Correlation Between Quadriceps and Hamstring Isokinetic Strength To Ball Velocity During A Soccer Kick

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ABSTRACT

When kicking a soccer ball, large forces are generated by the quadriceps and hamstring muscles that extend and flex the knee. The angular acceleration at this joint and the torques produced are related. **PURPOSE:** The goal of this pilot study was to explore the relationship between isokinetic strength of the quadriceps and hamstring muscles to velocity of a kicked soccer ball and determine if isokinetic testing of quadriceps and hamstring strength can predict soccer ball velocity during a kick. **METHODS**: Four female NCAA Division II soccer athletes completed maximal effort knee flexion and extension at three isokinetic speeds, 60°/second, 180°/second, and 300°/second using the Biodex 3 Isokinetic Dynamometer. Cortex 8.1 Motion Analysis Software was used to record three maximal kicks with the dominant leg. Bivariate Pearson correlation coefficients were calculated between both data sets using SPSS version 28. **RESULTS:** Ball velocity was significantly and positively correlated with Right Leg Flexion Acceleration time at 60°/second (r= 0.860), Left Leg Extension Acceleration at 180°/second (r= 0.950), and Left Leg Extension Acceleration at 300°/second (r= 0.915). Two significant negative relationships were discovered between ball velocity and left leg extension acceleration at 300°/second (r= -0.950), and left angle of peak extension torque at 300°/second (r= - 0.915). **CONCLUSION:** The ability to quickly accelerate the non-kicking leg to extension combined with the ability to reach angle of peak extension torque is associated with the ability to quickly stabilize the plant leg. Flexion of the kicking leg at a lower angular velocity corresponds with a higher force production and when combined with a positive correlation to ball velocity, suggests increased loading of the kicking leg prior to ball contact. Lastly, the negative correlation between ball velocity and kicking-leg extension acceleration would suggest that faster acceleration leads to increased ball velocity. Because of this, isokinetic testing of the quadricep and hamstring strength is likely a good predictor of kicking velocity. Further testing is required to determine if present correlations are applicable to other populations of soccer athletes, which can affect training and return-to-play practices.

INTRODUCTION

Kicking is the most common way to move a ball in the game of soccer, however there are many different types of kicks and an even greater number of variables that can impact how each is performed. For simplicity and consistency, this study only analyzed the instep kick, which is when the inner foot and arch area contact the ball, and how it is impacted by quadricep and hamstring isokinetic strength, which is the amount measured when the knee flexes or extends at a single speed throughout the entire range of motion. This kick specifically produces both high ball velocity and increased kicking accuracy. Little research has examined the relationship between biomechanical variables of a soccer kick and ball velocity. The goal of this pilot study was to explore the relationship between isokinetic strength of the quadriceps and hamstring muscles to velocity of a kicked soccer ball and determine if isokinetic testing of quadriceps and hamstring strength can predict soccer ball velocity during a kick.

