Original Article

Lower limb muscle activation during instep kick from different approach angles and relationship of squat jump with 10-m sprint, 30-m sprint, static balance, change of direction speed and ball velocity among soccer players

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Abstract

Six university soccer players were selected for a correlational and comparative study. The correlation between squat jump height and 10-metre sprints, 30-metre sprints, arrowhead agility test, static balance test and velocity of ball during instep kick were investigated. The comparative study involved comparisons between ball velocity and between the muscle activity of vastus lateralis, rectus femoris, biceps femoris and tibialis anterior of kicking limb and supporting limb during instep soccer kick from 0-degree, 45-degree and 60-degree angle of approach from the target with the dominant limb and non-dominant limb. A significant association was found between squat jump height and 10-metre sprints ($r = -0.93$, $p = 0.007$) and 30-metre sprints ($r = -0.88$, $p = 0.021$). Also, significantly greater ball velocities were attained from 45-degree angle of approach with the dominant limb ($F_{2,10} = 7.49$, $p = 0.010$, partial $\eta^2 = 0.37$, $p = 0.002$, partial $\eta^2 = 0.88$). Greater muscle activity was found in tibialis anterior of kicking limb ($F_{2,10} = 7.49$, $p = 0.010$, partial $\eta^2 = 0.60$) as well as non-dominant limb ($F_{2,10} = 6.52$, $p = 0.015$, partial $\eta^2 = 0.57$) when the dominant limb was used for instep kick and in rectus femoris of supporting limb ($F_{2,10} = 5.536$, $p = 0.024$, partial $\eta^2 = 0.52$) when non-dominant limb was used from 0-degree approach.

Keywords: 10 metre sprint, 30 metre sprint, ball velocity, squat jump, instep kick, electromyography, arrowhead agility test

Introduction

Football is one of the most popular sports in the world, played without exception in many countries (Reilly, 1996). Kicking is the most often and commonly studied skill in soccer (Kellis, Katis, & Gissis, 2004). Although there are many variants in this technique due to the type of player, the velocity and the position of the strike, the purpose and intent of the move, the version most widely reported in the literature is the instep kick of the static ball at maximum speed (Lees, 1996); (Nunome, Asai, Yasuo, & Sakurai, 2003); (Kellis, Katis, & Gissis, 2004); (Kellis & Katis, 2007); (Scurr & Hall, 2009); (Kapidzic, Huremovic, & Biberovic, 2014).

Many studies have been conducted in relation to soccer's instep kick where the football is placed at a stationary position (Barfield, Kirkendall, & Yu, 2002); (Dorge, Andersen, Sorensen, & Simonsen, 2002); (Nunome, Asai, Yasuo, & Sakurai, 2003); (Shan & Westerhoff, 2005). Numerous studies have been carried out to see the muscle activity of lower limbs during execution of soccer instep kick (Dorge, et al., 1999); (Brophy, Backus, Pansy, Lyman, & Williams, 2007); (Cerrah, et al., 2011); (Scurr, Abbott, & Ball, 2011); (Chen, Chang, Yang, & Chang, 2016); (Yadav, 2019). All the electromyography studies conducted on instep soccer kick involved only dominant foot kicks and no such electromyography studies have been conducted where a comparison is being made between muscular activity of lower limbs while kicking the ball with both foot from different angles of approach.

Generally, the angle of approach during the kick is often based on the player's choice and circumstances of the game (Lees & Nolan, 1998); (Scurr & Hall, 2009). The approach with an angled run is usually preferred as it rotates the body to gain a better range of hip and knee flexion, allowing the kicking limb to be slanted in the coronal plane so that the kicking foot can be positioned further below the ball (Lees & Nolan, 1998); (Kellis, Katis, & Gissis, 2004); (Scurr & Hall, 2009). Many studies have been conducted to analyse instep kick from different approach angles and find a relationship with either ball velocity or accuracy (Scurr & Hall, 2009); (Majelan, Rahmani-Nia, Norasteh, & Damirchi, 2011). And no such study has been conducted to see difference in muscular activity of lower limbs during an instep soccer kick from different approach angles.

