THE DIFFERENCE OF THE EFFECTS OF REGULAR STRENGTH AND CORE STRENGTH TRAINING PROGRAMS ON THE BIOMECHANICS OF FOOTBALL LONG PASS JUDGING FROM EYE-FOOT COORDINATION

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Abstract

This research purposes were (1) explained the difference in the effect of regular strength and core strength training programs on the results of football long pass based on biomechanics, (2) explain the difference in the results of football long pass between players who have high and low eye-foot coordination based on biomechanics, (3) the effect of the interaction between the training program and eye-foot coordination on the long passes football results. This research used an experimental method with a 2 x 2 factorial design. A total of 12 football players from the Faculty of Sports, Sebelas Maret University, Surakarta, aged 19.25±0.62 years, participated in this research. Each participant underwent an eye-foot coordination test and a long football pass. Data were analyzed using two-way ANOVA with a significance level of 0.05. Based on the research results, it can be concluded as follows: (1) there is a significant difference in effect of regular strength training program and core strength training program in improving football long pass results (F_{count} = 6.323, p-value = 0.036). The effect of the core strength training program is better than the regular strength training program in improving the results of long pass football. Seen from the biomechanics, the improvement of football long pass results was supported by a lower angle of knee flexion of the backswing kick leg and a greater angle of knee extension of the frontswing kick leg, a lower angle of inclination of the kicking leg and supporting leg at impact, a higher angle of inclination of the hip and shoulder during impact. Then this movement produces frontswing angular speed and acceleration, although the result is longer in the frontswing movement, but it was done with greater force, effort, and power, this produces greater momentum and impulse and faster ball. The core strength training program group produced higher energy and ball height and the ball was closer to the best target with an accuracy closer to 0.09 m. This movement ends with a smaller follow-through of hip angle, faster angular follow-through speed and deceleration, (2) there is a significant difference in effect between high-foot coordination and low-foot coordination on long pass football long pass football (F_{count} = 10.452, p-value = 0.012. The improvement of long pass results in football in players who have high eye-foot coordination is better than those who have low eye-foot coordination. Seen from the biomechanics, the improvement of football long pass results is supported by a lower angle of knee flexion of the backswing leg and the angle of extension of the knee of the frontswing leg, a lower angle of inclination of the kicking leg and supporting leg during impact, a higher angle of inclination of the hip and shoulder at the time of impact. Then this movement produces faster speed and angular acceleration in the frontswing movement, as well as greater force and power. However, the efforts made are not big so the momentum and impulse produced are smaller and the ball is also longer. With this support, players who have high eye-foot coordination produce lower energy and ball height, aiming to better control the fall of the ball, so that the fall of the ball is closer to the best target with a closer accuracy of 0.96 m. This movement, also ends with a smaller follow-through hip angle, as well as a faster angular follow-through speed and deceleration, (3) there is a significant interaction between the training program and eye-foot coordination for long pass football for long pass football (F_{count} = 18.581, p-value = 0.003. Players who have high eye-foot coordination are more suitable if given a core strength training program. Players who have low eye-foot coordination are more suitable if given a regular strength training program.

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Introduction

Football is a ball game in which one of the teams with a higher score is declared victorious within a predetermined time (Kai et al., 2018). The football game required a high level of physical conditioning throughout the competitive season. Therefore, one of the most important goals of the training program in the preparation period (pre-season) is improve football-specific strength. Football-specific strength is a concept that is widely used in training practice and can be defined as a football player's ability to use muscle strength and power effectively and consistently in games and throughout the season. During a football game, each player performs several dynamic movements (headers, cutting, tackling, sprints, kicks) which require excellent levels of muscle strength, power and endurance. Strength in its various forms (maximum and explosive strength, rate of force development) plays an important role in the performance of these skills. Football practice showm that a football player needs to develop maximum levels of strength and power, which are used effectively in the game.

Long pass is one of the kicking techniques in football, carried out using an instep kick. Instep kick is a basic element of the football game. This is a multijoint activity that depends on various factors, such as the maximum strength and power of the muscles activated during the kick, the precise timing and transfer of energy between the segments participating in the kick, the speed and angle of the player's approach to the ball and the utilization of the characteristic stretch–shortening cycle by the kicking leg muscles (Manolopoulos et al., 2006). Men's higher muscle strength is an important factor in being more successful in achieving goals with long-range full-instep kicks. The instep kicking technique used for medium or long distances and has higher precision (Althoff et al., 2010). Based on researchers' observations, football players in the Faculty of Sports, Sebelas Maret University, Surakarta, had problems with long passes using instep kicks and did not have good accuracy for their teammates'passes. The biomechanics understanding is needed in this case, because biomechanical characteristics consider that an athlete's body is influenced by motor control. Biomechanics studies the application of mechanics to biological systems such as human systems where human motor control is included in one of the performances studied in biomechanics. Therefore, biomechanics plays an important role in long pass accuracy movement patterns.

Rodríguez-Lorenzo et al. (2016) explained that the long pass can be described as a sum of forces. The movement pattern is generally accepted as a proximal-to distal sequence where the distal segments are allowed to lag behind the proximal segments when moving forward, where the foot is the last segment to intervene and the fastest segment in the open kinetic chain. The timing of muscle activation can be described by activation of the hip flexors such as the iliopsoas followed by the rectus femoris, which is the hip flexor and knee extensor, and finally by the activation of the knee extensors such as the vastus lateralis. Therefore, the hip flexor and knee extensor muscles are important for developing high foot velocity. In addition, the knee flexors (hamstrings) and hip extensors (gluteal muscles), which function as antagonists to slow the leg swing after ball impact, are also significantly active in maximal football kicks. In general, these antagonists require eccentric fundamental strength, while agonists require concentric strength.

Muscle strength is an important factor in kicking technique (Althoff et al., 2010). However, the training program currently used has not been able to increase muscle strength to achieve long passes with good accuracy for his teammates. Football coaches need to use training programs appropriately in providing strength training. Training programs that can be applied to increase muscle strength in doing long passes are regular strength and core strength. Regular strength training programs are carried out with strength training that focuses on the lower limb muscles consisting of the hamstrings, quadriceps, glutes and calves. Meanwhile, the core strength training program is carried out with strength training that focuses on the abdominal and lower back muscles. Regular strength training program is a general training program. This training is the basis of all strength, so an athlete must initially have basic strength to increase muscle coordination and endurance as well as neural adaptation, before proceeding to the stage of increasing muscle cross-sectional area and maximum strength. The core strength training program is an advanced stage for strength training. This training program is important to implement because it can control the position of the hip and provide synergy between the upper and lower extremities in strong movements. Strengthening the core helps stabilize the spine and hip. This provides a stronger platform for all movements performed, increasing the body's efficiency in transferring power to the limbs.

An athlete's personal factors in the form of internal and external factors also determine the success or failure of a long pass kick. This is because developing towards successful performance is not only based on the talent you have but the surrounding environment (external factors) also influences it. Internal conditions are factors that exist within the individual, such as eye-foot coordination abilities. Foot-eye coordination influences movement training, so this is the main requirement in achieving peak performance for a soccer athlete to master the soccer long pass.