References

Accuracy measurement of different marker based motion analysis systems for biomechanical applications: A round robin study. (2022). PloS One, 17(7), e0271349– .https://doi.org/10.1371/journal.pone.0271349
Ball, K. (2012, December 11). *Loading and performance of the support leg in kicking*. Journal of Science and Medicine in Sport. Retrieved November 1, 2022, from https://www.sciencedirect.com/science/article/pii/S1440244012002101?ref=pdf_download&fr=RR-2&rr=75c351e1987e876c
Cochrane, J. L., Hart, N. H., Nimphius, S., Spiteri, T., & Newton, R. U. (2016, May 23). Relationship between leg mass, leg composition and foot velocity on kicking accuracy in Australian football. Journal of Sports Science and Medicine. Retrieved November 9, 2022, from https://www.jssm.org/jssm-15-344.xml>Fulltext#
Cook, G., & Plisky, P. (2015). Y Balance Test. Functional Movement Systems, 3–16. https://doi.org/https://www.functionalmovement.com/files/Articles/660a_YBT%20Online%20Manual%20v1.pdf
Jones, P. A., Herrington, L., & Graham-Smith, P. (2016, May 24). *Braking characteristics during cutting and pivoting in female soccer players*. Journal of Electromyography and Kinesiology. Retrieved November 1, 2022, from https://www.sciencedirect.com/science/article/pii/S1050641116300463?ref=pdf_download&fr=RR2&rr=7636b105bc07e14b
Kellis, & Katis, A. (2007). Biomechanical characteristics and determinants of instep soccer kick. Journal of Sports Science & Medicine, 6(2), 154–165. Retrieved November 8th, 2022.
Manolopoulos, E. , Katis, A. , Manolopoulos, K. , Kalapotharakos, V. & Kellis, E. (2013). Effects of a 10-Week Resistance Exercise Program on Soccer Kick Biomechanics and Muscle Strength. *Journal of Strength and Conditioning Research, 27* (12), 3391-3401. doi: 10.1519/JSC.0b013e3182915f21.
Moreira, P. V. S., Falco, C., Menegaldo, L. L., Goethel, M. F., Paula, L. V. de, & Gonçalves, M. (2021, June 9). Are isokinetic leg torques and kick velocity reliable predictors of competitive level in taekwondo athletes? PLOS ONE. Retrieved November 9, 2022, from https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0235582
Noguchi, T., Demura, S., & Nagasawa, Y. (2012, August). Relationship between Ball Kick Velocity and Leg Strength: A Comparison between Soccer Players and Other Athletes . Scientific Research. Retrieved November 9, 2022, from https://www.scirp.org/journal/paperinformation.aspx?paperid=21919
Orloff, H., Sumida, B., Chow, J., Habibi, L., Fujino, A., & Kramer, B. (2008). Ground reaction forces and kinematics of plant leg position during instep kicking in male and female collegiate soccer players. *Sports Biomechanics*, *7*(2), 238–247. https://doi.org/10.1080/14763140701841704
POMATAHU, A. I. S. A. H. R. (2018, May 21). The relationship between leg length and crescent kick speed in Pencak Silat sport. TSS Home. Retrieved November 9, 2022, from http://tss.awf.poznan.pl/
Three-dimensional kinematics and ground reaction forces during the instep and outstep soccer kicks in pubertal players. Taylor & Francis. (2010, September 14). Retrieved November 1, 2022, f
rom https://www.tandfonline.com/doi/full/10.1080/02640414.2010.504781

METHODS

The subjects were seated in the optimal position (75–85-degree seat angle) to get reliable results. Straps were secured over the shoulder, chest, and hip to limit the participant. The Biodex 3 Isokinetic Dynamometer was used to measure the isokinetic strength of the hamstring and quadriceps muscle groups in the participants. Participants began with a general cardiovascular warm up for at least five minutes on a cycle ergometer at a moderate pace and load (50-100 W). This was then followed up by a 10-minute session of dynamic stretching of the lower limbs. The subjects were seated in the optimal position (75–85-degree seat angle) to get reliable results. Straps were secured over the shoulder, chest, and hip to limit the participants' movement during testing, and the cuff of the lever arm was attached to the distal shank, just superior to the ankle. All seat positions were recorded and repeated. To be familiarized with the test, participants completed a submaximal trial before each angular velocity. After familiarization, five maximal effort repetitions of flexion/extension were performed at each angular velocity (60 deg/sec, 180 deg/sec, and 300 deg/sec) through a 0–90-degree ROM on both legs. There was a five-second rest between submaximal and maximal sets, a one-minute rest between angular velocities, and a three-minute rest between legs. Testing order was randomized between the dominant and non-dominant leg.

