Physical Therapy in Sport xxx (xxxx) 1–5

Contents lists available at ScienceDirect

Physical Therapy in Sport

journal homepage: http://ees.elsevier.com

Original Research

Field-based evaluation of hip adductor and abductor strength in professional male ice hockey players: Reference values and influencing factors

Ruben Oliveras [a,b], Mario Bizzini [a], Romana Brunner [a], Nicola A. Maffiuletti [a,*]

[a] *Human Performance Lab, Schulthess Clinic, Zurich, Switzerland*
[b] *ETH, Zurich, Switzerland*

ARTICLE INFO

Article history:
Received 2 November 2019
Received in revised form 11 March 2020
Accepted 19 March 2020
Available online xxx

Keywords
Muscle strength
Ice hockey
Hip adductors
Hip/groin pain

ABSTRACT

Objectives: To provide reference values and examine the influence of hip/groin pain on hip adductor and abductor strength in professional male ice hockey players, by using a straightforward 5-min procedure.
Design: Cross-sectional study.
Setting: On-field assessment of hip/groin muscle strength with dynamometry, together with the concomitant level of hip/groin pain with a visual analogue scale.
Participants: Professional male ice hockey players competing in the Swiss National League (n = 187).
Main outcome measures: Hip abductor strength, hip adductor strength and hip adductor:abductor ratio.
Results: Reference values by playing position (goalkeepers, defenders and forwards) are provided for asymptomatic athletes. Players with hip/groin pain during adduction displayed lower hip adductor strength ($p = 0.001$) and hip adductor:abductor ratio ($p = 0.012$) than their symptom-free peers.
Conclusions: The presence of hip/groin pain during adductor testing may contribute to selective hip adductor weakness, whose cause-effect relation with possible groin problems remains to be demonstrated.

1. Introduction

Hip and groin problems (including adductor-related injuries) are common in sports that involve rapid accelerations and decelerations as well as sudden changes in direction such as ice hockey (Emery & Meeuwisse, 2001; Nicholas & Tyler, 2002; Pettersson & Lorentzon, 1993; Worner, Thorborg, & Eek, 2019). Groin strains accounted for 10% of all injuries in elite Swedish ice hockey players (Lorentzon, Wedren, & Pietila, 1988; Pettersson & Lorentzon, 1993), and for 43% of all muscle strains in elite Finnish ice hockey players (Molsa, Airaksinen, Nasman, & Torstila, 1997). In a study comprising over 1′000 National Hockey League players, Emery & Meuwisse (Emery & Meeuwisse, 2001) reported that more than 80% of all groin and abdominal strain injuries were classified as “groin adductor muscle” injuries.

A recent systematic review reported a high-level evidence for previous groin injury, higher level of play and lower hip abductor and adductor strength to be associated with an increased risk of groin injury in different sports (Whittaker, Small, Maffey, & Emery, 2015). Measurement of hip/groin muscle strength using hand-held dynamometry and sphygmomanometer methods have become popular in team sports (Nedelec et al., 2014; Schache, Crossley, Macindoe, Fahrner, & Pandy, 2011), particularly in elite soccer (Thorborg et al., 2011; Wollin, Thorborg, Welvaert, & Pizzari, 2018), while surprisingly research on hip adductor and abductor strength profiles of ice hockey players is still scanty. For example, Tyler et al. (Tyler, Nicholas, Campbell, & McHugh, 2001) found that preseason hip strength testing of professional ice hockey players could identify those at risk of developing adductor muscle strains. A player was 17 times more likely to sustain an adductor muscle strain during the competitive season if his adductor strength was less than 80% of the abductor strength. Wörner et al. (Worner et al., 2019) recently evaluated hip abductor and adductor strength in a large sample of male professional and semi-professional ice hockey players from Sweden (n = 333), but did not provide reference values - which can be useful for descriptive, diagnostic (e.g., to identify at risk athletes) and treatment-planning purposes.