Factors such as position and movements that have been carried out need to be considered by athletes. Athletes can correct and control their own movements if they are aware of the positions and movements they have made, so this factor becomes important when playing a match. The classification of high and low eye-foot coordination influences the mastery of football long pass techniques. Differences in eye-foot coordination are a determining consideration in mastering football long pass movements. Different eye-foot coordination is a consideration in determining a training program according to the characteristics of each athlete so that they can achieve maximum training results according to their respective potential

A correlation study has reported that across all movement amplitudes, a correlation was found between temporally aligned foot kinematics and the eye (Hollands et al., 2004). This means that during the whole-body rotation paradigm there is substantial eye-foot coordination, as well as the motor systems responsible for coordinating eye and head movements to peripheral targets influencing the output of the motor systems responsible for moving the feet. An idea related to a coordinated motor system between the eye and the limb, producing patterns in eye and limb movements. This is supported by the correlation between eye and foot movement latencies. A kinematic analysis also supports the idea that the way the foot is moved to align with the target, as indicated by the time course of rotation, is substantially similar to the way the eye moved to the target approximately 1 second previously (Hollands et al., 2004).

Based on the background that has been explained, it is known that the training program has an effect on the success of long football passes with good accuracy. Regular strength and core strength training programs need to be considered to produce football long pass movement patterns with good accuracy. Therefore, this research was conducted with the aim of finding out (1) explaining the difference in the effect between regular strength and core strength training programs on football long pass results based on biomechanics, (2) explaining differences in long pass results football between players who have high eye-foot coordination and low based on biomechanics, (3) the effect of interaction between the training program and eye-foot coordination on the results of long passes football.

Methods

A total of 12 football players in the Faculty of Sports, Sebelas Maret University, Surakarta aged 19.25 ± 0.62 years participated in this research. An experimental method using a 2x2 factorial design was used in this research. In this study, a 2x2 factor design was used where 2 training method factors and 2 eye-foot coordination factors, so that each training method factor was crossed with the eye-foot coordination factor, so there were 4 groups, i.e.:

K-a1b1 = HEFC-RST (n = 3)

K-a2b1 = LEFC-RST (n = 3)

K-a1b2 = HEFC-CST (n = 3)

K-a2b2 = LEFC-CST (n = 3)

Information:

K : Group

HEFC : High Eye-Foot Coordination

LEFC : Low Eye-Foot Coordination

RST : Regular Strength Training

CST : Core Strength Training

Training Procedures

Each sample underwent an exercise program 3 times every week for 8 weeks. The training program is carried out with a circuit concept containing 1-8 posts. Maximum training load 40-55%, 3-6 sets, rest between sets 60 seconds, work duration 15-20 seconds. The regular strength group underwent exercises consisting of leg curl, glute-ham holds, leg extension, single leg extension, leg press, single leg press, seated calf raise and barbell calf raise-rear. In the core strength group, they underwent exercises consisting of body dish-supine, medicine ball lift, lateral side raises, medicine ball elbow to knee, lower leg lift, hanging knee raise, hip raise-shoulder bridge, and controlled back raise (Paul Collins, 2010).

Data collection

Participants underwent an eye-foot coordination test using the Football Wall Volley Test (Kirkendall, Gruber, & Jhonson, 1980). Eye-foot coordination data was measured before treatment was given. Eye-foot coordination data was used to group participants into 2 eye-foot coordination factors, i.e high and low. Each eye-foot coordination factor was then divided into two and underwent different training for 8 weeks. Before and after training, a football long pass test was also carried out for each participant. To collect football long pass biomechanics data, this is done by recording the football long pass movement. The Canon EOS 1100D DSLR camera is positioned in wide, side and rear positions to record long pass kinematics. The camera records when the subject makes a long pass to a target of 25 m away. Subjects were instructed to pass an airborne ball over a pole 1 meter high and 3 meters high (≥ 3 m above the ground) with their instep to reach a circular target when the ball first bounced on the ground. Long pass is done 5 times. The scoring of the long pass test is that if the ball falls first and bounces on the ground. The concept of assessing a ball fall is as follows (Doewes, Elumalai, & Azmi, 2022):

a. 50 points are awarded for a ball that falls within 1 meter;

b. 40 points are awarded for a ball that falls within 2 meters;

c. 30 points are awarded for a ball that falls within 3 meters;

d. 20 points are awarded for a ball that falls within 4 meters;

e. 10 points are awarded for a ball that falls within 5 meters;

Data analysis

Kinovea software is used to analyze the long pass movement, where the long pass movement is then explained in two sequences of movements, i.e the movement when swinging the leg and the movement at impact until the ball is released. To determine the differences between the two exercises, the data were analyzed using a two-way analysis of variance (ANOVA) technique at α = 0.05. Conclusions are drawn based on the $F_{count} > F_{table}$ or p-value < α (0.05), which means that it shows the difference between the two exercises and the interaction between the training method and the level of eye-foot coordination. In this study, the assumptions of normally distributed and homogeneous data have been fulfilled. Data analysis was carried out using SPSS17.

Results

Data description and ANOVA test

The results of the study showed that there was an increase in the average football long pass results in players who underwent regular strength training, both players who had high and low eye-foot coordination (an increase of 43.33 ± 23.09 in players who had high eye-foot coordination and 53.33 ± 5.77 in players who have low eye-foot coordination). The average increase in football long pass results also occurred in players who underwent core strength training, both players who had high and low eye-foot coordination (an increase of 106.67 ± 5.77 in players who had high eye-foot coordination and 36.67 ± 20.82 in players who have low eye-foot coordination) (Table 1). The results of the two-way ANOVA test show that there is a difference in the influence of regular strength training and core strength training on football long pass results with a value of F = 6.323, α = 0.036; there is a difference in football long pass results between players who have high eye-foot coordination and low eye-foot coordination with a value of F = 10.452, α = 0.012; and there was an interaction between training method and the level of eye-foot coordination on football long pass results with a value of F = 18.581, α = 0.003 (Table 2).

Description of Foot ball Long Pass Biomechanics Data

After testing between groups, the results showed that foot ball players who given core strength training and players who had high eye-foot coordination showed better long pass results. To explain why the long pass results are better, the long pass movement was analyzed using biomechanics. The biomechanics discussed in the long pass movement are related to the accuracy of the closest distance the ball can fall from a long pass kick to the distance to the highest target point. Biomechanical analysis of foot ball long passes is presented in (Tables 3 and 4).

The biomechanical analysis of football long passes for each group at the leg swing stage is presented in table 3. To produce the highest accuracy of the ball

Table 1. Description of Football Long Pass Results Data.

Treatments	Level of Eye-Foot Coordination	N	Average Increase
Regular strength training program	High	3	43.33±23.09
	Low	3	53.33±5.77
Core strength training program	High	3	106.67±5.77
	Low	3	36.67±20.82

Table 2. Results of the two-way ANOVA test.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	9133.333[a]	3	3044.444	11.785	.003
Intercept	43200.000	1	43200.000	167.226	.000
K	1633.333	1	1633.333	6.323	.036
KMK	2700.000	1	2700.000	10.452	.012
K * KMK	4800.000	1	4800.000	18.581	.003
Error	2066.667	8	258.333		
Total	54400.000	12			
Corrected Total	11200.000	11			

Table 3. Biomechanical Analysis of Football Long Passes for Each Group at the Leg Swing Stage.

