of the study. When questioned verbally, however, all subjects reported that they had not engaged in any such activities. However, those subjects (n = 5) who completed and returned the logs did report some minimal exposure to ball games during physical education classes (i.e., basketball, soccer) conducted once or twice a week. One subject also reported that she had played golf almost daily. She was not excluded from the study, however, because golf did not involve any interception skills.

During the training period, the subjects in the experimental group were requested to provide written comments concerning their impressions of each of their training sessions. The comments were general in nature and included statements such as, "I was looking at the ball and trying to see where my feet should be," or "I was trying to see where the ball will land and whether it is in or out." One subject indicated that she repeatedly pointed to an area on the video screen where she thought the ball would land. The total mean attendance for the 14 training sessions was 12.4 (SD = 1.50). Two subjects missed two training sessions, and one subject missed four sessions.

Results

The mean performance scores obtained by the training group and the control group for the pre-training, post-training, and transfer serve-reception tests are presented in Table 1. Since paired t-tests with adjusted alpha-levels (.05 / 3 = .016) revealed no significant differences between the two servers for the pre-training ($t = .44$, $p < .673$), post-training ($t = -.48$, $p < .641$) and, transfer serve-reception tests ($t = -.62$, $p < .553$), pooled data were used for all subsequent analyses. For the pooled data, the mean pre-training performance score derived from the serve-reception test was 2.04 (SD .75) for the experimental group, whereas the mean pre-training performance score for the control group was 2.64 (SD .71). Although there was a slight increase in the post-training performance score obtained by the experimental group ($\bar{M} = 2.26$, $SD = .72$), the mean score obtained by the control group for the post-training test ($\bar{M} = 2.53$, $SD = .47$) still remained higher than that of the experimental group. This trend was also evident following a review of the performance scores obtained for the transfer serve-reception test. The mean score for the experimental group was 2.10 ($SD = .70$) while the control group obtained a mean score of 2.46 ($SD = .96$). Mean performance scores obtained by each subject for the pre-training, post-training and transfer serve-reception test are presented in Table E-2 (see Appendix E).

The standard deviations of the movement time obtained by the experimental and the control group during the pre-training, post-training and transfer serve-reception test are presented in Table 2. While the

Table 1

Mean scores and standard deviations obtained by the experimental and the control group for the pre-training, post-training and transfer serve-reception test as a function of server

	Pre-training		Post-training		Transfer	
Experimental group *	$\bar{M}$	SD	$\bar{M}$	SD	$\bar{M}$	SD
Server 1	**1.9**	.89	**2.0**	.64	**2.1**	.80
Server 2	**2.3**	.72	**2.5**	.82	**2.3**	.81
Control group *	$\bar{M}$	SD	$\bar{M}$	SD	$\bar{M}$	SD
Server 1	**3.0**	.43	**2.6**	.76	**2.4**	1.1
Server 2	**2.4**	1.1	**2.4**	.55	**2.5**	.80

* n = 5

Table 2

Mean standard deviation of the movement time obtained by the experimental and the control group during the pre-training, post-training and transfer serve-reception test

	Pretraining		Post-training		Transfer	
	$\bar{M}$	SD	$\bar{M}$	SD	$\bar{M}$	SD
Experimental group (n = 5)	**106 ms**	8 ms	**121 ms**	15 ms	**127 ms**	45 ms
Control group (n = 5)	**129 ms**	25 ms	**99 ms**	28 ms	**117 ms**	16 ms

experimental group demonstrated less variability in movement time when compared to the control group during the pre-training test, this group exhibited increased variability for both the post-training and transfer test. In contrast, the control group demonstrated less variable movement times in both the post-training and transfer serve-reception test. Mean standard deviations of the movement time obtained by each subject for the pre-training, post-training and transfer serve-reception test are presented in Table E-3 (see Appendix E).

The performance scores obtained by the experimental and the control group for the pre- and post-training perceptual-motor test are presented as a function of viewing-condition in Table 3. For the correlational analyses, in which only pre-training performance scores were used, the scores obtained for the two different viewing conditions were combined to form a more general index of the subject's perceptual-motor skill. The mean total score was 27.2 points (SD 2.2) for the experimental group and 29.0 points (SD 5.0) for the control group. The maximum total score was 60. Performance scores obtained by each of the subjects for the pre-training and post-training perceptual-motor test under long and short viewing conditions are presented in Table E-4 (see Appendix E).

In order to determine whether a relationship existed between competitive experience and the serve-reception test pre-training score, a Pearson product-moment correlation analysis was conducted. The obtained

Table 3

Mean scores and standard deviations obtained by the experimental and the control group for the pre- and post-training perceptual-motor test as a function of viewing condition (long vs. short)

	Pre-training		Post-training	
Experimental group *	$\bar{M}$	SD	$\bar{M}$	SD
Long	**13.8**	1.3	**12.2**	2.5
Short	**13.4**	1.4	**14.0**	2.9
Control group *	$\bar{M}$	SD	$\bar{M}$	SD
Long	**15.0**	2.3	**13.0**	2.9
Short	**14.2**	3.0	**15.6**	3.4

* n = 5

coefficient was statistically significant ($r = .71$, $p < .02$), which was to be expected. More experienced players achieved higher scores than players with less competitive experience. Conversely, no significant relationship was demonstrated to exist between competitive experience and the performance score obtained for the pre-training perceptual-motor test, $r = .42$ ($p < .20$).

Thus, hypothesis one which stated that the pre-training performance scores obtained in a serve-reception and a perceptual-motor test are positively related to years of experience in competitive volleyball was only partially supported. A positive relationship existed between these two variables for the serve-reception test only. Furthermore, no significant correlations were found between starting age and pre-training performance scores for either the serve-reception test ($r = .03$, $p < .47$) or, the perceptual-motor test ($r = -.23$, $p < .26$). Hypothesis two, which stated that the pre-training performance scores obtained in a serve-reception and a perceptual-motor test are negatively related to the age at which the player first started playing volleyball was therefore rejected. The results indicated no significant relationship to exist between starting age and either of the two test scores obtained.

