Comparison of BKFO Test Scores for Core Stability and Muscle Endurance in Active Women Aged 18–25 with Chronic Groin Pain and Healthy Women in Urmia

1.Roghayeh Ahmari ,2. Somayeh Momeni
1-Master's Degree in Sports Injuries and Corrective Movements Department of Sports Sciences, Faculty of Physical Education, Payame Noor University, South Tehran Branch, Tehran, Iran-**Email**: Sagarahmari@yahoo.com **ORCID**: 0009-0003-3057-2712
2-Assistant Professor of Sports Injuries and Corrective Movements Department of Sports Sciences, Faculty of Physical Education, Payame Noor University, South Tehran Branch, Tehran, Iran - Email: Dr.momeni@pnu.ac.ir ORCID: 0000-0002-7889-9701

Abstract

This study aimed to compare BKFO test scores as a screening tool for assessing core stability and muscle endurance in active women aged 18–25 with chronic groin pain and a healthy group in Urmia. This cross-sectional analytical study included 34 participants (17 with groin pain and 17 healthy), selected through purposive sampling. The BKFO test was used to evaluate lumbopelvic stability, and demographic data were collected via questionnaires and physical examinations. Statistical analysis, including the Shapiro-Wilk test and independent t-test, revealed a significant difference in BKFO test scores between the two groups ($p < 0.05$), with the groin pain group showing poorer stability. The findings suggest that reduced core stability and muscle endurance may be risk factors for chronic groin pain. These results emphasize the importance of targeted rehabilitation and preventive measures to improve lumbopelvic stability in athletes.

Keywords: Core stability, groin pain, BKFO test, lumbopelvic stability, functional screening, athletes

Introduction

Groin and hip pain is a common musculoskeletal complaint among young and middle-aged individuals, significantly affecting their physical performance. Groin injuries are prevalent in multi-directional sports requiring activities such as running, jumping, repeated starts, kicking, shooting, speed, and twisting movements, including soccer, Australian football, rugby, cricket, ice hockey, basketball, and handball (Holmich et al., 2014; Thorborg et al., 2018). Recent studies have focused on injuries from proximal to distal regions. Given the interconnected chain of body segments, athletes require strength and stability in the trunk and lower limb muscles to maintain movement stability across all three planes (Leetun et al., 2004). Research indicates that joint instability and uncontrolled joint movements may alter lower limb and distal segment motion, increasing the risk of lower limb injuries (Ferber et al., 2015; Hein et al., 2012).

Functional tests have gained attention for identifying and correcting faulty movement patterns and preventing sports-related injuries caused by these patterns. Consequently, movement screening tests have expanded significantly to assess athletes' and active individuals' performance, identify movement pattern weaknesses, and predict injuries. Screening tests evaluate injury risk, functional movement deficits, neuromuscular control, balance, and core stability (Garrison et al., 2015; Kiesel et al., 2014). The goal of functional screening tests is to identify individuals at risk of injury, enabling appropriate interventions to correct movement impairments and improve physical readiness. Assessing core stability is essential for identifying motor control deficits and movement strategies. Given the close relationship between neuromuscular performance of the hip/groin muscles and the lumbopelvic complex, and their impact on movement patterns, and considering the lack of studies on screening tests for core stability and muscle endurance in women with hip/groin pain, this study aimed to compare BKFO test scores in active women aged 18–25 with chronic groin pain and healthy counterparts in Urmia.

Impact of Muscle Activity Impairment on Movement Patterns

Repetitive movements and prolonged improper postural alignment alter muscle tissue characteristics, leading to imbalances in the global muscle system. This causes stress and strain in specific directions on various body structures, which, if exceeding tissue tolerance, results in recurrent pain and chronic musculoskeletal pain syndromes.

Movement pattern disorders are a significant factor in musculoskeletal impairments. Therefore, efforts focus on achieving coordinated activity among all muscles within a balanced muscle system for pain treatment and prevention. Reduced or excessive activity in synergistic muscles involved in movement disrupts movement

rhythm and causes pain. Thus, muscle activity levels or the sequence and timing of muscle activation are used as criteria for evaluating movement patterns.

