ELECTROMYOGRAPHY ANALYSIS OF DIFFERENT INSTEP KICKING ANGLE BETWEEN KICKING AND SUPPORTING LEG IN FOOTBALL: A SCOPING REVIEW

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by

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CERTIFICATE

This is to certify that the dissertation entitled "Electromyography Analysis Of Different Instep Kicking Angle Between Kicking And Supporting Leg In Football: A Scoping Review" is the bonafide record of research work done by Mr Muhammad Hafizuddin Bin Ahmad Rosdi during the period from January 2021 to June 2021 under my supervision. I have read this dissertation and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation to be submitted in partial fulfilment for the degree of Bachelor of Health Science (Honours) (Exercise and Sport Science).

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DECLARATION

I hereby declare that this dissertation is the result of my investigations, except where otherwise stated and duly acknowledged. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at Universiti Sains Malaysia or other institutions. I grant Universiti Sains Malaysia the right to use the dissertation for teaching, research, and promotional purposes.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	Percentage
=	Equal to
-	To
#	Hashtag
±	Plus, minus
/	Or
&	And
<	Less than
>	More than
n	Frequency
r	Radial error/ Radial variable error
m	Metre
s	Seconds
cm	Centimetre
kg	Kilogram
Hz	Hertz
mV	Millivolt
Cohen’s d	Difference between two mean
Et. al	Et alis (others)
i.e,	That is
K	Angle degree
RE	Radial error
SD	Standard deviation
BF	Bicep femoris
VM	Vastus medialis
VL	Vastus lateralis
AM	Adductor magnus
AL	Adductor longus

TA	Tibialis anterior
RF	Rectus femoris
GAS	Gastrocnemius
EMG	Electromyography
BMI	Body mass index
MVR	Mean velocity right leg
RVE	Radial variable error
ARV	Averaged rectified value
MVL	Mean velocity left leg
GRFs	Ground reaction force
RMSL	Root mean square left leg
MVIC	Maximal voluntary isometric contraction

ANALISIS ELEKTROMIOGRAFI SUDUT TENDANGAN SISI BERBEZA ANTARA KAKI TENDANG DAN KAKI SOKONGAN DALAM BOLA SEPAK: KAJIAN SKOP

ABSTRAK

Dari sifat semula jadi permainan bola sepak, kemahiran dalam pergerakan dibantu oleh latihan bola sepak. Untuk menganalisis aktiviti otot pemain bola sepak, aktiviti otot dianalisis menggunakan analisa EMG. Pemain cenderung mengalami kecederaan otot ketika melakukan tendangan dalam permainan, penyelidikan mengenai teknik tendangan berdasarkan otot tertentu masih sedikit. Maklumat dari kajian ini diharap dapat digunakan untuk memahami lebih lanjut mengenai mekanisme otot semasa tendangan pada sudut yang berbeza yang akan membantu pemain dalam mencegah kecederaan dan memaksimumkan prestasi tendangan. Sumber data yang diperoleh dicari secara elektronik melalui 4 empat pangkalan data. Kemudian pemilihan kajian dilakukan dengan menggunakan garis panduan Meta-analisis (PRISMA). Setelah itu, tajuk dan abstrak artikel yang diambil ditinjau menggunakan kriteria yang ditentukan untuk menentukan sama ada teks lengkap diperlukan untuk analisis lebih lanjut dalam pengekstrakan data. Hasil kajian mendapati semasa tendangan sisi, peningkatan permukaan EMG diperhatikan pada otot adductor magnus (AM), tetapi tidak pada otot adductor longus (AL), vastus lateralis (VL), atau bicep femoris (BF), ketika kelajuan bola meningkat. Permukaan elektromiografi (EMG) otot AM dan AL di kaki sokongan meningkat dengan peningkatan kelajuan bola sebelum hentakan bola. Hasil kajian ini juga menunjukkan bahawa dalam kedua-dua aktiviti menendang, otot hamstring kaki menendang menunjukkan magnitud yang signifikan EMG sebelum dan sesudah kaki menendang bersentuhan dengan bola, menunjukkan bahawa otot hamstring diaktifkan.