The relationship between pre-training performance scores obtained for the serve-reception test and the perceptual-motor test was also investigated using a Pearson product-moment correlation analysis. The test scores were not significantly related as indicated by a correlation coefficient of $r = .36$, ($p < .20$). Based on this result, hypothesis three, which stated that the pre-training performance score obtained for a serve-reception test is positively related to the pre-training performance score obtained for a perceptual-motor test was also rejected.

The effectiveness of the perceptual training was investigated in three separate analyses. The first of these analyses, a 2 x 2 (Group x Time) multivariate repeated measures MANOVA, was conducted to investigate possible effects of perceptual training as measured by a pre-training and post-training serve-reception test. The independent variable of group constituted the between-subjects factor with the independent variable of time serving as a within-subjects factor. The dependent variables analyzed were the mean performance score and the standard deviation of the subject's movement time. The correlation between the dependent variables was $r = .16$ for the pre-training test and $r = .05$ for the post-training test, indicating that multicollinearity was not a factor.

The MANOVA procedure revealed that the sphericity assumption was not violated (Greenhouse-Geisser Epsilon = .99761, significance = .992). Based on the guidelines presented by Schutz and Gessaroli (1987), the univariate rather than multivariate results were thus interpreted, since this latter procedure constitutes a more powerful test when the sphericity assumption is not violated. For the dependent variable of performance score, both the main effect for Group ($F(1, 8) = 5.89$, $p < .041$) and the main effect for Time ($F(1, 8) = 118.27$, $p < .001$) were statistically significant. No interaction effect for the variables of Group and Time was evident ($F(1, 8) = .84$, $p < .386$). These results only indicated a significant difference in the mean performance score between the two groups and between the two testing sessions. The mean performance score obtained by the experimental group was 2.22 (SD = .62), while the control group obtained a higher mean performance score of 2.59 (SD = .57). The mean performance score obtained for the pre-training testing session was 2.30 (SD = .66) and the mean performance score obtained for the post-training testing session was 2.40 (SD = .59). Based on these findings, perceptual training does not lead to statistically significant improvements in performance. Hypothesis four was therefore rejected.

The second dependent variable, standard deviation of the movement time, was analyzed using the same univariate analyses. Although no significant main effect for Group was found ($F(1, 8) = 1.18$, $p < .309$), the main effect for Time was significant ($F(1, 8) = 100.67$, $p < .001$). No interaction between Group and Time was evident ($F(1, 8) = 3.51$, $p < .098$). These findings only indicated that the variability of the movement time was different in the two testing sessions. The mean standard deviation of the movement time was 117 ms (SD = 22 ms) in the pre-training and 110 ms (SD = 24 ms) in the post-training serve-reception test. Hypothesis five, which stated that perceptual training would decrease the variability of the time period elapsing between the onset of the movement towards an oncoming ball and contact with the ball was thus rejected.

A 2 x 2 (Group x Time) multivariate repeated measures MANOVA was intended to be used to investigate the effect of perceptual training as measured by a perceptual-motor test. The dependent variables to be included in the analysis were the performance scores obtained for a pre- and post-training perceptual-motor test performed under two different viewing conditions (i.e., long and short). However, review of the correlation matrix during the preliminary analysis revealed high positive correlations between the dependent variables for both the pre-training ($r = .66$) and post-training test ($r = .76$). These high correlations indicated that multicollinearity existed. Thus, instead of a MANOVA, two separate 2 x 2 (Group x Time) repeated measures ANOVAs were performed, one ANOVA for performance score under longer viewing time condition and one ANOVA for performance score under shorter viewing condition. The alpha level was adjusted accordingly (.05/2 = .025). In each of the two analyses, the independent variable of Group constituted a between-subjects factor while Time constituted a within-subjects factor. For the longer viewing period condition, neither the Group main effect ($F(1, 8) = .71$, $p < .42$), the Time main effect ($F(1, 8) = 4.70$, $p < .06$) nor the Group x Time interaction ($F(1, 8) = .06$, $p < .82$) were statistically significant.

Similarly, for the shorter viewing period neither the Group main effect ($F(1, 8) = .59$, $p < .47$), the Time main effect ($F(1, 8) = 1.08$, $p < .33$) or the Group x Time interaction ($F(1, 8) = .17$, $p < .69$) were statistically significant. Based on these results, hypothesis six, which stated that subjects receiving perceptual training will achieve a significantly higher performance score in a post-training perceptual motor test when compared to subjects who did not receive perceptual training, was rejected.

A transfer serve-reception test was conducted to investigate whether the possible benefits of perceptual training would be evident in a task slightly different from the one originally performed. Since the transfer serve-reception test was conducted only after the completion of the training period, no repeated measures analyses were needed. A MANOVA procedure was used to investigate the possible group differences in performance score and standard deviation of the movement time obtained for the transfer serve-reception test. The correlation between these dependent variables was $r = -.38$, indicating that multicollinearity was not a factor. The MANOVA analysis revealed that the Group main effect was not significant (Wilks lambda = .938, $F(2, 7) = .23$, $p < .80$). Thus, hypotheses seven and eight were rejected. The findings indicated that training did not achieve a significantly higher performance score in a transfer serve-reception test when compared to subjects who did not receive perceptual training. Furthermore, perceptual training, as conducted in the present study, does not lead to a significant change in the consistency of a performer's movement towards the oncoming ball which can be transferred to a new playing context.

Discussion

As expected, the performance scores obtained in the serve-reception test were shown to be significantly related to years of experience in competitive volleyball. This finding was similar to the results reported by Docherty and Boyd (1982) indicating the importance of experience in the prediction of performance in volleyball.