One of the main factors influencing the voluntary force-generating capacity of a muscle is the presence of pain. As such, the impact of hip/groin pain on hip adductor and abductor strength has recently been investigated in different team-sport athletes. Malliaras et al. (Malliaras, Hogan, Nawrocki, Crossley, & Schache, 2009) demonstrated that football players with groin pain during running or rapid agility movements and in passive conditions generated less strength on the adductor squeeze test than their asymptomatic peers. Thorborg et al. (Thorborg et al., 2011) showed that the ratio between hip adduction and abduction strength was significantly lower in soccer players with groin pain during hip adduction testing compared with symptom-free play-

* Corresponding author.
E-mail address: nicola.maffiuletti@kws.ch (N.A. Maffiuletti)

https://doi.org/10.1016/j.ptsp.2020.03.006
1466-853/© 2020.

ers. More recently, hip adductor and abductor strength were found to be significantly lower in ice hockey players with higher hip/groin pain scores during the 5-s squeeze test (Worner et al., 2019). Thus, the concomitant evaluation of hip abductor/adductor strength with portable dynamometry and hip/groin pain with self-reported scales has potential value for clinical assessment of team-sport athletes.

The objectives of this study were to provide reference values for hip adductor and abductor strength, and to examine the influence of different factors on hip/groin strength - hip/groin pain during maximal contractions in particular - in a large sample of professional male ice hockey players. Because coaching and medical staff of professional teams are interested in valid and reliable testing procedures that are easy and quick to perform on the field, we aimed to conduct all the assessments with a straightforward field-based methodology that only required 5 min per player.

2. Methods

2.1. Participants and experimental procedure

One hundred eighty-seven professional male ice hockey players from different teams competing at the highest level in the Swiss National League volunteered to participate in this study. Their age, height, weight and playing experience (defined as the number of years competing at the highest level) were provided by respective medical teams (Table 1). All players except those underage and suffering a time-loss injury on the test day (i.e., being unable to fully participate in the subsequent practice session) had their hip adductor and abductor strength with concomitant pain levels evaluated by a group of three experienced examiners (RO, RB, MB). For each player, the entire testing procedure lasted approximately 5 min and was consistently completed before a conventional practice session at respective team training centres. All evaluations were performed between the end of the preseason preparatory phase and the beginning of the competitive season. Study approval was obtained from the local Ethics Committee (ID# 2017-00085). All participants were informed about the aim of the study and signed the informed consent prior to data collection.

Table 1
General characteristics of the ice hockey players by playing position.

	Goalkeepers (n = 12)	Defenders (n = 73)	Forwards (n = 102)	Total (n = 187)
Age (yrs)	26 ± 4	27 ± 5	26 ± 5	26 ± 5
Height (cm)	185 ± 6	184 ± 5	182 ± 5	183 ± 5
Weight (kg)	86 ± 8	88 ± 7	86 ± 7	87 ± 7
Playing experience (yrs)	5.4 ± 3.7	5.7 ± 5.5	5.4 ± 5.0	5.5 ± 5.1
Hip/groin pain during abduction (n)	0	4	0	4
Hip/groin pain during adduction (n)	1	11	13	25

Mean values ± SD.

2.2. Assessment of hip/groin strength

Maximal hip adductor and abductor strength was evaluated in isometric conditions by means of a recently-developed measurement device (GroinBar, Vald Performance, Albion, Australia) which has been shown to ensure a valid and reliable assessment of hip/groin muscle strength (Desmyttere, Gaudet, & Begon, 2019; O'Brien, Bourne, Heerey, Timmins, & Pizzari, 2019; Ryan, Kempton, Pacecca, & Coutts, 2019). The device consists of two independent load cells mounted on an adjustable frame, with a setup comparable to stabilized commercial dynamometers (Click Fenter, Bellew, Pitts, & Kay, 2003; Widler et al., 2009). Participants were asked to lie down in the supine position, with 45° of hip flexion and approximately 90° of knee flexion (Fig. 1). These angles were consistently verified with a manual goniometer (Orthopedic Goniometer, Orthopedic Equipment CO, Bourbon, Indiana, USA) both before and during the assessments. Participants were instructed to cross their arms across the chest and to keep their feet hip-width apart on the ground. The height of the measuring device was adjusted so that the center of the knee joints was aligned with the center of the dynamometer pads. This position was subsequently maintained during the entire testing session. For each muscle group, two submaximal contractions were performed for warm-up and familiarization purposes. Then, three sets of alternate hip adduction and abduction maximal isometric contractions were completed with rest periods of 10 and 30 s within and between each set, respectively (Fig. 1). The order of the assessments (i.e., hip adduction then abduction or vice versa) was randomized to avoid systematic bias. Following a standardized countdown (i.e., “3, 2, 1, go”), participants were instructed to squeeze (hip adduction) or pull (hip abduction) bilaterally against the dynamometer pads with a gradual build-up of force, and to sustain the maximal contraction for at least 3 s to ensure a force plateau. Consistent verbal encouragement (i.e., “go, go, go”) was provided throughout each contraction. For each muscle group and side, only the trial with the highest peak force was retained. The main outcomes were hip abductor and adductor strength (mean of left and right side) expressed in both absolute and relative units (normalized to body weight) as well as the ratio between hip adductor and hip abductor strength (hereafter referred to as hip adductor:abductor ratio).

