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Normative data for the functional movement screen in healthy taekwondo athletes

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Abstract. Regarding the literature there is a considerable risk of injury in taekwondo competition. Injuries can be reduced in taekwondo athletes by a pre-participation screening tool that can identify injury risk. The Functional Movement Screen (FMS) can be used by athletes as a reliable clinical tool to predict injury; however, the FMS has not been tested on taekwondo athletes. The current study aims to establish normative FMS values for taekwondo athletes. 45 healthy taekwondo athletes has performed the FMS. Descriptive statistics were analyzed; independent t-tests were conducted to evaluate the gender and experience effect as well as injury background on FMS scores. The existence of any significant differences in scores for any component of the FMS was evaluated using a Chi-square test. The mean FMS score was 13.12 ± 1.9. No significant differences in FMS scores were found between novice and experienced athletes ($p = 0.72$) or athletes with an injury in their background as well as those without any injury ($p = 0.20$). Although male and female athletes did not show any significant difference in their total FMS score ($p = 0.62$), noticeable differences were observed in the deep squat ($p < 0.05$), trunk stability push-up ($p < 0.001$) and active straight leg raise components ($p = 0.003$). This study provides normative values for FMS scores while testing uninjured taekwondo athletes.
Key words: *functional movement screen, injury, taekwondo.*

Introduction

Taekwondo is an old systematic and scientific Korean martial art that requires multiple physical fighting skills. This well-known Olympic sport is regulated by the World Taekwondo Federation and has been one of the most popular sports worldwide, between 75– 120 million people practice taekwondo in more than 140 countries. In the London 2012 Olympic Games Spain achieved most of the medals and it has traditionally gained great international sporting success (1). Taekwondo competitive performance depends on a variety of factors like physical, (2–6) psychological, (7, 8) technical (9, 10) and tactical (11–13).

Practitioners compete in gender and weight-matched categories in a full-contact event between two opponents which divided into three semi continuous rounds of 2 minutes, with 1 minute rest between the rounds. Taekwondo athletes are equipped with a padded trunk protector, protective padded headgear, protective gloves and shin guards. The player who gained higher scores for the specific fighting techniques allowed (kicks and punches), accurately and powerfully, in the legal scoring areas (the abdomen, both sides of the flank and the permitted parts of the face) is promulgated as the winner.

Understanding the injury pattern of a particular sport and its inherent risk factors is a key factor in the area of current sports medicine (14). There is also a high risk of injury in elite athletic performance in taekwondo, like other combat sports (15–21). With the assumption that injury is any situation in which the athlete sought the assistance of on-site medical personnel, the latest reviews on competition injuries in taekwondo concluded that total injury rates are between 20.6–139.5 per 1000 athlete-exposure (A-E) for elite men and 25.3–105.5 per 1000 A-E for elite women. Considering only time-loss injuries are, rates are between 6.9–33.6 per 1000 A-E for men and 2.4–23.0 per 1000 A-E for women (20). The main injuries in taekwondo occurred in direct contact, especially in the exchange of accurate turning kicks and poorly performed or non-existent blocking skills (17, 20, 22, 23). Injuries are mostly localized to the lower extremities, especially the instep of the foot, and these are primarily contusions, sprains and muscle strains (17, 20, 24, 25). The head and neck are the next regions most prone to receive injuries in taekwondo competition (17, 20).

The use of laboratory equipment and an experienced examiner usually unavailable in typical clinical settings, are prerequisites for the evaluation of techniques biomechanics. Several researchers have recommended a clinical screening process through which practitioners could identify athletes at risk for injury (26, 27). However hitherto no screening tool has been utilized or validated to identify risk of injury in taekwondo athletes. The Functional Movement Screen (FMS) is a screening tool used to concurrently evaluate multiple domains of function (balance, strength, range of motion) and improve the accuracy of risk identification in athletes (28). The screen examines fundamental movement patterns essential for sports. The screening tool includes 7 tests that use a variety of basic positions and movements, which are assumed to provide the foundation for more complex athletic movements to be performed efficiently. These movements include functional mobility of the lower extremity joints, tests that evaluate stride mechanics, the interplay between distal mobility and proximal stability, and multi-plane movements (29, 30).
The FMS has been validated in several athletic populations during competitive seasons and may provide a method for clinical examination of the multifactorial nature of injury and risk determinants (31, 32). The FMS should be evaluated and used in taekwondo. Hence, this research was to establish normative values for the FMS in a population of taekwondo athletes with secondary aims of investigating whether the performance differed between males and females, as well as those with and without an injury their athletic background, and experience. It is hypothesized that less-experienced athletes with and those who have injury before would gain lower scores on the FMS. We did not expect any difference in scores between male and female athletes.