Impact of Injury on Movement

Examining the effect of a localized distal joint injury on proximal muscle performance is critical in assessing and treating musculoskeletal injuries. Although few studies exist in this area, analyzing empirical evidence provides valuable insights into compensatory mechanisms. A controlled study by Cook et al. (2010) compared hip muscle performance in individuals with a history of severe unilateral ankle sprains to a control group. Electromyography recorded the activation patterns of the gluteus maximus, hamstrings, and lateral spinal extensors on both the affected and unaffected sides during prone hip extension. Analysis showed significant differences in muscle activation patterns in the injury group compared to the control group, observed on both sides. A notable difference was the delayed onset of gluteus maximus activation in the injury group. These subtle changes in muscle performance post-injury highlight the importance of comprehensive injury assessment.

Proximal changes may represent an inhibitory protective response to prevent further injury or may reduce or alter proprioception in the injured distal region, leading to decreased coordination in the proximal muscle system during functional activities. Alternatively, changes may stem from pain associated with the original injury, leaving a residual inhibitory effect even after the injury resolves.

These explanations align with findings by Vladimir Janda et al. (2017), who provided a framework for comprehensive rehabilitation addressing secondary proximal effects of primary distal injuries. The primary goal of movement screening is to assess fundamental movement patterns and motor control, identify restrictions or asymmetries, and evaluate their effects. Once significant asymmetries and restrictions are identified, more precise measurements can be conducted. The core idea of screening is to describe movement pattern quality using a simple grading system.

Research indicates a close anatomical and muscular relationship between the groin and lumbopelvic regions, influencing each other's performance. Studies show that athletes with groin pain exhibit core region deficits and musculoskeletal coordination issues compared to healthy peers. Given the lack of studies on female athletes engaged in activities prone to groin injuries, this study aimed to address this gap by comparing BKFO test scores for core stability and muscle endurance in active women aged 18–25 with chronic groin pain and healthy women in Urmia.

Study Design and Population

This cross-sectional analytical study included active women aged 18–25 engaged in multi-directional sports. The sample consisted of 34 active women (scoring 13–15 on the Baecke Physical Activity Questionnaire) in Urmia's futsal clubs, divided into healthy and groin pain groups. After coordination with Takhti Sports Complex in Urmia, participants meeting inclusion criteria completed information forms and were enrolled. The study was conducted over nine months in 2021–2022.

Sampling Method and Sample Size

Purposive sampling was used, with participants selected after completing consent forms, information questionnaires, and meeting inclusion/exclusion criteria. The sample size was calculated using G*Power software, with a statistical power of 0.80, a significance level of 0.05, and an effect size of 0.80, accounting for a 5% dropout rate, resulting in a total of 34 participants.

Inclusion and Exclusion Criteria

Inclusion Criteria for Women with Hip/Groin Pain:

- Groin pain during or after sports activity persisting for over six weeks

- Tenderness on palpation of the adductor tendon or pubic symphysis

- Positive squeeze test at 45° hip flexion or pain during active abduction against resistance

- No history of surgery in the lower abdomen, hip, or groin

- No inguinal hernia

- No history of low back or sacroiliac pain in the past year

- No neurological symptoms (e.g., numbness, burning, tingling) in the lower limbs

Inclusion Criteria for Healthy Individuals:

- Negative squeeze test at 45° hip flexion

- No history of lower limb injury in the past year

Ethical Considerations

This non-invasive study posed no risk to participants. All procedures were explained, and written information was provided. Participants signed informed consent forms and could withdraw at any stage. Data were protected and accessible only to the research team. The researcher facilitated participants' involvement in the study.