Sebagai kesimpulan, semua kajian mendapati aktiviti otot semasa menendang bola sepak. Teknik tendangan sisi yang tepat ditentukan oleh corak pengaktifan otot, dan pembahagian daya dan kekuatan otot di antara kaki penyokong dan kaki tendangan memainkan peranan penting dalam meramalkan dan mengelakkan kecederaan ekstremis bawah dalam bola sepak.

ELECTROMYOGRAPHY ANALYSIS OF DIFFERENT INSTEP KICKING ANGLE BETWEEN KICKING LEG AND SUPPORTING LEG IN FOOTBALL: A SCOPING REVIEW

ABSTRACT

From the nature of the football games, movement skill is being facilitated by football practice. To analyse muscle activity for a football player, the muscle activities are analysed using EMG analysis. Players are prone to have muscle injury when performing a kick in the game, however the research on kicking technique based on the specific muscle activation is still lacking. Information from this study can be used to understand more about muscle mechanisms during kicking at a different angle that will help players in injury prevention and improve kicking performance. Data sources were acquired electronically by searching through 4 databases. The study selection was conducted using the Meta-analyses (PRISMA) guideline. Afterwards, the titles and abstracts of retrieved articles were reviewed using the criteria specified to determine whether full texts were required for further analysis in the data extraction. From review results, during instep kicking, an increase in surface EMG was observed in the Adductor Magnus muscle, but not in the Adductor Longus, Vastus Lateralis, or Bicep Femoris muscles, as the ball speed increased. The surface EMG of both the AM and AL muscles in the supporting leg increased considerably with an increase in ball speed before ball impact. The results of this review also revealed that in both kicking activities, the hamstring muscles of the kicking leg exhibited a significant magnitude of EMG activities before and after the kicking foot made contact with the ball, indicating that the hamstring muscles were activated. In conclusion, all of the studies found major muscle group activity during football kicking. The exact technique of instep kicking is thought to be determined by

the pattern of muscle activation, and the muscular power and force distribution between the supporting leg and the kicking leg which plays a significant part in predicting and avoiding lower extremity injuries in football.

CHAPTER 1

INTRODUCTION

1.1 Background of study

Based on Encyclopaedia Britannica, football is a team sport played with a spherical ball between two teams of 11 players. It is played by approximately 250 million players in over 200 countries, making it the world's most popular sport. The game is played on a rectangular field called a pitch with a goal at each end. The object of the game is to score by moving the ball beyond the goal line into the opposing goal. It is a popular sport among men, but now women also participate in football. It can be played by various age groups. Many categories in football being made to suits the age of the players. Football is the most popular sport in the world and is performed by men and women, children, and adults with different levels of expertise.

Football performance depends upon a myriad of factors such as technical/biomechanical, tactical, mental, and physiological areas. One of the reasons why football is so popular worldwide is that players may not need to have an extraordinary capacity within any of these performance areas but possess a reasonable level within all areas. However, there are trends towards more systematic training and selection influencing the anthropometric profiles of players who compete at the highest level. Efforts to improve football performance often focus on technique and tactics at the expense of physical fitness.

In an endurance context, numerous explosive bursts of activity are required, including jumping, kicking, tackling, turning, sprinting, changing pace, and sustaining forceful contractions to maintain balance and control of the ball against defensive pressure. By practising football, players use a lot of lower limb muscle groups during jumping, kicking, tackling, turning, sprinting, changing pace, and sustaining forceful contractions to maintain balance and control of the ball against defensive pressure. Specifically, kicking involved receiving the ball and shooting the ball. From the nature of the games, the development of muscle, bone, and movement skills is being facilitated by football practice. To determine muscle activation of kicking, the muscle activities are analysed using EMG analysis.

