throws using a VICON eight-camera motion system with reflective markers placed on the hand (FIN), wrist (MED, LAT), elbow (LAT), shoulders, head, chest (STERN, CLAV), back (C7, T10), waist (LASI, RASI, LPSI, RPSI) and dart.

RESULTS AND DISCUSSION

Analysis of the cross-correlations of the movement patterns used at each joint was significantly (p<0.05) different for each joint across time, for all four experiments. The displacement patterns of the wrist, elbow, and shoulder indicated changes in movement patterns used over time as novices learned their respective tasks. Across the three days of practice, learners became more consistent in the pattern used. The displacement at the elbow was significantly different (p<0.05) than the shoulder and wrist for the two consistent tasks (no IV); while the variable tasks (w/IV) revealed the elbow and wrist to be similar (p>0.05). These results indicate the amount of IV in the EC had an effect on the learning strategy used. Analysis of the cross-correlations of joint-linkages showed the elbow-wrist linkage to be significantly different (p<0.05) from the elbow-shoulder and the shoulder-wrist linkages, for all four experiments. These observations suggest that the subject released the degrees of freedom at the shoulder initially, while the elbow and wrist remained linked. These data follow the proximal to distal strategy suggested by the learning literature; however, no clear trend was evident when comparing the rate of change within each of the four experiments.

SUMMARY

Novice dart throwers practiced throwing a dart at a stationary target for 480 trials. Kinematic analysis showed that with increasing amounts of practice participants began to release the linkage between shoulder and elbow while continuing to link the wrist and elbow during the throw, regardless of the EC in which they trained. As novices acquired more experience, they began to release these degrees of freedom to increase their skill performance capabilities. The correlations of the elbow-wrist joint-linkage presented a different pattern for the moving tasks when compared to the stationary. The results of these experiments provide evidence that the environment in which one practices affects how one performs the movements and how the changes take place over time.

REFERENCES


INTRODUCTION

Coordination changes can best be evaluated in the manner described by Bernstein (1967). As the learner determines the most efficient or effective way to perform a skill, changes in the person’s movement coordination pattern occur. How this coordination changes from one point in time to the next provides critical information about how the learner adapts a movement to produce skilled activity. More specifically, coordination describes how the joints are positioned at a specific moment of time, and how those positions change across several moments of time. As the beginner performs a new task, he/she typically tries to reduce the number of degrees of freedom that must be controlled by constraining the body or multiple body segments. During the progression of skill learning, the degrees of freedom are released gradually, allowing the learner to control the degrees of freedom in functional ways. The research literature contains limited biomechanical information describing how coordination changes as a new motor skill is learned and how the environmental context (EC) affects these changes. This study was aimed to provide a description of those changes throughout the course of learning to throw a dart to either a stationary or moving target, either with or without intertrial variability (IV). The four experiments presented here extend research by Higgins and Spaeth (1972), which involved learning dart throwing in a closed (stationary target) and open (in-motion target) EC. By adding an IV component (see Gentile, 2000), a four-component motor skill taxonomy was investigated. Of interest was the task-demand relationship of IV and EC characteristics of the learning of the dart throw.

METHODS

Participants threw standard darts at a circular target that either remained stationary or moved across the target board. IV was created by changing the location of the target’s start position on each trial. Thus, the four tasks were: (1) a stationary target that did not change location on each trial (closed w/no IV), (2) a stationary target that changed location on each trial (closed w/IV), (3) a moving target that did not change location at the start of each trial (open w/no IV), (4) a moving target that changed location at the start of each trial (open w/IV). Volunteers each participated in only one experiment. Novice dart throwers (<3 times/yr.) were instructed to stand in a comfortable position at a specified location and told to throw the dart to the target projected on a Styrofoam board in front of them at approximately eye level. The dart was removed after each throw so that subjects would start each practice trial with an uncluttered target. Each subject performed 160 throws per day for three days. Subjects were told only the goal of the task; no instructions were given about how to throw the dart. After each throw, the X, Y coordinates of the dart and the target were recorded. Kinematics was recorded on every 20