Research Tools and Data Collection

- Interview and Questionnaire: To assess healthy active women and those with hip/groin pain history

- Baecke Physical Activity Questionnaire: To determine physical activity levels

- Physical Examination: Conducted by a physiotherapist

- Consent Form: To confirm participants' willingness to participate

- Demographic Information Form: For individual data collection

- SECA 755 Analog Scale: For weight measurement (accuracy: 0.01 kg)

- SECA 220 Height Meter: For height measurement (accuracy: 1 cm)

- Omax Digital Timer: For recording test performance time (accuracy: 0.01 seconds)

- Pressure Device: To assess lumbopelvic stability during the BKFO test

Tests Used

Bent Knee Fall Out (BKFO) Test:

Participants lay supine, with a pressure device placed vertically under the lumbar spine, its lower edge 2 cm from the posterior superior iliac spine on the tested side. A rolled towel was placed under the lumbar spine where the leg rested flat on the ground. Participants flexed the knee on the tested side to 120° and slowly abducted and laterally rotated the hip to approximately 45°, then returned to the starting position. The other knee remained neutral, with the foot flat on the ground.

Procedure

Participants were active women aged 18–25 with or without groin pain, engaged in multi-directional futsal in Urmia's clubs. After coordination with club management and coaches, eligible participants were selected purposively based on inclusion/exclusion criteria and informed consent. A physiotherapist evaluated participants for groin pain, diagnosed by tenderness in the proximal adductor muscles and positive results in at least two specific tests (resisted adduction and squeeze test). Pain during the squeeze test was measured using a pain ruler. Each participant performed the screening test under identical conditions in a single session, with scores recorded. Data were compared between healthy and groin pain groups. For the groin pain group, core stability tests were conducted after inflammation subsided, as acute inflammation could affect performance.

Data Analysis and Hypothesis Testing

Descriptive statistics were used to extract participant characteristics, including central tendency and dispersion for age, height, weight, and BMI, presented in Table 1.

Table 1: Mean and Standard Deviation of Participants' Demographic Characteristics in Healthy and Groin Pain Groups

Group / Variable	Healthy Group (Mean ± SD)	Groin Pain Group (Mean ± SD)	Significance (p-value)
Age (years)	21.82 ± 2.12	21.47 ± 2.29	0.66
Height (cm)	166.5 ± 4.57	167.9 ± 4.81	0.58
Weight (kg)	57.6 ± 4.67	58.5 ± 4.72	0.82
Body Mass Index (kg/m²)	20.3 ± 0.99	20.6 ± 1.02	0.40

Findings showed no significant differences in demographic characteristics between groups ($p > 0.05$). The Shapiro-Wilk test assessed data normality, and statistical analyses were performed using SPSS version 23, with a significance level of $p < 0.05$.

Table 2: Shapiro-Wilk Test Results for Study Variables by Group

Group	Variable	N	Significance (p-value)
Healthy Group	BKFO	17	0.55
Groin Pain Group	BKFO	17	0.61

The Shapiro-Wilk test showed that study variables were normally distributed in both groups ($p > 0.05$), allowing the use of the independent t-test to compare scores between groups.

The hypothesis stated a significant difference in lumbopelvic stability test scores between active women aged 18–25 with chronic groin pain and healthy counterparts.

Table 3: Mean Scores of Lumbopelvic Stability Between Healthy and Groin Pain Groups

Variable	Group	Mean ± SD	t value	Significance (p-value)
BKFO	Healthy	2.56 ± 0.90	-15.47	0.00
	Groin pain	10.48 ± 1.90		

The independent t-test showed a significant difference in BKFO test scores for lumbopelvic stability between groups ($p < 0.05$). The groin pain group exhibited weaker stability and lumbopelvic dysfunction compared to the healthy group, confirming the hypothesis.

