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AN INVESTIGATION OF ADDUCTOR SQUEEZE STRENGTH AND FUNCTIONAL LEVEL IN ADOLESCENT ATHLETES WITH ADDUCTOR RELATED GROIN PAIN

ORIGINAL ARTICLE

ABSTRACT

Purpose: Adductor-related groin pain (ARGP) are the most common groin problem in athletes. The present study aimed to compare adductor squeeze strength and functional levels of adolescent athletes having ARGP with asymptomatic controls.

Methods: A total of 52 adolescent athletes (26 in the ARGP group; 26 in the healthy control group) were included in the study. Visual Analog Scale was used for pain intensity. Stabilizer (pressure biofeedback unit) was used to evaluate the adductor squeeze strength. The Hip Outcome Score (HOS) was used to determine functional levels.

Results: Demographic characteristics were similar between groups ($p>0.05$). Adductor squeeze strength was lower in the ARGP group when compared to controls ($p<0.001$). The HOS activity of daily living and sport subscales were lower in the ARGP group than the control group ($p<0.001$).

Conclusion: Athletes with ARGP demonstrated lower muscle strength and functional levels than healthy controls. Determining the muscle strength and functional levels of adolescent athletes is critical to identify the athletes at risk to prevent the re-injury of the adductor muscles.

Key Words: Adolescent; Groin; Hip; Muscle Strength.

ADDUKTOR KASLAR İLE İLİŞKİLİ KASIK AĞRISI OLAN ADOLESAN SPORCULARDA ADDUKTOR SIKIŞTIRMA KUVVETİ VE FONKSİYONEL SEVİYENİN İNCELENMESİ

ARAŞTIRMA MAKALESİ

ÖZ

Amaç: Adduktor kaslarla ilişkili kasık ağrısı (AKİKA) sporcularda en sık görülen kasık problemidir. Çalışmamızın amacı, adduktor kaslarla ilişkili kasık ağrısı (AKİKA) olan adolesan sporcuların adduktor sıkıştırma kuvveti ve fonksiyonel seviyelerini asemptomatik kontrolleri ile karşılaştırmaktır.

Yöntem: Çalışmaya toplamda 52 adolesan sporcu (26 AKİKA grubu, 26 sağlıklı kontrol grubu) dahil edildi. Ağrı seviyesi için Görsel Analog Skala kullanıldı. Adduktor sıkıştırma kuvvetini değerlendirmek için stabilizer (basınç biofeedback ünitesi) kullanıldı. Fonksiyonel seviyeyi belirlemek için Kalça Değerlendirme Skoru (HOS) kullanıldı.

Sonuçlar: Demografik özellikler gruplar arasında benzerdi ($p>0,05$). Sağlıklı kontrolleri ile karşılaştırıldığında adduktor sıkıştırma kuvveti AKİKA grubunda daha düşüktü ($p<0,001$). HOS günlük yaşam aktiviteleri ve spor alt bölümleri AKİKA grubunda kontrol grubuna göre daha düşüktü ($p<0,001$).

Tartışma: AKİKA olan sporcular sağlıklı kontrolleri ile karşılaştırıldığında daha düşük kas kuvveti ve fonksiyonel seviyeye sahiptir. Adolesan sporcuların sezon öncesi dönemde kas kuvveti ve fonksiyonel seviyelerinin belirlenmesi, adduktor kasların yeniden yaralanmasını önlemek ve risk altındaki sporcuları tespit etmek için kritik öneme sahiptir.

Anahtar Kelimeler: Adolesan; Kasık; Kalça; Kas Kuvveti.

INTRODUCTION

A groin injury is a challenging injury for athletes participating in multi-directional high-impact sports (1-3). It accounts for 4% to 19% of the time loss of all injuries (2). Adductor-related groin pain is the most common groin problem in athletes and comprised approximately 2/3 of all groin injuries (4). ARGP is defined as a musculotendinous junction injury with pain on adductor tendons or palpation of the tendon's attachment to the pubic bone. The adductor muscles' primary function is to stabilize the lower extremity and pelvis in the closed kinetic chain and to adduct the thigh in open kinetic chain positions. Adductor muscles are the second most common reinjured muscles after hamstrings with 29% re-injury rate (5).

