DEVELOPMENTAL DIFFERENCES OF KINEMATIC AND MUSCULAR ACTIVATION PATTERNS IN INSTEP SOCCER KICK

Ali Onur Cerrah[1] Deniz Şimşek[1], Abdullah Ruhi Soylu[2] Hayri Ertan[1] Hiroyuki Nunome[3]

Sport Science Faculty, Anadolu University, Eskişehir, Turkey[1]
School of Medicine Biophysics Department, Hacettepe University, Ankara, Turkey [2]
Faculty of Sports & Health Science, Fukuoka University, Japan [3]

The aim of the study was to evaluate kinematic and muscular activation differences amongst different age groups of soccer players. Thirty male youth soccer players were divided into 3 groups according to their age (age 12-13; age 14-15; age 16-17). There were significant differences in ball velocities and isokinetic strength values amongst groups. Angular and linear velocities of hip, knee, ankle and toe were also significantly different ($p<0.05$) amongst groups in different phases. Furthermore, there were significant differences amongst groups regarding EMG activity of m. rectus femoris (RF), m. vastus medialis (VM), m. biceps femoris (BF) ($p<0.05$). From these results, it was suggested that that the ball velocity of in-step kicking increased with age that reflects the development of both muscular strength and coordination of kicking leg.

KEY WORDS: soccer, instep kick, kinematics, electromyography.

INTRODUCTION: In soccer, the in-step kick is widely used as main offensive, technical action during the game. In general, the instep kicking is used to produce faster ball velocity than other kicking technique, thereby giving the goalkeepers less time to react, thus expanding one's chances of scoring (Sterzing & Hennig, 2008; Amiri-Khorasani, Abu Osman, & Yusof, 2011). This coordinated action occurs as a result of the controlled recruitment of a high number of muscles generating resultant joint moment acting about a particular joint (Kellis & Katis, 2007; Nunome, Ikegami, Asai, & Sato, 2002). Barfield (1998) stated that soccer players started to learn kicking techniques from 4 to 6 years of age. Then, the kicking skills matured (refinement of motor skills) through adolescence with adequate coaching and practice (Pearson, Naughton, & Torode, 2006). Therefore, to understand the process on how the kicking techniques to be refined, is important for organization of youth kicking technique training. However, to date, this aspect of kicking has received little attention from researchers.

Therefore, the present study had two aims: (1) to define the relationship between the ball velocities and kicking leg strength parameters amongst different age groups, (2) to clarify the differences of kinematics and muscular activation patterns during the instep kicking amongst the groups. We hypothesized that there would be a significant increases in ball velocities and leg strength parameters with age, and also there would be a significant differences in some kinematic and muscular activation parameters amongst the groups.

METHODS: Of thirty male youth soccer players who belong to the youth academy (from U12-U17) of a Turkish First Division Soccer Club, 10 players for each age group (Group I: age 12-13; Group II: age 14-15; Group III: age 16-17) were randomly chosen, thus total thirty male youth players were recruited in the present study.

Isokinetic strength (60 deg/s and 180 deg/s) of the knee extensors and flexors of the kicking leg were measured using a Cybex isokinetic dynamometer. Maximum voluntary isokinetic contractions (MVIC) were performed with 1 min break between trials and the best result was used for further analyses. Analogue signals were band pass filtered between 20–500 Hz and digitized by a 12-bit A/D converter at 2000 Hz.

EMG during kicking were measured from m. tibialis anterior (TA), m. medial gastrocnemius (GAS), m. rectus femoris (RF), m. vastus lateralis (VL), m. vastus medialis (VM), long head of m. biceps femoris (BF), m. gluteus maximus (GMAX) and m. gluteus medius (GMED). The