Material and method

45 healthy taekwondo athletes (24 M; 21 F; mean age = 23.1 ± 4.2) aged between 19 and 27 years volunteered to participate in the study. Participants were selected from Iranian taekwondo academy. Subjects were included in the study have been examined to determine that if they were currently trained for a major regional or national competition, have been without injury for at least 3 months prior to testing, having no surgery within the last 6 months, and also were willing to be contacted through email for the study. An injury was defined as "any situation in which the athlete needed the assistance of the on-site medical personnel." This definition was presented by Pieter et al. (33). If subjects were elite or professional taekwondo athletes, they would be excluded. Athletes were considered elite if they met the qualifying time for Olympic Trials or had made distinguished accomplishments in taekwondo in the past 2 years prior to testing (34). The study was conducted in conformance with the ethical standards of the Int J Sports Med (35), and was approved by Tehran University Human Ethics Committee. Written permission was achieved prior to data collection process. Subjects were categorized into two groups of novice and experienced athletes. Novice athletes were those with 3 or less years of experience in taekwondo, and experienced athletes were those with more than 3 years' experience; athletes with less than 3 years' experience showed a greater risk of injury (36).
Procedures. Data collection was done at Iranian taekwondo academy sites. Participants took part in the study with their usual training clothes and footwear. Data were collected by licensed physical therapists and an athletic trainer, and a certified FMS instructor took the responsibility of training the investigators to perform the screening of subjects before data collection. The 7 components of the FMS screening tool include whole-body movements which are to assess mobility and strength concurrently. They include a deep squat, a hurdle step, an in-line lunge, a shoulder mobility test, an active straight leg raise test, a trunk stability push-up, and a rotary stability test. Cook et al. (29, 30) provide more details on each component and the FMS. The FMS has had excellent inter-rater reliability for composite scores (ICC = 0.981) and between individual test components (k = 0.70–1.0) (37). Reliability has also been evaluated for both novice and expert raters. Neither novice nor expert raters fell below a moderate level of agreement. The novice raters had agreed upon 2 more test components compared to the expert raters (6 vs. 4); however, the percent of agreement was about the same (89.6 and 86.7 % for novice and expert raters, respectively). The novice raters and expert raters having been compared, 14 of the 17 tests were in excellent conformity (38).
Functional Movement Screen Testing. The FMS screening instructions and scoring process were followed in association with the standardized version of the test to assure scoring accuracy and consistency among test administrators. Test components were not randomized. Each participant took part in 3 trials for the deep squat, and 2 trials for the hurdle step, in-line lunge, trunk stability push-up, and rotary stability test. Subjects took part in one trial for shoulder mobility and active straight leg raise. Each trial was scored on a scale of zero to 3. A score of 0 indicated the pain during the movement or that the participant was unable to get into

the test position and perform the movement; a score of one showed the failure in completing the movement or loss of balance during the test; a score of 2 illustrated the performance of the movement with compensation; and a score of 3 showed the perfect form during the movement. For test components scores were recorded in right and left side, the lower of the 2 scores was carried over as a final score for that component of the FMS. In addition to the 7 test components, 3 clearing tests (active scapular stability or impingement test, spinal extension and spinal flexion clearing) were conducted and scored as either positive or negative where a positive response indicated pain during the examination movement. If subjects were positive for any clearing exam, they got zero for the corresponding FMS component movement. Final scores for each component were added to get an overall composite FMS score with a maximum value of 21.

Data analysis. Descriptive statistics were numerated for patient demographics including age, anthropometrics, years of training and gender. Independent t-tests were conducted to examine differences between male and female athletes, like those who had an injury in the last 12 months or those who were novice compared to experienced athletes. Chi-square tests were done to examine if there were any significant differences between males and females in the scores distribution for the different tests. Calculations were done through Stata 12.1/IC software (StataCorp, 2009). Stata Statistical Software: Release 12. College Station, TX: Stata- Corp LP) and the a priori level of significance was set at $p \leq 0.05$.