Several risk factors are identified for adductor injuries including decreased adductor strength (6, 7), strength imbalance between adductor and abductor muscles, previous history of adductor injury (5), total hip rotation range of motion below 85° (8), higher body mass index (9) and decrease in sport-specific performance (7). The adductor strength has been the most investigated factor for adductor injuries (10-13). Therefore, adductor strength test is a powerful screening tool in sport to specify athletes at risk and the early detection of athletes who are prone to develop groin injury (14). Furthermore, athletes with weak adductors had four times of injury risk than athletes with normal strength (15).

Several methods are defined for adductor muscle strength assessment such as using a hand-held dynamometer (13); isokinetic testing (16) and adductor squeezing test (17). Adductor squeezing test is frequently used by clinicians to assess adductor function, due to its ease of use (10, 17-19). This test gives information on bilateral adductor strength and a diagnostic evaluation for adductor-related groin injury (17). Adductor-related pain adversely affects lower extremity function and participating in sports activities. Therefore, determining the functional outcomes are as essential as determining muscle strength.

Comparing the muscle strength differences and functional outcomes between athletes with and without ARGP may improve our understanding of the adolescent population's deficits. Previous studies have examined adductor strength and functional level, mostly in elite or amateur male football players (5,10-14,16). We have not met any study examining different sports branches in the literature. This study aimed to determine the muscle strength deficits and functional levels in Olympic adolescent athletes with ARGP and compare the results with healthy controls. The hypothesis was that adolescent athletes with ARGP would have decreased adductor strength and lower functional levels.

METHODS

Cross-sectional study design was used for this study. Ethical approval was obtained from Hacettepe University Ethics Committee for Non-Interventional Clinical Research with the number of GO18/782 (Approval Date: 09.10.2018). The data was collected between October 2018 and December 2019. The measurements were performed at Turkey Athlete Training, Health and Research Center of Turkish Ministry of Youth and Sport. A priori sample size calculation was undertaken using G*Power 3.1.9.2 (Franz Faul Universitat, Kiel, Germany) based on the previously published study of Malliaras et al. (11). Using the calculated effect size (1.13) for differences in adductor squeeze test values and the following values, α error probability=0.05, power (1–β error probability)=0.95 and an allocation ratio of N2/N1=1, it was calculated that 22 athletes per group were required.

A total of 52 adolescent athletes [26 athletes in ARGP group (median age=16), (13 male-13 female); 26 athletes in healthy control group (median age=16.5) (13 male-13 female)] were included in the study. Athletes were divided into two groups according to their injury status. The athletes in ARGP group were recruited by a sports physician if they had pain two out of three provocation tests (pain with resisted adduction; pain with palpation of proximal adductor tendons; pain during adductor squeeze test) (20). For the ARGP group: injury date, recurrence, injury mechanism (overuse, contact injury, non-contact injury) and the injury site were recorded. Inclusion criteria for ARGP group were having experienced grade 1 or grade 2 adductor strain at least in four weeks; not receiving

any treatment related to ARGP; groin pain during or after sports activities, two out of three provocation tests were positive. Any history of acute orthopedic injuries in the last three weeks; using medication; having another groin related injury were excluded in the study. Age, gender, height, weight, body mass index (BMI) and sports type matched non-injured athletes were included in the control group. Inclusion criteria for the healthy control group had no adductor-related groin injury; no previous injury of the lower extremity and having the same demographic characteristics as the ARGP group. Exclusion criteria for the controls were any history of surgery, using medication, lower extremity alignment disorders (hip retroversion and anteversion, genu recurvatum, bowleg, pes planus and planovalgus) (10,13).

All athletes and their family members read and signed a written and informed consent. All data were obtained in the pre-season period.

Adductor Squeezing Test: The athletes were asked to lie on their back with both hands were on the chest, and the hip flexed at 45°. Hip flexion was determined using a goniometer. The stabilizer (pressure biofeedback unit) (Chattanooga Stabilizer Group Inc., Hixson, TN, USA), previously set at a pressure of 10 mmHg, was placed between the knees and the athlete was asked to squeeze the stabilizer with full force (Figure 1). During the evaluation, pain in the groin's anterior and/or medial part was interpreted as positive and documented (17). The measured values of both groups were recorded as mmHg.

Pain Intensity: Visual Analogue Scale (VAS) was used for subjective evaluation of pain intensity in the ARGP group during adductor squeezing test. The athletes were asked to mark the pain level they felt during the test on the horizontal 10 cm line (0=no pain, 10=extreme pain). The marked distance was measured with a tape measure.