No	Biomechanical Variables	Eye-Foot Coordination			
		High		Low	
		Regular Strength	Core Strength	Regular Strength	Core Strength
1.	Knee flexion angle of the backswing kick leg (0)	89.33±5.69	98.33±10.21	102.33±1.53	91.33±8.08
2.	Knee extension angle of support leg (0)	144.33±13.05	150.67±12.66	160.00±8.54	152.33±6.66
3.	Frontswing hip angle (rad)	1.25±0.37	1.25±0.17	1.23±0.38	1.22±0.20
4.	Knee extension angle of frontswing kick leg (0)	139.67±16.07	158.33±3.51	144.67±6.03	155.00±10.82
5.	The angle of inclination of the kicking leg at impact (0)	66.67±5.51	63.33±7.23	75.33±8.14	70.33±5.03
6.	The angle of inclination of the supporting leg at impact (0)	62.67±4.93	57.67±3.21	70.67±3.06	62.67±10.60
7.	Hip tilt angle at impact (0)	9.00±3.46	10.67±4.51	7.00±1.00	11.33±4.04
8.	Shoulder tilt angle at impact (0)	5.00±2.65	8.33±2.89	5.00±1.00	5.67±2.08
9.	The distance between the supporting foot and the ball (m)	0.27±0.03	0.32±0.05	0.28±0.04	0.26±0.01
10.	Time of the foot touches the ball (s)	0.20±0.00	0.13±0.06	0.20±0.00	0.20±0.00
11.	Frontswing time (s)	0.60±0.10	0.73±0.06	0.77±0.12	0.77±0.15
12.	Frontswing angular speed (rad/s)	2.04±0.32	1.71±0.29	1.60±0.37	1.62±0.29
13.	Frontswing angular acceleration (rad/s2)	3.42±0.25	2.36±0.51	2.10±0.52	2.22±0.85
14.	The ball speed after impact (m/s)	15.90±0.29	15.69±0.45	15.86±0.38	16.22±0.25
15.	Ball momentum (Ns)	7.16±0.13	7.06±0.20	7.14±0.17	7.30±0.11
16.	Touch force (N)	35.78±0.65	59.11±21.39	35.68±0.85	36.50±0.57
17.	Impuls (Ns)	7.16±0.13	7.06±0.20	7.14±0.17	7.30±0.11
18.	Power (Watt)	569.08±20.79	932.29±353.10	565.93±26.99	592.09±18.32
19.	Work (J)	113.82±4.16	110.82±6.37	113.19±5.40	118.42±3.66
20.	Hip angle follow through (rad)	0.37±0.12	0.30±0.22	0.77±0.71	0.41±0.33
21.	Follow through time (s)	0.83±0.06	0.67±0.21	1.00±0.36	0.67±0.21
22.	Follow through angular speed (rad/s)	0.44±0.12	0.42±0.18	0.69±0.39	0.55±0.28
23.	Angular follow through deceleration (rad/s2)	-0.52±0.12	-0.61±0.11	-0.68±0.21	-0.80±0.15

Table 4. Biomechanical Analysis of Football Long Passes for Each Group at the Ball Passage Stage.

No	Biomechanical Variables	Eye-Foot Coordination			
		High		Low	
		Regular Strength	Core Strength	Regular Strength	Core Strength
1	The kinetic energy of a moving ball (J)	56.91±2.08	55.41±3.18	56.59±2.70	59.21±1.83
2	Height of the ball (m)	3.39±0.14	3.49±0.45	3.76±0.87	3.87±0.04
3	Energi potensial bola bergerak (J)	14.95±0.62	15.41±1.99	16.57±3.82	17.07±0.19
4	The mechanical energy of a moving ball (J)	71.86±2.67	70.82±5.17	73.16±4.76	76.28±1.89
5	The ball distance (m)	22.48±1.09	22.30±1.88	23.17±0.96	23.53±0.44

falling to the target, the average football long pass performance of the regular strength training group with high eye-foot coordination at the leg swing stage is carried out with a backswing kick leg knee flexion angle of 89.330, support leg knee extension angle is 144.330, frontswing hip angle is 1.25 rad, frontswing kick leg knee extension angle is 139.670, kicking leg tilt angle at impact is 66.670, support leg tilt angle at impact is 62.670, hip tilt angle at impact is 90, shoulder tilt angle at impact is 50, and the distance between the supporting foot and the ball is 0.27 m, with the contact time of the foot with the ball being

0.20 seconds and the time required for the frontswing of 0.60 seconds. The long pass movement with the angles and distance of the supporting leg as well as the time required to make the long pass, produces a frontswing angular velocity of 2.04 rad/s, a frontswing angular acceleration of 3.42 rad/s2, a ball speed after impact of 15.90 m/s, ball momentum is 7.16 Ns, contact force is 35.78 N, impulse is 7.16 Ns, power is 569.08 watts, work is 113.82 J. To end the long pass movement, it is done with a follow through hip angle of 0.37 rad, follow through time of 0.83 seconds, the follow through angular speed is 0.44 rad/s, and the follow through angular deceleration is -0.52 rad/s2.

To produce the highest accuracy of falling the ball with the highest target, the average long pass football performance of the core strength training group with high eye-foot coordination at the leg swing is carried out with a knee flexion angle of the backswing kick leg of 98.330, support leg knee extension angle of 150.670, frontswing hip angle is 1.25 rad, frontswing kick leg knee extension angle is 158.330, kicking leg tilt angle at impact is 63.330, support leg tilt angle at impact is 57.670, hip tilt angle at impact is 10.670, shoulder tilt angle moment of impact is 8.330, and the distance of supporting foot and the ball is 0.32 m, with the foot contact time with the ball is 0.13 seconds and the time required for the frontswing is 0.73 seconds. The long pass movement with the angles and distance of the supporting leg as well as the time required to make the long pass, produces a frontswing angular velocity of 1.71 rad/s, a frontswing angular acceleration of 2.36 rad/s2, a ball speed after impact of 15.69 m/s, ball momentum is 7.06 Ns, contact force is 59.11 N, impulse is 7.06 Ns, power is 932.29 watts, work is 110.82 J. To end the long pass movement, it is done with a follow through hip angle of 0.30 rad, follow through time of 0.67 seconds, the follow through angular speed is 0.42 rad/s, and the follow through angular deceleration is -0.61 rad/s2.

To produce the highest accuracy of falling the ball to the target, the average football long pass performance of the regular strength training group with low eye-foot coordination at the leg swing stage was carried out with a backswing kick leg knee flexion angle of 102.330, extension angle the knee of the supporting leg is 1600, the frontswing hip angle is 1.23 rad, the knee extension angle of the frontswing kicking leg is 144.670, the tilt angle of the kicking leg at impact is 75.330, the tilt angle of the supporting leg at impact is 70.670, the hip tilt angle at impact is 70, the tilt angle shoulder at impact is 50, and the distance between the supporting foot and the ball is 0.28 m, with the foot contact time with the ball is 0.20 seconds and the time required for the frontswing is 0.77 seconds. The long pass movement with the angles and distance of the supporting leg as well as the time required to make the long pass, produces a frontswing angular velocity of 1.60 rad/s, a frontswing angular acceleration of 2.10 rad/s2, a ball speed after impact of 15.86 m/s, ball momentum is 7.14 Ns, contact force is 35.68 N, impulse is 7.14 Ns, power is 565.93 watts, work is 113.19 J. To end the long pass movement, it is done with a follow through hip angle of 0.77 rad, follow through time is 1 second, the follow through angular speed is 0.69 rad/s, and the follow through angular deceleration is -0.68 rad/s2.