Lower body power of an athlete has shown relationship with performance in shorts sprints (Shalfawi, Sabbah, Kailani, Tonnessen, & Enoksen, 2011); (Lockie, Jallilvand, Callaghan, Jeffriess, & Murphy, 2015).

Soccer players are involved in about 90% of sprints which last less than 5 seconds (Marcin, Jan, Beata, Ryszard, & Andrzej, 2013). COD speed is essential fitness components for effective performance within many team field sports, soccer being one of them (Serpell, Young, & Ford, 2011).

The study's first objective was to observe the association among lower body power (squat jump) and sprints (10-meter and 30-meter), COD speed (arrowhead agility test), static balance (Centre of Pressure) and velocity of ball. The second objective of the research was to compare the ball velocity when kicked with the dominant limb as well as the non-dominant limb from different approach angles (Nunome, Asai, Yasuo, & Sakurai, 2003); (Kellis, Katis, & Gissis, 2004); (Kellis & Katis, 2007); (Kapidzic, Huremovic, & Biberovic, 2014); (Nunome, Inoue, Watanabe, Iga, & Akima, 2018). The third objective of the research was to compare the activation of selected kicking limb muscles and supporting limb muscles when the ball was kicked through different angles of approach with both the dominant limb and non-dominant limb, viz. 0-degree approach, 45-degree approach and 60-degree approach from ball line to the target.

Method

Subjects

Subjects in this study included six right limb dominated male university soccer players (mean $\pm$ SD; age 22.2 ± 2.8 years, height 172.2 ± 6.6 cms and body mass 68.2 ± 6.3 kg). The players self-selected limb dominance based on their response to which limb they wanted to kick for optimum ball velocity (Barfield, Kirkendall, & Yu, 2002); (Brophy, Backus, Pansy, Lyman, & Williams, 2007). During data collection, all subjects had 7 or more years of playing experience. The subjects were physically active and no records of recent history of lower limb, neurological or spinal injury were found. Subjects signed written informed consent and the institute's Research Committee approved the study.

Procedure

Lower body power (squat jump height)

A 10-minutes warm-up was performed by all subjects including dynamic stretching, plyometric exercises, and joint mobility exercises. The lower body power was measured using squat jump protocol with BTS G-sensor. The subjects squatted with their leg shoulder-width apart, back straight, and thigh and glutes parallel to the surface during the squat jumps. After familiarization with the test, each subject performed maximum squat-jump (Scurr, Abbott, & Ball, 2011); (Nunome, Inoue, Watanabe, Iga, & Akima, 2018). All the subjects were allowed three trials and a rest period of 1 minute was given in between the trials. The squat jump with maximum jump height was selected for the purpose of analysis (Vescovi & McGuigan, 2007); (Turner, Unholz, Potts, & Coleman, 2012).

Change of Direction speed, 10 metre and 30 metre sprints

The Arrowhead agility test which is a part of the assessment battery for SPARQ soccer was selected as a COD speed test (Wood, 2008). The subjects performed 15-20 minutes of soccer-specific warm-up before the collection of data. Freelap (USA) timing gates (± 0.02 sec error) were used for recording time in the arrowhead agility test, 10-metre sprints and 30-metre sprints. One Tx-Junior transmitter was placed ahead of the first cone of arrowhead agility drill 80 centimetres after the start or finish line and the stopwatch was tied on waist of the subject. While, in case of 10-metre and 30-metre sprint time, one Tx-Junior transmitter was placed ahead of the starting cone 80 centimetres after the start line and thereafter the second Tx-Junior transmitter was placed ahead of 10-metre cone and third Tx-Junior transmitter was placed ahead of 30-metre cone. The stopwatch started automatically when in a range of 80 centimetres around the Tx-Junior transmitter and lap timing started automatically when it again came in the range of the next Tx-Junior transmitters.

Three trials were allowed to subjects for each test and a rest period of 1 minute was given between trials. The best timing was considered for the investigation.