Based on developmental considerations it was also hypothesized that the subjects who had started playing at an earlier age would perform at a higher level in the pre-training serve-reception test than the subjects who did not begin playing volleyball until a later age. The negative relationship predicted to exist between the performance score and the age when the subjects started playing proved to be non-significant. This finding can be interpreted in two ways: 1) starting age plays only a minor role in the process of acquiring the perceptual-motor skills needed in serve-reception or 2) the small number of subjects tested was insufficient to demonstrate the relationship. The latter explanation appears most viable. An additional factor may have been the wide range in starting age (from 7 to 14 years) which did not necessarily reflect competitive experience in volleyball. For example, one subject had started playing at the age of seven years but had only completed one year of competitive experience. Moreover, the position that the subjects had been playing in their team most likely affected the amount of exposure to serve-reception practice and experience. This is especially true for the setters, who tend to maintain their specific role even during practice drills. In the 5-1 offensive system (five hitters and one designated setter) that is commonly used in high-school games, the setter plays at the net in every rotation order instead of taking her turn in receiving and passing served balls while in the back-row rotation.

The lack of significant correlations between either the starting age or competitive experience and performance score in the perceptual-motor test could indicate that the simulated serve-reception test was not a natural enough setting for exploitation of earlier acquired perceptual abilities. Furthermore, it may reflect the subjects' inexperience in performing a task without knowledge of results. Unlike the serve-reception test, subjects could not see the outcome of their performance. This, combined with the fact that they did not receive any verbal encouragement during the tests, was very unusual for these high-school players, who were accustomed to constant encouragement from their coach and team-mates. Some players seemed rather uncomfortable with the uncertainty of how they were doing.

The tendency to become discouraged could explain the poorer performance in the post-training test for the longer viewing time.

Interestingly, the performance scores obtained during both testing sessions were slightly higher for the shorter viewing time as compared to the longer viewing time suggesting that occluding the ball's flight path for a longer time period was not as detrimental to performance as subjects may have perceived. Familiarity with the testing procedures during the post-training testing session could account for the observed improvement, albeit non-significant, in the mean performance score for the shorter viewing time.

No significant relationship was evident between the performance scores obtained for the pre-training serve-reception test and those obtained for the pre-training perceptual-motor test. It is possible that less developed perceptual-motor abilities were compensated for in the serve-reception test with motor skills associated with actual ball handling. However, given the earlier discussion of the methodological problems associated with the administration of the perceptual-motor test, such as lack of knowledge of results, this relationship should be subject to further research.

The primary purpose of the study was to investigate the possible influence of perceptual training. The findings of the pre- and post-training tests did not indicate any significant improvements in performance as a function of perceptual training. However, while all the perceptual training-related hypotheses were rejected, it should be noted that the training group did demonstrate a marginal improvement in performance when mean pre-training serve-reception test scores were compared to those obtained for the same test administered after the training period ($\bar{M}$ = 2.0, SD = .76 vs. $\bar{M}$ = 2.3, SD = .72). In the case of the control group, however, the mean pre-training score obtained ($\bar{M}$ = 2.6, SD = .71) was almost identical to the mean post-training score ($\bar{M}$ = 2.5, SD = .47). Given the small number of subjects tested and the higher than expected variability in skill level observed, the testing procedure clearly lacked the sensitivity to detect small changes in performance. The a priori power calculations were based on a minimum group sizes of ten, which seemed feasible at the time. As a function of difficulties in recruiting subjects and constraints associated with the use of a field setting, the number of subjects who volunteered was small (i.e., N=10) despite an existing subject pool of 30 players. Moreover, the skill level within the subject pool proved to be more heterogeneous than expected, which resulted in higher standard deviations. A post hoc multivariate power analysis (see Stevens, 1980) for the serve-reception test revealed that with the obtained moderate effect size of .50, a minimum of 15 subjects per group would have been needed to obtain a power as low as .44 using the pre-set alpha-level of .05. Apart from the sample-size problem, the lack of a motor-component during the actual training process could have been detrimental to the recoupling of perception and action required for successful performance in the post-training perceptual-motor test.

Most of the recent perceptual training studies using the hardware approach (i.e., Darden, 1990; Salitsky, 1990) also reported non-significant improvements in performance when subjects were tested in actual motor tasks. McLeod (1991a) achieved some success with his soccer players participating in a 4-week perceptual training, but his results were conflicting and the tests used were subject to criticism (Cohn and Chaplik, 1991; McLeod, 1991b). In respect to improvements of perceptual abilities in-and-of themselves, however, some training protocols using the hardware approach have been successful. Similarly, Burroughs (1984) reported significant improvements among subjects receiving perceptual training based on the software or information-processing approach. However, the post-training test in his study required subjects to make a verbal prediction of the landing location of a pitched baseball, rather than a specific motor response. Whether the subjects would have been able to successfully couple the enhanced perceptual abilities to corresponding motor actions, as was required in the present study, was not evident from the results.

Based on recent research findings (Bootsma, Houbiers, Whiting and van Wieringen, 1991), it was hypothesized that the movement time in serve-reception would become more consistent as a function of training. In the Bootsma et al. study, novice table-tennis players demonstrated increased consistency of the timing of their stroke as a result of a four day training period incorporating motor action. The present study investigated the effects of purely perceptual training in the context of volleyball and did not yield similar results. In the post-training serve-reception test, however, the control group demonstrated greater consistency in movement time, albeit non-significant, when compared to the standard deviations in movement time recorded by the experimental group. In the pre-training test the mean standard deviation of the movement time was 106 ms (SD = 8 ms) for experimental group and 129 ms (SD = 25 ms) for the control group. In the post-training test the mean standard deviation of the movement time was 121 ms (SD = 15 ms) for the experimental group and 99 ms (SD = 28 ms) for the control group. Similar results were evident in the transfer serve-reception test as well, the mean standard deviation of the movement time was 127 ms (SD =49 ms) for the experimental group and 117 ms (SD = 16 ms) for the control group. Although these findings are opposite to the hypothesized decrease in movement-time variability expected as a result of perceptual training, they may reflect some changes occurring among the experimental group with respect to the perceptual-motor timing aspects of the task. Thus, the initial influence of purely perceptual training may be to adversely affect the consistency of performance. A period of adjustment may be required before any consistent improvement in performance becomes evident.