To produce the highest accuracy of falling the ball to the highest target, the average long pass football performance of the core strength training group with low eye-foot coordination at the leg swing stage is carried out with a backswing kick leg knee flexion angle of 91.330, extension angle the knee of the supporting leg is 152.330, the frontswing hip angle is 1.22 rad, the knee extension angle of the frontswing kicking leg is 1550, the tilt angle of the kicking leg at impact is 70.330, the tilt angle of the supporting leg at impact is 62.670, the tilt angle of the hip at impact is 11.330, the shoulder tilt angle at impact is 5.670, and the distance between the supporting foot and the ball is 0.26 m, with the foot contact time with the ball is 0.20 seconds and the time required for the frontswing is 0.77 seconds. The long pass movement with the angles and distance of the supporting leg as well as the time required to make the long pass, produces a frontswing angular velocity of 1.62 rad/s, a frontswing angular acceleration of 2.22 rad/s2, a ball speed after impact of 16.22 m/s, ball momentum is 7.30 Ns, contact force is 36.50 N, impulse is 7.30 Ns, power is 592.09 watts, work is 118.42 J. To end the long pass movement, it is done with a follow through hip angle of 0.41 rad, follow through time of 0.67 seconds, the follow through angular speed is 0.55 rad/s, and the follow through angular deceleration is -0.80 rad/s2.

Biomechanical analysis of football long passes for each group at the ball trajectory stage is presented in table 4. From the movements that occur at the swing stage, the ball trajectory is produced. At the ball trajectory stage, the average football long pass performance of the regular strength training group with high eye-foot coordination resulted in a kinetic energy of the moving ball of 56.91 J, a height of the ball of 3.39 m, a potential energy of the moving ball of 14.95 J, and a mechanical energy of the moving ball of 71.86 J. To reach the target with the energy and height of the ball, the ball travels a distance of 22.48 m.

At the ball trajectory stage, the average footbal long pass performance of the core strength training group with high eye-foot coordination resulted in a kinetic energy of the moving ball of 55.41 J, a ball height of 3.49 m, a potential energy of the moving ball of 15.41 J, and a mechanical energy of the moving ball of 70.82 J. To reach the target with the energy and ball height, the ball travels a distance of 22.30 m.

At the ball trajectory stage, the average football long pass performance of the regular strength training group with low eye-foot coordination produced a kinetic energy of the moving ball of 56.59 J, a height of the ball of 3.76 m, a potential energy of the moving ball of 16.57 J, and a mechanical energy of the moving ball of 73.16 J. To reach the target with the ball's energy and height, the ball travels a distance of 23.17 m.

At the ball trajectory stage, the average soccer long pass performance of the core strength training group with low eye-foot coordination resulted in a kinetic energy of the moving ball of 59.21 J, a height of the ball of 3.87 m, a potential energy of the moving ball of 17.07 J, and a mechanical energy of the moving ball of 76.28 J. To reach the target with the ball's energy and height, the ball travels a distance of 23.53 m.

Foot ball Long Pass Movement Analysis

In football long passes, the accuracy of the long pass is influenced by the backswing and frontswing movements. Backswing is when preparing to kick the ball, if the right foot that will kick is in the preparation stage the right foot must be far back while frontswing is a forward swing movement. The large flexion angle of the kicking leg during the backswing will have a large enough effect on the foot's impact on the ball so that the ball will go far forward at the maximum possible speed and approach the target or away from the target.

Below is an analysis of football long pass movements in football players in the form of images that have been analyzed using kinovea software. The pictures below explain the long pass movement starting from the leg swing stage with 6 figures, namely: (a) knee flexion angle of the backswing kick leg; (b) knee extension angle of the support leg; (c) frontswing hip angle; (d) extension angle of frontswing kick leg knee; (e) frontswing time; (f) follow through hip angle. Then, in the foot impact stage with the ball, there are 9 figures, namely: Kemudian tahap impact kaki dengan bola terdapat 9 gambar yaitu: (a) kick elevation angle; (b) time of foot contact with the ball; (c) the distance of the supporting foot to the ball; (d) tilt angle of support leg; (e) tilt angle of kicking leg; (f) hip tilt angle; (g) shoulder tilt angle; (h) height of the ball; (i) distance traveled by the ball.

In the long pass movement, performing a backswing movement with a backswing kick leg knee flexion angle of 830 for player 1, 820 for player 2, 940 for player 3, 910 for player 4, 1040 for player 5, 1100 for player 6, 960 for player 7, 940 for player 8, 910 for player 9, 1010 for player 10, 1020 for player 11, 960 for player 12; a support leg knee extension angle of 1590 for player 1, 1580 for player 2, 1400 for player 3, 1370 for player 4, 1690 for player 5, 1530 for player 6, 1540 for player 7, 1620 for player 8, 1340 for player 9, 1520 for player 10, 1590 for player 11, 1450 for player 12; performing a frontswing movement with a frontswing hip angle of 48 rad for player 1, 61 rad for player 2, 90 rad for player 3, 82 rad for player 4, 47 rad for player 5, 71 rad for player 6, 83 rad for player 7, 62 rad for player 8, 76 rad for player 9, 90 rad for player 10, 75 rad for player 11, 66 rad for player 12; a frontswing kick leg knee extension angle of 1330 for player 1, 1640 for player 2, 1580 for player 3, 1620 for player 4, 1440 for player 5, 1580 for player 6, 1430 for player 7, 1550 for player 8, 1280 for player 9, 1390 for player 10, 1510 for player 11, 1580 for player 12; a frontswing time of 0.5 s for player 1, 0.8 s for player 2, 0.7 s for player 3, 0.7 s for player 4, 0.7 s for player 5, 0.8 s for player 6, 0.9 s for player 7, 0.7 s for player 8, 0.6 s for player 9, 0.9 s for player 10, 0.7 s for player 11, 0.6 s for player 12; and follow through movement with a follow through hip angle of 28 rad for player 1, 10 rad for player 2, 21 rad for player 3, 31 rad for player 4, 22 rad for player 5, 7 rad for player 6, 45 rad for player 7, 14 rad for player 8, 14 rad for player 9, 91 rad for player 10, 20 rad for player 11, 15 rad for player 12 (figure 1; 3; 5; 7; 9; 11; 13; 15; 17; 19; 21; 23).

b. Player 2

1) Leg Swing Phase

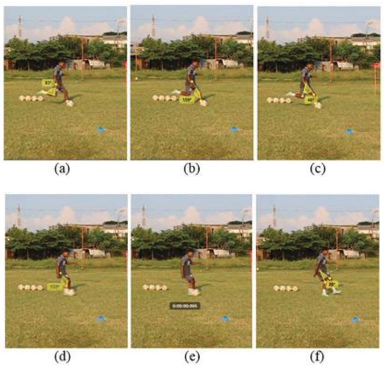


Figure 1. Leg Swing Movement of Player 1.