Figure 1. Arrowhead agility test set up

Figure 2. 10-metre sprints and 30-metre sprints set up

Static balance

The static balance of subjects was measured using BTS P-Walk (baropodometric pressure platform), which measures the foot plantar pressure in static and dynamic stages. The pressure platform was firmly placed

on the ground. In order to record data, subjects were requested to stand upright in bipedal step stance with hands placed on hips and eyes focused on a red mark fixed on the subject's front wall (Muehlbauer, Besemer, Wehrle, Gollhofer, & Granacher, 2012). Instructions were given to subjects to remain as stable as possible and to avoid any voluntary action throughout the trials (Muehlbauer, Besemer, Wehrle, Gollhofer, & Granacher, 2012). Prior to final testing, subjects performed two preparation trials on the pressure platform (Muehlbauer, Besemer, Wehrle, Gollhofer, & Granacher, 2012). Three trials were then conducted and recorded. Out of the three trials, the best trial was selected on the basis of least CoP displacements which was used for further analysis (Muehlbauer, Besemer, Wehrle, Gollhofer, & Granacher, 2012). The CoP distance (in millimetres) were recorded for 20 seconds.

Muscular Activity and ball velocity during instep kick from different approach angles

All participants performed a 5-minute dynamic stretching warm-up (Scurr, Abbott, & Ball, 2011). Muscles selected for assessment of muscle activity were vastus lateralis (VL), rectus femoris (RF), biceps femoris (BF) and tibialis anterior (TA) of kicking limb as well as supporting limb (Nunome, Asai, Yasuo, & Sakurai, 2003); (Kellis, Katis, & Gissis, 2004). Electrode location and placement procedures were undertaken in accordance with recommendation given by SENIAM group (Surface Electromyography for Non-Invasive Assessment of Muscle) (Scurr, Abbott, & Ball, 2011); (Nunome, Inoue, Watanabe, Iga, & Akima, 2018). BTS FREEEMG with 8 channels was used for recording of muscular activity of selected muscles. The process of normalization of the recorded EMG signal was not carried out as this study involved comparisons of amplitude signals from selected muscles (between instep kick from different angle of approach) within an individual in the same session under the same experimental conditions without making any changes to the EMG electrode set-up (Halaki & Ginn, 2012).

Kicking velocity was measured using a Bushnell radar gun (± 2 kph error) positioned behind the goal (Sterzing & Hennig, 2008). FIFA approved ball (Adidas Capitano) was used for the study. Ball was placed 11 metres away from the goal and different approach angles were marked accordingly. A space of 2 metres for the approach run was marked and only two steps approach were allowed for the kick.

Figure 3. Set up for data collection of EMG and ball velocity

Data Analysis

For analysing the data of squat jump G-STUDIO (version 3.3.22.0) software for G-Sensor was used and the Squat Jump section under the Jumps protocol was selected. The data of static balance was analysed using G-STUDIO software for BTS P-Walk. For the evaluation of CoP displacements stabilometric data section in G-STUDIO was used.

BTS EMG-Analyzer (version 2.9.40.0) was used for analysis of the electromyography signals. EMG signals were band pass filtered using Butterworth smoothing technique with a cut off frequency 20 Hz and 400 Hz. Root mean square was calculated with a fixed window of 100 ms.

Fig. 4. Sample EMG envelopes by mobile RMS of kicking limb in 0-degree approach instep kick with non-

Fig. 5. Sample EMG envelopes by mobile RMS of supporting limb in 0-degree approach instep kick with non-dominating limb

Statistic analysis

SPSS (version 20.0) was used for statistical analysis. Shapiro-Wilk's test was used to check for normality. Levene's test was used to check for homogeneity of variance. A p-value of less than 0.05 was considered statistically significant.

assumptions of normality using Shapiro-Wilk test. Non-parametric tests were used in case data violated the assumptions of normality.

Pearson product-moment correlation was used to study the association of lower body power (squat jump) with COD speed, 10 metre sprint, 30 metre sprint, static balance and ball speed. Correlation coefficient (r value), level of significance (p -value) and the amount of variance explained (r^2) described the associations found in the study. Values of $r = 0.10$ specifies a low, $r = 0.30$ a moderate and $r = 0.50$ a high association, i.e. effect size (ES) (Cohen, 1992); (Muehlbauer, Gollhofer, & Granacher, 2012); (Muehlbauer, Besemer, Wehrle, Gollhofer, & Granacher, 2012). To determine a model for prediction, linear regression analysis was used (Turner, Unholz, Potts, & Coleman, 2012).