The perceptual-motor test was designed to assess spatial accuracy of the subject's movement towards a served ball. Since certain portions of the ball's trajectory were occluded, the movements had to be based on the subject's prediction of the ball's landing location. In computer simulations (i.e., Todd, 1981), subjects were able to determine whether an oncoming object would land in front or, behind them. In the present study, the subjects also were quite accurate in predicting the landing location of the oncoming ball, even when the prediction included two dimensions (i.e., backward or forward and left or right). The fact that the subjects generally performed no better, or even worse when the viewing time was extended from 500 to 830 ms, supported the conclusion of Todd (1981), who argued that subjects do not profit from the additional information gained by seeing the object at the top of its trajectory.

Similar results have also been reported in studies involving ball catching tasks. For instance, Lamb and Burwitz (1987) showed that increasing viewing time of the approaching ball beyond the first 200 ms of a total of 400 ms flight time did not significantly affect catching performance, even when the trajectory of the ball was unpredictable. Several studies, however, have emphasized the interactive effects of the viewing time and the subsequent period of time spent not viewing the ball (Sharp, 1975; Sharp & Whiting, 1974; Whiting & Sharp, 1983). These authors' interpretation of their findings was based on the indirect view of perception:

while a long non-viewing time allowed ample time for information processing, it eventually became long enough to induce more prediction error.

In the present study, the flight time of the served ball was considerably longer than in any of the ball-catching studies. The viewing conditions in the perceptual-motor test created combinations of either 830 ms viewing time with a non-viewing time of 310 - 870 ms or 500 ms viewing time with a non-viewing time of 640 - 1200 ms. Both non-viewing time periods may have been long enough to introduce similar prediction errors in both conditions, since the longer occlusion period actually yielded better performance. By assuming that the subjects were more prone to rely on direct perception under the shorter viewing condition, the slightly higher scores could be explained as a result of eliminating some of the prediction errors associated with cognitive processing. However, without proper hypothesis setting this possibility still remains speculative.

Unlike the serve-reception test, the experimental group did not demonstrate any improvement in the scores obtained for the perceptual-motor test before and after the perceptual training period. However, one subject in the experimental group, who added a motor-component to the training by pointing to the video screen in order to predict where the ball would land, achieved the greatest improvement in post-training performance scores for the perceptual-motor test (her total score increased from 26 to 32 points). Her total post-training performance score was second only to the score obtained by the most experienced player (i.e., 36 points).

In general, the total performance scores were lower in the post-training perceptual-motor test, possibly reflecting a motivational problem arising from the training and testing procedures used. Without any knowledge of their performance outcome, some of the subjects may have become discouraged. The training period may also have been too short to induce performance changes among these individuals who already had been exposed to volleyball for several years.

In conclusion, the three-week perceptual training protocol used in this study did not significantly influence performance in the volleyball serve-reception. The small, but non-significant changes in the timing aspects of the serve-reception demonstrated by the experimental group could, however, suggest a change in the perceptual strategy being used. Further studies which include a motor component or a perceptual-motor adjustment period for coupling perception with action will be needed to further investigate this issue.

Discussion

General Discussion

The purpose of this study was to investigate the possible effects of perceptual training on performance in the serve-reception in volleyball. In designing the study, special attention was directed to providing an ecologically valid setting in which to study the research question of interest. This was done to afford the subjects an opportunity to use any naturally available visual information, that is strongly advocated by proponents of the ecological approach to the study of perception and action.

The subjects in this study were ten adolescent female volunteers who were participating in an inter-scholastic high-school volleyball program. The subjects were randomly assigned to an experimental or control group and were then tested during two sessions conducted three weeks apart. During the three-week perceptual training period, subjects in the experimental group watched an eight-minute training videotape five times a week. The video depicted an approaching ball in a serve-reception drill situation. Members of the control group did not engage in any type of volleyball training or playing during this training period.

The pre- and post-training testing sessions involved the administration of two separate tests, one for testing actual volleyball serve-reception skills and one testing perceptual-motor abilities using a simulated serve-reception test. In addition, a transfer serve-reception test was administered after the post-training testing session to investigate the generalizability or transferability of the perceptual learning. Prior to testing, subjects completed a questionnaire related to their previous experience in volleyball.

The results provided support for the prediction that a significant positive relationship exists between competitive experience and performance score in the serve-reception test, indicating the importance of formal practice and exposure to game-situations. The negative relationship predicted to exist between the performance score and the age when the subjects started playing proved to be non-significant. Also, no significant relationships were found between starting age or amount of competitive experience and the performance scores obtained in a pre-training perceptual-motor test. This suggests that a later starting age may not be detrimental to achieving perceptual-motor abilities needed in an interceptive act such as volleyball serve-reception. The non-significant relationship between performance scores obtained in a serve-reception and perceptual-motor test further suggests that for some individuals, motor skill deficiencies, rather than perceptual-motor abilities are the limiting factor in the actual task of serve-reception. It is likely that inadequate technique in receiving and passing the ball can seriously restrict performance, regardless of the spatial accuracy abilities needed to intercept the ball. Another contributing factor is the temporal accuracy of the movement, an aspect that could have been monitored in the perceptual-motor test by time-locking the recording video camera with the original testing tape.

The results failed to show any statistically significant improvement in the performance of the experimental group, either in the post-training or the transfer serve-reception test. This finding can be partly attributed to the small sample size, since slight improvements in experimental group were evident. However, as the pre-training scores of the experimental group were lower than those of the control group, the observed changes could also be a result of regression towards the mean. Nevertheless, this trend provides grounds for further investigation.

It was hypothesized that perceptual training would lead to a more consistent movement time during the serve-reception performance. The results indicated that in the case of the control group, the standard deviation of the movement time did, indeed, decrease, possibly reflecting a practice effect associated with the testing process itself. The experimental group, however, did not demonstrate a similar trend. On the contrary, the observed increase in the standard deviation of the movement time indicated that the performance of subjects who received perceptual training became more variable in terms of timing. This non-significant finding may reflect unsuccessful early attempts to combine newly discovered perceptual strategies with motor action.