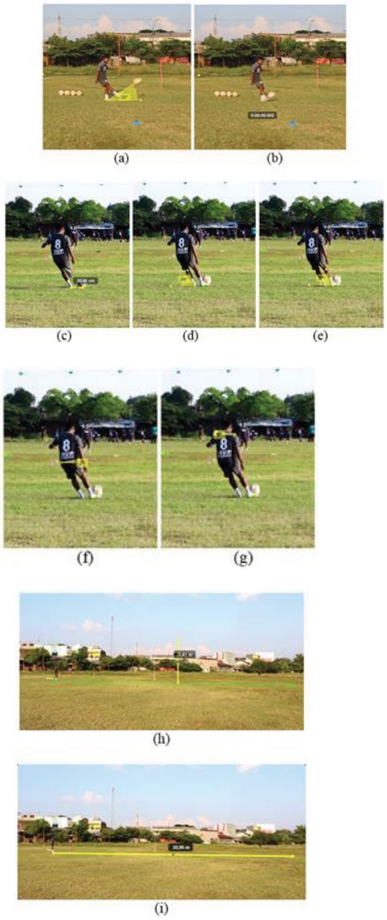
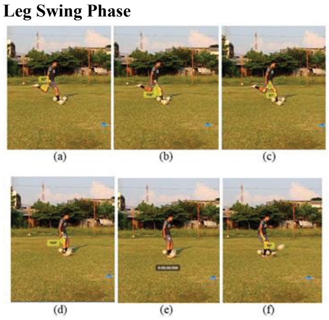


Figure 2. Movement of Foot Impact with Ball of Player 1.

b. Player 2

1) Leg Swing Phase



a. Player 2

1) Leg Swing Phase

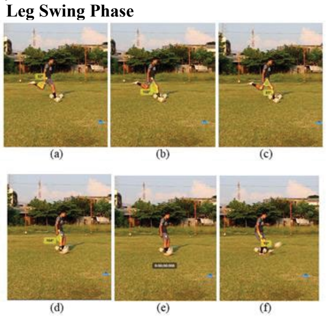


Figure 3. Leg swing movement of Player 2.

When the ball impacts, a long pass movement with a kick elevation angle of 320 for player 1, 320 for player 2, 290 for player 3, 320 for player 4, 340 for player 5, 290 for player 6, 310 for player 7, 330 for player 8, 300 for player 9, 310 for player 10, 320 for player 11, 290 for player 12; contact time of the foot with the ball 0.2 s for player 1, 0.2 s for player 2, 0.2 s for player 3, 0.1 s for player 4, 0.2 s for player 5, 0.2 s for player 6, 0.2 s for player 7, 0.1 s for player 8, 0.2 s for player 9, 0.2 s for player 10, 0.2 s for player 11, 0.2 s for player 12; distance of the supporting foot to the ball 26.41 cm (0.26 m) for player 1, 25.22 cm (0.25 m) for player 2, 24.62 cm (0.25 m) for player 3, 28.10 cm (0.28 m) for player 4, 24.63 cm (0.25 m) for player 5, 37.77 cm (0.38 m) for player 6, 25.20 cm (0.25 m) for player 7, 28.99 cm (0.29 m) for player 8, 30.15 cm (0.30 m) for player 9, 31.76 cm (0.32 m) for player 10, 28.99 cm (0.29 m) for player 11, 26.90 cm (0.27 m) for player 12; tilt angle of the supporting foot 650 for player 1, 740 for player 2, 570 for player 3, 540 for player 4, 740 for player 5, 590 for player 6, 610 for player 7, 600 for player 8, 660 for player 9, 680 for player 10, 700 for player 11, 530 for player 12; the tilt angle of the kicking leg 670 for player 1, 750 for player 2, 610 for player 3, 550 for player 4, 790 for player 5, 670 for player 6, 710 for player 7, 680 for player 8, 720 for player 9, 660 for player 10, 810 for player 11, 650 for player 12; a hip tilt angle of 70 for player 1, 90 for player 2, 130 for player 3, 110 for player 4, 80 for player 5, 150 for player 6, 90 for player 7, 60 for player 8, 70 for player 9, 60 for player 10, 70 for player 11, 160 for player 12; and shoulder tilt angle of 80 for player 1, 50 for player 2, 30 for player 3, 100 for player 4, 60 for player 5, 100 for player 6, 40 for player 7, 50 for player 8, 40 for player 9, 50 for player 10, 40 for player 11, 80 for player 12; resulting in a ball flight movement with a ball height of 3.41 m for player 1, 3.85 m for player 2, 3.24 m for player 3, 3.99 m for player 4, 4.74 m for player 5, 3.11 m for player 6, 3.92 m for player 7, 3.38 m for player 8, 3.52 m for player 9, 3.42 m for player 10, 3.11 m for player 11, 3.84 m for player 12; and a ball travel distance of 22.95 m for player 1, 23.28 m for player 2, 21.23 m for player 3, 24.03 m for player 4, 23.61 m for player 5, 20.30 m for player 6, 24.03 m for player 7, 22.58 m for player 8, 23.26 m for player 9, 23.82 m for player 10, 22.07 m for player 11, 23.27 m for player 12 (Figure 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24).

2) Impact Phase of Foot with Ball and Ball Trajectory

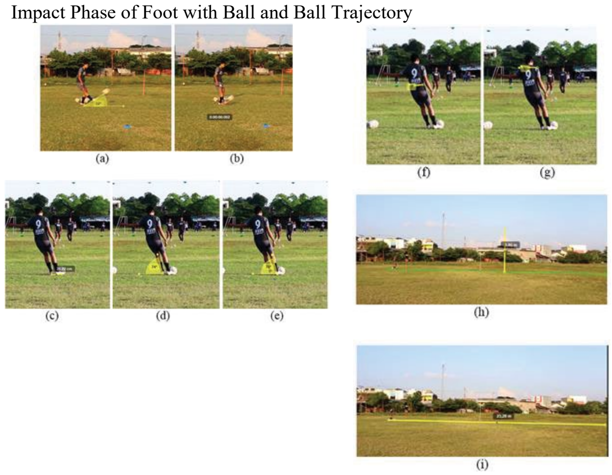


Figure 4. Movement of Foot Impact with Ball of Player 2.

b. Player 3

1) Leg Swing Phase

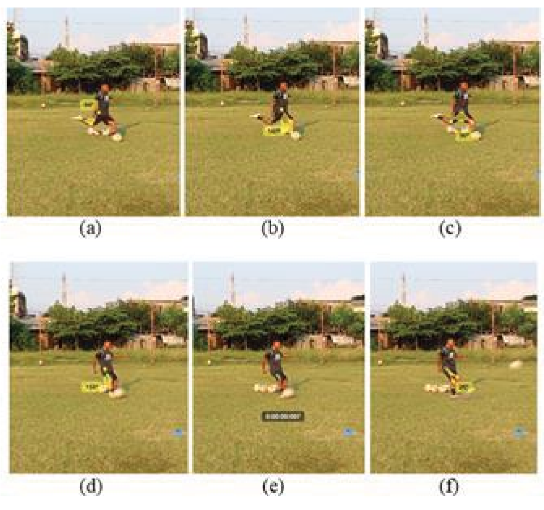


Figure 5. Leg swing movement of Player 3.

2) Impact Phase of Foot with Ball and Ball Trajectory

Figure 6. Movement of Foot Impact with Ball of Player 3.

c. Player 4

1) Leg Swing Phase

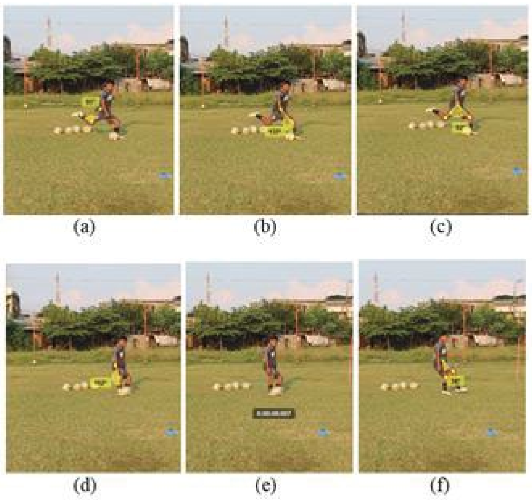


Figure 7. Leg swing movement of Player 4.

