KINEMATIC ANALYSIS OF THE INSTEP KICK OF ELEMENTARY SCHOOL STUDENTS IN SOCCER—FOCUS ON BALL VELOCITY AND REBOUND RATIO—

Takahito Tago[1], Kenichi Kaneko[1], Daisuke Tsuchioka[1], Tadashi Wada[2]

Tokushima Bunri University, Japan[1]
Kokushikan University, Japan[2]

The purpose of this study was to establish guidelines for proper selection of soccer balls for elementary school students. Ten youth soccer team players aged 8-11 years, who all kicked using their right foot, were included in this study. The participants were asked to perform an instep kick with full strength to hit a stationary soccer ball toward a target. Two types of balls with different masses were used in the experiment. For kinematic calculations, ball velocity, toe velocity, and rebound ratio (ball velocity / toe velocity right before impact) were calculated. A significant difference was observed in velocities in both kicks ($p<0.01$). In particular, a high correlation was observed with the light ball ($r=0.820$). This suggests that when kicking the light ball, all participants were able to efficiently transfer their kinetic momentum from their kicking foot to the ball, but there were children who could not do this with the normal ball.

KEY WORDS: three dimensional motion analysis, youth generation, ball kicking.

INTRODUCTION: Elementary school students in Japan typically use size 4 soccer balls. Grade 1 and Grade 6 elementary school students often use balls of the same size and weight. In contrast, in England, there is a clear specification that children in U-8 levels should use a size 3 ball, and that those in U-9 and higher levels should use a size 4 ball. Despite the elementary school years being the most appropriate time for learning basic skills, using an inappropriately sized ball can place excessive stress on a student's body and may hinder the learning of proper technique. Consequently, for elementary school students with significant individual differences in development, it is crucial to choose the most appropriate ball, with regard to physical development and skills. Several studies (Isokawa et al, 1988; Levanon et al, 1998; William et al, 2002)have been conducted on instep kicking and inside kicking but most have targeted adults, and only few studies have involved elementary school students. The purpose of this study was to establish guidelines for proper selection of soccer balls for elementary school students by conducting a kinematic analysis of the form displayed by students of a youth soccer team when kicking two types of balls with differences in mass—a size 4 ball (360 g) and size 3 ball (300 g).

METHODS: Ten youth soccer team players aged 8-11 years, who all kicked using their right foot, were included in this study. Given that all of the participants in this study were minors, the purpose and safety aspects of the study were explained to their parents/guardians, and their consent to participate in the study was obtained prior to the start of the study. On a youth soccer pitch, the participants were asked to perform an instep kick with full strength to hit a stationary soccer ball toward a target (2 m × 2 m) 8 m away (the penalty kick distance). Two types of balls (with different masses) were used in the experiment—a size 4 ball weighing 360 g (hereafter, 'normal') and a size 3 ball weighing 300 g (hereafter, 'light'). A minimum of 5 kicks with each ball were allowed. Prior to the experiment, the participants were given sufficient time to warm up, and they were permitted to practice in order to familiarize themselves with the light

ball. For data collection, a Vicon optical three-dimensional motion analysis system was used. Twelve cameras, which were set up at a height of approximately 2.2 m to surround the participants, were used. The sampling frequency was set at 250 Hz. The passive markers (15mm in diameter), which were placed externally on the soccer ball and participants' lower limbs at the following anatomic landmarks: anterior superior iliac spine; posterior superior iliac spine; greater femoral trochanter; lateral and medial femoral epicondyle; head of fibula; lateral and medial malleolus; calcaneus; cuboid bone; toe-distal end of the fifth metatarsal. Raw coordinate data were filtered through a fourth-order Butterworth low-pass filter with a cut-off frequency of 12.4 Hz. A kick was analysed if the ball hit the target and when both the participant and investigator assessed the kick to be satisfactory. For kinematic calculations, ball velocity, toe velocity, and rebound ratio (ball velocity / toe velocity right before impact) were calculated. Linear regressions were employed to verify the relationship between the resultant velocity of the toes of the kicking foot right and ball velocity and ball type. The Pearson correlation coefficient was used to verify the relation between the resultant velocity of the toes of the kicking foot right and ball velocity. An alpha level of 0.01 was used in all statistical analyses, which employed IBM SPSS statistics 27 software.