measurement sites were prepared according to SENIAM recommendations (Hermens, Freriks, Disselhorst-Klug, & Rau, 2000). The filtered EMG signals were first rectified, then 40 ms rms (root-mean-square) smoothing filter was applied. The epochs of the smoothed EMG parts (450 ms before and 250 ms after ball impact) were normalized by the corresponding maximal voluntary isometric contraction EMG activity of the each participant (See Cerrah et al., 2011 for detailed explanation).
Two electrically synchronized high-speed video cameras (Mikrotron Cube 7, Germany) were used to sample the kicking motion at 1000 fps from the kicking leg (right) side. The six body landmarks including: right shoulder (acromion process), hip (greater trochanter), knee (lateral epicondyle), ankle (lateral malleolus), heel and toe (metatarsal-phalangeal joint) were manually digitized. The direct linear transformation (DLT) method (Abdel-Azis & Karara, 1971) was used to obtain the 3-D coordinate of each landmark. The soccer kick measurement was performed in an indoor sport area and on a FIFA Star 2 artificial grass platform. Five successful kicks were recorded and the best 3 successful and the fastest kicks were analysed. All kicks were performed with the dominant (right) leg towards a target set in the goal 11m away. The initial ball velocities were measured by a radar gun (Cerrah et al., 2011).
The soccer kick motion was divided into 5 phases. In each phase, normalized EMG and kinematic data were averaged. Statistical analysis was performed to these phase averaged values. One-way ANOVA was used and followed by Tukey's multiple-comparison test to determine statistical differences amongst the groups for all parameters. The level of significance was set at $p < 0.05$.

RESULTS: There were significant differences for the initial ball velocities and both isokinetic strength (60 and 180 deg/s) amongst three age groups. All the variables in 16-17 age group were significantly higher than those of 12-13 and 14-15 age groups. Likewise, all the variables of 14-15 age group were also significantly higher than those of 12-13 age group. .
During preparation phase, 16-17 age group showed significantly faster hip angular velocity than that of 12-13 age group. During forward swing phase, both 14-15 and 16-17 age groups showed significantly faster knee angular velocity than that of 12-13 age group while there were no significant differences for ankle angular velocities amongst groups throughout the entire kicking phase. There observed significant differences amongst three age groups for the hip, knee, ankle and toe linear velocity. 16-17 age groups consistently showed the fastest velocity amongst the groups, which resulted in significantly faster toe velocity at ball impact than the other two groups.
As shown in Figure 1, significant differences were observed for EMG of RF, BF and VM. During preparation phase, BF was the only muscle showed significantly higher EMG in 16-17 age than that of 12-13 age group. During late-cocking phase, 16-17 age group showed significantly higher EMG of VL and GAS than those of 12-13 age group. During forward swing phase, there were significant differences between 16-17 age group and 14-15 age group for EMG of VM and also EMG of GAS of 16-17 age group was significantly different than 12-13 age group. During ball impact phase, the difference observed for EMG of VM was maintained and 16-17 age group showed significantly higher EMG of GAS than the other groups. After ball impact phase, VM was the only muscle showed significant differences of EMG amongst groups, in which 16-17 age group showed significantly higher EMG than those of the other groups.