1.1.1 Electromyography Features

Electromyography (EMG) is a diagnostic procedure to assess the health of muscles and the nerve cells that control them (motor neurons). EMG results can reveal nerve dysfunction, muscle dysfunction or problems with nerve-to-muscle signal transmission. Motor neurons transmit electrical signals that cause muscles to contract. An EMG uses tiny devices called electrodes to capture and translate these signals into graphs, sounds or numerical values that are then interpreted by a specialist. For a needle EMG, a needle electrode is inserted directly into a muscle for recording the muscle activity. A nerve conduction study, another part of an EMG, uses electrode stickers applied to the skin (surface electrodes) to measure the speed and strength of signals travelling between two or more points. EMG sensors are also placed only on major muscles of the lower limb, which include quadriceps, hamstrings, tibialis anterior and calves. These are the muscles responsible for flexion and extension of knee and ankle, and essential during kicking in football. The sensor should be placed along the longitudinal midline centre of muscle between motor point and tendon insertion.

1.1.2 Kicking

Kicking is a very important factor in football and one of the most fundamental skills. It should be practised from an early age. It is one of the most studied football skills as many research have examined kinematics, kinetics and EMG variables. It involves multipoint movements that depend on various factors such as the maximum strength and power of the muscles of the kicking and supporting leg that take part during the kicking action, the angle that the player approaches the ball and the speed that he has before the impact phase. It also, depends on the coordination between the agonist muscles (vastus lateralis and medialis, rectus femoris, tibialis anterior and m. iliopsoas) and the antagonists (gluteus maximus, biceps femoris and semitendinosus) during the kick. During the game, muscle strength is important because players perform dynamic movements, such as kicking, headers, tackling, and sprinting. Studies have demonstrated positive correlations between force measured in the laboratory and performance in the field. Also, studies with ball velocity and kicking distance have revealed that lower limb and toe velocity and maximal strength of the knee extensor muscle are important determinants of kick performance and muscle strength is directly responsible for increasing the speed of the foot. Therefore, the purpose of the present study is to examine the relation between knee and ankle muscles strength and kicking performance at angular velocities and to investigate the correlation between the football players.

1.1.3 Balance Ability

In biomechanics, balance is an ability to maintain the line of gravity (vertical line from the centre of mass) of a body within the base of support with minimal postural sway. Balance is the ability to stay upright or stay in control of body movement, and coordination is the ability to move two or more body parts under control, smoothly and efficiently. There are two types of balance: static and dynamic. Static balance is maintaining equilibrium when stationary, while the dynamic balance is maintaining equilibrium when moving. We use our eyes, ears and 'body sense' to help retain our balance.

Coordination is a complex skill that requires not only good balance, but good levels of other fitness components such as strength and agility. Balance and coordination can be improved through practice and training within specific sports.

1.2 Problem Statement

Football is a popular sport around the world. The previous study mostly focused on biomechanics and the prevention of injuries by evaluating the player's movement. Players prone to have muscle injury when performing a kick in the game, the research about kicking technique based on the specific muscle is still lacking. This study review focused on the analysis of the EMG signal from the players during instep kicking motion. The activation and usage of the muscle will be explored. The information from this study review can be utilised to improve player strength and reduce muscle fatigue. Direct or indirect benefits of muscle strength can also be related to the balance ability when we analyse the result of the players.

1.3 Objectives of the review

1.3.1 General Objective

To explicate the characteristics of muscle activation, power and force distribution between different instep kicking angles in football.

1.3.2 Specific Objective

1) To determine the muscle activation of the supporting leg and kicking leg between different instep kicking angles.

2) To determine muscle power of supporting leg and kicking leg between different instep kicking angles.

3) To determine force distribution between different instep kicking angles.

1.4 Research Question of the review

1) What is the muscle activation of the supporting leg and kicking leg during different instep kicking angles?

2) What is the muscle power of the supporting leg and kicking leg between different instep kicking angles?

3) What is the force distribution between different instep kicking angles?

1.5 Significant of the review

Football is a very popular sport worldwide. It is being practised by all age groups. A small group of research has been done involving muscle activity during performing kicking in the game. The information from this study can be used to understand more about muscle mechanisms during kicking at a different angle that will help players in injury prevention and maximise kicking performance.