2) Impact Phase of Foot with Ball and Ball Trajectory

Figure 8. Movement of Foot Impact with Ball of Player 4.

d Player 5

1) Leg Swing Phase

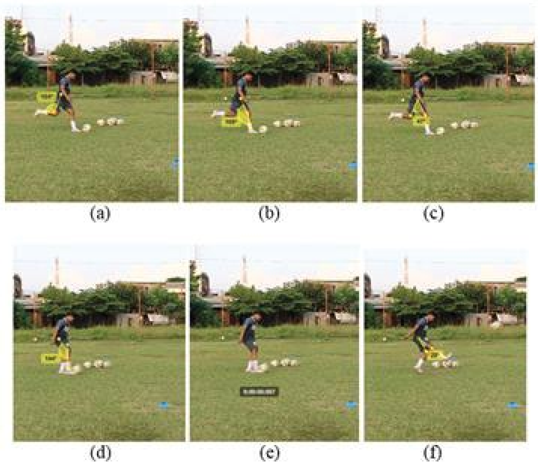


Figure 9. Leg swing movement of Player 5.

2) Impact Phase of Foot with Ball and Ball Trajectory

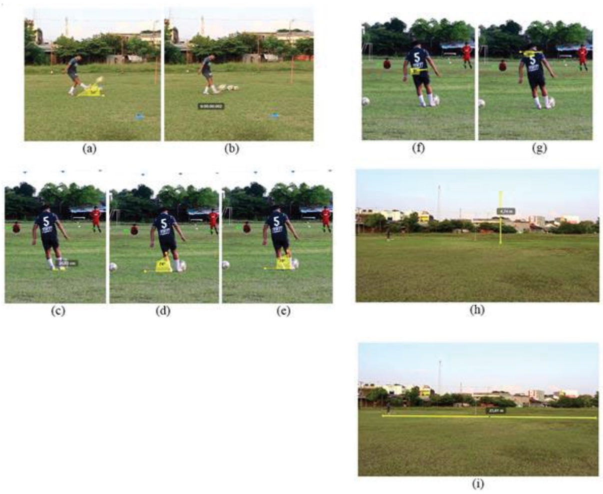


Figure 10. Movement of Foot Impact with Ball of Player 5.

e. Player 6

1) Leg Swing Phase

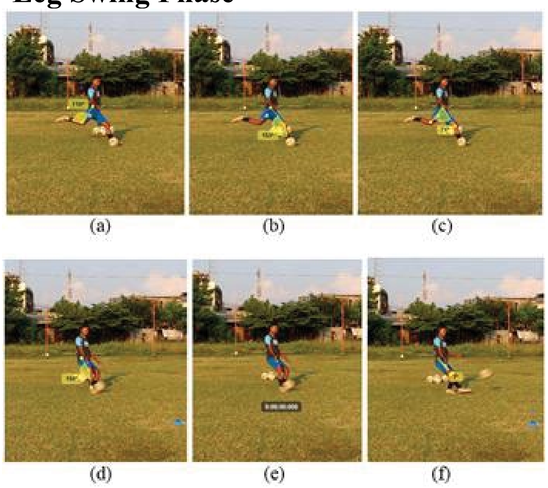


Figure 11. Leg swing movement of Player 6.

2) Impact Phase of Foot with Ball and Ball Trajectory

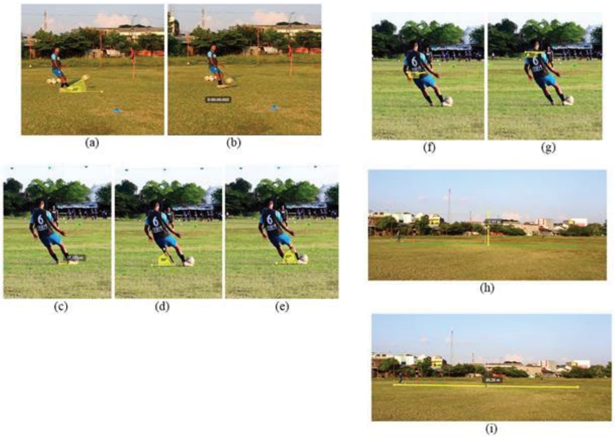


Figure 12. Movement of Foot Impact with Ball of Player 6.

f. Player 7

1) Leg Swing Phase

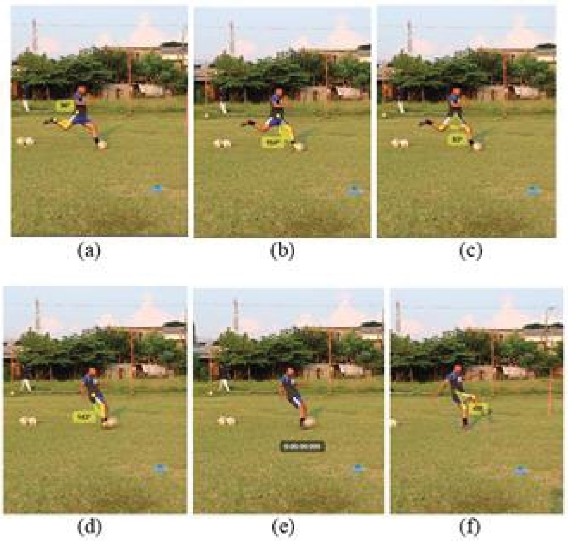


Figure 13. Leg swing movement of Player 7.

2) Impact Phase of Foot with Ball and Ball Trajectory

Figure 14. Movement of Foot Impact with Ball of Player 7.

g. Player 8

1) Leg Swing Phase

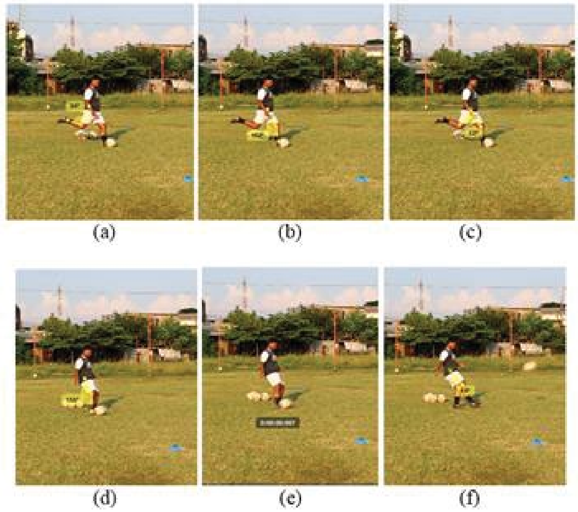


Figure 15. Leg swing movement of Player 8.

2) Impact Phase of Foot with Ball and Ball Trajectory

Figure 16. Movement of Foot Impact with Ball of Player 8.

h. Player 9

1) Leg Swing Phase

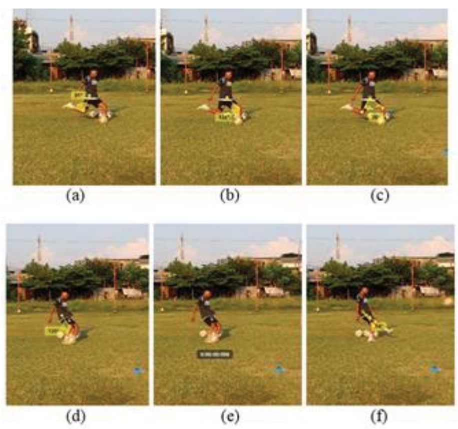


Figure 17. Leg swing movement of Player 9.