Conclusion

The BKFO test compared core stability performance between active women with chronic groin pain and healthy counterparts. Scores for core stability and muscle endurance were significantly lower in the groin pain group. Although it is unclear whether these results predate or result from the injury, the significant performance difference suggests these factors as key risk factors for groin injury recurrence. Thus, strengthening and enhancing core stability should be prioritized in managing this condition. Preventive programs focusing on screening and reducing injury risk factors are crucial. Reduced core stability and muscle endurance are significant risk factors, and rehabilitation targeting these areas is effective for prevention and treatment. It is recommended to focus on movement patterns, core stability, and muscle strength/endurance in rehabilitation and pre-season injury screening.

References

Bahiraei, S., Sharbatzadeh, R., & Nouri, M. (2019). *Relationship between core stability and Functional Movement Screening test in athletes*.

Caldemeyer, L. E., Brown, S. M., & Mulcahey, M. K. (2020). Neuromuscular training for the prevention of ankle sprains in female athletes: a systematic review. *The Physician and Sportsmedicine*, *48*(4), 363–369.

Chaari, F., Rebai, H., Boyas, S., Rahmani, A., Fendri, T., Harrabi, M. A., & Sahli, S. (2021). Postural balance impairment in Tunisian second division soccer players with groin pain: A case-control study. *Physical Therapy in Sport*, *51*, 85–91.

Cook, G. (2010). Movement: Functional movement systems: Screening, assessment. *Corrective Strategies (1st Ed.). Aptos, CA: On Target Publications*, 73–106.

Cook, G., Burton, L., & Hoogenboom, B. (2006). Pre-participation screening: the use of fundamental movements as an assessment of function - part 1. *North American Journal of Sports Physical Therapy : NAJSPT*, *1*(2), 62–72. Retrieved from https://pubmed.ncbi.nlm.nih.gov/21522216

Cook, G., Burton, L., Hoogenboom, B. J., & Voight, M. (2014). Functional movement screening: the use of fundamental movements as an assessment of function-part 1. *International Journal of Sports Physical Therapy*, *9*(3).

Coughlan, G. F., Fullam, K., Delahunt, E., Gissane, C., & Caulfield, B. M. (2012). A comparison between performance on selected directions of the star excursion balance test and the Y balance test. *Journal of Athletic Training*, *47*(4), 366–371.

Cowan, S. M., Schache, A. G., Brukner, P., Bennell, K. L., Hodges, P. W., Coburn, P., & Crossley, K. M. (2004). Delayed onset of transversus abdominus in long-standing groin pain. *Medicine and Science in Sports and Exercise*, *36*(12), 2040–2045.

Davies, A. G., Clarke, A. W., Gilmore, J., Wotherspoon, M., & Connell, D. A. (2010). Review: imaging of groin pain in the athlete. *Skeletal Radiology*, *39*(7), 629–644. https://doi.org/10.1007/s00256-009-0768-9

Ekstrand, J., Hägglund, M., & Waldén, M. (2011). Injury incidence and injury patterns in professional football: the UEFA injury study. *British Journal of Sports Medicine*, *45*(7), 553 LP – 558.

Ekstrand, J., & Hilding, J. (2007). The incidence and differential diagnosis of acute groin injuries in male soccer players. *Scandinavian Journal of Medicine & Science in Sports*, *9*(2), 98–103. https://doi.org/10.1111/j.1600-0838.1999.tb00216.x

Elliott, A. M., Smith, B. H., Penny, K. I., Smith, W. C., & Chambers, W. A. (1999). The epidemiology of chronic pain in the community. *Lancet (London, England)*, *354*(9186), 1248–1252.

Falvey, E. C., Franklyn-Miller, A., & McCrory, P. R. (2009). The groin triangle: a patho-anatomical approach to the diagnosis of chronic groin pain in athletes. *British Journal of Sports Medicine*, *43*(3), 213 LP – 220.

Ferber, R., Bolgla, L., Earl-Boehm, J. E., Emery, C., & Hamstra-Wright, K. (2015). Strengthening of the hip and core versus knee muscles for the treatment of patellofemoral pain: a multicenter randomized controlled trial. *Journal of Athletic Training*, *50*(4), 366–377. https://doi.org/10.4085/1062-6050-49.3.70

Garrison, M., Westrick, R., Johnson, M. R., & Benenson, J. (2015). Association between the functional movement screen and injury development in college athletes. *International Journal of Sports Physical Therapy*, *10*(1), 21.