CHAPTER 2

LITERATURE REVIEW

2.1 Football

Most football injuries are caused by trauma; between 9% and 34% of all injuries during the season are classified as overuse injuries. An important cause of football injuries in contact with another player and 12% to 28% of all injuries are attributed to foul play. During a major international tournament, this proportion is even higher. The percentage of non-contact injuries varies from 26% to 59%. Non-contact injuries occur mainly during running and turning. Approximately 20–25% of all injuries are re-injury of the same type and location. (Chew-Bullock et al., 2012)(Junge & Dvorak, 2004)

A total of 6030 injuries were reported over the two seasons with an average of 1.3 injuries per player per season. Professional football players are exposed to a high risk of injury and there is a need to investigate ways of reducing this risk. Areas that warrant attention include the training programme implemented by clubs during various stages of the season, the factors contributing to the pattern of injuries during matches concerning time, and the rehabilitation protocols employed by clubs. (Woods et al., 2004)

A total of 353 injuries were reported for the lower leg (79.7% of all injuries and incidence of 7.9 per 1000 player-hours). A total of 142 injuries were reported on the thigh (32% of injuries and incidence of 3.2 per 1000 player-hours). Knee injuries represented 17.6% of all injuries (incidence of 1.7 per 1000 player-hours), while ankle injuries accounted for 14.4% of all injuries (incidence of 1.4 per 1000 player-hours). No significant difference in localisation was observed between the two sub-cohorts (*P* = 0.77).(Fouasson-Chailloux, Mesland, Menu, & Dauty, 2019)

2.2 Electromyography Features

_EMG was used in different research areas for football ranging from muscle activation study to muscle strength study. One study showed that the electromyography (EMG) signals from the hip flexor and knee extensor muscles indicated a similar proximal to distal muscular activation pattern, starting with the activation of the iliopsoas muscle followed by the activation of the rectus femoris muscle and finally the vastus lateralis muscle. Although this relationship between the relative motion of the segments and the muscle activation pattern seems appropriate, one must consider that the motion dependent interactive forces between body segments during human movement may exert significant torques. The EMG signals from the rectus femoris and the vastus lateralis indicated activation of the knee extensor muscles just before impact, although there was a net flexor torque about the knee joint at the same time. This may have been caused by the activity of the biceps femoris muscle and, further, that the knee joint was extending so fast that the extensor muscles were confined by the force-velocity relation.(Dörge et al., 2007)

The previous study aimed to investigate EMG muscle activity of three quadriceps muscles during football kicking towards a high or a low target on the right and left sides of a goal. Peak EMG values ranged from 57% in Phase 3 for the rectus femoris when kicking to the bottom left of the goal to 121% for the vastus lateralis in Phase 3 when kicking to the top right of the goal. Across all target areas, the vastus lateralis demonstrated a higher level of activation in Phase 1 compared with the other muscles. However, statistical analysis revealed no significant interaction effect in normalized EMG when accounting for target, muscle, and phase. When examining the main statistical effects, EMG activity displayed no significant difference across the three muscles of the quadriceps and no significant difference across each phase of the kick. A significant main effect on EMG activity was identified when kicking to different areas of the goal (F2,13 ¼ 4.34, P ¼ 0.02, partial Z2 ¼ 0.22).(Scurr, Abbott, & Ball, 2011)

The EMG techniques are used to estimate the muscle strength responsible for the knee and ankle movement during kicking action. The experimental measurements of knee and ankle kinematics. Mean and standard deviation player of right knee and ankle joint moment are computed in all three planes (coronal, sagittal and transverse). Through the observation of the joint moments from all planes, knee joint moments are found to be greatest at the transverse plane. These joint moments are noted during the peak performance of the football kick. Maximum knee joint moment was also obtained during mid-stance of kick action. Similarly, it is noted that the ankle joint moment recorded as high in the coronal plane. These are the actual maximum joint moments of the player based on their BMI. These moments are reflected in the muscles, which are responsible for flexion and extension of the knee and ankle, which are essential during football kicking action. Therefore, muscle strength is the essential factor to determine the performance of the football kicking action. The energy required for the peak performance of a football kicking dependent on the muscle responsible for knee and ankle moments. The application of EMG and its processing technique combined with advancement in surface marker techniques offer a wide range of solutions in terms of analysing the kinematics and kinetics of human locomotion. Several mathematical models have been developed and studied considering the peak performance of a football player during front and side kicking actions. (Bing, Parasuraman, & Ahmed Khan, 2012)

