EFFECTS OF PRACTICE ON INTERSEGMENTAL COORDINATION

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INTRODUCTION

Magill (1993) states "One of the changes that occurs while progressing from being a novice to a skilled performer relates to the characteristics of the development of the control of coordination" (p. 65). Coordination has often been evaluated based on the timing and sequencing of segmental contributions (intersegmental coordination) which can be either simultaneous or sequential or somewhere in between. Simultaneous indicates the segments initiate and terminate the propulsive phase at the same time and is usually the coordination pattern exhibited by skilled performers of heavy, slow activities such as weight lifting (Broer, 1973; Hudson, 1995). Sequential means the larger more proximal segments precede the smaller distal segments in a temporal progression during propulsion. Highly skilled strikers generally employ a sequential pattern of segmental coordination because more force can be applied to a relatively light object by the transfer of momentum principle (Broer, 1973; Kreighbaum & Barthels, 1990). Novice performers often exhibit the opposite pattern of coordination (e.g., sequential in heavy, slow activities and simultaneous in ballistic activities) (Hudson, 1995; Kreighbaum & Barthels, 1990).

The sequencing and timing of segmental contributions to striking skills is of particular interest because of the velocity demands. Smith, Ludwig, Butcher, and Wilkerson (1996) compared novice and experienced performers of the badminton deep serve, the racquetball forehand drive serve, and the racquetball forehand drive. In all three tasks, the experienced performer demonstrated proximal to distal or sequential patterns whereas the novice exhibited variable but more simultaneous patterns.

Bird, Hills, and Hudson (1991) investigated the intersegmental coordination of beginning and advanced performers on a badminton deep serve. Four beginners, with six weeks of instruction, and one advanced badminton player were videotaped performirig the skill. Shoulder and wrist angular velocities were computed to determine the pattern of coordination. Propulsive phase for each segment began when joint angular velocity was zero and ended when the velocity was maximum. Shared positive contribution was calculated as the time both segments were in positive propulsion divided by the time either segment was in positive propulsion. The advanced performer demonstrated an optimally sequential pattern of coordination (proximal to distal) in both initiation and termination of segmental contribution. Shared positive contribution was 0%. Two of the beginners exhibited a predominantly sequential pattern which was proximal to distal in initiation but distal to proximal in termination. Shared positive contribution was 15-20%. The other two beginners initiated the movement with shoulder flexion but initiated the wrist before the shoulder peaked. Shared positive contribution was 45% and was labeled intermediate.

Southard and Higgins (1987) investigated the effects of practice and demonstration on elbow and wrist patterning during a racquetball forehand drive. The novice participants experienced significant changes in both racquet velocity and limb patterning over five days of practice.

The purpose of the present study was to evaluate the changes over time in intersegmental coordination as a result of practicing a racquetball forehand drive serve. The analysis was done in three-dimensions, included limb and torso contributions, and was performed over time to determine when the changes occurred.

METHODS

. Informed consent was obtained from each participant. Each female adult volunteer (N = 10) was right-handed and was a novice to racket sport activities. None of the participants had played racquetball and the few who had participated in tennis had only played a maximum of 2 or 3 times. Ages ranged from 21 to 49 years (M = 30, SD = 9.06). The performers were videotaped performing the skill in a laboratory setting. The PEAK5 system used four high speed (120 Hz) video cameras to track reflective markers placed in the following locations on each participant and on the equipment: (a) left shoulder, (b) right shoulder, (c) right elbow, (d) right wrist, (e) left anterior superior iliac spine (ASIS) of the pelvis, (f) right ASIS of the pelvis, (g) top of the racket head, and (h) ball.

Each participant was videotaped before practicing the skill on Day 1 and after 10 minutes of practice on each of five consecutive days. A total of six sessions were recorded for each subject. Coordination was evaluated based on analysis of the graphical displays of the angular velocities. Six graphs for each subject were analyzed for changes in the sequencing and timing of the segmental contributions during performance of the movement. The pattern of coordination was defined as simultaneous when the segments initiated and terminated propulsion at the same time and sequential when the more proximal segments preceded the distal segments in a temporal progression. Because coordination patterns often fall somewhere between simultaneous and sequential, a method of categorization was developed.

Shared positive contribution (SPC) was assessed between each of the following adjacent two-segment combinations: (a) pelvic rotation and upper torso rotation, (b) upper torso rotation and shoulder rotation, (c) shoulder rotation and elbow rotation, and (d) elbow rotation and wrist rotation. SPC was calculated as the time both segments were in positive propulsion divided by the total time either segment was in positive propulsion (Bird et al., 1991; Hudson, 1986). Unfortunately, not all measures of SPC translated to usable data without altering the aforementioned formula in some cases. In cases where initiation of propulsion was proximal to distal, the formula gave an accurate portrayal of the pattern of coordination. However, the novice participants often initiated propulsion in a distal segment before the proximal segment which was actually less productive than even a simultaneous pattern (100% SPC). To numerically demonstrate the difference between SPC of proximal to distal initiation from SPC of distal to proximal initiation, the SPC of distal to proximal was subtracted from 200 and recorded as a value between 100 and 200. For example, an SPC of 50% (proximal to distal) was recorded as 50% whereas an SPC of 50% (distal to proximal) was recorded as 150%. Any value over 100% indicated a distal to proximal initiation of propulsion and a very immature pattern of coordination. To assess the overall coordination of the skill, a composite index of synchronization (Hudson, 1986) was calculated by averaging the four SPCs. The following classifications were used: (a) sequential pattern, 0% - 33% SPC; (b) intermediate pattern, 34% - 66% SPC; (c) simultaneous pattern, 67% - 100% SPC; and (d) jerky pattern 101% - 200%.