Gray Cook, L. B., Hoogenboom, B. J., & Voight, M. (2014). Functional movement screening: The use of fundamental movements as an assessment of function-Part 2. *International Journal of Sports Physical Therapy*, *9*(4), 549.

Greene, P. F., Durall, C. J., & Kernozek, T. W. (2012). Intersession reliability and concurrent validity of isometric endurance tests for the lateral trunk muscles. *Journal of Sport Rehabilitation*, *21*(2), 161–166.

Gribble, P. A., Hertel, J., & Plisky, P. (2012). Using the Star Excursion Balance Test to assess dynamic postural-control deficits and outcomes in lower extremity injury: a literature and systematic review. *Journal of Athletic Training*, *47*(3), 339–357.

Hagglund, M. (2006). Previous injury as a risk factor for injury in elite football: a prospective study over two consecutive seasons. *British Journal of Sports Medicine*, *40*(9), 767–772. https://doi.org/10.1136/bjsm.2006.026609

Hein, T., Schmeltzpfenning, T., Krauss, I., Maiwald, C., Horstmann, T., & Grau, S. (2012). Using the variability of continuous relative phase as a measure to discriminate between healthy and injured runners. *Human Movement Science*, *31*(3), 683–694. https://doi.org/10.1016/j.humov.2011.07.008

Hides, J. A., Brown, C. T., Penfold, L., & Stanton, W. R. (2011). Screening the Lumbopelvic Muscles for a Relationship to Injury of the Quadriceps, Hamstrings, and Adductor Muscles Among Elite Australian Football League Players. *Journal of Orthopaedic & Sports Physical Therapy*, *41*(10), 767–775. https://doi.org/10.2519/jospt.2011.3755

Hodges, P W. (2004). Lumbopelvic stability: a functional model of the biomechanics and motor control. *Therapeutic Exercise for Lumbopelvic Stabilization*.

Hodges, Paul W. (2003). Core stability exercise in chronic low back pain. *Orthopedic Clinics*, *34*(2), 245–254.

Holmich, P., Thorborg, K., Dehlendorff, C., Krogsgaard, K., & Gluud, C. (2014). .Incidence and clinical presentation of groin injuries in sub-elite male soccer. *British Journal of Sports Medicine*, *48*(16), 1245–1250. https://doi.org/10.1136/bjsports-2013-092627

Janse van Rensburg, L., Dare, M., Louw, Q., Crous, L., Cockroft, J., Williams, L., & Olivier, B. (2017). Pelvic and hip kinematics during single-leg drop-landing are altered in sports participants with long-standing groin pain: A cross-sectional study. *Physical Therapy in Sport : Official Journal of the Association of Chartered Physiotherapists in Sports Medicine*, *26*, 20–26. https://doi.org/10.1016/j.ptsp.2017.05.003

Jansen, J., Weir, A., Dénis, R., Mens, J., Backx, F., & Stam, H. (2010). Resting thickness of transversus abdominis is decreased in athletes with longstanding adduction-related groin pain. *Manual Therapy*, *15*(2), 200–205.

Kibler, W. Ben, Press, J., & Sciascia, A. (2006). The role of core stability in athletic function. *Sports Medicine*, *36*(3), 189–198.

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.

Koulouris, G. (2008). Imaging review of groin pain in elite athletes: an anatomic approach to imaging findings. *AJR. American Journal of Roentgenology*, *191*(4), 962–972. https://doi.org/10.2214/AJR.07.3410

Kulas, A. S., Hortobágyi, T., & DeVita, P. (2012). Trunk position modulates anterior cruciate ligament forces and strains during a single-leg squat. *Clinical Biomechanics*, *27*(1), 16–21.