There were insignificant effects of approach angle on maximum normalised EMG Bicep Femoris (BF), Vastus Medialis (VM), and Vastus Lateralis (VL) values. For all kicks, the BF

EMG significantly increased until 50% before ball contact and then declined ($P < 0.01$). In the last four intervals of the pre support phase and the first four intervals after ground contact, the K0 EMG of BF was significantly lower compared with the corresponding K45 and K90 values ($P < 0.01$). The VM and VL EMG were similar for all kicks. Both VM and VL EMG increased significantly from 20% after ground contact until 70% and then declined during the last two phases before ball contact ($P < 0.01$).(Kellis, Katis, & Gissis, 2004).

2.3 Kicking

The process of kicking a ball from a biomechanical perspective can be separated into components in various ways. Some article defines kicking in soccer through six stages. They are approach angle, plant foot forces, swing limb loading, flexion at the hip and extension at the knee, foot contact with the ball, and follow-through. Most research supports the belief that the optimal support foot position is 5 to 10 cm to the left of the ball, assuming the kicker is kicking with the right foot. Placing the support foot parallel and adjacent to the ball, perpendicular to an imaginary line drawn across the middle of the ball seems to provide the best setting for a good instep kicking performance. When skilled and unskilled players were compared, the skilled athletes placed the support foot alongside and closer to the ball, whereas unskilled players tended to position the support foot behind the ball. They also found no significant differences between preferred and nonpreferred limbs. Based on EMG studies, peak activity in the hamstrings occurs near the time of ball contact, which will likely retard a strong equilibrium and balance between the flexors and extensors is likely to reduce the incidence and frequency of injury, improve the neuromuscular kick pattern, and generally improve kick performance. Based on Barfield (1998), research in the field of biomechanics is needed because there continue to be several unresolved issues including the following: approach angle; the influence forces on the plant foot play in dictating ball velocity, plant foot force; more definitive fractionization of moments and forces at the hip and knee, swing limb loading; the relative contributions each makes to kicking, and flexion at the hip; the eccentric role of the hamstrings as a protective injury mechanism. With increased participation in soccer from every aspect of society young to old, men and women, and diverse ethnic groups-there will continue to be a need for active ongoing research to improve training, prevent injury, and assist with rehabilitation techniques.

The kick is one of the most important skills in football and it is used for passing the ball or more often for scoring. Improving football kick performance represents one of the basic aims of strength training in football, at least at the individual player level. For this reason, the determinants of football kick performance have been investigated. The previous study has reported a moderate to a high correlation between isokinetic muscle strength and various indices of football performance.(Kellis & Katis, 2007)

2.4 Balance Ability

In a 2009 study on balance ability and muscle, the response was investigated using 3 systems as balance ability measurement which are, Biodex Stability System, EquiTest System and Tetrax system. Stability measurement using the Biodex Stability System revealed no statistically significant difference between the preferred and the non-preferred leg. Tetrax System Stability was much higher in the two-leg stance. In single-leg stance with and without an underlying soft pillow, the nonpreferred leg showed better stability, but this was not statistically significant. The difference between the legs was higher when using the pillow. For EquiTest System, there was no statistically significant difference in any of the four tested muscles between the two legs. The biceps femoris muscle of the preferred leg reacted faster in all test conditions. The latencies of the quadriceps femoris muscle of the nonpreferred leg were shorter when the plate was moving forward and toes up and down. The tibialis anterior muscle of the preferred leg reacted faster when the plate was moving forward and toes down, whereas in moving backwards and toes up, the nonpreferred leg reacted faster. The gastrocnemius muscle of the nonpreferred leg reacted faster in plate moves forward and toes up; in moving toes down, both legs showed the same latency time. The power analyses for EMG tests ranged from power of 6.9% for testing the gastrocnemius muscle (movement of the plate: toes up) to 57.8% for testing the biceps femoris muscle (movement of the plate: forward). The effective sample sizes ranged from 38 in testing the biceps femoris muscle (movement of the plate: forward) to 4577 in testing the gastrocnemius muscle (movement of the plate: toes up). This means that between 38 and 4577 soccer players would have to be tested to reveal probable statistically significant differences between the preferred and nonpreferred legs.(Gstöttner et al., 2009)