The comparison of the ball velocity between kicking with the dominant limb and the non-dominant limb was rendered using the student's t -test for paired samples. Sixteen single factor repeated-measures ANOVAs (seven in kicking done by dominant limb and nine in kicking done by non-dominant limb) with three levels (0-degree, 45-degree and 60-degree approach) were used to compare ball velocity and muscle activity between instep kick from different angle of approach. Mauchly's Sphericity Test were used to check the violations of assumptions of sphericity and wherever the assumptions of sphericity had been violated Greenhouse-Geisser correction were used. Post-hoc paired t -tests with a Bonferroni adjustment ($P=0.017$) and LSD were used to find the significant differences between different levels. Instead of repeated measures ANOVA, two Friedman's tests (non-parametric) were also used for comparison as the data violated the assumptions of normality.

For repeated measure ANOVA tests, to determine the effect size of the statistical analysis partial eta-squared (η^2) values were calculated, with 0.01 defining a small, 0.06 a moderate, and 0.14 a large effect size (Cohen, 1988); (Lockie, Murphy, Knight, & Janse de Jonge, 2011). Cohen's d were calculated to determine the effect size for student's t -test for paired sample, with $d = 0.20$ defining a small, $d = 0.50$ defining a medium and $d = 0.80$ defining a large effect size (Cohen, 1988); (Lockie, Murphy, Knight, & Janse de Jonge, 2011). For all the statistical analysis level of significance was set at $P=0.05$.

Results

Relationship between lower body power (squat jump) and 10-metre sprint, 30-metre sprint, COD speed (Arrowhead agility test), static balance (CoP distance) and velocity of ball during instep kick

Statistically significant association was found using Pearson's correlation coefficient ($N=6$) between lower body power (squat jump) and 10 metre sprint ($r = -0.93$, $p = 0.007$) and 30 metre sprint ($r = -0.88$, $p = 0.021$). A model for prediction of 10 metre sprint and 30 metre sprints with lower body power (squat jump) as independent variable was developed using linear regression analysis.

$$y = -0.19x + 2.294 \text{ (linear regression model for 10 metre sprint)}$$

$$y = -0.25x + 5.109 \text{ (linear regression model for 30 metre sprints)}$$

Regression analysis was also used to compute the coefficient of determination (r^2) in each model (Turner, Unholz, Potts, & Coleman, 2012). Accordingly, 86.5% of the variance in 10 metre sprints was explained by lower body power (squat jump), while, 77.4% of variance in 30 metre sprints was explained by lower body power (squat jump). No, statistically significant correlation were found between lower body power (squat jump) and COD speed (arrowhead agility test), static balance (CoP distance) and ball kicking velocity.

Table 1. Correlation coefficient (r) table

	10-m Sprint	30-m Sprint	CoP distance	COD	B.V. D.L.	B.V. N.D.L.
L.B.P. (r)	-0.930**	-0.880*	-0.594	-0.683	-0.322	-0.179
P-value	0.007	0.021	0.214	0.135	0.534	0.734

**Denotes significant correlation at 0.01 level, *Denotes significant correlation at 0.05 level, L.B.P. = Lower body power, B.V. = Ball velocity, COD = Change of direction speed, CoP = Centre of pressure, K = Kicking limb, S = Supporting limb, D.L. = Dominant Limb, N.D.L. = Non-dominant Limb.

Comparison of velocity of ball during instep soccer kick from various approach angles

Student's t -test for paired-samples ($N=18$) of velocity of ball between kicking with the dominant limb and kicking with the non-dominant limb showed insignificant statistical difference irrespective of the approach angles ($t_{17} = 1.123$, $p = 0.277$). While, single factor repeated measure's ANOVA ($N=6$) showed significant statistical difference in velocity of ball when kicked with dominant limb from different approach angles ($F_{2,10} = 7.49$, $p = 0.010$, partial $\eta^2 = 0.60$). Post hoc tests using the Bonferroni correction revealed that ball velocity from 45-degree approach was significantly higher than 0-degree approach ($t_5 = 4.71$, $p = 0.005$, $d = 1.27$). While, statistical difference between 0-degree approach and 60-degree approach angle ($t_5 = 1.79$, $p = 0.146$) and between 45-degree approach and 60-degree approach angle ($t_5 = 2.091$, $p = 0.091$) was found to be insignificant. Further, in analysis of ball velocity with single factor repeated measures ANOVA when kicked with non-dominant limb from different approach angles, Mauchly's Sphericity Test specified that the assumption of sphericity were violated ($\chi^2(2) = 12.854$, $p = 0.002$) and consequently, a Greenhouse-Geisser correction was used in the analysis. Significant difference in velocity of ball was found when kicked with non-

