Portuguese Journal of Sport Sciences
11 (Suppl. 2), 2011

TRICEPS SURAE MUSCULOTENDINOUS STIFFNESS: RELATIVE DIFFERENCES BETWEEN SOCCER AND NON-SOCCER PLAYERS

Aurélio Faria[1], Ronaldo Gabriel[2], João Abrantes[3], Paola Wood[4] and Helena Moreira[5]

Department of Sport Science, CIDESD, University of Beira Interior, Covilhã, Portugal[1]
Department of Sport Sciences Exercise and Health, CITAB, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal[2]
MovLab, CICANT, Universidade Lusófona de Humanidades e Tecnologias, Lisbon, Portugal[3]
Department of Biokinetics, Sport and Leisure Sciences, University of Pretoria, Pretoria, South Africa[4]
Department of Sport Sciences Exercise and Health, CIDESD, University of Trás-os-Montes e Alto Douro, Vila Real, Portugal[5]

The purpose of this study was to investigate the muscle-tendon unit stiffness of the ankle between professional soccer players and non-soccer players. Fifteen soccer players and twenty-one non-soccer players participated in this study. The stiffness of the triceps surae muscle-tendon unit was measured in vivo from the damped frequency of oscillation of the shank about the ankle using a free oscillation technique. Using the t-test no significant differences ($P > 0.05$) were found between the soccer and the control groups for muscle-tendon unit stiffness of the triceps surae. The soccer group showed stiffness values of 22059 (SD 3623) N/m, while the control group showed values of 20427 (SD 4517) N/m. These results suggest that neither the soccer training nor the games itself affected the stiffness of the ankle of the players.

KEY WORDS: Biomechanics, Soccer, Ankle stiffness.

INTRODUCTION: Soccer players require physical, technical and tactical skills to succeed. The role of each one of these characteristics in performance is difficult to discriminate, nevertheless all of them are important and contribute to performance differences. According to Jan Hoff (2005) muscular strength, power and endurance are important physical resources enhancing basic physiological capacities for playing soccer. Bangsbo et al. (1991) reported that acceleration and speed skills such as turning, sprinting and changing pace are critical to soccer and may be improved by increasing the available force of muscular contractions in the appropriate muscle groups. During soccer training, changes of the muscle-tendon units should occur with repercussions for force production which might reflect in stiffness. Typical soccer skills like running (Seyfarth et al., 2002), jumping (Arampatzis et al., 2001) and sprinting (Stefanyshyn & Nigg, 1998) have been reported as being related with leg stiffness. Furthermore ankle stiffness play an important role in leg stiffness (H. Hobara et al., 2007).
The focus of the present work is within the physical characteristics of soccer players, specifically, in the study of the muscle–tendon unit (MTU) stiffness of the triceps surae. Generally defined, stiffness can be described as the ratio of force change to length change (Butler et al., 2003).The investigation of stiffness is often developed as it relates to performance and the risk of injury. Particularly, lower and higher values of stiffness may lead to soft tissue and bone injuries, respectively (Butler, et al., 2003). Furthermore studies (Nielsen & Yde, 1989; Engström et al., 1991) on soccer injuries have showed that knee and ankle injuries are the most prevalent.
In summary, soccer training may change the muscles and tendons which in turn can affect the MTU stiffness. Both insufficient and excessive MTU stiffness can increase the risk of injuries. MTU stiffness can be related to soccer performance and the risk of injury. To the authors' knowledge MTU stiffness of professional soccer players has never been assessed

and compared with a control group. Therefore the aim of this study was to investigate the muscle-tendon unit stiffness of the ankle between professional soccer players and non-soccer players.

METHODS: Thirty-six men participated in this study. Of these, fifteen were professional soccer players and twenty-one non-soccer players. The soccer players were training six times and played an official match per week. The university students (non-soccer players) did not perform physical activity on a regular basis. All subjects were healthy and had no injuries. The body mass and height of each subject was measured by a conventional scale and the stadiometer (Seca 220, Hamburg, Germany), respectively. To evaluate vertical ground reaction force for muscle-tendon unit stiffness assessment a Kistler force plate was used (Kistler 9281B; Kistler Instruments, Amherst, NY, USA). Kinetic data were collected with the software BioWare 4.0 type 2812A (Kistler Instruments, Amherst, NY, USA). The equipment illustrated in Figure 1 was used in conjunction with the force plate with a sampling rate of 1000 Hz. The vertical ground reaction forces were used to calculate maximal voluntary isometric contraction (MVIC) and free oscillation data in this order respectively. With the same equipment a damped oscillation technique was applied to assess "in vivo" MTU stiffness of plantar flexors, after having calculated the MVIC. Free oscillation data was obtained using external pure gravitational mass equivalent to 30% of MVIC (McNair & Stanley, 1996; Hunter et al., 2001; Blackburn et al., 2006). More details of the procedures can be found in the literature (Thomson, 1981; Faria et al., 2009, 2010).