Lanning, C. L., Uhl, T. L., Ingram, C. L., Mattacola, C. G., English, T., & Newsom, S. (2006). Baseline values of trunk endurance and hip strength in collegiate athletes. *Journal of Athletic Training*, *41*(4), 427.

LeBlanc, K. E., & LeBlanc, K. A. (2003). Groin pain in athletes. *Hernia*, *7*(2), 68–71. https://doi.org/10.1007/s10029-002-0105-x

Leetun, D. T., Ireland, M. L., Willson, J. D., Ballantyne, B. T., & Davis, I. M. (2004). Core stability measures as risk factors for lower extremity injury in athletes. *Medicine and Science in Sports and Exercise*, *36*(6), 926–934.

Linek, P., Booysen, N., Sikora, D., & Stokes, M. (2019). Functional movement screen and Y balance tests in adolescent footballers with hip/groin symptoms. *Physical Therapy in Sport*, *39*, 99–106. https://doi.org/https://doi.org/10.1016/j.ptsp.2019.07.002

Mansourizadeh, R., Letafatkar, A., & Khaleghi-Tazji, M. (2019). Does athletic groin pain affect the muscular co-contraction during a change of direction. *Gait & Posture*, *73*, 173–179.

Mascal, C. L., Landel, R., & Powers, C. (2003). Management of patellofemoral pain targeting hip, pelvis, and trunk muscle function: 2 case reports. *Journal of Orthopaedic & Sports Physical Therapy*, *33*(11), 647–660.

McGill, S. M., Childs, A., & Liebenson, C. (1999). Endurance times for low back stabilization exercises: clinical targets for testing and training from a normal database. *Archives of Physical Medicine and Rehabilitation*, *80*(8), 941–944.

McKenzie, C. R., Whatman, C., Brughelli, M., & Borotkanics, R. (2019). The effect of the NetballSmart Dynamic Warm-up on physical performance in youth netball players. *Physical Therapy in Sport*, *37*, 91–98.

Mitchell, U. H., Johnson, A. W., & Adamson, B. (2015). Relationship between functional movement screen scores, core strength, posture, and body mass index in school children in Moldova. *The Journal of Strength & Conditioning Research*, *29*(5), 1172–1179.

Morrissey, D., Graham, J., Screen, H., Sinha, A., Small, C., Twycross-Lewis, R., & Woledge, R. (2012). Coronal plane hip muscle activation in football code athletes with chronic adductor groin strain injury during standing hip flexion. *Manual Therapy*, *17*(2), 145–149. https://doi.org/10.1016/j.math.2011.12.003

Nesser, T. W., Huxel, K. C., Tincher, J. L., & Okada, T. (2008). The relationship between core stability and performance in division I football players. *The Journal of Strength & Conditioning Research*, *22*(6), 1750–1754.

O'Sullivan, P. B., Beales, D. J., Beetham, J. A., Cripps, J., Graf, F., Lin, I. B., … Avery, A. (2002). Altered motor control strategies in subjects with sacroiliac joint pain during the active straight-leg-raise test. *Spine*, *27*(1), E1-8. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/11805650

Peate, W. F., Bates, G., Lunda, K., Francis, S., & Bellamy, K. (2007). Core strength: a new model for injury prediction and prevention. *Journal of Occupational Medicine and Toxicology*, *2*(1), 1–9.

Persson, U. M., O'Sullivan, R. M., Morrissey, D., & Wallace, J. (2017). The ability of athletes with long-standing groin pain to maintain a stable lumbopelvic position: A laboratory study. *Physical Therapy in Sport*, *23*, 45–49.