Results

22 taekwondo athletes (51 %) reported an injury in their background in the past 12 months and several athletes reported more than one injury. Table I shows the descriptive data for subjects, and injury locations are enlisted in Table II.

Table I. Patient demographics

	Novice (0–3 years) (n = 14)	Experienced (3 + years) (n = 31)	All (n = 45)
Gender			
Male	48%	57%	52%
Female	52%	43%	48%
Age (years)	22.1 ± 3.5	24.2 ± 2.4	23.1 ± 4.2
Weight (kg)	66.2 ± 11.6	68.6 ± 11.4	67.4 ± 11.4
Height (cm)	169.3 ± 10.2	172.1 ± 10.5	171.2 ± 10.4
Training experience	2.2 ± 0.8	7.7 ± 3.5	5.6 ± 5
Prior history of injury	42%	55%	51%

Table II. The location of injury for previously injured athletes.

Injury location	Count	Percentage (%)
Knee	5	9.8
Thigh	8	15.7
Hip	6	11.8
Calf	1	2.0
Ankle	2	3.9
Achilles	1	2.0
Foot	4	7.8
Toe	1	2.0

Subjects completed all components of the FMS, including clearing tests for pain. Among 45 subjects, 6 reported pain with the impingement clearing test, 5 with the press-up clearing test, and none of them had pain during the posterior rocking clearing test. The mean composite FMS score was 13.12 ± 1.9 out of a maximum of 21. Athletes obtained the highest scores for in-line lunge component with a mean score of 2.15±0.53 and the lowest score was recorded on the rotary stability component with the mean score was 1.61 ± 0.49. Table III illustrates the descriptive data for FMS scoring. Male and female athletes did not show any significant difference in their total FMS score ($p = 0.55$); the total score for males were 13.08 ± 1.64 and for females 13.33 ± 1.9.

However, significant differences for gender were observed for 3 FMS components – the deep squat (chi-square = 6.198, p = 0.045), trunk stability pushup (chi-square = 18.49, p < 0.001), and active straight leg raise (chi-square = 12.78, p = 0.002). The majority of men (78.3 %) and women (66.7 %) score '2' for the deep squat. 13 % of men scored '3', and no woman scored '3'. On the trunk stability push-up component, the majority of women (61.9 %) scored '1', while most of the men (47.8 %) scored '2'. While 43.5 % of men scored '3', no women got '3' on the trunk stability push-up test. However the majority of women (57.1 %) scored '3' on the active straight leg raise component, while only 8.7 % of men got '3'. The most common score recorded for men (65.2 %) was '2'. Differences were also determined in FMS scores between athletes with an injury in the last 12 months. In those athletes with an injury experience in the past 12 months, the mean FMS score was 13.59 ± 0.40, while mean FMS score for athletes without any injury was 12.9 ± 0.34. For the mean composite score (p = 0.202) or for any component of the FMS test, no significant differences were shown between athletes with an injury in their background and those without. In novice and experienced athletes, differences in FMS scores were compared. Novice and experienced athletes did not show any significant difference in their FMS scores (p = 0.708), the average in novice athletes was 13.28 ± 0.41 and in experienced athletes the value of 13.06 ± 0.35 was recorded as average for their total FMS scores. There was no noticeable differences for any component of the FMS test between novice and experienced athletes.

Table III. Functional Movement Screen (FMS) test scores for taekwondo athletes

	Deep squat	Hurdle step	In-line lunge	Shoulder mobility	Active straight leg raise	Trunk stability push-up	Rotatory stability	Total
Gender								
Male	2.0 ± 0.47*	2.0 ± 0.47	2.1 ± 0.51	1.7 ± 0.96	1.8 ± 0.58*	2.3 ± 0.65**	1.5 ± 0.51	13.1 ± 1.7
Female	1.7 ± 0.48*	1.7 ± 0.54	2.3 ± 0.67	2.3 ± 0.72	2.5 ± 0.60*	1.4 ± 0.50**	1.7 ± 0.44	13.3 ± 1.9
Experience level								
Novice	1.7 ± 0.47	2.0 ± 0.39	2.3 ± 0.61	2.3 ± 0.73	2.2 ± 0.58	1.8 ± 0.80	1.8 ± 0.43	13.3 ± 1.5
Experienced	1.9 ± 0.51	1.8 ± 0.54	2.1 ± 0.50	1.8 ± 0.93	2.1 ± 0.72	1.97 ± 0.75	1.5 ± 0.51	13.1 ± 1.9
Prior history of injury								
Yes	1.9 ± 0.53	1.9 ± 0.61	2.1 ± 0.56	2.0 ± 0.93	2.1 ± 0.75	2.1 ± 0.75	1.6 ± 0.50	13.6 ± 1.9
no	1.8 ± 0.51	1.8 ± 0.40	2.2 ± 0.54	2.1 ± 0.77	2.3 ± 0.56	1.7 ± 0.73	1.7 ± 0.48	12.9 ± 1.5

