Table tennis and motor development

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I. Introduction

The purpose of this review is to support the hypothesis that "table tennis practice speeds up motor development in young children" and to determine by what mechanisms this might occur. As a physical educator with 20 years experience of playing table tennis, including training in Japan and Sweden, also as a certified regional coach, I feel qualified in making this statement. The performance of table tennis skills at an intermediate-club level requires complex, fine motor coordination. In order to appropriately respond to changing spin, speed, force and trajectory of an oncoming ball a child must learn to adjust racquet movements and react quickly. From this research it is concluded that the practice of table tennis skills, given the abundance of interaction time with the object-stimulus, will increase the normal rate of motor learning in children up to 14 years old. At this age children's motor development slows because of growth changes associated with adolescence.

The focus of this hypothesis and accrued research is targeted at the mechanisms that control the coordination of movement in a developing child. This critical growth stage in the motor development of children is a formative period in motor learning as the nervous system matures, which delivers information to muscles to control movement. During this period coordination matures from motor movements that are simple and gross to coordination that is also capable of complex and fine motor movements (Sage, 1984).

II. Review of literature

In reviewing literature on stages of development and classification of motor abilities as defined by Sage (1984), one can make inferences about table tennis practice and the rate of motor development. For example, the middle childhood stage (ages 6-9 years) of development is characterized by uneven motor development with large muscles better developed than finer muscles (Sage, 1984). By the late childhood and preadolescent stage (ages 9-14), a child achieves increased coordination of fine muscles and skill in manipulation. The characteristics for classifying psychomotor abilities are: control precision, multi-limb coordination, response orientation, reaction time, speed of arm movement, rate control, manual dexterity, arm-hand steadiness, wrist-finger speed and aiming (Sage, 1984). These are factors in motor development, and all are utilized in the practice of table tennis skills.

Development of neuromuscular skill, conditioned reflexes, and concentration (attention) is necessary for skilled table tennis practice. On one hand, the closed-loop system of movement control accounts for feedback information (proprioceptive, visual stimulus) and makes any necessary adjustments during the movement (Tyldesley, 1976).

A proprioceptor is a specialized sensory nerve located in muscles and tendons that transmits information to the central nervous system used to coordinate muscular activity. On the other hand, the open-loop system requires that impulses be sent to the appropriate muscles in proper sequence, timing and force, as predetermined by a motor program, according to Keele (1973). Tyldesley's (1976) study of table tennis skills had to solve the problem of determining "the exact mode of control at a given time during the course of a complex multiphasic movement". Changes in the form and detail of a recorded movement pattern (a forehand drive is used to return balls fed from a robot into a target on a standard table tennis table) between skill levels compared to known and controlled environmental variation provided the basis to infer the mode of control. Analysis of the film record was used to determine displacement data on horizontal and vertical velocities and accelerations of various anatomical features. A computer was used to plot the parameters of displacement, velocity, and acceleration against time. Results showed a high consistency in patterning on all three parameters among the intermediate and expert performers of this study. From Tyldesley's (1976) research a composite model was constructed to explain and integrate movement control at the muscular, perceptual-motor and movement outcome levels. The model proposed that movements are controlled by an alternating system of open and closed loop portions.

From a neurophysiological perspective, Wise and Desimone (1988) discuss visual stimulation, attention, and coordinate systems of movement. They hypothesize two stages in visual stimulation. The first stage leading to movement, such as a bat striking a ball, requires "figure-ground separation," distinguishing figures from their background. The second stage involves object or feature selection, which "attention is thought to operate serially on one or two objects at a time". Wise and Desimone further state that "attention serves both to control access to memory and to facilitate behavioral responses". This hypothesis supports Fitts' (1951) statement about the relative importance of internal (proprioceptors, neural control) versus external (visual, sensory input) feedback and the optimum combination of both in motor performance.

The high rate of response associated with repeated striking of a ball during table tennis practice provides a large amount of visual feedback in a short time. Both Fitts (1951) and Fleishman and Rich (1963) hypothesize that "visual control is important while an individual is learning a new perceptual motor task". As performance becomes habitual, however, it is likely that proprioceptive feedback or 'feel' becomes more important. For example, Fleishman and Rich's (1963) research comparing kinesthetic sensitivity (internal control, proprioceptors) and visual-spatial ability (external control, sensory) of 40 male Yale undergraduate subjects from a psychology course supported this hypothesis. The results confirmed the hypothesis that sensitivity to proprioceptive cues are more important later in perceptual-motor learning while sensitivity to external cues (visual-spatial) are more critical earlier in learning.