Reiman, M. P., Krier, A. D., Nelson, J. A., Rogers, M. A., Stuke, Z. O., & Smith, B. S. (2012). Comparison of different trunk endurance testing methods in college-aged individuals. *International Journal of Sports Physical Therapy*, *7*(5), 533–539. Retrieved from https://pubmed.ncbi.nlm.nih.gov/23091786

Robinson, P., Barron, D. A., Parsons, W., Grainger, A. J., Schilders, E. M. G., & O'Connor, P. J. (2004). Adductor-related groin pain in athletes: correlation of MR imaging with clinical findings. *Skeletal Radiology*, *33*(8), 451–457. https://doi.org/10.1007/s00256-004-0753-2

Roughead, E. A., King, M. G., Crossley, K. M., Heerey, J. J., Lawrenson, P. R., Scholes, M. J., … Kemp, J. L. (2022). Football players with long standing hip and groin pain display deficits in functional task performance. *Physical Therapy in Sport*, *55*, 46–54.

Roussel, N., Nijs, J., Truijen, S., Vervecken, L., Mottram, S., & Stassijns, G. (2009). Altered breathing patterns during lumbopelvic motor control tests in chronic low back pain: a case–control study. *European Spine Journal*, *18*(7), 1066–1073.

Safari, S., Naseri, N., Nakhostin Ansari, N., Sarafzadeh, J., & Mansoor Sohani, S. (2013). Comparison of core stability between male soccer players with and without hip adductors strain. *Modern Rehabilitation*, *7*(1). Retrieved from http://mrj.tums.ac.ir/article-1-8-fa.html

Safran, M., & Karahan, M. (Eds.). (2019). *Hip and groin pain in the athlete*. Springer Berlin Heidelberg.

Sarto, F., Grigoletto, D., Baggio, E., Paoli, A., & Marcolin, G. (2019). Do lower limb previous injuries affect balance performance? An observational study in volleyball players. *Physical Therapy in Sport*, *37*, 49–53.

Sayed Mohammad, W., Ragaa Abdelraouf, O., & Abdel-aziem, A. A. (2014). Concentric and eccentric strength of trunk muscles in osteitis pubis soccer players. *Journal of Back and Musculoskeletal Rehabilitation*, *27*(2), 147–152. https://doi.org/10.3233/BMR-130429

Sharrock, C., Cropper, J., Mostad, J., Johnson, M., & Malone, T. (2011). A pilot study of core stability and athletic performance: is there a relationship? *International Journal of Sports Physical Therapy*, *6*(2), 63.

Tak, I., Glasgow, P., Langhout, R., Weir, A., Kerkhoffs, G., & Agricola, R. (2016). Hip Range of Motion Is Lower in Professional Soccer Players With Hip and Groin Symptoms or Previous Injuries, Independent of Cam Deformities. *The American Journal of Sports Medicine*, *44*(3), 682–688. https://doi.org/10.1177/0363546515617747

Tammareddi, K., Morelli, V., & Reyes, M. (2013). The Athlete's Hip and Groin. *Primary Care: Clinics in Office Practice*, *40*(2), 313–333. https://doi.org/10.1016/j.pop.2013.02.005

Thorborg, K., Reiman, M. P., Weir, A., Kemp, J. L., Serner, A., Mosler, A. B., & HOlmich, P. (2018). Clinical Examination, Diagnostic Imaging, and Testing of Athletes With Groin Pain: An Evidence-Based Approach to Effective Management. *The Journal of Orthopaedic and Sports Physical Therapy*, *48*(4), 239–249. https://doi.org/10.2519/jospt.2018.7850

Willson, J. D., Dougherty, C. P., Ireland, M. L., & Davis, I. M. (2005). Core stability and its relationship to lower extremity function and injury. *The Journal of the American Academy of Orthopaedic Surgeons*, *13*(5), 316–325.

Willson, J. D., Ireland, M. L., & Davis, I. (2006). Core strength and lower extremity alignment during single leg squats. *Medicine & Science in Sports & Exercise*, *38*(5), 945–952.

Zech, A., Meining, S., Hötting, K., Liebl, D., Mattes, K., & Hollander, K. (2018). Effects of barefoot and footwear conditions on learning of a dynamic balance task: a randomized controlled study. *European Journal of Applied Physiology*, *118*(12), 2699–2706.