Research on the stability and velocity of the centre of pressure showed that mean velocity of the centre of pressure for the right leg (MVR) was significantly correlated with right kicking leg radial error (RE) ($r = .50$) and radial variable error (RVE) ($r = .52$) but not with RE or RVE on the left kicking leg. The main finding of the present study was that some selected isometric strength of the lower limb muscles was significantly related to dynamic balance assessed through the Y-balance test. This result suggests that increasing lower limb isometric strength may improve dynamic balance ability among young elite soccer players. A previous study also showed that isometric strength demands of the support leg changed according to the reaching direction and leg used to support the body's weight.(Chtara et al., 2018)

CHAPTER 3

METHODOLOGY

3.1 Data Sources

Related studies were searched electronically using the following databases: PubMed, Ebscohost, Scopus and Science Direct. Briefly, the selected studies were hand-searched using the same selection criteria as described below. In addition, cross-referencing on the related previously published study was performed to obtain additional information. Peer-reviewed articles in the English language were used. No attempts were made to contact the authors for additional information. Comparable searches were made for the other databases.

3.2 Study Selection

The search was conducted according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidelines. The following keywords were used during the search: #Electromyography and (#Instep Kicking or Kicking). Studies were screened for employing EMG analysis, and instep kicking or kicking as outcome measures or stimulus. Controlled trials and laboratory studies on humans were included in this review. The mediations comprised: (i) muscle activation of the supporting leg and kicking leg, and (ii) muscle power of supporting leg and kicking leg, and (iii) force distribution between different instep kicking angles.

3.3 Data Extraction

The titles and abstracts of retrieved articles were reviewed using the criteria specified to determine whether full texts were required for further analysis. Each full-text manuscript was evaluated systematically according to the study: (1) objective/s, (2) characteristics of the study (study design, participants, age, and sample size), (3) contents of analysis (analysis types or mode of EMG tested (4) targeted outcome/s, and (5) main findings. The outcomes extracted from those studies were not combined, reanalysed, or changed due to the nature of this scoping review.

CHAPTER 4

RESULTS

4.1 Search Results

The initial search from the databases identified 235 potential articles while another 2 were found through cross-referencing. After removing duplicates, 166 articles were assessed based on titles and abstracts against the selection criteria. A total of 154 articles were excluded because they did not investigate EMG and (Instep kicking or kicking). After a detailed analysis of the 12 full-text articles, only 11 were included in this scoping review. The excluded articles were not in the English language. Fig. 1 describes the PRISMA flow diagram for the study selection.