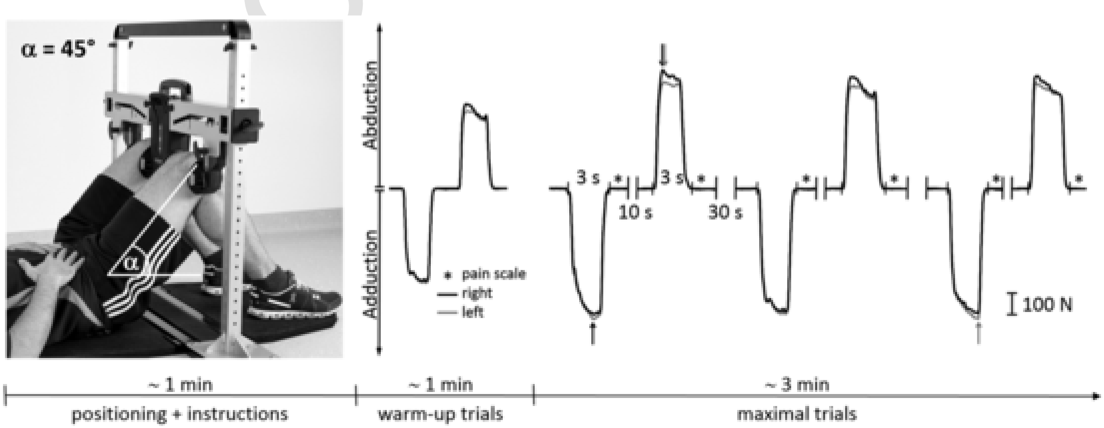

Fig. 1. Schematic representation of the 5-min testing procedure embracing a preparation phase, a standardized warm-up/familiarization phase and the maximal contractions. The position of the participants, representative hip abduction and adduction force-time curves from the left and right side (arrows show respective peak forces), as well as the duration of rest periods and timing of hip/groin pain evaluation are also shown.

2.3. Assessment of hip/groin pain

Hip/groin pain for abduction and adduction trials was evaluated using a visual analogue pain scale (Huskisson, 1974) immediately after each contraction. The level of hip pain ranged from "no pain" to "unbearable pain", which equated to a hidden 0–10 numerical rating scale. Participants were considered to have hip/groin pain during hip abduction/adduction trials if the mean level of pain was >2 (Worner et al., 2019). Hip/groin pain >2 was reported by 4 (2%) and 25 (13%) players for hip abduction and adduction, respectively (Table 1). Only one player had symptoms for both hip abduction and adduction trials, thus the remaining 159 players were considered asymptomatic.

2.4. Statistical analyses

For each dependent variable, mean values and standard deviations (SD) with the corresponding 95% confidence intervals (CI) as well as 25th and 75th percentiles were calculated to provide reference values for asymptomatic players. One-way ANOVAs, Pearson's product-moment correlations and unpaired t-tests were performed to investigate respectively the influence of playing position (goalkeepers vs. defenders vs. forwards), general characteristics (age, body weight and playing experience) and hip/groin pain (players with vs. without pain during hip adduction) on the dependent variables. The level of significance was set at $p < 0.05$.

3. Results

Absolute and relative hip abductor and adductor strength as well as hip adductor:abductor ratio are presented separately for goalkeepers, defenders and forwards in Table 2. For each variable and playing position, "low" and "high" refer respectively to the 25th and 75th percentiles. For the ensemble of the dependent variables, no significant difference was observed between goalkeepers, defenders and forwards ($p > 0.05$). In the same way, age, height and playing experience were not significantly correlated to hip abductor strength, hip adductor strength or hip adductor:abductor ratio ($p > 0.05$). Body weight was positively correlated to both hip abductor ($r = 0.41$, $p < 0.001$) and adductor ($r = 0.26$, $p < 0.001$) absolute strength, while it was negatively correlated with relative strength ($r = -0.16$, $p = 0.026$ for abduction; $r = -0.16$, $p = 0.029$ for adduction). No significant correlation was observed between body weight and hip adductor:abductor ratio ($p > 0.05$). Players with hip/groin pain during hip adduction ($n = 25$) had similar hip abductor strength compared to players with no pain ($n = 162$) (Fig. 2A), but lower hip adductor strength ($p = 0.001$; Fig. 2B) and hip adductor:abductor ratio ($p = 0.012$; Fig. 2C).