RESULTS

Shared positive contribution (SPC) was assessed between adjacent two-segment combinations and a composite index of synchronization (CIS) was calculated by averaging the SPC of the pelvis-upper torso, upper torso-shoulder, shoulder-elbow, and elbow-wrist. CIS and coordination pattern for each trial of each participant can be observed in Table 1. A sample velocity graph of a simultaneous pattern can be seen in Figure 1. The initiation of propulsion of the pelvis and torso preceded the initiation of the shoulder, elbow, and wrist. However, the peak velocities of all five were within 12 frames of each other resulting in a simultanwus (93% SPC) pattern of propulsion.

Table 1. Composite Index of Synchronization (CIS) and Coordination Pattern

ID Composite Index/Pattern

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 6
A	70/sim[a]	98/sim	48/int[b]	93/sim	90/sim	84/sim
B	55/int	45/int	101/jer[c]	53/int	47/int	61/int
C	40/int	69/sim	29/seq[d]	101/jer	63/int	62/int
D	67/sim	85/sim	68/sim	74/sim	69/sim	75/sim
E	91/sim	82/sim	64/int	78/sim	56/int	54/int
F	54/iny	103/jer	51/int	88/sim	104/jer	35/int
G	88/sim	32/seq	68/sim	73/sim	88/sim	61/int
H	122/jer	183/jer	78/sim	57/int	79/sim	93/sim
I	37/int	125/jer	66/int	68/sim	54/int	68/sim
J	77/sim	50/int	86/sim	82/sim	83/sim	81/sim

Note. Values between 0 and 100 represent average SPCs between segments with proximal to distal initiation of propulsion. Values over 100 are numerical representations of segments with distal to proximal initiation.
[a]Simultaneous, [b]Intermediate, [c]Jerky, [d]Sequential

Results of the 60 total trials were divided as follows; sequential - 2, intermediate - 21, simultaneous - 30, and jerky - 7. Most of the participants (6 of 10) exhibited the same pattern on trial 6 as on trial 1. Of the 4 whose patterns changed, 3 moved to a better (more sequential) category and the 4th moved to an inferior (more simultaneous) pattern. The only two sequential patterns observed were performed by 2 different participants, one on day 2 and the other on day 3.

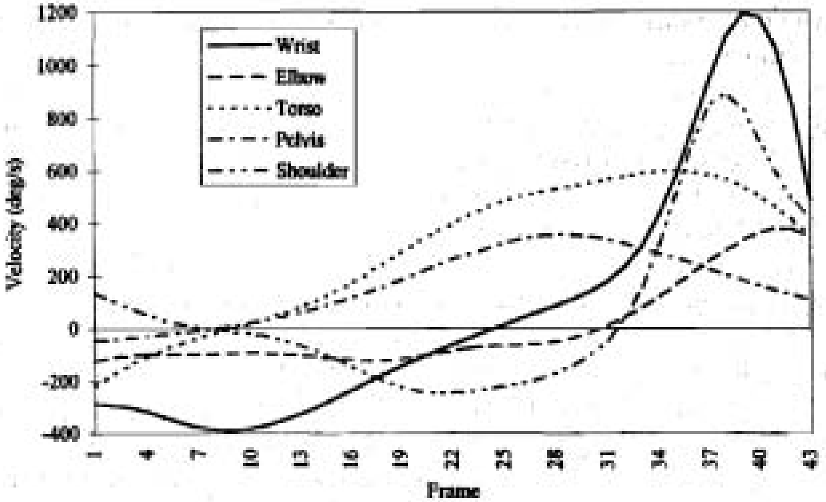

Figure 1. Participant A - Trial 4. 93% CIS - Simultaneous Pattern

DISCUSSION

It was not surprising to find half the trials fit into the simultaneous category because the participants were all novice to the task. Practice was expected to impact changes in coordination patterns. As the novice participants became more proficient performing the skill as a result of practice, changes in coordination patterns from simultaneous to more sequential, or at least intermediate, were expected. However, the results in the present investigation did not necessarily support this expectation.

Although most of the participants remained in the same category on trial 6 as on trial 1, 3 participants did make a positive categorical change. It is certainly plausible that 5 days of practice is not enough to positively impact coordination patterns even though significant changes were observed in racket velocity. Perhaps with more practice, a higher number of participants would have shown positive changes in coordination patterns.

Although improvement in coordination over the 5 days was not documented, evidence that novice participants of a striking task generally employ a simultaneous pattern of coordination was observed. Support was also provided for Hudson's (1995) assumption that changes in velocity of motion can be expected before changes in coordination patterns.

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