POSITIVE RELATIONSHIP OF TRUNK MOVEMENTS AND ACCELERATION DURING 20M SPRINT TEST IN ELITE MALE FOOTBALL PLAYERS

Krešimir Šoš[1] and Pavle Mikulić[2]
Football Club Dinamo, Zagreb, Croatia[1]
Faculty of Kinesiology, University of Zagreb, Zagreb, Croatia[2]

The purpose of this study was to investigate the association between trunk movements and whole-body acceleration, velocity and performance time during an all-out 20 m sprint test. This study encompassed 21 male top level football players. The participants were equipped with a Catapult OptimEyeX4 device that included a GPS sensor, an accelerometer and a gyroscope. The results indicated that average angular velocity about the vertical axis correlated with maximal whole-body acceleration. Furthermore, the sum of angular velocities about all three axes correlated with maximal acceleration. However, maximal acceleration did not correlate with maximal velocity and sprint performance time, while average acceleration did. The findings point to the importance of trunk movements, especially rotation about the vertical axis, for developing a player's maximal acceleration.

KEYWORDS: thoracic spine, movement pattern, maximal acceleration, velocity, GPS

INTRODUCTION: Football at the elite level consists of different activities. Many of these activities pertain to sprinting accelerations and decelerations, which play an important role in performance (Andrzejewski et al., 2013). Phase of acceleration is influenced by many motor abilities, where coordination and movement quality are often researched (Aminian et al., 2004). Practical experience shows us a connection between trunk movement, external hip rotation and acceleration of body in space.

The main purpose of this study is to investigate the association between trunk movements (linear accelerations in three plains and angular velocities about three axes) and maximal and average acceleration of the body during a 20 m sprint test. We hypothesized that trunk movements, especially rotations about the vertical axis, correlate with maximal acceleration. Also, we assumed that maximal and average accelerations of the body would correlate with 20 m test performance time. The rationale for our hypotheses is grounded in the biomechanical ways of generating force for running activity (Buchheit et al., 2014).

METHODS: This study encompassed 21 male elite football players (age: 22.8±4.2 yrs, height: 181.5±5.5 cm, weight: 76.3±6.4 kg). The players performed a 20 m sprint test during which performance time (t) was recorded. Two pairs of MicroGate's Witty photocells were used for this purpose. The first photocell was positioned at the start line, 10 cm above the ground level, and a second photocell was positioned at the finish line, 90 cm above the ground level. The participants were instructed to cover the test distance as fast as they could. At the start line they assumed a stationary two-point athletic stance and performed a self-paced start. The test was repeated twice and faster performance time for each participant was selected for further analysis. The participants were wearing an OptimEyeX4 GPS device (produced by Catapult Sports, Australia). The devices were placed in original vests, between first and fifth thoracic vertebrae.

Testing was performed on artificial grass, at the beginning of a preparatory phase (January, 2015) for the spring half-season. OptimEyeX4's sensor collected two groups of data. One was based on recording the position in time via a GPS signal collected at 10 Hz frequency with good precision (HDOP 0.8±0.04, VDOP 1.2±0.3). The second group of data were integrated accelerometer and gyroscope data, collected at 100 Hz, in three plains and about three axes. GPS devices were calibrated according to manufacturer's recommendation.

The first group of variables consists of time-related variables as measured by photocells (t) and GPS-based data: average smoothed velocity (Vx), maximal smoothed velocity (Vmax), average acceleration (ACCx) and maximal acceleration (ACCmax) where t is expressed in seconds (s). Smoothed velocities calculated from raw data are expressed in meters per second (m/s) and accelerations are expressed in meters per second squared (m/s^2). The