Table 2
Reference values of hip abductor and adductor strength by playing position (asymptomatic players).

	Absolute strength (N)			Relative strength (N/kg)		
	Mean (95%CI)	Low	High	Mean (95%CI)	Low	High
Hip abductor						
Goalkeepers (n = 11)	466 (418–515)	<407	>515	5.52 (5.12–5.91)	<5.09	>5.97
Defenders (n = 59)	457 (439–474)	<406	>492	5.20 (5.02–5.39)	<4.80	>5.56
Forwards (n = 89)	460 (447–473)	<425	>491	5.36 (5.22–5.51)	<4.89	>5.72
Hip adductor						
Goalkeepers (n = 11)	491 (430–553)	<445	>531	5.85 (5.07–6.63)	<5.00	>6.50
Defenders (n = 59)	472 (449–495)	<436	>553	5.38 (5.13–5.63)	<4.73	>6.12
Forwards (n = 89)	467 (450–484)	<422	>522	5.45 (5.26–5.64)	<4.93	>6.01
Hip adductor:abductor						
Goalkeepers (n = 11)	1.07 (0.92–1.21)	<0.89	>1.17			
Defenders (n = 59)	1.05 (0.99–1.10)	<0.94	>1.17			
Forwards (n = 89)	1.02 (0.99–1.05)	<0.93	>1.13			

"Low" and "high" refer to values below the 25th percentile and above the 75th percentile, respectively. CI: confidence interval.

4. Discussion

We have provided reference values for hip adductor and abductor strength using a straightforward field-based methodology, and demonstrated the negative impact of hip/groin pain on hip adductor strength and adductor:abductor ratio in a relatively large sample of professional male ice hockey players. We have also shown that playing position, age and playing experience have no major influence on frontal plane hip/groin strength.

The on-field methodology adopted in this study for the assessment of hip/groin strength - which involves the use of a recently-introduced and validated portable device (Groinbar) - is particularly adapted for professional teams, where time is an issue within the busy preparatory and competitive season. Besides allowing immediate feedback to the players and staff, this methodology is extremely time saving as only 2 h were necessary to obtain valid strength measures from a team of approximately 25 players. Because the maximal amount of time tolerated by the coaching and medical staff of the different teams for testing a single player was 5 min, no attempts were made to implement additional investigations of hip/groin disability and associated problems (using for example the HAGOS questionnaire) or to carefully document previous hip/groin injuries on an individual basis.

The absolute and relative reference values for hip/groin strength we have provided are potentially useful for descriptive, diagnostic and treatment-planning objectives. Potential applications of these easily-obtainable objective data include longitudinal monitoring across a competitive season (Wollin, Thorborg, & Pizzari, 2018) or during/after a congested phase (Wollin, Thorborg, & Pizzari, 2018) with the ultimate goal to implement injury prevention/rehabilitation/post-exercise recovery interventions, but also cross-sectional comparisons within and between teams/groups of athletes to identify weak/at risk players ("low" category for hip adductor strength and adductor:abductor ratio in Table 2) or strong athletes/talents ("high" category) by playing position. In this respect, it is interesting to note that the ice hockey players enrolled in our current study display the highest average strength values compared to other team-sport athletes tested with the Groinbar device at a similar hip position (Bourne et al., 2019; Desmyttere et al., 2019; O'Brien et al., 2019; Ryan et al., 2019) (see Table 3). Actually, in this study the test configuration with the hip flexed at 45° was preferred to the one with the hip (and knee) fully extended as ice hockey players skate almost constantly in hip flexed positions (Chang, Turcotte, & Pearsall, 2009; Sim & Chao, 1978), but also because of the recent evidence showing a strong association between low hip adductor strength during a squeeze test with the hip flexed at 45° and sports-related groin pain in athletes (Kloskowska, Morrissey, Small, Malliaras, & Barton, 2016). This despite the fact that the contribution of hip rotator muscles is greater in this semi-flexed position com-

