STRENGTH AND COORDINATION IN THE SOCCER KICK

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Different teaching strategies are often employed for instructing skills to children of different ages. This is attributed to increases in physical performance in conjunction with increments in both strength and motor coordination as children become older (Asmussen & Heeboll-Nielson, 1955, 1955-56). In a paper presented by Miyashita and Kanehisa (1979), differences in performance at different age levels were speculated to be attributed to varying contributions of strength and motor coordination. The relative contributions of strength and coordination to the performance of various skills by different age levels remains unknown. Previous investigators (Boyer, 1963; Hess, 1965) have indicated that strength is a major factor influencing kicking displacement for high-level adult soccer players, but this relationship has not been investigated for young soccer players. Therefore, the purpose of this study was to determine the relative influence of isokinetic quadracep leg strength to motor coordination (ball angle of vertical projection and lateral deviation, and movement patterns of kicking limb) on maximal horizontal ball displacement for young soccer players.

METHODS AND PROCEDURES

Twenty-two elite volunteer male soccer players ranging in age from 9 to 17 years were used as subjects. The subjects were placed into one of three age groups (9 to 12, $\underline{n}$ = 12; 13 to 15, $\underline{n}$ = 5; 16 to 17, $\underline{n}$ = 5) and asked to kick a stationary soccer ball as far as possible along a designated straight line. Two mini-soccer balls were used for the 9-to-12 year-old group, whereas two offical N.A.S.L. balls were used for the two older age groups. The mini-soccer balls used were inflated to a pressure of 69,000 Newton-Meters squared with masses of 347 and 349 grams. The balls used for the older age levels were inflated to 65,500 Newton-Meters squared with masses of 414 and 423 grams.

A Locam 16 mm, double pin registered camera with a 6-factor shutter and a 10-millimeter lens was operated at 150 frames per second and positioned perpendicular to the kicking plane at a height of one meter and a distance of five meters from the stationary ball. Each subject was filmed until three good trials were obtained or a maximum of six trials. A good trial was recorded if the ball landed within a 10-degree angle on either side of the straight line.

Measurement of the ball projection angle and the angular displacement, velocity, and acceleration of the kicking thigh and leg were obtained from a film motion analyzer on-line with a digitizer and micro-computer

interfaced with McGills main frame computer. The motor coordination patterns of the thigh and leg were plotted for all trials.

Peak isokinetic quadricep leg strength and impulse were obtained on a Cybex II apparatus at 30 and 120 degrees per second. Each subject was given three trials at each velocity, with the mean value of the two highest torques generated at each speed used as the strength score. Impulse was determined from the average of the three recorded and integrated force-time curves as determined by planimetry, for each speed.

RESULTS

Zero-order correlations and stepwise regressions were used to identify the measured variable(s) (from Figure 1) which has the greatest association with horizontal ball displacement for the various age groups. Results indicated that the largest variation in performance was accounted for by (1) the ball angle of projection in the 9-to-12 year-old age group ($\underline{RSQ}$ = .84*; $\underline{r}$ = .92*); (2) The linear ball velocity in the 13-to-15 year-old age group ($\underline{RSQ}$ = .91*; $\underline{r}$ = .95*; and (3) isokinetic impulse at 30 degrees per second for the 16-to-17 year-old age group ($\underline{RSQ}$ = .97*; $\underline{r}$ = .98*). Further analysis revealed motor coordination variables to have a greater influence on horizontal ball displacement than strength variables for the 9-to-12 year-old level (angle of projection; $\underline{RSQ}$ = .84*; angle of lateral deviation, $\underline{RSQ}$ = .71*), whereas strength variables had greater influence on horizontal ball displacement for the 13-to-15 and 16-to-17 year age levels (impulse at 30 degrees per second, $\underline{RSQ}$ = .64* and .97*, respectively, strength at 30 degrees per second, $\underline{RSQ}$ = .56* and .92*, respectively). In Table 1 are zero-order correlations between horizontal ball displacement and the various strength and motor coordination variables for different age levels.

All subjects displayed a mature kicking pattern as defined by a decrease in angular velocity of the kicking thigh corresponding to an increase in angular velocity of the kicking leg prior to ball-foot contact. For illustrative purposes, the angular displacement, velocity, and acceleration kicking pattern of the leg and thigh of a 9-year-old subject are presented in figures 2, 3, and 4.