RESULTS: Figure 1 shows, for kicking with both the normal and light balls, the relationship between the resultant velocity of the toes of the kicking foot right before impact and ball velocity. A significant difference was observed in velocities in both kicks ($p<0.01$). In particular, a high correlation was observed with the light ball ($r=0.820$). Table 1 shows the rebound ratio when kicking with the normal and light balls. The average value of the rebound ratio with the normal

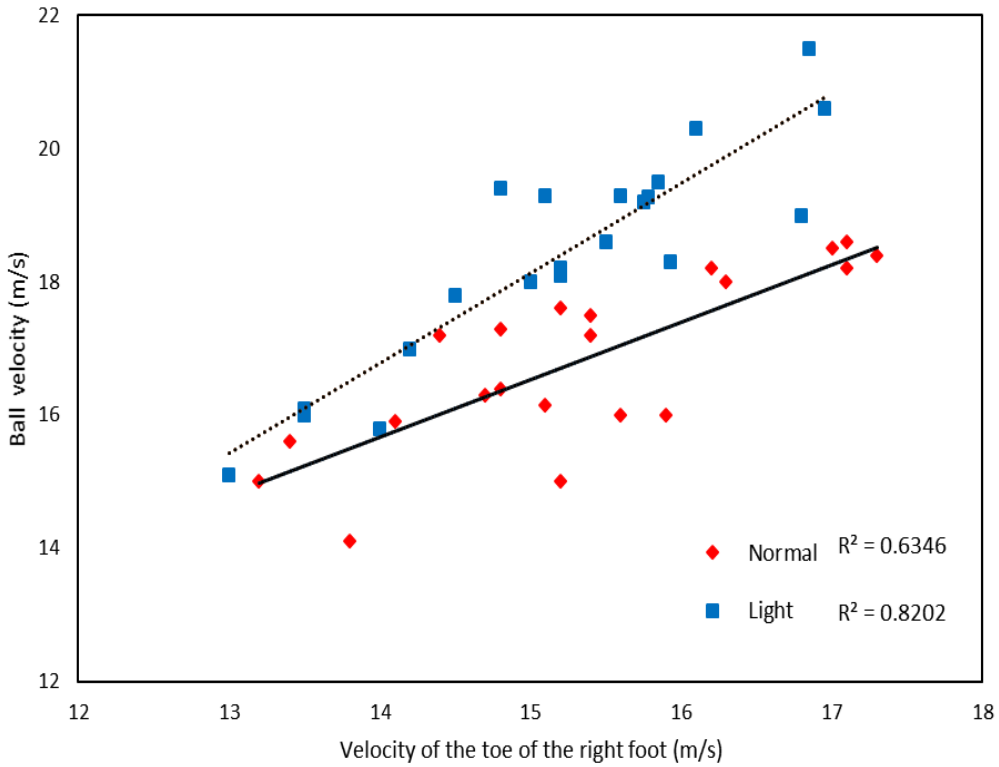

Fig.1 The relationship between the resultant velocity of the toes of the kicking foot right and ball velocity.

Table 1. The rebound ratio of the normal and light balls.

Subject	Light ball	Normal ball	Light / Normal	Group
1	1.238	1.166	1.061	SG
2	1.228	1.171	1.048	
3	1.250	1.174	1.065	
4	1.198	1.214	0.986	
5	1.182	1.142	1.035	
6	1.250	1.178	1.061	
7	1.196	1.095	1.091	WG
8	1.143	1.016	1.165	
9	1.207	1.059	1.110	
10	1.246	1.050	1.280	
Mean	1.214	1.126	1.077	—
SD	0.049	0.076	0.057	

ball was 1.126±0.076 and with the light ball was 1.214±0.049. Based on the finding that the average light-to-normal rebound ratio value was 1.077, participants with light-to-normal ratios lower than the average were placed in the SG group and those with ratios larger than the average were placed in the WG group. Figure 2 shows the respective rebound ratio for kicking with the normal and light balls in the SG and WG groups. Both the SG and WG groups showed higher values when kicking with the light ball than with the normal ball. When the normal ball was kicked by the WG group, the rebound ratio was smaller than that obtained with other