second group of variables, which are based on integrated accelerometer and gyroscope data, are presented as means (x), standard deviations (sd), and ranges (ran). Variables are as follows: trunk accelerations in sagittal plane (SIDEx, SIDEsd, SIDEran), trunk accelerations in coronal plane (FORWx, FORWsd, FORWran), trunk accelerations in transverse plane (UPx, UPsd, UPran), absolute value of sums of 3-axial angular velocities (SPINx, SPINsd, SPINran), angular velocities in longitudinal axis - roll (G1x, G1sd, G1ran), angular velocities in lateral axis - pitch (G2x, G2sd, G2ran) and angular velocities in vertical axis - yaw (G3x, G3sd, G3ran). Trunk accelerations are expressed in meters per second squared (m/s^2). Angular velocities and SPIN variables are expressed in degrees per second (d/s). Acceleration variables are calculated from positive values which represent real accelerations and negative values represent decelerations of trunk movement. Positive and negative values in angular velocity variables represent opposite directions. Positive values represent: in G1 movement to the right, in G2 movement forward and in G3 counter-clockwise direction of movement. Angular velocity variables are simply compared with acceleration variables in its original form.
The collected data was downloaded from the GPS devices onto the Catapult Sports, Sprint 5.1 software then subsequently exported to Microsoft Excel and finally analyzed with Dell Inc. Statistica 64 program. We used correlation analysis to investigate the strength of association between the observed variables.

RESULTS: Time (t) achieved in 20 m sprint test correlated with maximal velocity (Vmax) as it is shown in Table 1. Also, performance time correlated with average acceleration (ACCx), as was expected. There was no correlation between average velocity (Vx) and maximal acceleration (ACCmax).

Table 1
Correlates of time with velocities and accelerations in elite footbal players (n = 21)

VARIABLE	Vx (m/s)	Vmax (m/s)	ACCx (m/s^2)	ACCmax (m/s^2)
t (s)	-0.35	-0.67*	-0.90*	-0.15

* Marked correlations are significant at $p < 0.05$

Variable FORWran negatively correlated with time and Vx, as shown in Table 2. FORWsd also correlated with Vx. Variables that describe angular velocities, SPINsd, G1ran and G2ran, significantly correlated with performance time. SPINsd and SPINran correlated with maximal acceleration. Variables that describe angular velocities about the vertical axis all correlated with maximal acceleration.

Table 2
Correlates of GPS based with unit integrated variables in elite footbal players (n = 21)

VARIABLE	t (s)	Vx (m/s)	Vmax (m/s)	ACCx (m/s2)	ACCmax (m/s2)
SIDEx (g)	-0.13	0.42	0.03	0.02	0.10
SIDEsd (g)	0.07	-0.17	-0.24	-0.08	0.10
SIDEran (g)	0.11	-0.17	-0.13	-0.11	0.06
FORWx (g)	0.10	0.41	0.21	0.04	-0.22
FORWsd (g)	-0.39	0.51*	0.22	0.21	0.13
FORWran (g)	-0.44*	0.56*	0.38	0.40	0.24
UPx (g)	-0.09	-0.41	0.03	0.04	0.04
UPsd (g)	-0.42	0.08	0.08	0.29	0.33
UPran (g)	-0.31	0.00	0.02	0.24	0.41
SPINx (d/s)	-0.42	0.02	0.09	0.32	0.25
SPINsd (d/s)	-0.44*	0.01	0.07	0.37	0.45*
SPINran(d/s)	-0.27	-0.11	-0.15	0.16	0.51*
G1x (d/s)	-0.02	-0.16	0.19	0.08	0.08

G1sd (d/s)	-0.41	-0.11	0.18	0.38	0.10
G1ran (d/s)	-0.47*	-0.11	-0.14	0.32	0.18
G2x (d/s)	-0.30	-0.14	-0.09	0.17	-0.12
G2sd (d/s)	-0.36	0.23	0.08	0.20	0.15
G2ran (d/s)	-0.44*	0.10	0.20	0.31	0.14
G3x (d/s)	-0.08	-0.22	-0.19	-0.02	0.46*
G3sd (d/s)	-0.27	-0.08	-0.1	0.21	0.45*
G3ran (d/s)	-0.07	0.08	-0.12	0.12	0.48*

* Marked correlations are significant at $p < 0.05$

DISCUSSION: The observed correlation between sprint performance time and smoothed maximal velocity (Vmax) is expected and logical. The more players are able to develop their maximal velocity, the better their test result. Given the observed correlation between 20 m performance time and average acceleration (ACCx), we can emphasize the importance of continuous speed build-up. Average velocity (Vx) is a variable that varies from player to player, so there is no significant correlation with test performance time. Standard deviation and range of acceleration values in coronal plane (FORWsd and FORWran) correlated with average velocity (Vx).