2) Impact Phase of Foot with Ball and Ball Trajectory

Figure 18. Movement of Foot Impact with Ball of Player 9.

i. Player 10

1) Leg Swing Phase

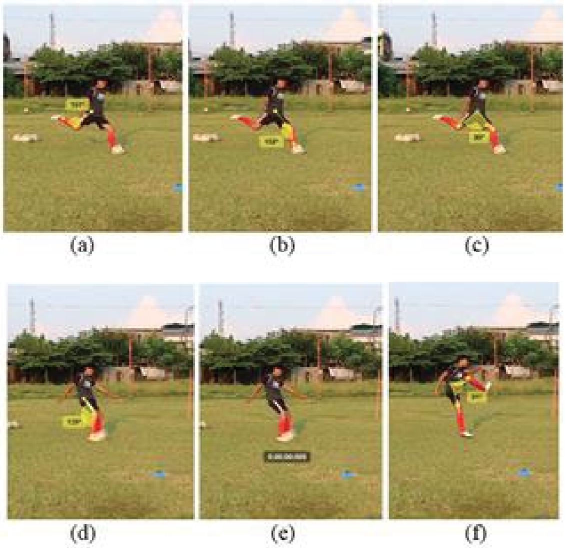


Figure 19. Leg swing movement of Player 10.

2) Impact Phase of Foot with Ball and Ball Trajectory

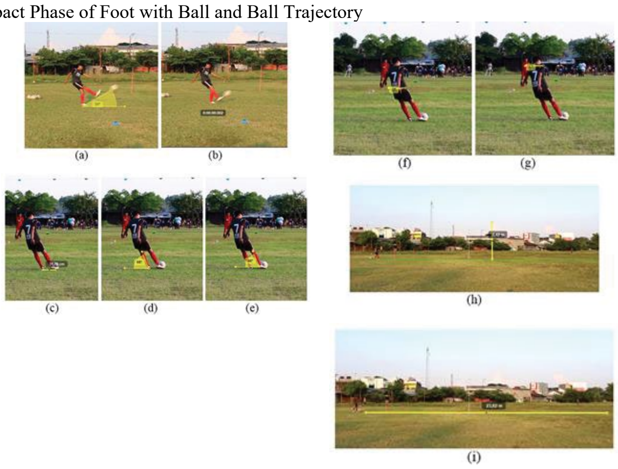


Figure 20. Movement of Foot Impact with Ball of Player 10.

j. Player 11

1) Leg Swing Phase

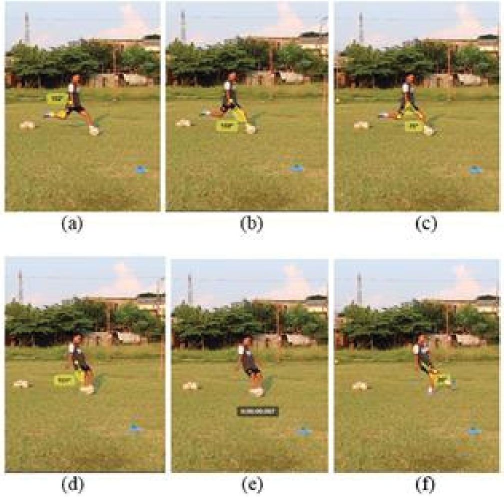


Figure 21. Leg swing movement of Player 11.

2) Impact Phase of Foot with Ball and Ball Trajectory .

Figure 22. Movement of Foot Impact with Ball of Player 11.

k. Player 12

1) Leg Swing Phase

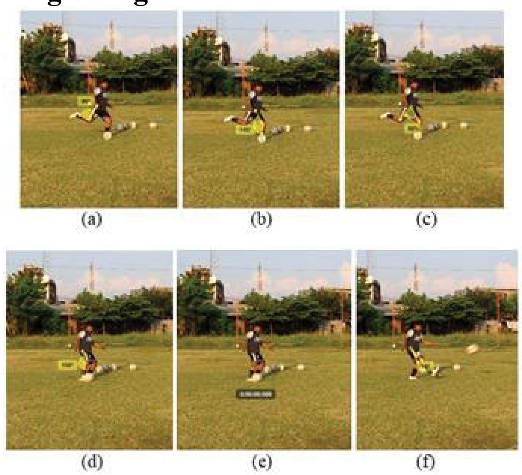


Figure 23. Leg swing movement of Player 12.

2) Impact Phase of Foot with Ball and Ball Trajectory.

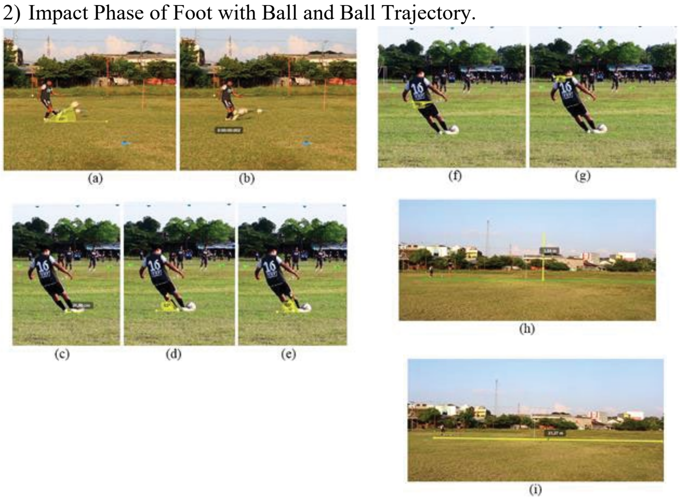


Figure 24. Movement of Foot Impact with Ball of Player 12.

Discussion

Based on the first hypothesis testing, there is a real difference in effect between the group of players who received the regular strength training program and the group of players who received the core strength training program on improving football long pass results. The group of players who received the core strength training program had a better improvement in football long pass results compared to the group of players who received the regular strength training program. This is because core strength has a significant effect on an athlete's ability to create and transfer forces to the extremities (Shinkle et al., 2012). During core exercise, significant increases were found in knee extensors peak torque, knee flexors peak torque and flexors/extensors peak torque ratio reported by Iacono, Padulo, & Ayalon (2015) as well as an increase in mean muscle activation for dominant muscles (57.8% maximum voluntary isometric contraction [MVIC]) and nondominant multifidus (56.4% MVIC) and dominant gluteus maximus (48.3% MVIC) and medius (65.3% MVIC) reported by Oliver et al (2010).

The figures produced in the data analysis show that the average percentage increase in football long pass results produced by the core strength training program is 23,333 higher than the regular strength training program. If compare the biomechanics, to produce the highest accuracy of the ball falling to the target, the average football long pass performance in the core strength training group was carried out with the backswing kick leg knee flexion angle 10 smaller, extension angle of the support leg knee was 0.67 smaller, and a frontswing hip angle that was the same, the extension angle of frontswing kick leg knee is greater at 14,50°, the tilt angle of kicking leg at impact is lower of 4,17, the tilt of the support leg at impact is at a lower angle of 6,50°, the tilt of the hip at impact is at a higher angle of 3°, the tilt of the shoulder at impact with a higher angle of 2, and the distance between the supporting foot and the ball is 0.01 m further, with the foot contact time with the ball being 0.03 seconds faster while the time required for the frontswing is 0.07 seconds longer.