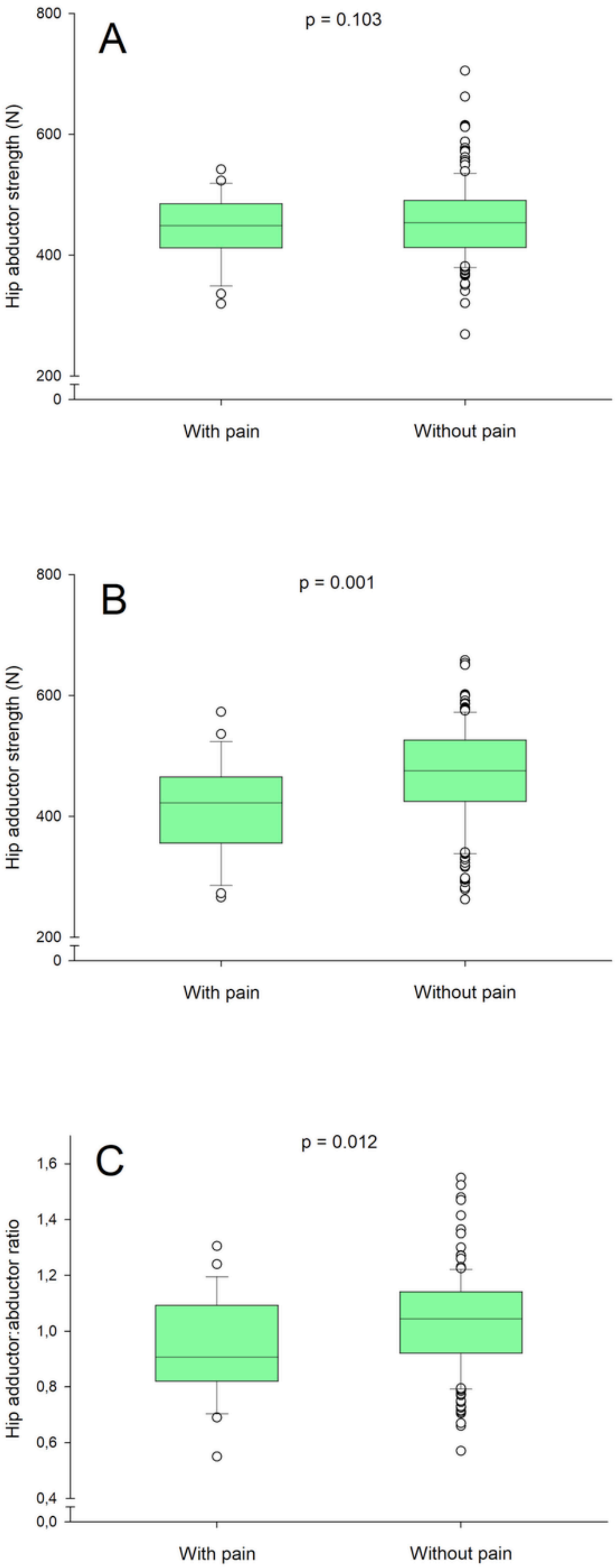

Fig. 2. Hip abductor strength (A), hip adductor strength (B) and hip adductor:abductor ratio (C) in players with (n = 25) vs. without (n = 162) hip/groin pain during hip adduction trials. The box represents the interquartile range, the horizontal line represents the median and the two whisker boundaries represent the 10th percentile and 90th percentile (outliers are also shown).

pared to full hip extension (Delp, Hess, Hungerford, & Jones, 1999; Johnson & Hoffman, 2010).

The presence of hip/groin pain during adductor testing had a negative impact on hip adductor strength and adductor:abductor ratio, thus confirming previous findings obtained in elite/sub-elite football (Malliaras et al., 2009), soccer (Thorborg et al., 2014; Thorborg et al., 2011) and ice hockey players (Worner et al., 2019). In turn, preseason hip strength testing of professional ice hockey players revealed that an adductor:abductor ratio lower than 0.8 represented a serious risk factor for adductor muscle strain (Tyler et al., 2001). Even if these data were obtained under somewhat different conditions with respect to our study (handheld dynamometry, unilateral contractions and side-lying body position), and we made no attempt to document previous/future groin injuries/problems, selective hip adductor weakness may help identifying ice hockey players who could potentially benefit from exercise programs designed to reduce the risk of groin injury (Tyler, Nicholas, Campbell, Donellan, & McHugh, 2002). However, neither our current study nor any other previous investigation established a cause-effect relation between hip/groin pain during a squeeze test, hip adductor muscle weakness and groin adductor muscle injuries. In the same way, the significance of these findings from a training load management and injury prevention perspectives remains to be demonstrated.