dominating limb from different angle of approach ($F_{1,102.1,5.103} = 37.50$, $p = 0.002$, partial $\eta^2 = 0.88$). Post-hoc tests using Bonferroni correction revealed that ball velocity when kicked from 45-degree approach and 60-degree approach were significantly higher than 0-degree approach ($t_5 = 34.464$, $p = 0.000$, $d = 2.27$; $t_5 = 4.029$, $p = 0.010$, $d = 1.04$). While, there was insignificant difference between velocity of ball when kicked with non-dominating limb from 45-degree approach and 60-degree approach ($t_5 = 2.99$, $p = 0.030$).

Table 2. Comparison of velocity of ball (km/hr) in different angle of approach

	B.V. (irrespective of approach)	B.V. 0 D.A.	B.V. 45 D.A.	B.V. 60 D.A.
D.L.	92.33 $\pm$ 6.88	88.17 $\pm$ 6.18	96.00 $\pm$ 6.20*	92.83 $\pm$ 6.85
N.D.L.	90.94 $\pm$ 8.64	83.50 $\pm$ 5.61	97.33 $\pm$ 5.89*	92.00 $\pm$ 8.41

*Denotes greater ball velocity, D.L. = Dominant Limb, N.D.L. = Non-dominant Limb, B.V. = Ball Velocity, D.A. = Degree Approach

Comparison of muscle activity when kicking the ball from different approach angles

Repeated measure's ANOVA with single factor was used to analyse muscle activity when the ball was kicked with the dominant limb from different approach angles. Significant statistical differences was found in muscle activity of tibialis anterior of kicking limb ($F_{2,10} = 6.52$, $p = 0.015$, partial $\eta^2 = 0.57$). Post-hoc tests using the Bonferroni corrections revealed that muscle activity in tibialis anterior was significantly greater when kicked from 0-degree approach ($t_5 = 3.887$, $p = 0.012$, $d = 1.41$) than kicking from 60-degree approach. Insignificant statistical differences were found in muscle activity of tibialis anterior between kicking with dominant limb from 45-degree approach and 60-degree approach ($t_5 = 2.333$, $p = 0.067$) and between 45-degree approach and 0-degree approach ($t_5 = 1.557$, $p = 0.180$). Statistically insignificant differences were found in muscle activity of rectus femoris ($F_{2,10} = 3.210$, $p = 0.391$), vastus lateralis ($\chi^2(2) = 2.333$, $p = 0.311$) and biceps femoris ($F_{1,105.5,5.124} = 1.435$, $p = 0.285$) of kicking limb, rectus femoris ($F_{2,10} = 0.443$, $p = 0.654$), vastus lateralis ($F_{2,10} = 0.013$, $p = 0.987$), biceps femoris ($F_{2,10} = 0.391$, $p = 0.686$) and tibialis anterior ($\chi^2(2) = 2.333$, $p = 0.311$) of supporting limb when dominant limb was used for instep kick from different approach angles.

Table 3. Comparison of muscle activity (RMS) when the ball was kicked from different approach with dominating limb

	K.R.F.	K.V.L.	K.B.F.	K.T.A.	S.R.F.	S.V.L.	S.B.F.	S.T.A
0-D.A.	259 ± 82 ± 30	313 ± 112	217 ± 97		297 ± 90*	238 ± 59	224 ± 13	166
45-D.A.	290 ± 50 183 ± 55	276 ± 108 232 ± 96	218 ± 94		228 ± 42	226 ± 58	227 ± 29	
60-D.A.	223 ± 37 171 ± 64	244 ± 30 233 ± 101	255 ± 76		175 ± 26	210 ± 57	227 ± 66	