Measurement of Self-Reported Hip Function: Self-reported hip function was measured using the Turkish version of Hip Outcome Score (HOS) (21). The required permission was taken from the researchers. The HOS involved 28 questions, including two functional subscales: activity of daily living (ADL) and sport. This questionnaire was developed

Figure 1: Adductor Squeezing Test.

to assess the treatment outcomes of hip arthroscopy in young-to-middle-aged individuals (21,22). HOS was reliable and precise enough for use at active young adults with hip and groin pain (23). Each question is answered on a Likert scale, and a total score for each subscale is normalized, ranging from 100 to zero, 100 indicating higher, and 0 indicating lower levels of physical function.

Statistical Analysis

All statistical analyses performed using SPSS Version 25.0 (IBM SPSS Inc., Chicago, USA). Shapiro Wilk test was used to determine the normal distribution of the data. Body height and adductor squeeze strength test were normally distributed, and the Student t-test was used to compare these variables between the groups. Mann Whitney-U test was used to compare the differences between groups for the rest of the variables. The significance level was set at 0.05.

RESULTS

Descriptive characteristics of the groups are presented in Table 1. Height, body weight, BMI, and sports year were similar between groups ($p>0.05$).

The median pain level during adductor squeezing test was 2.6 (0,60-8,20) in ARGP group. Adductor squeezing strength was lower in the ARGP group when compared to healthy controls ($p<0.001$).

The HOS-ADL and sport subscale results were lower in the ARGP group than healthy controls ($p<0.05$) (Table 2).

Table 1: Characteristics of the Groups.

Characteristics	ARGP Group (n=26)	Control Group (n=26)	p
	Median (IQR)	Median (IQR)	
Age (year)	16 (15-17)	16.5 (16-17)	**0.387¥**
Height (m)ϕ	1.72±0.13	1.70±0.11	**0.765§**
Weight (kg)	60.5 (52-84)	58.50 (54-67)	**0.653¥**
BMI (kg/m²)	21.13 (20.2-23.27)	21.24 (19.47-22.11)	**0.654¥**
Sports Duration (years)	6 (4-6)	6 (4-7)	**0.896¥**

ϕMean±SD. §Student t test, ¥ Mann Whitney U-Test. IQR: Inter Quartile Range Interquartile Range. ARGP: Adductor Related Groin Pain, BMI: Body Mass Index.

Table 2: Comparison of Groups in Terms of Muscle Strength and Functional Levels.

Variable	ARGP Group (n=26)	Control Group (n=26)	p
	Median (IQR)	Median (IQR)	
Muscle Strength			
Adductor Squeeze Strength (mmHg) ϕ	151.54±35.02	185.38±20.59	**<0.001*¶**
Functional Level			
HOS Activities of Daily Living Subscale	88.24(70.59-92.65)	100(98.53-100)	**<0.001*¥**
HOS Sport Subscale	76.39(63.89-88.89)	100(94.44-100)	**<0.001*¥**

*p<0.05. ϕMean±SD. §Student t test, ¥ Mann Whitney U-Test. IQR: Inter Quartile Range Interquartile Range. ARGP: Adductor Related Groin Pain, HOS: Hip Outcome Score.

DISCUSSION

This study's main findings showed that athletes with ARGP demonstrated decreased muscle strength and functional levels compared to healthy athletes in the pre-season period.

The adductor squeeze test is an accurate and reliable provocation test that could easily apply during the groin region's painful conditions and test adductor muscle activation and strength (11, 24). Delahunt et al. reported that the adductor muscles showed maximum activation and maximum compression pressure at 45° of hip flexion during the adductor squeeze test (17). For this reason, we preferred the supine position of the hip at 45° flexion for the evaluation. The ARGP group presented a mean of 153.3-mmHg adductor squeeze strength when healthy controls' strength was 185.4-mmHg. ARGP group produced 17.3% less force (mean 32.1 mmHg) than the controls, and also this group demonstrated lower squeeze strength than previously published normative data (18). Coughlan et al. aimed to create a norm data and reported that the average adductor squeeze strength of the athletes at 45° hip flexion was 228.2 mmHg in healthy adolescent rugby players (18). They stated that clinicians should examine the adductor squeeze test in asymptomatic athletes before the season to determine the athletes at risk. Nevin et al. found the mean difference of adductor squeeze strength in 18 athletes with groin pain (mean=202 mmHg) and the control group (mean=269 mmHg) was 66.4 mmHg (10). Similarly, Malliaris et al. compared adductor squeeze strength in adolescent soccer players (mean age=17.5 years) with and without inguinal pain. The mean difference between the groups was reported as 29.1 mmHg (11). The researchers explained this group difference with three possible mechanisms. The first mechanism is the loss of muscle strength due to reflex inhibition following injury. The second mechanism is that the pain generated during the adductor squeeze test would adversely affect force production. The third mechanism is explained as the combination of the previously mentioned two mechanisms. The adductor squeeze strength results of the present study were in line with the study mentioned above results. We believe that the pain during testing would reduce

muscle strength, and it would adversely affect the athletes' functional outcomes.