Discussion and Conclusion

The study aims to establish normative values for the FMS in a population of taekwondo athletes and also to detect any differences between males and females (whether with an injury in their history or without) and between novice and experienced athletes. Numerous studies have shown a higher injury rate in novice taekwondo athletes (16-18, 22, 23). Furthermore, this idea was proposed that taekwondo athletes may get injured due to their musculoskeletal tissues strength and it is related to how or how much they have been trained (18). A While we expected to see significantly lower FMS scores for taekwondo athletes with an injury in their history and also for novice athletes, our findings did not support this.

Our findings were near to those of Schneider's et al. (39); they performed the FMS on 209 young, active adults. They did not find any notable difference in scores for gender or those with an injury. Surprisingly, the mean composite score was 15.7 for their population, which is a bit higher than ours (13.12). Mean composite score for taekwondo athletes is even lower than that of other athletic populations. For instance, the mean composite score for professional football players is recorded as 16.9 (40). Lower scores on the FMS may indicate that most taekwondo athletes have undertaken repetitive, single plane movement training, as the FMS tests more multi-planar functional movements. Our findings supported this idea that taekwondo athletes scored the highest for the inline lunge component, which indicates that the movement pattern is mostly similar to training, and is the poorest on the rotary stability test.

While no significant differences were observed for gender, males scored noticeably higher than females on the deep squat and trunk stability pushup. Although male athletes were shown to be stronger than females, the gender differential found between FMS components might be due to differences in core muscle activity rather than strength. This is due to the dynamic, functional and multi-planar nature of the FMS testing and the definition and evaluation of core stability (41).

Furthermore, gender differences in core stability may increase the probability of injury in female athletes or result in poor mechanics during single leg activities (42). In a study conducted by Schneider's et al. (43), significant differences were observed in rotary stability scores between genders. Our study however found no notable difference between genders regarding this component of the FMS. This was however the lowest component score among all athletes. The purpose of the rotary stability test is to examine complex movement which requires proper neuromuscular coordination and energy transfer from one segment of the body to another through the torso and also needs adequate transverse plane stability (30). Lower scores on this component may indicate that taekwondo athletes have impaired trunk, pelvis and hip muscular control, which can be a contributing factor to abnormal lower extremity mechanics (44). Athletes with an injury experience showed higher mean composite scores than those without injury (13.59 vs. 12.9). Although these differences were not noticeable, higher scores in previously injured athletes may be due to the focused treatment, such as physical therapy or strength training, which they received for the treatment of a particular injury. To determine whether this is a contributing factor, more information on current training programs and previous treatment is necessary. This is the first study which examines the FMS scores in taekwondo athletes. Our study had adequate power for determining normative values for the screen. One limitation of our study is the limited power to determine whether truly significant differences exist in our subgroups (i.e. gender, experience level, prior history of injury). Furthermore, our sample size makes difficult the analysis of contributing factors influencing FMS scores. To approve our findings further research is required. Future studies with larger sample sizes and a longitudinal design and control for risk factors such as mechanics, training factors, and alignment are required. The incorporation of clinical lower extremity functional screening tests such as the Small Knee Bend (SKB) and Frontal Plane Projection Angle (FPPA) may provide reliable information on lower extremity dynamic alignment and fulfill the need for sophisticated laboratory equipment. Moreover, we did not obtain any information on strength training or other activities athletes perform or on their history of treatment and prior injury. Future research should be done with a focus on the ability of baseline FMS score to anticipate injury in taekwondo athletes through a comprehensive model for risk assessment (45, 46) as well as examining different training programs that focus on core and multi-planar functional strength in comparison with pure taekwondo training.