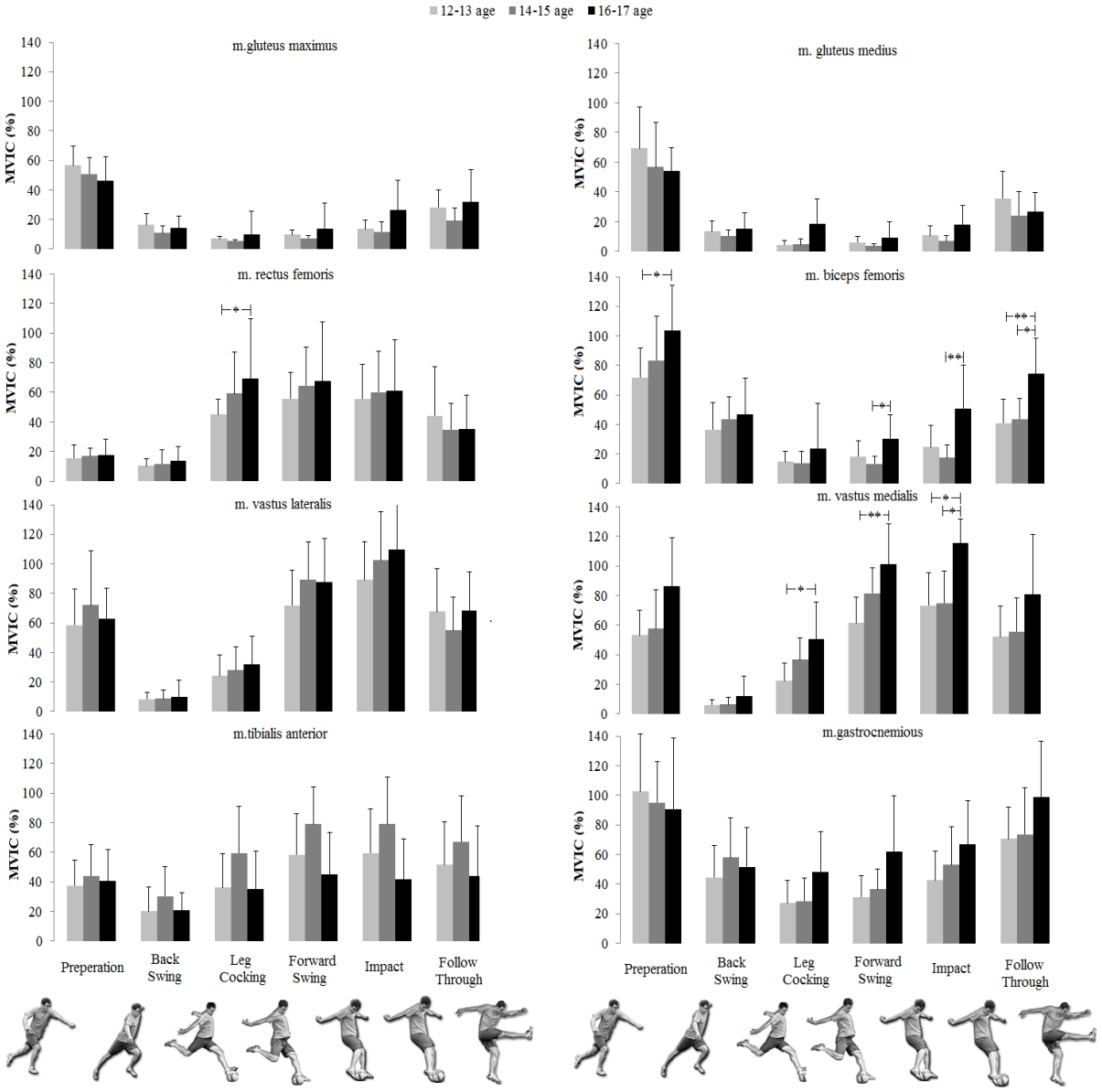

Figure 1: Muscular activation of muscles in different age soccer players during in-step kick.

DISCUSSION: The aims of the present study were twofold (1) defining ball velocities and kicking leg strength parameters in different age groups of youth players and (2) defining kinematic and muscular activation patterns differences regarding kicking leg amongst the age groups. The main findings of the present study were that ball velocities and leg strength increased with chronological age of youth players and muscular activations and kinematic parameters were different amongst the age groups in several important phases of the in-step kicking. Therefore, there was sufficient evidence to claim that the resultant ball velocity of the in-step kicking velocity increases with chronological age of youth players. Kellis and Katis (2007) suggested that the determinant of soccer kicking performance would differ in different age groups probably due to the increased muscle mass (strength), improved coordination and refined technique. The relationship between isokinetic strength parameters and chronological age have been analysed in several studies (Kellis, Kellis, Manou, & Gerodimos, 1999; Forbes et al. 2009). However, to the authors' knowledge, there have been no cross-sectional studies, which examine the differences in muscular strength, muscular activation pattern and kinematic parameters of younger age regarding the in-step kicking simultaneously.

The data of the present study showing a systematic increase of chronological age (12-17), are in line with the study of Kellis et al. (1999). Even though the EMG and kinematic data (linear and angular velocities) shows similar patterns in three age groups, there were important differences, which likely explain the superior kicking performance of the oldest age group (16-17 age group). It can be assumed that their higher BF activation during preparation phase might contribute to faster hip linear velocity, thereby increasing their approach velocity towards ball. Especially, their higher RF activation during leg-cocking phase and VM activation during forward swing phase might represent a better elastic energy transfer process towards ball impact using stretch-shortening cycle mechanism. These important features might explain our main finding that the resultant ball velocities of the in-step kicking increased with chronological age of youth players.

CONCLUSION: In conclusion, the resultant ball velocities of the in-step kicking increased with chronological age of youth players as a result of our cross-sectional study. There are similar patterns for muscle activation and motion kinematics in three age groups, there were important differences, which likely explain the superior kicking performance in elder age group. These can be represented as follows: significantly higher biceps femoris activation during preparation phase, rectus femoris and vastus medialis activation during leg-cocking phase.

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