5. Conclusion

Using a straightforward field-based testing methodology, the present study offered reference values of hip abductor and adductor strength from a relatively large sample of professional male ice hockey players, and confirmed that the presence of hip/groin pain during adductor testing may contribute to selective hip adductor weakness. The current study also demonstrated that age, playing position and experience have no impact on hip muscle strength.

Funding

None declared.

Ethical statement

Study approval was obtained from the local Ethics Committee (ID# 2017-00085). All participants were informed about the aim of the study and signed the informed consent prior to data collection.

Declaration of competing interest

None declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2020.03.006.

Table 3
Hip abductor and adductor strength in different Groinbar studies and groups of sportsmen.

	Ice hockey (n = 187; NL) [Present study]	Australian football (n = 18; AFL) [Ryan et al.]	Australian football (n = 36; AFL) [O'Brien et al.]	Soccer (n = 20; varsity) [Desmyttere et al.]	Soccer (n = 31; A-League) [O'Brien et al.]	Soccer (n = 204; elite) [Bourne et al.]
Absolute strength (N)						
Hip abductor	458 ± 63	/	387 ± 83	340 ± 53	386 ± 78	420 ± 76
Hip adductor	464 ± 85	382 ± 94	347 ± 107	348 ± 76	328 ± 24	424 ± 95
Relative strength (N/kg)						
Hip abductor	5.3 ± 0.7	/	4.6 ± 1.0	4.5 ± 0.7	5.3 ± 1.1	5.4 ± 1.0
Hip adductor	5.4 ± 1.0	4.9 ± 1.2	4.1 ± 1.3	4.6 ± 1.0	4.9 ± 1.5	5.5 ± 1.2
Hip adductor:abductor	1.02 ± 0.18	/	0.9 ± 0.2	1.05 ± 0.20	0.9 ± 0.2	0.99

Mean values ± SD. When data were provided separately for both sides, only the dominant/stronger side was presented. When only absolute strength data were provided, they were divided by mean body weight to give relative strength, and vice versa. AFL: Australian football league. NL: National league./: not measured.

References

Bourne, M N, Williams, M, Jackson, J, Williams, K L, Timmins, R G, & Pizzari, T (2019). Preseason hip/groin strength and HAGOS scores are associated with subsequent injury in professional male soccer players. Journal of Orthopaedic & Sports Physical Therapy, 1–34.

Chang, R, Turcotte, R, & Pearsall, D (2009). Hip adductor muscle function in forward skating. Sports Biomechanics, 8, 212–222.

Click Fenter, P, Bellew, J W, Pitts, T A, & Kay, R E (2003). Reliability of stabilised commercial dynamometers for measuring hip abduction strength: A pilot study. British Journal of Sports Medicine, 37, 331–334.

Delp, S L, Hess, W E, Hungerford, D S, & Jones, L C (1999). Variation of rotation moment arms with hip flexion. Journal of Biomechanics, 32, 493–501.

Desmyttere, G, Gaudet, S, & Begon, M (2019). Test-retest reliability of a hip strength assessment system in varsity soccer players. Physical Therapy in Sport, 37, 138–143.

Emery, C A, & Meeuwisse, W H (2001). Risk factors for groin injuries in hockey. Medicine & Science in Sports & Exercise, 33, 1423–1433.

Huskisson, E C (1974). Measurement of pain. Lancet, 2, 1127–1131.

Johnson, S, & Hoffman, M (2010). Isometric hip-rotator torque production at varying degrees of hip flexion. Journal of Sport Rehabilitation, 19, 12–20.

Kloskowska, P, Morrissey, D, Small, C, Malliaras, P, & Barton, C (2016). Movement patterns and muscular function before and after onset of sports-related groin pain: A systematic review with meta-analysis. Sports Medicine, 46, 1847–1867.