This is the first study providing normative data for the FMS on a cohort of taekwondo athletes. Our findings can be used as a standard for physical therapists and coaches to evaluate the functional ability of uninjured taekwondo athletes. Future research is needed to improve our understanding of the utility of FMS as a screening tool for injury and baseline functional strength in taekwondo athletes.

References

1. World-Taekwondo-Federation. *http://www.wtf.org/wtf_eng/main/main_eng.html* (accessed 29 Apr 2015).
2. Heller J, Peric T, Dlouha R, et al (1998). Physiological profiles of male and female taekwondo (ITF) black belts. *J Sports Sci*; 16:243–9.
3. Gao B (2001). Research on the somatotype features of Chinese elite male taekwondo athletes. *Sport Sci*; 21:58–61.
4. Melhim A (2001). Aerobic and anaerobic power responses to the practice of taekwondo. *Br J Sports Med*; 35:231–5.
5. Ball N, Nolan E, Wheeler K (2011). Anthropometrical, physiological, and tracked power profiles of elite taekwondo athletes 9 weeks before the olympic competition phase. *J Strength Cond Res*; 25:2752–63.
6. Estevan I, Alvarez O, Falco C, et al (2011). Impact force and time analysis influenced by execution distance in a roundhouse kick to the head in taekwondo. *J Strength Cond Res*; 25:2851–6.
7. Grosser M, Brüggemann P, Zintl F (1989). *Alto rendimiento: planificación y desarrollo*. Madrid: Martínez Roca.
8. Gónzalez de Prado C (2011). Caracterización técnico-táctica de la competición de combate de alto nivel en taekwondo efectividad de las acciones tácticas [dissertation]. Barcelona: Universitat de Barcelona.
9. Bridge CA, Jones MA, Drust B (2011). The activity profile in international taekwondo competition is modulated by weight category. *Int J Sports Physiol Perform*; 6:344–57.
10. Cular D, Krstulovic S, Tomljanovic M (2011). The differences between medalists and non-medalists at the 2008 Olympic Games taekwondo tournament. *Hum Mov*; 12:165–70.
11. Hardy L, Jones G, Gould D, eds (1996). *Understanding psychological preparation for sport*. New York: John Wiley and Sons.

