SEGMENTAL ASYMMETRY AND ITS RELATIONSHIP WITH LOWER LIMB STRENGTH AND RANGE OF MOTION IN YOUNG SOCCER PLAYERS

Pedro Forte[1, 3], Tiago M. Barbosa[2, 3], Jorge E Morais[1, 3], António Reis[1, 3]

[1] Polytechnic Institute of Bragança, Bragança, Portugal
[2] Nanyang Technological University, Singapore
[3] Research Centre in Sports, Health and Human Development, Portugal

The aim of this study was to assess the relationship between range of motion, strength and limb alignment in young soccer players. Forty-seven young soccer players were evaluated for limb alignment with photogrammetry. Isometric strength was assessed with a strain gauge during leg curl and leg extension. Flexibility was measured using goniometry. Association between segmental asymmetry and strength were non-significant ($-0.28<r<0.04$; $0.61<p<0.96$). However, significant Pearson's correlations were found between segmental asymmetry and range of motion ($-0.34<r<0.29$; $0.02<p<0.05$). It can be concluded that segmental asymmetry influences young soccer players' range of motion.

KEY WORDS: strength, flexibility, posture, young, soccer.

INTRODUCTION: Soccer is a sport characterised by several specific actions (Reilly & Doran, 2003) and strength is a key-factor in the multiple accelerations performed over a match (Reilly & Thomas, 1976). Fitness components such as strength and flexibility may play a role in such accelerations and are related to body posture, notably to segmental alignment and potential asymmetries. Flexibility is influenced by muscle shortening related to agonist/antagonist imbalance, and postural changes (Sena, et al., 2013). Strengthening exercises should be prescribed to promote agonist/antagonist balance, prevent muscle-tendon shortening and realign body segments (Hrysomallis & Goodman, 2001).
Correct posture aims to minimize joint stress and avoid body misalignment that will impair the mechanics and physiologic efficiency. Sports may induce or prevent the misalignment in body segments, resulting in alterations in strength, range of motion, balance and motor coordination (Aruin, 2006; Wojtys, et al., 2000; dos Santos, et al., 2007). Postural changes are related to pain, injuries and poor performance. For example, players with muscle strains had higher incidence of lumbar lordosis, sway back and knee abnormal inter-space (Watson, 1995). Back injuries were associated with shoulder asymmetry, scapula abduction, back asymmetry, kyphosis, lordosis and scoliosis (Watson, 1995). A bad posture seems to contribute to sports injuries in young and adult players (Alter, 1996; Bertolla, et al., 2007).
However, the body of knowledge of the relationships or associations between segmental alignment, strength and range of motion in young soccer players is scarce. The aim of this study is to assess the association between these three components, hypothesising that there are significant associations between them.

METHODS: Forty-seven young Portuguese soccer players (13.02 $\pm$ 2.51 years) participated in this research, all with parental consent. Ten players compete in the U11, 10 in the U13, 12 in the U15 and 15 in the U17 local competitions.
Segmental alignment was assessed with photogrammetry (SAPo, v. 0.086, Sao Paulo, Brazil). One picture was taken with a digital camera (Casio Exilim Zoom ex z1000, Shangai, China) in the frontal (anterior) view, with the subject in the orthostatic position. Styrofoam markers (2.5cm diameter), were placed on the main anatomical landmarks: antero-superior iliac spines, femoral trochanters, patellae, tibial tuberosities, knee joint line and the lateral and medial malleoli. The above landmarks were selected as parameters for misaligment. The

magnitude of asymmetry was obtained by the module difference of the demarcated points, with the software analysis of asymmetry measured in metres (ICC = 1.00; P<0.001).
Isometric strength (Newtons) during the leg curl was assessed with a strain gauge, and extension at 60 degrees of the right (MaxF-RLL-Flex) and left lower limbs (MaxF-LLL-Flex) was with a dynamometer (Kellis & Baltzopoulos, 1996). Each participant performed three trials (2 minute rest between trials) with the best trial (i.e., highest value) selected for analysis (Ramsay, et al., 1990; Hebestreit, Mimura & Bar Or, 1993).
Flexibility, i.e. range of motion, was assessed with a goniometer (Jamar, China). Hip flexion, extension and abduction, knee and foot flexion are the most solicited joints in performing soccer techniques (Ekstrand & Gillquist, 1982), and so chosen to be the selected variables.
Normality and homoscedasticity assumptions were analysed with Kolmogorov-Smirnov and Levene tests, respectively. The main results are presented in mean, standard deviation and coefficient of variation (CV). Pearson's correlation test ($p<0.05$) was selected to assess the associations between limb asymmetry, strength and range of motion.

RESULTS: Descriptive statistics for range of motion, strength and limb alignment are presented in table 1. Table 2 presents the significant correlations between range of motion, strength and limb alignment. Despite the mean of asymmetry, it is also pertinent to alert the known existence of asymmetry in some subjects and the variation of group values. The main correlations found in lower limb asymmetry were hip flexion with femoral trochanters (r = -0.32; p = 0.03), hip abduction with lateral malleolus (r = 0.29; p = 0.05). Knee and foot flexion with femoral trochanters (r =-0.34; p = 0.02) and knee joint line (r = -0.31; p = 0.04), respectively.