DISCUSSION

Horizontal ball displacement is primarily a result of the transfer of momentum to the ball which is a function of the interaction of both leg strength and motor coordination. Leg strength is manifested as foot velocity whereas motor coordination determines the direction of force applied through the mass center of the ball, resulting in angles of projection and deviation. This interaction has resulted in a report of skilled soccer players producing higher ball velocities than unskilled players, for a given foot velocity prior to impact (Shibukawa, 1973). Alexander (1973) stated that of a 25% variance in punting performance, there was only a 2% variance in final foot velocity. In this investigation, the best predictor(s) of horizontal ball displacement was found to vary with different age levels. They were determined to be: (1) strength for the 16-to-17 years old; (2) a combination of strength and motor coordination which was manifested as linear ball velocity for the 13-to-15 years old; and (3) the ball projection angle for the 9-to-12 years old. Strength was identified to be a better predictor of

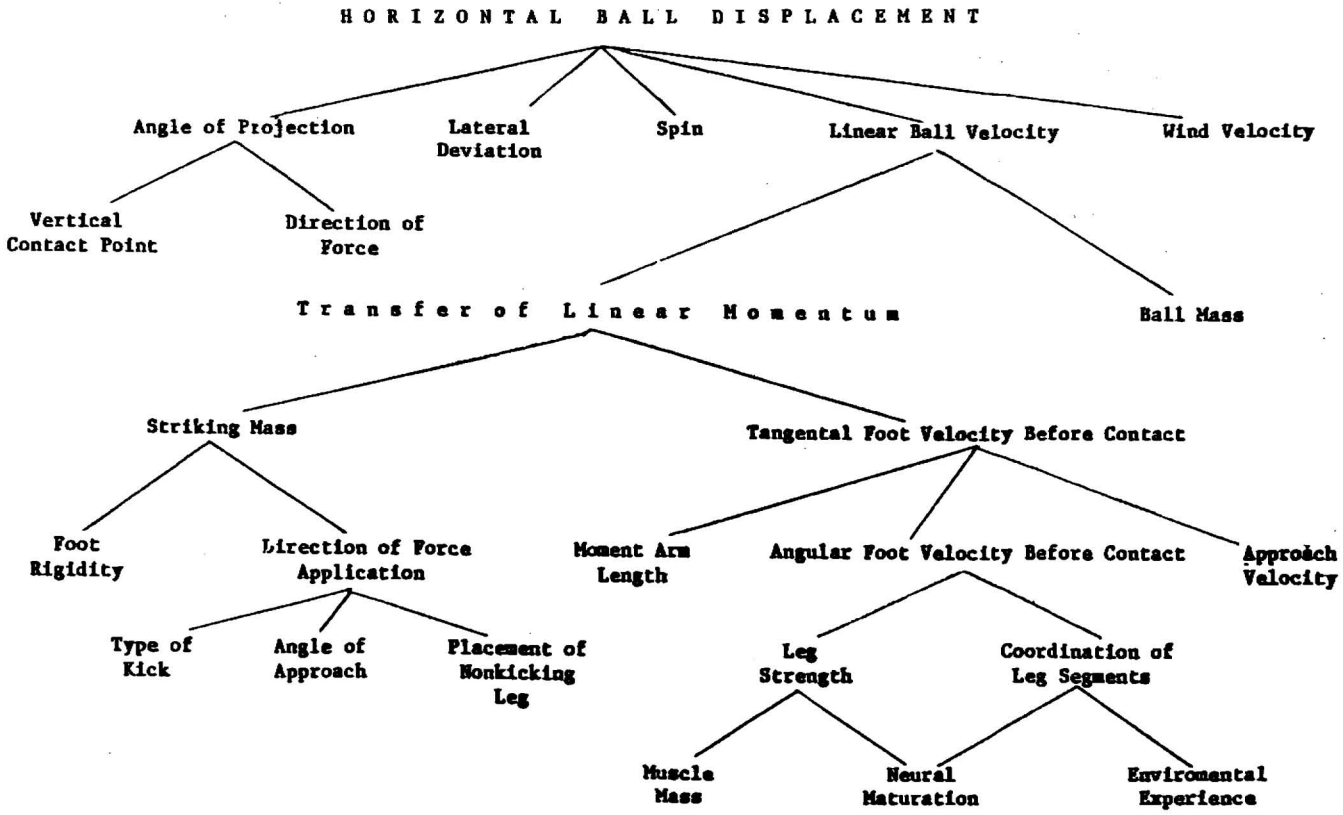


FIGURE 1. Biomechanical Ball Displacement Performance Model

TABLE 1

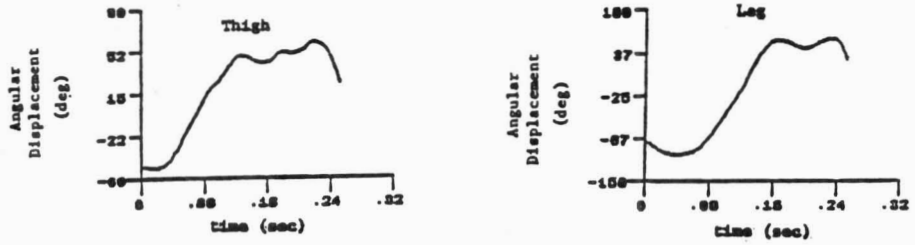
Zero-Order Correlations of Selected Dependent Variables with Various Independent Variables of Different Age Groups