The movement times for the transfer serve-reception test reflected the non-significant changes observed in the post-training serve-reception test. Even in this new task the experimental group demonstrated higher variability in movement time than the control group.

Conclusions

The results of this study indicated that the three-week perceptual training program used in this study is not adequate by itself to significantly improve the volleyball serve-reception performance of adolescent female competitors. Based on the results, acquired experience in a real-life game setting may not be adequately simulated by a video-driven perceptual-motor task. Alternatively, perceptual training that does not incorporate action may require a period of motor adjustment before the newly discovered perceptual strategies can be used in a consistent manner.

Future Recommendations

The idea of integrating direct and indirect views of perception provides a fruitful area for future research. The comprehensive body of research in ball-games could be approached with a quest to provide natural context to the tasks. A rapidly developing computer technology is also likely to enable researchers to create more sophisticated simulations of game situations. For instance, technologies such as virtual reality have already been made available to Olympic development teams in some disciplines. Similar computer simulations could be used for conducting research and/or training team members.

While the present study failed to provide evidence for the benefits of perceptual training, it may have served a useful purpose in developing guidelines for further investigation of the issue. A major methodological issue evolving from the findings was the apparent need for including a motor component in the perceptual training. Alternatively, a transition period may be necessary in order for players to recouple perception and action following a training period that only focuses on improving perceptual abilities.

Another important finding was the observed apprehension experienced by the subjects during the perceptual-motor test. This was likely due to the fact that subjects were not provided with any feedback related to their performance during the training period or either testing session. In future studies it will be important to provide subjects with contingent feedback related to their performance, particularly during the training period. Also, appropriate verbal encouragement during the testing could increase subject motivation while also helping the subjects maintain an adequate level of self-efficacy. These aspects should also be quantitatively measured.

The present study was delimited in aspects such as gender, age and skill-level. Future studies could be designed to examine the benefits of perceptual training for younger children as well as novice and elite players. Furthermore, a mixture of different types of serves and serving styles could be combined. Finally, similar methods could be used to examine other interceptive actions, such as digging a spike in volleyball, or, catching a fly-ball in baseball.

References

Abernethy, B. (1987). Selective attention in fast ball sports II: Expert - novice differences. The Australian Journal of Science and Medicine in Sport, 19, 4, 7-16.

Abernethy, B. (1989). Expert novice differences in perception: How expert does the expert have to be? Canadian Journal of Sport Science, 14, 1, 27-30.

Abernethy, B., & Russel, D. G. (1987). The relationship between expertise and visual search strategy in a racquet sport. Human Movement Science, 6, 283-319.

Allard, F., Graham, S., & Paarsalu, M. L. (1980). Perception in sport: basketball. Journal of Sport Psychology, 2, 14-21.

Allard, F., & Starkes, J. L. (1980). Perception in sport: volleyball. Journal of Sport Psychology, 2, 22-33.

Aurell, C. G. (1984). Note on Gibson's direct visual perception. Perceptual and Motor Skills, 58, 540-542.

Bailey, B. J. (1968). The relationship of various degrees of binocular vision to a specific test of depth perception. Dissertation Abstracts International, 29, 3853-A.

Bakker, F. C., Whiting, H. T. A., van der Brug, H. (1990). Sport psychology: concepts and applications. Guildford: John Wiley & Sons Ltd.

Banister, H., & Blackburn, J. M. (1931). An eye factor affecting proficiency at ball games. British Journal of Psychology, 21, 382-384.

Bartlett, J., Smith, L., Davis, K., & Peel, J. (1991). Development of a valid volleyball skills test battery. Journal of Physical Education, Recreation and Dance, 62, 2, 19-21.

Belyaev, A. V. (1983a). Methods of developing work capacity in volleyball. Soviet Sport Review, 20, 2, 87-90.

Belyaev, A. V. (1983b). Methods of developing work capacity in volleyball. Soviet Sport Review, 20, 3, 146-150.

Blundell, N. L. (1982). An analysis of the visual/perceptual attributes of male and female tennis players of varying ability levels. Unpublished doctoral dissertation, University of Tennessee.

Blundell, N. L. (1985). The contribution of vision to the learning and performance of sports skills: Part one. The role of selected visual parameters. The Australian Journal of Science and Medicine in Sport, 17, 3, 3-11.

Bootsma, R. J., Houbiers, M. H. J., Whiting, H. T. A., & van Wieringen, P. C. W. (1991). Acquiring an attacking forehand drive: The effects of static and dynamic environmental conditions. Research Quarterly for Exercise and Sport, 62, 3, 276-284.

Borgeaud, P., & Abernethy, B. (1987). Skilled perception in volleyball defense. Journal of Sport Psychology, 9, 400-406.

Bower, T. G. (1982). Development in infancy. San Francisco, CA: Freeman.

Brandt, C. (1979). Entwicklung der visuellen orientierungsfahigkeit bei volleyballspielern [Development of the visual orientation ability among volleyball players]. Theorie und Praxis der Khorperkultur, 114-117.

Burg, A. (1966). Visual acuity as measured by static and dynamic tests: a comparative evaluation. Journal of Applied Psychology, 50, 6, 460-466.

Burroughs, W. A. (1984). Visual simulation training of baseball batters. International Journal of Sport Psychology, 15, 117-126.

Burton, A. W. (1990). Assessing the perceptual-motor interaction in developmentally disabled and non-handicapped children. Adapted Physical Activity Quarterly, 7, 325-337.

Christenson, G. N., & Winkelstein, A. M. (1988). Visual skills of athletes versus non-athletes: development of a sport vision testing battery. Journal of the American Optometric Association, 59, 666-675.

Cockerill, I. M. (1981). Distance estimation and sports performance. In I. M. Cockerill and W. W. MacGillivary (Eds.), Vision and sport, (pp. 116-125). Cheltenham, U.K.: Stanley Thornes.