Lorentzon, R, Wedren, H, & Pietila, T (1988). Incidence, nature, and causes of ice hockey injuries. A three-year prospective study of a Swedish elite ice hockey team. The American Journal of Sports Medicine, 16, 392–396.

Malliaras, P, Hogan, A, Nawrocki, A, Crossley, K, & Schache, A (2009). Hip flexibility and strength measures: Reliability and association with athletic groin pain. British Journal of Sports Medicine, 43, 739–744.

Molsa, J, Airaksinen, O, Nasman, O, & Torstila, I (1997). Ice hockey injuries in Finland. A prospective epidemiologic study. The American Journal of Sports Medicine, 25, 495–499.

Nedelec, M, McCall, A, Carling, C, Legall, F, Berthoin, S, & Dupont, G (2014). The influence of soccer playing actions on the recovery kinetics after a soccer match. The Journal of Strength & Conditioning Research, 28, 1517–1523.

Nicholas, S J, & Tyler, T F (2002). Adductor muscle strains in sport. Sports Medicine, 32, 339–344.

O'Brien, M, Bourne, M, Heerey, J, Timmins, R G, & Pizzari, T (2019). A novel device to assess hip strength: Concurrent validity and normative values in male athletes. Physical Therapy in Sport, 35, 63–68.

Pettersson, M, & Lorentzon, R (1993). Ice hockey injuries: A 4-year prospective study of a Swedish elite ice hockey team. British Journal of Sports Medicine, 27, 251–254.

Ryan, S, Kempton, T, Pacecca, E, & Coutts, A J (2019). Measurement properties of an adductor strength-assessment system in professional Australian footballers. International Journal of Sports Physiology and Performance, 14, 256–259.

Schache, A G, Crossley, K M, Macindoe, I G, Fahrner, B B, & Pandy, M G (2011). Can a clinical test of hamstring strength identify football players at risk of hamstring strain? Knee Surgery, Sports Traumatology, Arthroscopy, 19, 38–41.

Sim, F H, & Chao, E Y (1978). Injury potential in modern ice hockey. The American Journal of Sports Medicine, 6, 378–384.

Thorborg, K, Branci, S, Nielsen, M P, Tang, L, Nielsen, M B, & Holmich, P (2014). Eccentric and isometric hip adduction strength in male soccer players with and without adductor-related groin pain: An assessor-blinded comparison. International Refereed Journal of Orthopaedics Traumatology and Sports Medicine, 2. 2325967114521778.

Thorborg, K, Serner, A, Petersen, J, Madsen, T M, Magnusson, P, & Holmich, P (2011). Hip adduction and abduction strength profiles in elite soccer players: Implications for clinical evaluation of hip adductor muscle recovery after injury. The American Journal of Sports Medicine, 39, 121–126.

Tyler, T F, Nicholas, S J, Campbell, R J, Donellan, S, & McHugh, M P (2002). The effectiveness of a preseason exercise program to prevent adductor muscle strains in professional ice hockey players. The American Journal of Sports Medicine, 30, 680–683.

Tyler, T F, Nicholas, S J, Campbell, R J, & McHugh, M P (2001). The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. The American Journal of Sports Medicine, 29, 124–128.

Whittaker, J L, Small, C, Maffey, L, & Emery, C A (2015). Risk factors for groin injury in sport: An updated systematic review. British Journal of Sports Medicine, 49, 803–809.

Widler, K S, Glatthorn, J F, Bizzini, M, Impellizzeri, F M, Munzinger, U, & Leunig, M, et al. (2009). Assessment of hip abductor muscle strength. A validity and reliability study. J Bone Joint Surg Am, 91, 2666–2672.

Wollin, M, Thorborg, K, & Pizzari, T (2018). Monitoring the effect of football match congestion on hamstring strength and lower limb flexibility: Potential for secondary injury prevention? Physical Therapy in Sport, 29, 14–18.

Wollin, M, Thorborg, K, Welvaert, M, & Pizzari, T (2018). In-season monitoring of hip and groin strength, health and function in elite youth soccer: Implementing an early detection and management strategy over two consecutive seasons. Journal of Science and Medicine in Sport, 21, 988–993.

Worner, T, Thorborg, K, & Eek, F (2019). Five-second squeeze testing in 333 professional and semiprofessional male ice hockey players: How are hip and groin symptoms, strength, and sporting function related? International Refereed Journal of Orthopaedics Traumatology and Sports Medicine, 7. 2325967119825858.