During the adductor squeezing test, pain is one of the diagnosis criteria for groin injury (20). It is speculated that the adductor squeeze test may aggravate tension at the bone-tendon and/or muscle-tendon junction of the adductor musculature, and this may result in pain (24). Nociceptive afferent stimulation transmission increases with painful conditions. Motor unit firing rate decreases following nociceptive stimulation. This scenario decreases agonist muscles neuromuscular function and decreases muscle force production ability (25, 26). This situation explained with pain adaptation theory. Although the adaptation protects muscles from further pain and injury in the short-term, it would lead to severe challenges like muscle weakness, decreased movement quality, and modified joint loading in the long-term (27). Moreover, previous investigations showed that pain-induced muscle inhibition led to decreased activation levels in un-effected extremity and still present even pain relieved (26, 28). Strength deficit of ARGP group, might be explained with pain adaptation mechanism. With decreased motor unit firing rate, muscle inhibition would not allow adductor muscles to perform functional demands (10, 26, 27). It may limit the functional capacity of athletes with a chronic groin injury (17). Nevin et al. stated that football players with longstanding groin pain had decreased functional capacity than controls determined by Copenhagen Hip and Groin Outcome Score (HAGOS) function, sport and recreation subscale scores (10). Similarly, Thorborg et al. stated that all HAGOS subscales (especially in sports subscales) of football players with groin pain was significantly lower than the control group (13). In another study of the same authors, it was stated that all HAGOS subscales of the athletes who had pre-season groin pain were lower than the controls (29). Both researchers mentioned that the functional level of the athletes is decreasing significantly after a groin injury. Our results have similar characteristics to literature. The ARGP group demonstrated decreased functional level in HOS sports subscales. The HOS sport subscale results support the claim that adductor muscle pain would result in decreased functional outcomes.

Determining the adductor muscle strength is vital for adolescent athletes to prevent future overuse injuries (7,12,13,19). The adductor squeeze test is widely used as a clinical assessment tool for adductor-related groin pain (10,17,18,20). The test could efficiently perform in a clinical setting due to its cost-effectiveness, accessibility, and immediate applicability (10,20,24). A previous study showed reduced adductor squeezing strength related to sustain a groin injury, particularly adductor muscle injury (7,9,18,19). Determining adductor muscle strength in adolescent athletes at the pre-season period is crucial to identifying athletes at risk and preventing future injuries. Clinicians might easily detect athletes at risk using squeezing tests and prescribe personalized adductor strengthening programs to reduce groin injury risk (30). Previous studies have included only male subject involved in team sports (football or rugby) with a groin injury in their study groups (10-19). In the present study, we homogeneously include male and female athletes with groin injuries involved in different sports branches. Our results have implications for male and female adolescent athletes.

This study has some limitations. Adductor squeeze test reflects bilateral leg adduction strength. There is no information about injured leg muscle strength. This study might be clinically more qualified to use other adductor muscle strength methods, including unilateral isometric and eccentric strength. We prefer the HOS scale to determine athletes' functional level. HOS scale has not yet been shown to be a valid and reliable questionnaire for groin problems. We are aware that HAGOS scale should is frequently used for adductor-related groin pain, but its Turkish version has not been published yet. Another limitation is that the athletes in the present study did not include in a comprehensive evaluation procedure. Due to our study's cross-sectional design, it is impossible to make an inference that the difference between the groups is only due to groin pain.

In conclusion, athletes with adductor-related groin injury demonstrated decreased muscle strength and functional levels compared to healthy athletes. Determining the muscle strength and functional levels of adolescent male and female athletes is critical to identify the athletes at risk to prevent the re-injury of the adductor muscles. These find-

ings would encourage the clinicians to improve athlete-specific prevention programs and designing rehabilitation exercises for the athletes at risk.

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Conflict of Interest: The authors declare no conflict of interest.