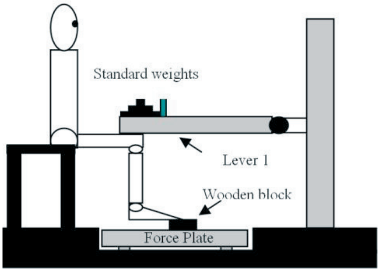

Figure 1: Equipment and position used to determine muscle-tendon unit (MTU) stiffness.

RESULTS: Table 1 shows the descriptive statistics of age and anthropometric parameters in each analyzed group.

Table 1
Subject characteristics

Variables	**Soccer players** (n = 15)	**Non-soccer players** (n = 21)
Age (years)	26 ± 6	22 ± 3
Height (m)	1.80 ± 0.07	1.76 ± 0.06
Mass (kg)	75.3 ± 6.6	68.8 ± 6.7
BMI (kg/m^2)	23.4 ± 0.94	22.1 ± 1.5

Values are mean ± standard deviation

The mean body mass index of the professional soccer players group was greater than the control group (Table 1). Nevertheless both groups were within the normal category as set out by the World Health Organization (WHO) for obesity levels (between 18.5 and 24.99 kg/m^2). After checking normality with the Shapiro-Wilk test and to examine the homogeneity of variance, the Mann–Whitney test was performed for MTU stiffness normalized for mass. The Student's *t*-test was used to assess differences between groups for maximal voluntary isometric contraction and MTU stiffness. No statistical significant differences were found for maximal voluntary isometric contraction, MTU stiffness and MTU stiffness normalized by mass between the soccer and the control groups (Table 2).

Table 2
Maximal voluntary isometric contraction (MVIC), muscle–tendon unit (MTU) stiffness and MTU stiffness normalized for mass, for each subject group.

Variables	Soccer Players (n = 15)	Non-soccer players (n = 21)	Mann–Whitney[M] & t-test (p-value)
MVIC (N)	778 ± 93	753 ± 110	0.470
MTU stiffness ($N.m^{-1}$)	22059 ± 3623	20427 ± 4517	0.245
MTU stiffness/mass ($N.m^{-1}.kg^{-1}$)	295 ± 53	299 ± 74	0.713[M]

Values are mean ± standard deviation

DISCUSSION: The purpose of this study was to investigate the muscle-tendon unit stiffness of the ankle between professional soccer players and non-soccer players. Despite the mean MTU stiffness of the soccer players (22059 $N.m^{-1}$) been slightly greater than the control group (20427 $N.m^{-1}$) the results of this study were non statistically significant neither for MTU stiffness nor for MTU stiffness when normalized by mass.

To respond effectively to the challenges and specific demands of soccer, athletic training should be focused and contain specific characteristics of soccer game (Hoff, 2005; Emre et al., 2008). Even if this training is not that different from the one performed in other types of sports it should, at least, differentiate the musculoskeletal system of professional soccer players from subjects who do not regularly train. The soccer training has a significant endurance and strength training base (Hoff, 2005). Hobara et al. (2010) compared endurance-trained athletes with untrained subjects and found that the endurance-trained group showed significant higher leg stiffness than the untrained group and these differences were attributable to differences in ankle and knee joint stiffness. This suggests that the musculoskeletal system of the soccer players can be developed and contain specific features, that can be reflected in the muscle–tendon unit stiffness of the triceps surae. Additionally, running economy is an important factor in aerobic performance in soccer (Hoff, 2005) which, according to Butler et al. (2003) , is related to stiffness. Furthermore according to Butler et al. (2003) stiffness may be changed through training, which can be reflected in the loads experienced by the lower extremity, thereby potentially decreasing the risk of injury. Nevertheless this study, did not found any significant differences between groups.

Some studies indicate that the physiological profile of players that play in different positions must be distinct (Dunbar & Power, 1997). Since MTU stiffness was assessed without discriminating the player position this could have influenced results, however other studies (Chamari et al., 2004; Yildirim et al., 2008) showed contradictory results and indicate that physiological capacities are independent of the playing position. Other argument that could help explain the non significant results obtained is that training might have improved some skills that allow soccer players to adjust stiffness in specific circumstances that were not reproduced by the methods used in this study. Future studies are needed to address these issues.

CONCLUSION: Soccer players showed slightly greater MTU stiffness than the non-soccer players group. However no statistically significant differences were found between groups for MTU stiffness and MTU stiffness normalized for mass. The study of stiffness has been frequently developed as it relates to both injury and performance. Nevertheless the results obtained suggest that the soccer training and the games itself does not affect the MTU stiffness of the ankle.