Cohn, E. C., & Chaplik, D. D. (1991). Visual training in soccer. Perceptual and Motor Skills, 72, 1238.

Colley, A. M. (1989). Learning motor skills: integrating cognition and action. In A. Colley and J. Beech (Eds.), Acquisition and performance of cognitive skills, (pp. 167-189). New York, NY: Wiley & Sons.

Darden, G. F. (1990). The effects of visual training on selected visual abilities and performance of a motor skill. Unpublished master's thesis, University of Maryland.

Docherty, D., & Boyd, D. G. (1982). Relationship of disembedding ability to performance in volleyball, tennis and badminton. Perceptual and Motor Skills, 54, 1219-1224.

Fechner, G. T. (1860). Elemente der psychopysik [Elements of psychophysics]. Leipzig: Brettkopf & Hartel.

Fischman, M. G., & Schneider, T. (1985). Skill level, vision, and proprioception in simple one-handed catching. Journal of Motor Behavior, 17, 2, 219-229.

Fitts, P. M., & Posner, M. I. (1967). Human performance. Belmont, CA: Brooks/Cole.

Gibson, E. (1982). The concept of affordances in development: The renascence of functionalism. In W. A. Collins (Ed.), The Minnesota symposia on child psychology. Vol. 15. The concept of development. Hillsdale, NJ: Erlbaum.

Gibson, E. (1987). Introductory essay: What does infant perception tell us about theories of perception? Journal of Experimental Psychology: Human Perception and Performance, 13, 4, 515-523.

Gibson, J. (1966). The senses considered as perceptual systems. Boston, MA: Houghton-Mifflin Company.

Gibson, J. (1979). The ecological approach to visual perception. Boston, MA: Houghton Mifflin Company.

Helmholtz, H. von (1867). Handbuch der pysiologischen optik [Manual for physiological optics]. Leipzig: Voss.

Israel, H. (1976). Die bewegungkoordination fruhzeitig ausbilden [Developing the movement co-ordination early]. Korpererziehungen, 11, 501-505.

Jeannerod, M. (1981). Inter-segmental co-ordination during reaching at natural visual objects. In J. Long and A. Baddeley (Eds.), Attention and Performance, (pp. 153-168). Hillsdale, NJ: Lawrence Erlbaum.

Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. Perception and Psychophysics, 14, 201-211.

Kaufmann-Hayoz, R. (1991). Perceptual development. In M. E. Lamb and H. Keller (Eds.), Infant development: perspectives from German-speaking countries, (pp. 219-243). Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Kellman, P. (1984). Perception of three-dimensional form by human infants. Perception and Psychophysics, 36, 353-358.

Kluka, D. (1987). Visual skill enhancement. Strategies, 5, 20-24.

Lamb, K., & Burwitz, L. (1988). Ball catching: A re-examination of some previous research findings. Journal of Human Movement Studies, 14, 93-99.

Laurent, M., Dinh Phung, R., & Ripoll, H. (1989). What visual information is used by riders in jumping? Human Movement Science, 8, 481-501.

Lee, D. N. (1976). A theory of visual control of breaking based on information about time to collision. Perception, 5, 437-459.

Lee, D. N., Lishman, J. R., & Thomson, J. A. (1982). Visual regulation of gait in long jumping. Journal of Experimental Psychology: Human Perception and Performance, 8, 448-459.

Lee, D. N., & Young, D. S. (1985). Visual timing of interceptive action. In D. Ingle, M. Jeannerod & D. N. Lee (Eds.), Brain mechanisms and spatial vision, (pp. 1-30). Dordrecht: Martinus Nijhoff.

Magill, R. A. (1989). Motor learning. Concepts and applications (4th ed.). Dubuque, IA: Wm. C. Brown Publishers.

Mark, L. S. (1987). Eyeheight scaled information about affordances: A study of sitting and stair climbing. Journal of Experimental Psychology: Human Perception and Performance, 13, 361-370.

McGown, C. (1974). Probability and team offense. Volleyball Technical Journal, 1, 2, 11-13.

McLeod, B. (1991a). Effects of eyerobics visual skills training on selected performance measures of female varsity soccer players. Perceptual and Motor Skills, 72, 863-866.

McLeod, B. (1991b). Eyerobics visual training for soccer, a reply. Perceptual and Motor Skills, 73, 612.

Michaels, C. F., & Carello, C. (1981). Direct perception. Englewood Cliffs, NJ: Prentice-Hall.

Miller, D. M. (1960). The relation between some visual perceptual factors and the degree of success realized by sport performers. Dissertation abstracts International, 21:1455-A.

Mizusawa, K., Sweeting, R. L., & Knouse, S. B. (1983). Comparative studies of colour fields, and movement perception limits among varsity athletes and non-varsity groups. Perceptual Motor Skills, 56, 887-892.

Piaget, J. (1954). The construction of reality in the child. New York, NY: Basic Books.

Piaget, J. (1969). The mechanism of perception. New York, NY: Basic Books.

Ripoll, H. (1988). Analysis of visual scanning patterns of volleyball players in a problem solving task. International Journal of Sport Psychology, 19, 9-25.

Rosengren, K. S., Pick, H. L., & von Hofsten, C. (1988). Role of visual information in ball catching. Journal of Motor Behavior, 20, 2, 150-164.

Rothstein, A. L. (1986). The perceptual process, vision, and motor skills. In L. D. Zaichowsky and C. Z. Fuchs (Eds.), The psychology of motor behavior: Development, control, learning and performance, (pp. 191-214). Ithaca, NY: Mouvement Publications, Inc.

Runeson, S. (1977), On the possibility of 'smart' perceptual mechanism. Scandinavian Journal of Psychology, 18, 172-179.

Salitsky, P. B. (1990). The effects of visual training on performance of a motor skill. Unpublished master's thesis, University of Maryland.

Saltzman, E., & Kelso, J. A. S. (1987). Skilled actions: A task-dynamic approach. Psychology Review, 94, 84-106.