*Denotes significantly greater muscle activation, D.A. = degree-approach, K = Kicking limb, S = Supporting limb, RMS value is in μV

In the situation where the ball was kicked from different approach angles with the non-dominant limb, a single factor repeated measure's ANOVA revealed statistically significant difference in muscle activity of rectus femoris of the supporting limb ($F_{2,10} = 5.536$, $p = 0.024$, partial $\eta^2 = 0.52$). Post-hoc test by means of LSD revealed that muscle activity in rectus femoris of supporting limb was greater in 0-degree approach than 45-degree ($t_5 = 3.046$, $p = 0.029$, $d = 0.49$) approach and 60-degree approach ($t_5 = 3.061$, $p = 0.028$, $d = 0.64$). There was insignificant statistical difference in muscle activity of rectus femoris of supporting limb between 45-degree approach angle and 60-degree approach angle.

Insignificant statistical differences were seen in the muscle activity of rectus femoris ($F_{2,10} = 0.886$, $p = 0.442$), vastus lateralis ($F_{2,10} = 1.327$, $p = 0.308$), biceps femoris ($F_{2,10} = 1.004$, $p = 0.401$), tibialis anterior ($F_{2,10} = 2.614$, $p = 0.122$) of kicking limb and vastus lateralis ($F_{2,10} = 2.854$, $p = 0.105$), biceps femoris ($F_{2,10} = 0.889$, $p = 0.441$), tibialis anterior ($F_{2,10} = 0.985$, $p = 0.407$) of supporting limb when the ball was kicked with the non-dominating limb from different approach angles.

Table 4. Comparison of muscle activity (RMS) when the ball was kicked from different angle of approach with non-dominating limb

	K.R.F.	K.V.L.	K.B.F.	K.T.A.	S.R.F.	S.V.L.	S.B.F.	S.T.A
0-D.A.	232± 37	260 ± 64	176 ± 23	228 ± 64	225 ± 49*	211 ± 15		
	193 ± 79	154 ± 26						
45-D.A.	210± 89	247 ± 23	182 ± 29	186 ± 62	201 ± 47	222 ± 35	170	
	± 76	143 ± 22						
60-D.A.	221± 50	288 ± 46	196 ± 52	218 ± 108	192 ± 33	262 ± 57	164 ± 76	
	144 ± 17							

*Denotes significantly greater muscle activation, D.A. = degree-approach, K = Kicking limb, S = Supporting limb

Discussion

Investigation of the association between lower body power (squat jump height) and selected variables which affect the performance of players in soccer was the first objective of this study. A previous study showed significant correlation between 10-metre sprint, 30-metre sprint and COD speed (T-test) (Little & Williams, 2003). This study showed a statistically significant association between lower body power, 10-metre sprint and 30-metre sprint, which supports the result of previous studies that found lower body power related to sprinting speed (Cronin & Hansen, 2005); (Peterson, Alvar, & Rhea, 2006); (Nimphius, McGuigan, & Newton, 2010); (Lockie, Murphy, Knight, & Janse de Jonge, 2011); (Lockie, Jalilvand, Callaghan, Jeffriess, & Murphy, 2015). In this study the power of the associations were large, the reason may be due to sample size being small and the predictive relationship were high. Additionally, there were statistically insignificant associations found between lower body power and COD speed, static balance and velocity of ball. A previous research study conducted on association between countermovement jump height and COD speed also found insignificant correlation (Nimphius, McGuigan, & Newton, 2010). Earlier studies which displayed significant correlation between jump height and COD speed failed to establish relationship strong enough to explain more than 50% of the variance (Sheppard & Young, 2006); (Barnes, et al., 2007); (Vescovi & McGuigan, 2007). The association between lower body power and ball kicking velocity could not be established, may be because of the fact that ball velocity is more dependent on technique and level of skill possessed by the player. An earlier study which found significant association between squat jump and ball velocity could explain only 22.6% variance in ball velocity caused by jump height (Rodriguez-Lorenzo, Fernandez-del-Olmo, Sanchez-Molina, & Martin-Acero, 2016). This study also failed to establish a statistically significant association between squat jump height and static balance. Similar studies conducted earlier were unable to find any significant association between squat jump height and CMJ, triple-hop distance and static balance (Vescovi & McGuigan, 2007); (Hamilton, Shultz, Schmitz, & Perrin, 2008); (Mehmet, Mehmet, Sakir, Metin, & Ali, 2016).