The more forward trunk acceleration is present, the more chance to increase average velocity. In previous research, authors also highlighted importance of body inclination and angular displacement for change-of-direction performance (Sasaki et al., 2011). If the difference between maximal acceleration and deceleration is higher, the impact on average velocity and time in test is also higher to a certain extent. Trunk movements are also related to 20 m sprint performance time, but also to maximal acceleration of the body. Kubo et al. (2011), for example, found cross section of muscles erector spinae and quadratus lumborum as significant contributors for prediction of mean velocity over 10 m and 20 m. In our case, if standard deviation and range of the 3-axial angular velocity sum (SPINsd, SPINran) increases, test performance time and maximal acceleration have also chance to be better. All three variables that describe angular velocity about the vertical axis (G3x, G3sd and G3ran) correlated with maximal acceleration and it seems to be more important to accelerate during the first part of the 20 m sprint performance test. Fujii et al. (2010) similarly found shoulder rotations during dribbling important for a reduced decrease of velocity compared to a maximal 20 m sprint.

In angular velocity variables, average value describes tendency to one direction of trunk movement. This type of asymmetry can be explained through possibly odd number of rotational cycles, evolutionary or sport-specific need for side dominance, or something else. However, that was not the subject of this study, but may be interesting for further investigation.

The limitation of this study may be the accuracy of GPS sensors. In that regard, Akenhead et al. (2013) found compromised accuracy in accelerations of over 4 m/s^2. Varley et al. (2011) indicated that latest GPS units produce sufficient accuracy to quantify acceleration, deceleration and constant velocity during straight-line running phases in team sports.

CONCLUSION: The main findings of this study pertain to the fact that maximal velocity and average acceleration correlated with 20 m sprint performance time in 21 male elite football players. Likewise, acceleration in coronal plane correlated with time and average velocity. Interestingly, magnitude of longitudinal and lateral angular velocities correlated with time, but vertical angular velocity correlated with maximal acceleration. In some way, for the task that players needed to perform, side and frontal trunk movements are more important. To generate maximal acceleration, beside explosive power, players also need quick trunk rotational movements for propulsion. In addition, the ability to use the thoracic spine freely in part of first to fifth vertebra can help them to perform more coordinated and functional movement. Practical application of this knowledge is possible in high-performance training in order to help football players improve their movement pattern. Moreover, GPS device, with accelerometer and gyroscope sensors integrated, seems to be a useful diagnostic tool.

REFERENCES:

Akenhead, R., French, D., Thompson, K.G. and Hayes, P.R. (2014). The acceleration dependent validity and reliability of 10Hz GPS. *Journal of Science and Medicine in Sport*, 17(5), 562-566.

Aminian, K. and Najafi, B. (2004). Capturing human motion using body fixed sensors: outdoor measurement and clinical applications. *Computer Animations and Virtual Worlds,* 15, 79-94.

Andrzejewski, M., Chmura, J., Pluta, B., Strzelczyk, R. and Kasprzak, A. (2013) Analysis of sprinting activities of professional soccer players. *Journal of strength and conditioning research,* 27(8), 2134-2140.

Buchheit, M., Samozino, P., Glynn, J.A., Michael, B.S., Al Haddad, H., Mendez-Villanueva, A. and Morin, J.B. (2014). Mechanical determinants of acceleration and maximal sprinting speed in highly trained young soccer players. *Journal of Sport Sciences*, 32(20), 1906-1913.

Fujii, K., Yamada, Y. and Oda, S. (2010). Skilled basketball players rotate their shoulders more during running while dribbling. *Perceptual and Motor Skills,* 110(3 Pt 1), 983-994.

Kubo, T., Hoshikawa, Y., Muramatsu, M., Iida, T., Komori, S., Shibukawa, K. and Kanehisa, H. (2011). Contribution of trunk musculatory on sprint run. *International Journal of Sports Medicine,* 32(3), 223-228.

Sasaki, S., Nagano, Y., Kaneko, S., Sakurai, T. and Fukubayashi, T. (2011). The relationship between performance and trunk movement during change of direction. *Journal of Sport Science and Medicine,* 10(1), 112-118.

Varley, M.C., Fairweather, I.H. and Aughey, R.J. (2011). Validity and reliability of GPS for measuring instantaneous velocity during acceleration, deceleration, and constant motion. *Journal of Sport Sciences*, 30(2), 121-127.