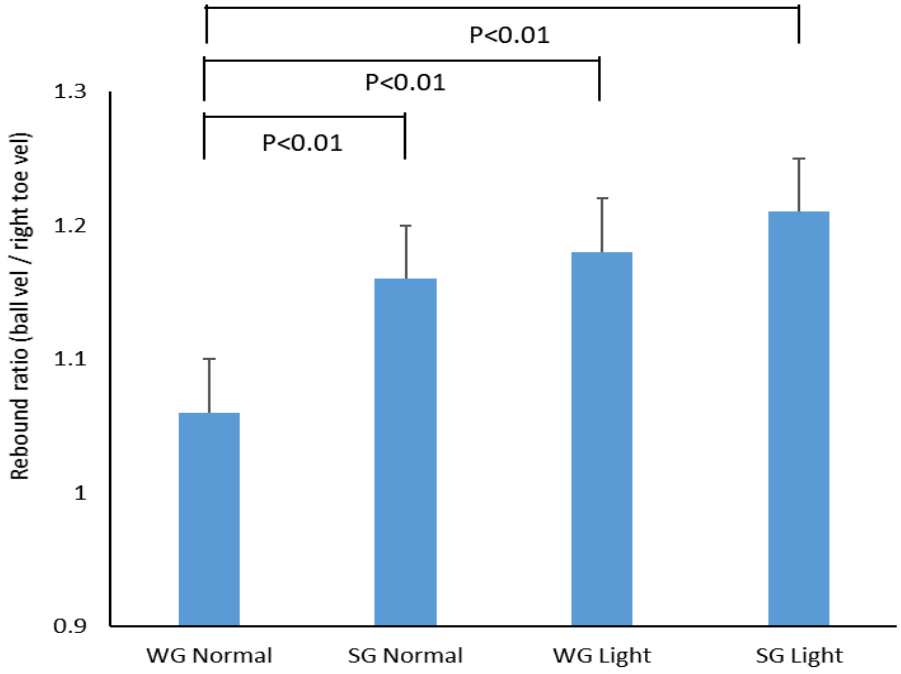

Fig.2 The respective rebound ratio for kicking with the normal and light balls in the SG and WG groups.

combinations.

DISCUSSION: The purpose of this study was to establish guidelines for proper selection of soccer balls for elementary school students by conducting a kinematic analysis of the form displayed by students of a youth soccer team when kicking two types of balls with differences in mass. Ball velocity was 17.18 m/s with the normal ball and 18.28 m/s with the light ball; thus, the velocity of the light ball was significantly greater than that of the normal ball ($p<0.01$). This suggests that when kicking the light ball, all participants were able to efficiently transfer their kinetic momentum from their kicking foot to the ball, but there were children who could not do this with the normal ball.

A significant difference was observed between kicks with the light and normal ball in the SG group and the kicks with the light ball in the WG group ($p<0.01$). This could be attributed to the WG group's lower efficiency in transferring kinetic momentum to the ball (normal) compared to that of the SG group. This suggests that 8–11-year-old elementary school students who lack the muscle strength and power of the WG group are unlikely to perform a proper kicking action with a size 4 ball. Thus, in order for students to acquire proper kicking techniques, ball selection according to age and physical development is important, and all elementary school students should not be treated as a single group. This study also suggests that a simple parameter like the rebound ratio between ball velocity and velocity of the toe of the kicking foot right before impact is sufficient for considering ball choice.

CONCLUSION: A significant difference was observed in velocities in both kicks ($p<0.01$). In particular, a high correlation was observed with the light ball ($r=0.820$). This suggests that when kicking the light ball, all participants were able to efficiently transfer their kinetic momentum from their kicking foot to the ball, but there were children who could not do this with the normal ball. A significant difference was observed between kicks with the light and normal ball in the SG group and the kicks with the light ball in the WG group ($p<0.01$). This could be attributed to the WG group's lower efficiency in transferring kinetic momentum to the ball (normal) compared to that of the SG group. This suggests that 8–11-year-old elementary school students who lack the muscle strength and power of the WG group are unlikely to perform a proper kicking action with a size 4 ball. Thus, in order for students to acquire proper kicking techniques, ball selection according to age and physical development is important, and all elementary school students should not be treated as a single group.

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