		All Subjects	Ages 9 - 12	Ages 13 - 15	Ages 16 - 17
MHD	with S30	0.58*	0.51*	0.75	0.96*
	S120	0.80*	0.49*	0.64	0.92*
	I30	0.58*	0.52*	0.80*	0.98*
	I120	0.76*	0.57*	0.60	0.75
	T of M	0.96*	0.57*	0.94*	0.72*
	LVel	0.96*	0.57*	0.95*	0.36
	AngPro	0.67*	0.92*	0.11	0.42
	AngDev	-0.31	-0.78	0.31	0.36

*$p < .05$

MHD - Measured horizontal ball displacement
S30 - Isokinetic leg strength at 30 degrees per second
S120 - Isokinetic leg strength at 120 degrees per second
I30 - Isokinetic leg impulse at 30 degrees per second
I120 - Isokinetic leg impulse at 120 degrees per second
T of M - Transfer of linear momentum
LVel - Linear ball velocity
AngPro - Ball angle of projection
AngDev - Lateral angle of deviation

horizontal ball displacement for both the 13-to-15 and 16-to-17 years old than motor coordination. This result appear to be consistent with those reported in the literature (Boyer, 1963; Hess, 1965). On the other hand, motor coordination variables (ball projection and deviation angles) were determined to be better predictors than strength variables for the 9-to-12 years old. There is insufficient evidence to determine whether this may be attributed to the use of a mini-soccer ball by the 9-to-12 years old; since a smaller ball may result in a greater influence on accuracy. Motor coordination, in this investigation, was also defined qualitatively by the kinematic pattern of the kicking thigh and leg. All subjects were determined to exhibit a mature kicking pattern. The deceleration of the kicking thigh corresponding with acceleration of the kicking leg prior to ball-foot impact, was consistent with those patterns reported in the literature (Alexander, 1975; Plagenhoef, 1971; Putnam, 1983; Youm et al., 1973).



Time of Ball-Foot Contact - .12 second

FIGURE 2. Angular Kicking Displacement Pattern of the Thigh and Leg for Subjects 9 - 12 Years of Age

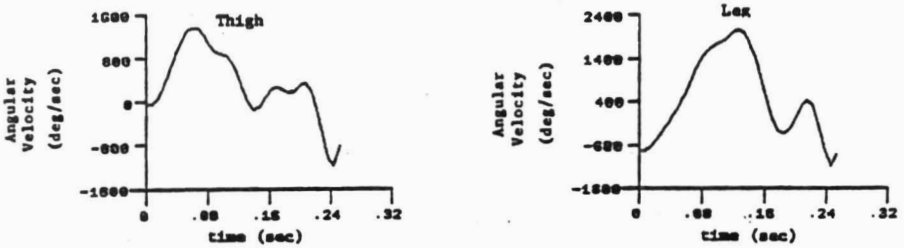


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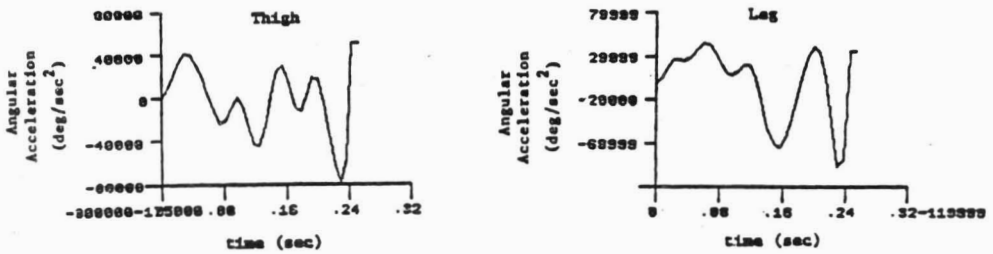
FIGURE 3. Angular Kicking Velocity Pattern of the Thigh and Leg for Subjects 9 - 12 Years of Age



Time of Ball-Foot Contact - .12 second

FIGURE 4. Angular Kicking Acceleration Pattern of the Thigh and Leg for Subjects 9 - 12 Years of Age

There are several implications regarding the coaching and instruction of specific skills to children based on the results of this investigation. Since performance of skills are influenced to varying degrees by strength and coordination at different age levels, it becomes important that appropriate coaching strategies and teaching cues are used for different age levels. Performance in kicking a ball for maximal horizontal displacement may be facilitated by strength training programs for children 13-to-17 years of age whereas greater emphasis may be stressed on properly contacting the ball when instructing kicking skills to children 9-to-12 years of age.

CONCLUSIONS

Motor coordination variables (ball angle of projection and lateral deviation) were identified to have a greater association with horizontal ball displacement than strength variables for the 9-to-12 year-old soccer players. Isokinetic strength variables (strength and impulse at 30 degrees per second) were identified to have a greater association with horizontal ball displacement than motor coordination variables for the 13-to-15 and 16-to-17 year-old soccer players.

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