12. Falcó C, Alvarez O, Castillo I, et al (2009). Influence of the distance in a roundhouse kick's execution time and impact force in taekwondo. *J Biomech*; 42:242–8.
13. González de Prado C, Iglesias X, Mirallas J, et al (2011). Sistematización de la acción táctica en el taekwondo de alta competición. Apunts. *Educación Física y Deportes*; 103:56–67.
14. Junge A, Engebretsen L, Alonso JM, et al (2008). Injury surveillance in multi-sport events: The International Olympic Committee approach. *Br J Sports Med*; 42:413–21.
15. Feehan M, Waller AE (1995). Precompetition injury and subsequent tournament performance in full-contact taekwondo. *Br J Sports Med*; 29:258–62.
16. Beis K, Tsaklis P, Pieter W, et al (2001). Taekwondo competition injuries in Greek young and adult athletes. *Eur J Sports Traumatol Relat Res*; 23:130–6.
17. Lystad RP, Pollard H, Graham PL (2009). Epidemiology of injuries in competition taekwondo: a meta-analysis of observational studies. *J Sci Med Sport*; 12:614–21.
18. Schluter-Brust K, Leistenschneider P, Dargel J, et al (2011). Acute injuries in taekwondo. *Int J Sports Med*; 32:629–34.
19. Kazemi M (2012). Relationships between injury and success in elite taekwondo athletes. *J Sports Sci*; 30:277–83.
20. Pieter W, Fife GP, O'Sullivan DM (2012). Competition injuries in taekwondo: A literature review and suggestions for prevention and surveillance. *Br J Sports Med*; 46:485–91.
21. Engebretsen L, Soligard T, Steffen K, et al (2013). Sports injuries and illnesses during the London Summer Olympic Games. *Br J Sports Med*; 47:407–14.
22. Pieter W, Zemper ED (1999). Head and neck injuries in young taekwondo athletes. *J Sports Med Phys Fitness*; 39:147–53.
23. Zetou E (2006). Injuries in taekwondo athletes. Physical Training. *http://ejmas.com/pt/2006pt/ptart_Zetou_0906. html* (accessed 30 May2013).
24. Kazemi M, Shearer H, Choung YS (2005). Pre-competition habits and injuries in taekwondo athletes. *BMC Musculoskelet Disord*; 6:26.
25. Pieter W. Taekwondo. In: Kordi R, Mafulli N, Wroble RR, Wallace WA, eds (2009). *Combat sports medicine*. London: Springer, pp263–86.
26. Kibler W B, Press J, Sciascia A (2006). The role of core stability in athletic function. *Sports Med*; 36: 189 – 19.
27. Wilson J, Davis I (2008). Utility of frontal plane projection angle in females with patellofemoral pain. *J Orthop Sport Phys Ther*; 38: 606 – 615.
28. Ryan M B, MacLean C, Taunton J E (2006). A review of anthropometric, biomechanical, neuromuscular and training related factors associated with injury. *Int Sports Med J*; 7: 120 – 1.
29. Cook G, Burton L, Hoogenboom B (2006). Pre-participation screening: the use of fundamental movements as an assessment of function – part 1. *North Am J Sports Phys Ther*; 1: 62 – 72.
30. Cook G, Burton L, Hoogenboom B (2006). *Pre-participation screening: the use of fundamental movements as an assessment of function* – Part 2. *N Am J Sports Phys Ther*.;1(2):62-72.
31. Kiesel, K., Plisky, P. J., & Voight, M. L. (2007). Can serious injury in professional football be predicted by a preseason functional movement screen. *N Am J Sports Phys Ther*; 2(3): 147-158.
32. Kiesel, K. B., Butler, R. J., & Plisky, P. J. (2014). Prediction of injury by limited and asymmetrical fundamental movement patterns in american football players. *Journal of Sport Rehabilitation*; 23(2): 88-94.
33. Lystad, R. P., Graham, P. L., & Poulos, R. G. (2015). Injury risk perception in Taekwondo: a cross-sectional study. *International Journal of Sport Psychology*; 46(3): 244-257.
34. Lystad, R. P., Swain, M. S., & Graham, P. L. (2013). Risk factors for injury in Olympic-style competition taekwondo: a systematic review. The Journal of sports medicine and physical fitness; 53(6): 655-664.
35. Harriss D J, Atkinson G (2013). Ethical standards in sports and exercise science research: 2014 update. *Int J Sports Med*; 34: 1025 – 1028.
36. Lystad, R. P., Graham, P. L., & Poulos, R. G. (2015). Injury risk perception in Taekwondo: a cross-sectional study. *International Journal of Sport Psychology*; 46(3): 244-257.
37. Shultz, R., Anderson, S. C., Matheson, G. O., Marcello, B., & Besier, T. (2013). Test-retest and interrater reliability of the functional movement screen. *Journal of athletic training*; 48(3): 331-336.
38. 31. Minick K I, Kiesel K, Burton L, Taylor A, Plisky P, Butler R J (2010). Interrater Reliability of the Functional Movement Screen. *J Strength Cond Res;* 24(2):479-86.
39. Schneiders A G, Davidsson A, Horman E, Sullivan J S (2011). Functional Movement Screen Normative Values in a Young, Active Population. *Int J Sports Phys Ther*; 6: 75 – 82.
40. Kiesel K B, Plisky P, Voight M I (2007). Can serious injury in professional football be predicted by a preseason functional movement screen? *North Am J Sports Phys Ther*; 2: 147 – 158.
41. Willson J D, Dougherty C P, Ireland M L, Davis I M (2005). Core stability and its relationship to lower extremity function and injury. *J Am Acad Orthop Surg*; 13: 316 – 325.
42. Willson J D, Ireland M L, Davis I S (2006). Core strength and lower extremity alignment during single leg squats. *Med Sci Sports & Exerc*; 38: 945 – 952.

43. Schneiders A G, Davidsson A, Horman E, Sullivan J S (2011). Functional Movement Screen Normative Values in a Young, Active Population. *Int J Sports Phys Ther*; 6: 75 – 82.
44. Cook G, Burton L, Hoogenboom B (2006). Pre-participation screening: the use of fundamental movements as an assessment of function – Part 2. *North Am J Sports Phys Ther*; 1: 132 – 139.
45. Bahr R, Holme I (2003). Risk factors for sports injuries – a methodological approach. *Br J Sports Med;* 37: 384 – 392.
46. Bahr R, Krosshaug T (2005). Understanding injury mechanisms: a key component of preventing injuries in sport. *Br J Sports Med*; 39: 324 – 329.

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