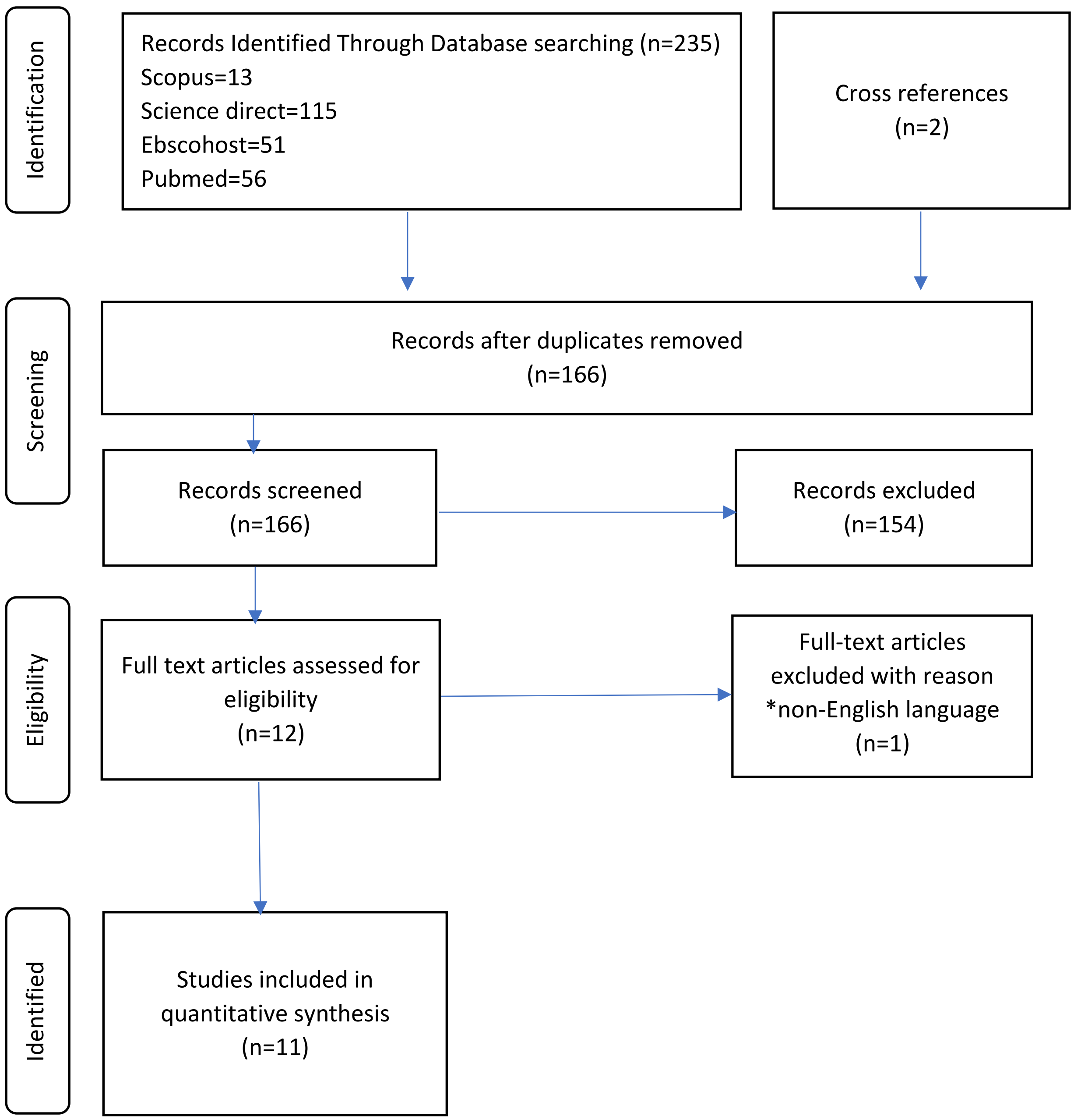

Figure 1 PRISMA flow for study selection

Table 1 Electromyography analysis of different instep kicking angles between kicking and supporting leg in football

No.	Authors and year	Study target/target population	Outcomes measures	Main finding	Comment
1	(Watanabe, Nunome, Inoue, Iga, & Akima, 2020) Electromyographic analysis of hip adductor muscles in soccer instep and side-foot kicking	Eight male experienced university-level soccer players (age = 20.4 ± 1.5 years, height = 172.4 ± 4.6 cm, body mass = 63.3 ± 5.2 kg, soccer experience = 13.1 ± 3.1 years with a minimum of 10 years) from a team in the regional top league for universities, volunteered to participate in the present study. All participants preferred to kick the ball with their right leg, and were free from any lower limb injuries when participated in the experiment	Touch-down of the supporting leg and ball impact of the kicking leg were used to determine the phases of the supporting leg. Average rectified values (ARV) of surface EMG signals between the events were averaged across the trials at the same ball velocity with each kicking style for each participant and used for further analysis.	In the AM muscle, significant effects of ball speed were noted in the kicking leg for instep kick in all four phases and the supporting leg for instep kick in phase 1 and side-foot kick in phases 1 and 2 ($p < 0.05$). For the kicking leg in all four phases, ARV at 100% ball speed was significantly higher than those at 50 and 75% ball speed ($p < 0.016$). For the supporting leg in phase 1, ARV at 75 and 100% ball speed were significantly higher ($p < 0.016$) than those at 50% ball speed for both kicking styles. In the AL muscle, significant effects of ball speed ($p < 0.05$) were noted in the supporting leg for instep and side-foot kicks in both two phases. For the supporting leg in phase 1, ARV at 100% ball speed was significantly higher than those at 50 and 75% ball speed, and ARV at 75% ball speed were significantly higher than those at 50% ball speed ($p < 0.016$) For the supporting leg in phase 2, ARV at 75 and 100% ball speed were significantly higher than that at 50% ball speed ($p < 0.016$). In the VL	surface EMG from the individual hip adductor muscles, i.e., AM and AL muscles, and quadriceps and hamstrings muscles during instep and side-foot kicking at various ball speeds. In the kicking leg, an increase in surface EMG with an increase in the ball speed was noted in the AM muscle, and not in AL, VL, or BF muscles, during instep kicking. In the supporting leg, surface EMG of