Table 1
Descriptive statistics for range of motion, strength and limb alignment.

Variables	Mean	SD	Min	Max	CV
MaxF-LLL-Ext [N]	241.82	143.13	63.77	618.03	0.59
MaxF-RLL-Ext [N]	232.01	121.64	50.03	590.56	0.52
MaxF-LLL-Flex [N]	208.66	116.74	51.99	499.33	0.56
MaxF-RLL-Flex [N]	194.83	115.86	50.03	549.36	0.59
Hip Flexion [º]	75.51	11.56	45	110	0.15
Hip Extension[º]	33.34	9.87	20	70	0.30
Hip Abduction [º]	59.34	8.03	40	81	0.14
Knee Flexion [º]	121.96	9.21	102	148	0.08
Foot Flexion [º]	30.26	7.49	15	55	0.25
Antero-Superior Iliac Spines Asymmetries [m]	0.0052	0.0087	0	0.053	1.67
Femur Trochanters Asymmetries [m]	0.0068	0.0081	0	0.026	1.19
Knee Articular Line Asymmetries [m]	0.0116	0.0108	0	0.045	0.93
Knees-cap Asymmetries [m]	0.0120	0.0086	0	0.037	0.72
Tibias Tuberosity Asymmetries [m]	0.0115	0.0071	0	0.029	0.62
Lateral Malleolus Asymmetries [m]	0.0098	0.0083	0	0.032	0.85
Medial Malleolus Asymmetries [m]	0.0070	0.0059	0	0.022	0.84

DISCUSSION: The aim of this study was to assess the association between strength, range of motion and limb alignment. Significant correlation was obtained between hip and foot flexion and lower limb asymmetry.
A positive correlation between hip flexion and maximum strength in knee flexion and extension for both legs were found. Positive relationships between strength and range of motion or flexibility, has also been reported in trunk flexion and maximum strength of the lower limbs, after a training program in basketball players (Song, et al., 2014). However, it is important to note that the muscular shortening may induce sarcomere reduction and compromise strength development. Flexibility training may contribute to strength building avoiding reduction of the sarcomeres (Kisner and Colby, 2005).

Significant correlation between hip flexion and femoral trochanteric asymmetry were also found. Moreover, associations between hip abduction and lateral malleolus asymmetry were identified. Femoral trochanters are commonly associated with lower limb and hip asymmetry; hip asymmetry relates to lumbo-pelvic flexion in ergometer rowing (Buckeridge, et al., 2012). Corrrelation of asymmetries between antero-superior iliac spine with knee joint line ($r = 0.38$; $p = 0.01$) and femoral trochanters were demonstrated ($r = 0.37$; $p = 0.01$), that may be explained by ground-up and top-down theories. These theories explain that upper body asymmetry may be predicted by asymmetry in the lower limbs of the body and vice-versa (Hollman, et al., 2006), that support the results obtained for lower limb asymmetry in this research. Hollman et al. (2006) also report that a reduction in strength of the hip abductors is associated with increased pronation of the foot. These findings are consistent with the hip abduction angle and the asymmetry with the lateral malleolus.

Table 2
Main correlations between range of motion, strength and limb alignment.

	Variables	R	P
Flexibility - Strength	Hip Flexion [º] - MaxF-LLL-Ext [kgf]	0.38	0.01
	Hip Flexion [º] - MaxF-RLL-Ext [kgf]	0.55	<0.001
	Hip Flexion [º] - MaxF-LLL-Flex [kgf]	0.39	0.01
	Hip Flexion [º] - MaxF-RLL-Flex [kg]	0.30	0.04
Posture – Range of Motion	Hip Flexion [º] - Femur Trochanters Asymmetries[cm]	-0.32	0.03
	Hip Abduction (º) - Lateral Malleolus Asymmetries [cm]	0.29	0.05
	Knee Flexion (º) - Femur Trochanters Asymmetries [cm]	-0.34	0.02
	Foot Flexion (º) - Knee Articular Line Asymmetries [cm]	-0.31	0.04
Posture - Posture	Antero-Superior Iliac Spines - Femur Trochanters Asymmetries [cm]	0.37	0.01
	Antero-Superior Iliac Spines - Knee Articular Line Asymmetries [cm]	0.38	0.01
	Lateral Malleolus - Medial Malleolus Asymmetries [cm]	0.32	0.03
	Antero-Superior Iliac Spines - Femur Trochanters Asymmetries [cm]	0.37	0.01

A high CV in femoral trochanter asymmetry and antero-superior iliac spines was observed; this is a descriptive value that only represents the internal variability within the groups (Bedeian & Mossholder, 2000). The range of ages in the test group should be considered: during adolescence there is an element of hormonal action, which influences bone growth at different speeds in different skeletal segments at different ages (Kelly, et al., 1990). However, despite flexibility and strength, the posture is also influenced by many factors, such as social status, motivation and segmental hyper-solicitation, contributing to the correlation of the asymmetry (Aruin, 2006; Wojtys, et al., 2000; dos Santos, et al., 2007). This could be an explanation for the weak to moderate correlations.