RESULTS

Isokinetic variables were measured on both legs but were only compared to ball velocity when kicked with the dominant (right) foot. Bivariate correlations between ball velocity and knee extension isokinetic variables are presented in Table 1. Correlation results relating ball velocity to flexion isokinetic variables are presented in Table 2.Three significant positive relationships were discovered between ball velocity and Right Leg Flexion Acceleration time at 60°/second ($r= 0.860$, $p < 0.05$), Left Leg Extension Acceleration at 180°/second ($r= 0.950$, $p < 0.05$), and Left Leg Extension Acceleration at 300°/second ($r= 0.915$, $p < 0.05$). Two significant negative relationships were discovered between ball velocity and left leg extension acceleration at 300°/second ($r= -0.950$, $p < 0.05$), and left angle of peak extension torque at 300°/second ($r= - 0.915$, $p < 0.05$).

Table 1. Correlational Value of Isokinetic Extension Variables and Ball Velocity

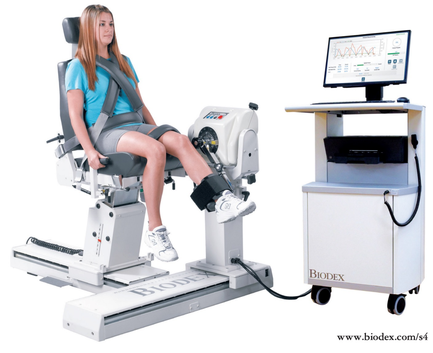
Extension		Speed		
		60°/S	180°/S	300°/S
Right Leg	Peak Torque	-0.233	-0.169	0.193
	Peak Torque/BW	-0.649	-0.517	-0.150
	Time to Peak Torque	0.476	-0.083	-0.646
	Angle of Peak Torque	-0.233	0.362	0.645
	Average Power	-0.764	-0.060	0.571
	Acceleration Time	0.026	0.351	-0.950
	Deceleration Time	-0.308	0.083	0.088
Left Leg	Peak Torque	-0.484	-0.092	0.003
	Peak Torque/BW	-0.573	-0.447	-0.175
	Time to Peak Torque	0.185	0.087	0.767
	Angle of Peak Torque	-0.492	-0.339	-0.933
	Average Power	-0.221	0.026	0.170
	Acceleration Time	-0.205	0.950	0.915
	Deceleration Time	-0.239	-0.296	0.115

Table 2. Correlational Value of Isokinetic Flexion Variables and Ball Velocity

Flexion		Speed		
		60°/S	180°/S	300°/S
Right Leg	Peak Torque	0.311	0.586	0.340
	Peak Torque/BW	-0.085	0.146	0.141
	Time to Peak Torque	0.394	0.730	-0.759
	Angle of Peak Torque	-0.346	0.122	-0.583
	Average Power	0.234	0.680	0.644
	Acceleration Time	0.860	-0.544	-0.708
	Deceleration Time	-0.409	0.012	-0.454
Left Leg	Peak Torque	-0.055	0.538	0.100
	Peak Torque/BW	-0.757	-0.563	-0.182
	Time to Peak Torque	-0.138	0.132	0.410
	Angle of Peak Torque	-0.632	-0.342	-0.450
	Average Power	0.129	0.312	0.403
	Acceleration Time	-0.072	-0.544	---
	Deceleration Time	-0.396	-0.678	-0.072

CONCLUSION

The correlational relationships seen are inline with the movements occurring during an instep soccer kick. The ability to quickly accelerate the non-kicking leg to extension combined with the ability to reach angle of peak extension torque is associated with the ability to quickly stabilize the plant leg. Flexion of the kicking leg at a lower angular velocity corresponds with a higher force production and when combined with a positive correlation to ball velocity, suggests increased loading of the kicking leg prior to ball contact. Lastly, the negative correlation between ball velocity and kicking-leg extension acceleration would suggest that faster acceleration leads to increased ball velocity. In the context of a soccer kick, faster acceleration of kicking leg extension in turn accelerates the foot, which is the contact point with the ball. The results isokinetic testing of the quadricep and hamstring strength is likely a good predictor of kicking velocity because the movements of this test are also seen in a soccer kick. Further implications can affect training and return-to-play practices as well. Given the small sample size and inclusion of right leg dominant kickers only, further testing is required to determine if present correlations are applicable to other populations of soccer athletes.



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