The long pass movement with the angles and distance of the supporting leg as well as the time required to make the long pass, results in a longer frontswing angular speed of 0.15 rad/s and a longer frontswing angular acceleration of 0.47 rad/s2. Even so, the momentum of the ball produced is 0.03 Ns greater, the ball speed after impact is 0.08 m/s faster, the contact force is 12.08 N greater, the impulse is 0.03 Ns greater, the power is 194.69 watts greater, and the work is 1.12 J greater. From the movements carried out in the swing stage, the core strength training group produced kinetic energy of the moving ball that was 0.56 J greater, the height of the ball was 0.11 m higher, the potential energy of the moving ball was 0.48 J greater, and the mechanical energy of the moving ball was 1.04 J greater. To reach the target with the energy and height of the ball, the ball covers a distance with a closer accuracy of 0.09 m. To end the long pass movement, it is performed with a smaller follow through hip angle of 0.22 rad and a faster follow through time of 0.25 seconds, resulting in a faster follow through movement with a faster follow through angular speed of 0.08 rad/s and a follow through angular deceleration of 0.11 rad/s2 faster.

Based on testing the second hypothesis, it turns out that there is a real difference in influence between groups of players with high eye-foot coordination and low eye-foot coordination on football long passes. The group of players with high eye-foot coordination had a higher increase in football long pass results than the group of players with low eye-foot coordination. In the group of players with high eye-foot coordination, they have higher potential than players who have low eye-foot coordination. This is because high eye-foot coordination provides evidence that the output of the motor system responsible for moving the feet is strongly influenced by the motor system responsible for generating and coordinating eye and head movements to peripheral targets. In addition, it has been proven that there is a correlation between eye and foot movements, which supports that the eye and limb motor systems work in a coordinated manner to produce patterned eye and limb movements (Hollands et al., 2004).

From the figures produced in the data analysis, it shows that the average ratio of increases in football long pass results for players who have high eye-foot coordination is 30,000 which is higher than the group of players who have low eye-foot coordination. If we compare the biomechanics, to produce the highest accuracy of the ball falling to the target, the average football long pass performance for players who have high eye-foot coordination is done with a smaller backswing kick leg knee flexion angle of 30, support leg knee extension angle smaller 8.670, frontswing hip angle greater 0.02 rad, knee extension angle of frontswing kick leg smaller 0.830, tilt of kick leg at impact at lower angle 7.830, tilt of support leg at impact at lower angle 6.500, hip tilt at impact with a higher angle of 0.670, shoulder tilt angle at impact is 1.330 higher, and the distance between the supporting foot and the ball is 0.02 m further, with the foot contact time with the ball being 0.03 seconds faster and the time required for the frontswing being 0.10 seconds faster.

The long pass movement with the angles and distance of the supporting leg as well as the time required to make the long pass, produces a frontswing angular speed is 0.27 rad/s faster and frontswing angular acceleration is 0.73 rad/s2 faster. However, the ball momentum and the resulting impulse are 0.11 Ns smaller and the ball speed after impact is also 0.24 m/s longer, even though the contact force is 11.36 N and the power is 171.68 watts, this is because it is done with a lower work of 3.48 J. From the movements carried out at the swing stage, players who have high eye-foot coordination produce kinetic energy of the moving ball is 1.74 J lower, ball height is 0.37 m lower, potential energy of the moving ball is 1.64 J lower, and mechanical energy of the moving ball is 3.38 J lower. To reach the target with the energy and height of the ball, the ball travels a distance with a closer accuracy of 0.96 m. To end the long pass movement, it is performed with a smaller follow through hip angle of 0.26 rad and a faster follow through time of 0.08 seconds, resulting in a faster follow through movement with a faster follow through angular speed of 0.20 rad/s and a greater follow through angular deceleration of 0.17 rad/s2.

Based on the third hypothesis, it shows that there is an interaction between training methods and the level of eye-foot coordination. The shape of the line changing the value of a football long pass is not parallel or crossed. However, this line has a meeting point between the use of training programs and eye-foot coordination. This means that there is a significant interaction between training programs and eye-foot coordination and also shows that eye-foot coordination has an effect on football long passes (Figure 25). The effectiveness of method in football long pass training is affected by the high and low eye-foot coordination. From this interaction it is clear that players who have high eye-foot coordination with a core strength training program have better football long pass results compared to players with high eye-foot coordination and receive regular strength training program treatment. Meanwhile, players who have low eye-foot coordination with a regular strength training program have better football long pass results than players with low eye-foot coordination who receive core strength training program.

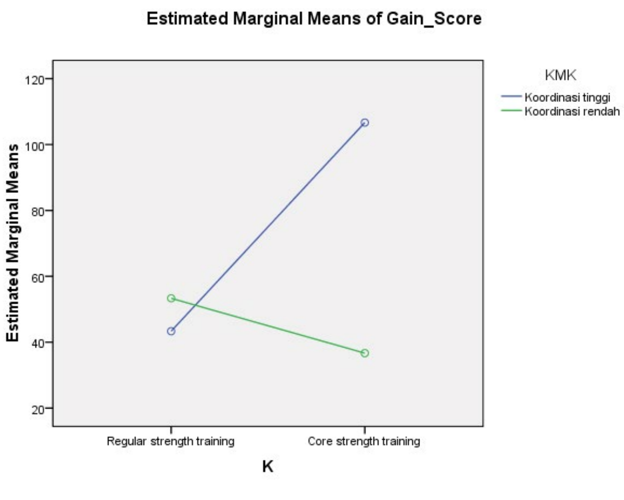


Figure 25. Interaction of training methods and eye-foot coordination.

Conclusion

Based on the data analysis that has been carried out, it can be concluded that the core strength training program is better than the regular strength training program in improving football long pass results. Judging from the biomechanics, the increase in football long pass results is supported by a lower flexion angle of the backswing kick leg knee and a greater extension angle of frontswing kick leg knee, a lower tilt angle on the kicking leg and the supporting leg at impact, a higher tilt angle on the hip. and shoulder at impact. This movement then produces frontswing angular speed and acceleration, although the result is longer in the frontswing movement, it is carried out with greater force, work and power, this produces greater momentum and impulse and the ball is also faster. With this support, the core strength training group of this program produces higher energy and ball height and the ball is closer to the best target with an accuracy closer to 0.09 m. This movement, ends with a smaller follow through hip angle, faster follow through angular speed and deceleration.

The increase in football long pass results in players who have high eye-foot coordination is better than those who have low eye-foot coordination. Judging from biomechanics, the increase in football long pass results is supported by lower knee flexion angles of the backswing kicking leg and knee extension angles of the frontswing kicking leg, lower tilt angles on the kicking leg and supporting leg at impact, higher tilt angles on the hips and shoulders at impact. This movement then produces faster angular speed and acceleration in the frontswing movement, as well as greater force and power. However, the work done is not large so the momentum and impulse generated are smaller and the ball also lasts longer. With this support, players who have high eye-foot coordination produce lower ball energy and height, aiming to better control the fall of the ball, so that the ball falls closer to the best target with a closer accuracy of 0.96 m. This movement, also ends with a smaller follow through hip angle, as well as a faster follow through angular speed and deceleration.

If the training method is related to the level of eye-foot coordination, players who have high eye-foot coordination are more suited to being given a core strength training program. Players who have low eye-foot coordination are more suited to being given a regular strength training program.

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