Dickinson's (1970) research found that aiming skill in children conflicts with the findings of Fleishman and Rich (1963). Dickinson (1970) determined that kinesthetic perception, as measured by weight sensitivity, shows a significant correlation with the performance of the 50 primary school children studied, whereas the ability to perceive distance as a visual-spatial measure did not correlate with performance of an aiming task at any stage.

A comparison of the pretest methods of the Fleishman and Rich (1963) and Dickinson studies, particularly Fleishman's spatial ability and Dickinson's measure of depth perception, suggests that these measure slightly different abilities. One determines a response to more than one object while the other measures the response to only one object in the visual field. Also, differences in samples studied between age and sex between the two groups studied, could account for the discrepancies in the results. Fleishman and Rich (1963) used only male subjects, and Dickinson did not mention the sexual makeup of his sample. Furthermore, the purpose of the studies differed in that Fleishman and Rich (1963) were concerned with the role of stated abilities in the process of perceptual motor learning, while Dickinson's results were directed toward the outcome of an aiming task with which the subject may have been familiar.

At a cortical level of movement control where decision making occurs, the practice of table tennis skills provides a great deal of interaction with the object-stimulus for the time spent. Table tennis requires quick decisions, a limiting factor to skilled performance. Glencross and Cibich (1977) analyzed the decision-making rate in three sport striking skills, based on a model of man as an information processor. Their studies of latency and reaction time have provided evidence for the limits of the control system. They conclude that "latency is related to the number of possible signals, the probability of the signals, the relationship or compatibility between stimulus and response, and the level of practice" (Glencross and Cibich, 1977). Through practice of a particular skill compatibility between stimulus and response improves, thus reducing the reaction time as more bits of information are introduced. This conclusion supports the specificity principle of training to develop neuromuscular control mechanisms for skilled performance. Glencross and Cibich (1977) further state that the acquisition of skill can be related to the development strategies to overcome the basic intermittency of the control system.

III. Conclusion

From my experience as an instructor and physical educator, table tennis skills and appropriate motor ability can be developed effectively as early as age six. The table tennis racquet and ball are light enough for young children to swing and strike the ball. Also, distance of ball contact and court depth are not as great as with other racquet sports. Furthermore, table tennis practice provides a great amount of interaction time, considering the ball is struck approximately every 1.5 seconds if continually fed. Therefore, table tennis practice can enhance the process and acquisition of skills of similar motor tasks and the mechanisms that govern complex, fine motor control.

In observing the sequence of events for learning a table tennis task, one can see development in a young child (5-8 years) of motor ability and perceptual motor learning. The most fundamental skill in table tennis is striking a moving object (ball) which requires coordination for every stroke. Based on this review the mechanisms that control coordination are from sensory input and the nervous system. For example, in learning a forehand drive, when a racquet and a ball are first introduced, the learner must find the object to be struck (figure-ground separation).

Then visual stimulus information is processed by open and closed loop systems, and impulses are sent to activate the appropriate response to swing the racquet and strike the ball. At first the child does not hit the ball often, and the ball rarely goes in the wanted direction on the table when hit. Through trial and error the output response improves quickly, becoming more consistent and accurate through the filtering of unwanted information. With practice and guidance the forehand drive movement pattern becomes a smooth, efficient and consistent movement. According to the research of Fitts (1951) and Fleishman & Rich (1963) initially skill development is primarily supported by external feedback (visual-spatial) which fine tunes the task. As unwanted information is filtered from the movement a motor program (open-loop control) can be developed and stored into memory, closed-loop mechanisms are now available to adjust the movement to achieve a new and higher level of skill.

The next goal with the forehand drive is the ability to execute this pattern under various conditions, changing the spin, speed, trajectory and placement of the ball to be hit. By varying these conditions of the oncoming ball, the child adapts his/her response to a changing environment by applying knowledge of angles, speed, force, timing and spatial and kinesthetic relationships. The successful response to these complex adjustments supports the research of Glencross and Cibich (1977) that through practice the flood of signals is differentiated and classified in order to make a proper response. This skill acquisition also demonstrates the characteristics of psychomotor abilities as related to a table tennis forehand drive, which is productive in the process of developing these abilities for other tasks. Given the abundance of striking in practice, table tennis provides more interaction with this psychomotor skill than any sport in a safe and fun environment. The practice of table tennis skills develops perceptual motor learning ability and speeds up the rate of motor development in young children as compared to other racquet sport activities.

The original hypothesis for this study refers to children at a primary stage of motor learning. Adults utilize the mechanisms of coordination throughout an active life. Practice in applying these mechanisms can only lubricate this process and provide stimulation to make coordination more fluid and skilled at any age. Thus this research implies that more research is indicated to review the benefits of fine motor coordination, the mechanisms by which it occurs and what activities promote its maintenance in an aging adult.

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