Sawula, L. (1975). Statistics: General and specific. Volleyball Technical Journal, 2, 1, 66-69.

Sawula, L., & Maxwell, J. (1982). Psychological conditioning. Volleyball Technical Journal, 7, 1, 21-22.

Schmidt, R. A. (1977). Schema theory: Implications for movement education. Theory into Practice, 2, 36-48.

Scully, D. M., & Newell, K. M. (1985). Observational learning and the acquisition of motor skills: towards a visual perception perspective. Journal of Human Movement Studies, 11, 169-186.

Seiderman, A., & Schneider, S. (1983). The athletic eye. New York, NY: Hearst Books.

Selinger, A., & Ackerman-Blout, J. (1986). Ariel Selinger's power volleyball. New York, NY: St. Martin's press.

Sharp, R. J., & Whiting, H. T. A. (1974). Exposure and occluded duration effects in a ball-catching task. Journal of Motor Behaviour, 6, 139-147.

Smyth, M. M., & Marriott, A. M. (1982). Vision and proprioception in a simple catching task. Journal of Motor Behavior, 14, 2, 143-152.

Starkes, J. L. (1987). Skill in field hockey: The nature of cognitive advantage. Journal of Sport Psychology, 9, 146-160.

Stevens, J. P. (1980). Power of the multivariate analysis of variance test. Psychological Bulletin, 88, 728-737.

Stine, C. D., Arterburn, M. R., & Stern, N. S. (1982). Vision and sports: A review of the literature. Journal of the American Optometric Association, 53, 8, 627-633.

Todd, J. T. (1981). Visual information about moving object. Journal of Experimental Psychology: Human Perception and Performance, 7, 795-810.

Turvey, M. T. (1977). Preliminaries to a theory of action with reference to vision. In R. Shaw and J. Bransford (Eds.), Perceiving, acting and knowing, (pp. 211-265). Hillsdale, NJ: Erlbaum.

Turvey, M. T., & Carello, C. (1988). Exploring law-based, ecological approach to skilled action. In A. M. Colley and J.R. Beech (Eds.), Cognition and action in skilled behavior, (pp. 191-203). Amsterdam: Elsevier Science Publishers B. V.

van Wieringen, P. C. W. (1988). Discussion: Self-organization or representation? Let's have both. In A. M. Colley & J. R. Beech (Eds.), Cognition and action in skilled behavior, (247-253). Amsterdam: North-Holland.

Warren, W. H. (1984). Perceiving affordances: Visual guidance of stair climbing. Journal of Experimental Psychology: Human Perception and Performance, 19, 683-703.

Warren, W. H., & Whang, S. (1987). Visual guidance of walking through apertures: Body-scaled information for affordances. Journal of Experimental Psychology: Human Perception and Performance, 13,371-383.

Warren, W. H., Young, D. S., & Lee, D. N. (1986). Visual control of step length during running over irregular terrain. Journal of Experimental Psychology: Human Perception and Performance, 12, 259-266.

Weber, E. H. (1852). Uber den raumsinn und die empfindungskreise in der haut und im auge [About the spatial sensation and receptive fields of skin and in the eye]. Zurich: Rascher.

Weeks, D. J., & Proctor, R. W. (1991). Comment. Ecological and process approaches to skill acquisition. Journal of Human Movement Studies, 20, 291-296.

Whiting, H. T. A., Alderson, G. J., & Sanderson, F. H. (1973). Critical time intervals for viewing and individual differences in performance of ball catching task. International Journal of Sports Psychology, 4, 155-164.

Whiting, H. T. A., & Sharp, R. H. (1974). Exposure and occluded duration effects in a ball catching skill. Journal of Motor Behavior, 3, 6, 139-146.

Williams, J. G. (1988). Ball catching skill. Physical Education Review, 11, 1, 40-51.

Wolf, M. D., & Landers, D. M. (1978). Eye color and reactivity in motor behavior. In D. M. Landers and R. W. Christina (Eds.), Psychology of motor behavior and sport, (pp. 255-263). Champaign, IL: Human Kinetics.

Yonas, A. (1981). Infants' responses to optical information for collision. In R. N. Aslin, J. R. Alberts and M. R. Petersen (Eds.), Development of perception. Psychobiological perspectives. Volume 2. The visual system, (pp. 313-334). New York, NY: Academic Press.

APPENDICES

Appendix A

Subject code number : ________________

Age: ____________ Height:_________

1. How many years have you played with your present team? ________

2. How many years have you played competitive volleyball altogether?

   ____

3. At what age did you start playing volleyball

   a) recreationally ? ________

   b) competitively ? ________

4. Do other members of your immediate family play volleyball? Please describe:

   ____

   ____

5. How often, if ever, did you go to watch volleyball games or practices before you started playing yourself?

   ____

6. During the competitive season, do you watch volleyball games or practices other than your own?

   ____

   If yes, how much and how often ? ____________________________

7. Do you watch volleyball on TV or on videos? ______________

   If yes, how much and how often ? ____________________________

8. Which position(s) do you play on your present team?

   ____

10. How would you rate your skill in serve reception on a scale from 1 to 5 (1= poor, 5=excellent)?

    ____

11. How often and how much do you usually play or practice

    a) during the volleyball season ? _________________

    b) during the rest of the year ? _________________

12. Please describe briefly your experience in other ball games if any:

____

____

____

____

____

____

13. Do you wear corrective lenses while playing volleyball ?

    If yes, please describe : ____________________

14. Do you play Nintendo or other video games? ____________

    If yes, how much and how often ? ____________________

15. If there is something else concerning your past exposure to volleyball that you would like to add, please use the space provided below. Thank you !

____

____

____

____

____

____

____

Appendix B

INFORMED CONSENT FORM FOR MINORS

Tuula Tyry, who is a doctoral candidate at Oregon State University, has requested my minor child's participation in a research project, involving two one hour testing sessions at Corvallis High School on two separate weekends during the Spring 1992. The title of the project is "Perceptual Training in Volleyball". The subjects in the study will be female volleyball players of Corvallis high schools.