The second objective of this study was to compare ball velocity as kicked from different approach angles with the dominant limb and non-dominant limb. First, when kicked with dominant and non-dominant limb, the velocity of the ball was compared, irrespective of approach angle. When kicked with the dominant limb, the ball's velocity was higher than when kicked with the non-dominant limb (Nunome, Asai, Yasuo, & Sakurai, 2003); (Kellis, Katis, & Gissis, 2004); (Belin, 2011). But the difference in ball velocity was statistically insignificant. A research conducted earlier showed similar outcomes, where the velocity of ball had shown insignificant differences when kicked with the dominant and non-dominant limbs under different conditions (Nunome, Asai, Yasuo, & Sakurai, 2003); (Kellis, Katis, & Gissis, 2004); (Marques, et al., 2011) (Wang & Fu, 2019); (Rada, et al., 2019). The second comparison was made when the ball was kicked from different approach angles with the dominant and non-dominant limb (Belin, 2011). The ball's maximum velocity was observed at an angle of approach of 45 degrees, regardless of the limb dominance, when the ball was kicked with the dominant and the non-dominant limb. In a similar study, a 45-degree approach angle was found to be ideal in skilled soccer players for maximum ball speed (Isokawa & Lees, 1988); (Nunome, Asai, Yasuo, & Sakurai, 2003); (Kellis, Katis, & Gissis, 2004); (Belin, 2011). Instep kick movement description suggests that a 45-degree approach angle opens the player's hips before ball contact, allowing the player's pelvis to move through a wider range of movement during the kick; which could be the reason for the maximum ball speed in 45-degree approach (Lees & Nolan, 1998); (Scurr & Hall, 2009).

The third objective of this research was to make comparisons between the muscle activity in kicking limb and supporting limb during soccer instep kick with the dominant limb as well as non-dominant limb from different angle of approach. Vastus lateralis, rectus femoris, biceps femoris and tibialis anterior of both kicking limb and supporting limb were selected for the comparative study (Brophy, Backus, Pansy, Lyman, & Williams, 2007); (Halaki & Ginn, 2012). In the tibialis anterior of the kicking limb with 0-degree angle of approach, a significantly greater muscle activity was found when the ball was kicked with the dominant limb. In case of the non-dominant limb kick, greater muscle activity in the tibialis anterior of the kicking limb could be seen with 0-degree angle of approach, but no statistical difference could be established (Nunome, Asai, Yasuo, & Sakurai, 2003); (Kellis, Katis, & Gissis, 2004); (Kellis & Katis, 2007); (Belin, 2011). A significantly greater muscle activity was also found in rectus femoris of supporting limb when kicked from 0-degree approach with non-dominant limb (Huang & Pang, 2019). Similarly, greater muscle activity was also seen in rectus femoris of supporting limb when kicked with 0-degree approach angle with the dominant limb, but again it lacked statistical difference. Due to insufficient studies in this domain, comparisons couldn't be made by the researchers. However, a study found approach path made by skilled players is curved and as a consequence the body is inclined towards the centre of rotation (Marques-Bruna, Lees, & Grimshaw, 2007). This curved direction was intended to ensure that the body produces and retains a lateral shift as the move is done (Lees & Nolan, 1998); (Peacock & Ball, 2018). In an approach of 0-degree the curve path is not attained, as attained in 45-degree and 60-degree approach and this might be a reason to obtain statistical differences in muscle activity in 0-degree approach kicks. This study did not include normalization of the EMG signals, which restricted the researchers in making comparisons between the muscle activity of different muscles during soccer instep kick from different angle of approach as well as between kicking with dominant and non-dominant limb (Halaki & Ginn, 2012).

There are lots of opportunity for studies in this domain and researchers should look forward into it. This study was a preliminary investigation in an area of soccer performance and the small sample size limits the generalizability of the conclusions made from this study. Future researchers should think of including the normalization of EMG signals for study which would help in determining the amount of muscle activation in each muscles in different angle of approach.

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