	muscle, significant effects of ball speed ($p < 0.05$) were found in the supporting leg for instep kick in both two phases. For the support. leg in phase 1, ARV at 100% ball speed were significantly higher ($p < 0.016$) than those at 50 and 75% ball speed. For the supporting leg in phase 2, ARV at 75 and 100% ball speed were significantly higher than that at 50% ball speed, and ARV at 75% ball speed were significantly higher ($p < 0.016$) than those at 50% ball speed. In the BF muscle, significant effects of ball speed ($p < 0.05$) were noted in the kicking leg for instep kick in phase 4 and the supporting leg for side-foot kick in both two phases. For the supporting leg in phase 1, ARV at 75 and 100% of ball speed were significantly higher than that in 50% of ball speed ($p < 0.016$). For the supporting leg, ARV in 75 and 100% of ball speed were significantly higher ($p < 0.016$) than that in 50% of ball speed in phase 1, and ARV in 100% of ball speed were significantly higher ($p < 0.016$) than that in 50% of ball speed in phase 2	both AM and AL muscles was significantly increased with an increase in the ball speed before ball impact during both instep and side-foot kicks. These results suggest that the AM muscle plays a marked role to intensify the instep kicking motion, and the AM and AL muscles of the supporting leg contribute to emphasise both insteps and side-foot kicking motions.

AM: Adductor Magnus, AL: Adductor Longus, BF: Biceps Femoris, ARV: Averaged Rectified Value

Table 1 *(Continued)*

No.	Authors and year	Study target/target population	Outcomes measures	Main finding	Comment
2	(Brophy, Backus, Pansy, Lyman, & Williams, 2007) Lower Extremity Muscle Activation and Alignment During the Soccer Instep and Side-foot Kicks	A cohort of 13 male NCAA Division I collegiate soccer players with no history of previous significant lower extremity injury were tested. Mean 6 SD subject age (20.1 6 1.6 years), height (178.5 6 8.1 cm), and body mass (74.9 6 8.8 kg).	The mean and standard deviation of the duration of each of the phases of kicking Average and standard deviation maximum kicking knee flexion, maximum kicking hip extension, and maximum supporting knee valgus/varus alignment were calculated. The mean and standard deviation muscle activation as a percentage of MVIC was calculated for each muscle in each of the 5 phases of both types of kick.	Kicking Lower Extremity: Instep Versus Side-foot Kick For the kicking lower extremity, comparing the instep kick to the side-foot kick, significant interaction effects were identified for the hamstrings (P = .02) and the tibialis anterior (P,.01) For the hamstrings, greater activity was noted for the side-foot kick during phase 5 (P = .03). The tibialis anterior demonstrated significantly greater activity during the side-foot kick in phases 2, 3, and 4 (P,.01). Supporting Lower Extremity: Instep Versus Side-foot Kick For the support lower extremity, comparing the instep kick to the side-foot kick, the only significant interaction effect identified was for the gastrocnemius (P = .036). The only significant phase-specific difference was greater activation with the instep kick during phase 4 (P = .02). There were no significant main effects for muscle activation level between the 2 kicks (P..05).	the soccer instep and side-foot kick occur with measurable phase timing and muscle activation by EMG. The different muscles can be grouped according to their activation pattern in a manner that appears logical. The 2 kicks are very similar with a few key differences in terms of the pattern and magnitude of muscle activation. The supporting limb musculature is activated with a different pattern compared to the kicking-limb musculature

MVIC: Maximal Voluntary Isometric Contraction