I have been informed that the purpose of the study is to investigate the possible benefits of perceptual training on serve reception in volleyball and to create a practical skill test for assessing the players' ability in serve reception.

I understand that my child will be asked to attend the two testing sessions, which will take place three weeks apart during the Spring 1992. Each session will consist of two skill tests performed on a regular volleyball court. Prior to the first session a brief questionnaire will be administered to obtain information on her volleyball background. After the first testing session half of the girls will be randomly assigned to a training group while the other half will serve as a control group.

I understand that if my daughter is assigned to the training group she will be asked to view a brief (8 min) videotape of volleyball serves five (5) times a week during a three week time period. Arrangements will be made to provide her with a convenient access to a VCR at the athletic department during her study-hall hour without having to interfere with schoolwork or weekend activities.

I understand that regardless of the group that my daughter is assigned to, she will be asked to keep a simple log on all ball game related activities during the three week time period and one week before and after the study. I have been informed that if my daughter is assigned to the control group she will have an opportunity to be engaged in the training program after the completion of the study. The second testing session will be identical for both groups and similar to the one described above.

I have been informed that participation in the study "Perceptual Training in Volleyball" does not involve any foreseeable risks or discomfort to the subject. The subjects will be videotaped during the skill tests to ensure objectivity in the scoring, but their identity, individual test scores, and any information obtained through the questionnaire will be held confidential.

I understand that the potential benefits to my daughter for her participation include getting an assessment of perceptual and motor skills in volleyball, evaluation of these skills as compared to other players at a similar level and, as a result of the training program, a possible increase in the perceptual and/or motor skills in the task of serve reception.

I understand that my daughter's participation is voluntary and refusal to participate will involve no penalty or loss of benefits to which she is otherwise entitled. I also understand that she may discontinue participation at any time without penalty or loss of benefits to which she is otherwise entitled.

I have been informed that any questions concerning the study may be addressed to Tuula Tyry tel. 737 - 6792 (W), 754 - 1985 (H), who will also be available for assistance throughout the study.

I understand that the University does not provide a research subject with compensation or medical treatment in the event the subject is injured as a result of participation in the research project.

I have read and understood the text above and give a permission for my daughter's participation in the study "Perceptual Training in Volleyball".

Parent's or guardians signature:

______________________________ Date ____________

Appendix C

TRAINING GROUP

You have been assigned to the training group. Please, sign up for a convenient daily viewing time and start the training TODAY (Monday).

There are 5 slightly different training tapes, each lasting 5 - 8 minutes. The tapes are labeled Monday, Tuesday etc.

You should watch "the tape of the day" each school day for the following three weeks. During each session, sit alone in front of the TV. It is very important that you concentrate on the task.

Try to see as early as possible where you should go to receive each of the serves and whether the serve is in or out.

There is a 10 second strip of blank tape between each of the 5 sets of 20 serves. Please use this time interval to rest your eyes and to relax. Then refocus on the viewing again.

After each session, while you are rewinding the tape (!), please fill in the attendance sheet. On the same sheet, describe what you were thinking about while viewing the video tape. You may also add any other comments concerning the session or your performance.

Thank you !

P.S. If you are unable to attend one of your scheduled training sessions, please contact Julie or Tuula (754 -1985) to arrange a make-up viewing time.

Appendix D

CONTROL GROUP

You have been assigned to the control group. (However, you will get an opportunity to view the training tapes later.)

During the following three weeks you should not watch the training video tapes or participate in any other visual training program.

Also, remember to list the time and nature of all your ball-game related activities, whether it is practice, playing or watching.

Please return your log each FRIDAY !

THANK YOU !!!

Appendix E

Table E-1

Descriptive information

Group	Subject	Age (yrs)	Starting age (yrs)	Experience (yrs)	Skill-rating (scale: 1-5)	Training (max 14)
Experimental						
	1	15	8	5	4	12
	2	14	7	1	3	14
	3	15	13	2	3	14
	4	15	13	2	3	12
	5	16	12	5	2	10
Control						
	6	17	8	7	4	-
	7	15	12	3	3	-
	8	15	13	2	3	-
	9	16	10	3	4	-
	10	17	14	3	3	-

Table E-2

Mean performance score obtained by each subject for the pre-training, post-training and transfer serve-reception test

Group	Subject	Pre-training	Post-training	Transfer
Experimental				
	1	2.92	2.54	2.67
	2	1.63	1.25	1.38
	3	1.64	1.77	1.39
	4	2.62	2.98	2.21
	5	2.02	2.75	2.86
Control				
	6	3.58	3.08	3.61
	7	2.23	2.56	2.02
	8	1.96	2.08	1.06
	9	2.23	2.04	2.54
	10	3.21	2.89	3.04

Table E-3

Mean standard deviation of the movement time obtained by each subject for the pre-training, post-training and transfer serve-reception test

Group	Subject	Pre-training	Post-training	Transfer
Experimental				
	1	102 ms	127 ms	127 ms
	2	107 ms	135 ms	204 ms
	3	104 ms	96 ms	100 ms
	4	119 ms	127 ms	94 ms
	5	97 ms	121 ms	110 ms
Control				
	6	126 ms	106 ms	124 ms
	7	108 ms	63 ms	111 ms
	8	171 ms	79 ms	141 ms
	9	110 ms	112 ms	99 ms
	10	129 ms	134 ms	111 ms

Table E-4

Performance scores obtained by each of the subjects for the pre-training and post-training perceptual-motor test under long and short viewing conditions

Group	Subject	Pre-training		Post-training	
		Long	Short	Long	Short
Experimental					
	1	15	15	10	12
	2	14	11	12	16
	3	12	14	14	18
	4	15	14	15	13
	5	13	13	10	11
Control					
	6	15	17	16	19
	7	19	18	15	17
	8	13	12	11	11
	9	14	14	14	18
	10	14	10	9	13