REFERENCES:

Arampatzis, A., Schade, F., Walsh, M., & Brüggemann, G. (2001). Influence of leg stiffness and its effect on myodynamic jumping performance. *Journal of Electromyography and Kinesiology, 11*(5), 355-364.

Bangsbo, J., Nørregaard, L., & Thorsøe, F. (1991). Active profile of competition soccer. *Canadian Journal of Sports Sciences, 16*, 110 – 116.

Blackburn, J. T., Padua, D. A., Weinhold, P. S., & Guskiewicz, K. M. (2006). Comparison of triceps surae structural stiffness and material modulus across sex. *Clinical Biomechanics, 21*(2), 159-167.

Butler, R. J., Crowell III, H. P., & Davis, I. M. (2003). Lower extremity stiffness: implications for performance and injury. *Clinical Biomechanics 18*(6), 511-517.

Chamari, K., Hachana, Y., Ahmed, Y. B., Galy, O., Sghaïer, F., Chatard, J.-C., et al. (2004). Field and laboratory testing in young elite soccer players. *British Journal of Sports Medicine, 38*(2), 191-196.

Dunbar, G., & Power, K. (1997). Fitness profiles of English professional and semi-professional soccer players using a battery of field tests. In Reilly, T., Bangsbo, J. & Hughes, M. (Eds.), *Science and Football III - The Proceedings of the Third World Congress on Science and Football* (pp. 27). Cardiff, Wales: Taylor & Francis.

Emre, A. K., Yıldırım, A., Çiçek, Ş., & Korkusuz, F. (2008). Comparison of physiological profiles of soccer players in U17, U19, U21 and over-21. In Reilly, T. & Korkusuz, F. (Eds.), *Science and Football VI - The Proceedings of the Sixth World Congress on Science and Football*. Antalya, Turkey: Taylor & Francis.

Engström, B., Johansson, C., & Tornkvist, H. (1991). Soccer injuries among elite female players. *The American Journal of Sports Medicine, 19*(4), 372-375.

Faria, A., Gabriel, R., Abrantes, J., Brás, R., & Moreira, H. (2009). Triceps-surae musculotendinous stiffness: Relative differences between obese and non-obese postmenopausal women. *Clinical Biomechanics, 24*(10), 866–871.

Faria, A., Gabriel, R., Abrantes, J., Brás, R., & Moreira, H. (2010). The relationship of body mass index, age and triceps-surae musculotendinous stiffness with the foot arch structure of postmenopausal women. *Clinical Biomechanics, 25*(6), 588-593.

Hobara, H., Kanosue, K., & Suzuki, S. (2007). Changes in muscle activity with increase in leg stiffness during hopping. *Neuroscience Letters, 418*(1), 55-59.

Hobara, H., Kimura, K., Omuro, K., Gomi, K., Muraoka, T., Sakamoto, M., et al. (2010). Differences in lower extremity stiffness between endurance-trained athletes and untrained subjects. [doi: DOI: 10.1016/j.jsams.2008.08.002]. *Journal of Science and Medicine in Sport, 13*(1), 106–111.

Hoff, J. (2005). Training and testing physical capacities for elite soccer players. *Journal of Sports Sciences, 23*(6), 573-582.

Hunter, D. G., Coveney, V., & Spriggs, J. (2001). Investigation into the effect of static stretching on the active stiffness and damping characteristics of the ankle joint plantar flexors. *Physical Therapy in Sport, 2*(1), 15-22.

McNair, P. J., & Stanley, S. N. (1996). Effect of passive stretching and jogging on the series elastic muscle stiffness and range of motion of the ankle joint. *British Journal of Sports Medicine, 30*(4), 313-317.

Nielsen, A. B., & Yde, J. (1989). Epidemiology and traumatology of injuries in soccer. *The American Journal of Sports Medicine, 17*(6), 803-807.

Seyfarth, A., Geyer, H., Günther, M., & Blickhan, R. (2002). A movement criterion for running. *Journal of Biomechanics, 35*(5), 649-655.

Stefanyshyn, D., & Nigg, B. (1998). Dynamic angular stiffness of the ankle joint during running and sprinting. *Journal of Applied Biomechanics, 14*(3), 292-299.

Thomson, W. T. (1981). *Theory of Vibrations with Applications* (2nd ed.). London: Allen & Unwin.

Yildirim, A., Emre, A. K., Korkusuz, F., & Çiçek, Ş. (2008). Physiological profiles of soccer players with respect to playing positions. In Reilly, T. & Korkusuz, F. (Eds.), *Science and Football VI - The Proceedings of the Sixth World Congress on Science and Football*. Antalya, Turkey: Taylor & Francis.

Acknowledgement

The authors would like to thank the support in data collection performed by the following students: Gonçalo Monteiro, João Belo and Luís Soares.