CONCLUSION: It was found an association between limb asymmetry and range of motions. The range of motion demonstrated significant correlation with the segmental alignment. Therefore, coaches and athletes should monitor body alignments on a regular basis to prevent injuries and performance impairment.

REFERENCES:

Reilly, T. & Doran, D. (2003). Fitness Assessment. In Reilly T. & Williams AM (Eds). *Science and Soccer*. London: Routledge,2, 21-46.

Reilly, T. & Thomas, V. (1976). A motion analyses of work-rate in different positional roles in professional football match-play. *Journal of Human Movement Studies*. 2, 87-97.

Kellis, E., Baltzopoulos, V. (1996). The effects of normalization method on antagonistic activity patterns during ec-centric and concentric isokinetic knee extension and flexion. *J Electromyogr Kinesiol*, 6, 235-45.

Ramsay, J. A., Blimkie, C. J., Smith, K., Garner, S., Macdougall, J. D., Sale, D. G. (1990). Strength training effects in prepubescent boys. *Med Sci Sports Exerc*, 22, 605-14.

Hebestreit, H., Mimura, K.I., Bar Or, O. (1993). Recovery of muscle power after highintensity short-term exercise: comparing boys and men. *J Appl Physiol*, 74, 2875-80.

Ekstrand, J., & Gillquist. J. (1982). The frequency of muscle tightness and injuries in soccer players. *Am J Sports Med.* 10(2), 75-78.

Song, H. S., Woo, S. S., So, W. Y., Kim, K. J., Lee, J., & Kim, J. Y. (2014). Effects of 16-week functional movement screen training program on strength and flexibility of elite high school baseball players. *Journal of exercise rehabilitation*, *10*(2), 124.

Buckeridge, E., Hislop, S., Bull, A., & McGregor, A. (2012). Kinematic asymmetries of the lower limbs during ergometer rowing. *Medicine and science in sports and exercise*, (44), 2147-53.

Hollman, J., Kolbeck, K., Hitchcock, J., Koverman, J., Krause, D. (2006) Correlations between hip strength and static foot and knee posture. Journal of Sport Rehabilitation. 15(1), 12-23.

Aruin, A. S. (2006). The effect of asymmetry of posture on anticipatory postural adjustments. *Neuroscience letters*, *401*(1), 150-153.

Wojtys, E., Miller, J., Huston, L., Moga, P. (2000). The association between training time and the sagittal curvature of the immature spine. *Am J Sports Med*. 28(4), 490-498.

dos Santos, S. G., Detanico, D. Graup, S. dos Reis, D. C. (2007). Relation between posture changes, prevalence of injuries and impact magnitude in lower limbs as regards the handball athletes. *Fitness & Performance*. 6(6), 388-393.

Raymond, C. T. L., Yi, W., Nicola M, Kai. M. C., Julie, J. L. C. (1996) Eccentric and concentric isokinetic knee fl exion and extension: a reliability study using the Cybex 6000 dynamometer. *Br F Sports Med*. 30, 156-160.

Schmikli SL, de Vries WR, Inklaar H, Backx FJG. Injury prevention target groups in soccer: injury characteristics and incidence rates in male junior and senior players. J Sci Med Sport. 2011;14(3):199-203.

Alter MJ. (1996). Science of flexibility. 2. ed. Champaign: Human Kinetics.

Bertolla, F., Baroni, B. M., Junior, L., Pinto, E. C., & Oltramari, J. D. (2007). Effects of a training program using the Pilates method in flexibility of sub-20 indoor soccer athletes. *Revista Brasileira de Medicina do Esporte*, *13*(4), 222-226.

Sena. D. A., Ferreira F. M., Galvão, R. H., Taciro, T. C., Carregaro R. L., Júnior, S. A. O. (2013). Analysis of the joint flexibility and prevalence of soccer-related injuries according to age. Fisioter. Pesq., 20(4), 343-348.

Watson, A .W. (1995). Sports injuries in footballers related to defects of posture and body mechanics. *The Journal of Sports Medicine and Physical Fitness*, 35(4), 289-294.

Hrysomallis, C., & Goodman, C. (2001). A review of resistance exercise and posture realignment. *The Journal of Strength & Conditioning Research*, *15*(3), 385-390.

Bedeian, A. G., & Mossholder, K. W. (2000). On the use of the coefficient of variation as a measure of diversity. Organizational Research Methods, 3(3), 285-297.

Kelly, P. J., Twomey, L., Sambrook, P. N., & Eisman, J. A. (1990). Sex differences in peak adult bone mineral density. Journal of bone and mineral research, 5(11), 1169-1175.