Ethical Approval: The study protocol was accepted by the Non-interventional Clinical Research Ethics Board of Hacettepe University (Approval Date: 09.10.2018 and Approval Number: GO 18/782).

Informed Consent: A written informed consent form was obtained from all participants and their parents.

Peer-Review: Externally peer-reviewed.

Author Contributions: Concept – EU, HGD; Design – EU, HGD; Supervision – HGD, BA, TK; Resources and Financial Support – HGD, TK, BA; Materials – HGD, TK, BA; Data Collection and/or Processing – EU, BA, TK, HGD; Analysis and/or Interpretation – EU, HGD; Literature Research – EU, HGD; Writing Manuscript – EU, HGD; Critical Review - HGD, BA, TK.

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REFERENCES

1. Thorborg K, Rathleff MS, Petersen P, Branci S, Hölmich P. Prevalence and severity of hip and groin pain in subelite male football: a crosssectional cohort study of 695 players. Scand J Med Sci Sports. 2017;27(1):107-14.
2. Waldén M, Hägglund M, Ekstrand J. The epidemiology of groin injury in senior football: a systematic review of prospective studies. Br J Sports Med. 2015;49(12):792-7.
3. Hölmich P, Thorborg K, Dehlendorff C, Krogsgaard K, Gluud C. Incidence and clinical presentation of groin injuries in sub-elite male soccer. Br J Sports Med. 2014;48(16):1245-50.
4. Mosler AB, Weir A, Eirale C, Farooq A, Thorborg K, Whiteley RJ, et al. Epidemiology of time loss groin injuries in a men's professional football league: a 2-year prospective study of 17 clubs and 606 players. Br J Sports Med. 2018;52(5):292-7.
5. Hägglund M, Waldén M, Ekstrand J. Risk factors for lower extremity muscle injury in professional soccer: the UEFA Injury Study. Am J Sports Med. 2013;41(2):327-35.
6. Tyler TF, Nicholas SJ, Campbell RJ, McHugh MP. The association of hip strength and flexibility with the incidence of adductor muscle strains in professional ice hockey players. Am J Sports Med. 2001;29(2):124-8.
7. Whittaker JL, Small C, Maffey L, Emery CA. Risk factors for groin injury in sport: an updated systematic review. Br J Sports Med. 2015;49(12):803-9.
8. Tak I, Engelaar L, Gouttebarge V, Barendrecht M, Van den Heuvel S, Kerkhoffs G, et al. Is lower hip range of motion a risk factor for groin pain in athletes? A systematic review with clinical applications. Br J Sports Med. 2017;51(22):1611-21.
9. Ryan J, DeBurca N, Mc Creesh K. Risk factors for groin/hip injuries in field-based sports: a systematic review. Br J Sports Med. 2014;48(14):1089-96.
10. Nevin F, Delahunt E. Adductor squeeze test values and hip joint range of motion in Gaelic football athletes with longstanding groin pain. J Sci Med Sport. 2014;17(2):155-9.
11. Malliaras P, Hogan A, Nawrocki A, Crossley K, Schache A. Hip flexibility and strength measures: reliability and association with athletic groin pain. Br J Sports Med. 2009; 43(10): 739-44.
12. Crow JF, Pearce AJ, Veale JP, VanderWesthuizen D, Coburn PT, Pizzari T. Hip adductor muscle strength is reduced preceding and during the onset of groin pain in elite junior Australian football players. J Sci Med Sport. 2010;13(2):202-4.
13. Thorborg K, Branci S, Nielsen MP, Tang L, Nielsen MB, Hölmich P. Eccentric and isometric hip adduction strength in male soccer players with and without adductor-related groin pain: an assessor-blinded comparison. Orthop J Sports Med. 2014;2(2):2325967114521778.
14. Light N, Thorborg K. The precision and torque production of common hip adductor squeeze tests used in elite football. J Sci Med Sport. 2016;19(11):888-92.
15. Engebretsen AH, Myklebust G, Holme I, Engebretsen L, Bahr R. Intrinsic risk factors for hamstring injuries among male soccer players: a prospective cohort study. Am J Sports Med. 2010;38(6):1147-53.
16. Belhaj K, Meftah S, Mahir L, Lmidmani F, Elfatimi A. Isokinetic imbalance of adductor–abductor hip muscles in professional soccer players with chronic adductor-related groin pain. Eur J Sport Sci. 2016;16(8):1226-31.
17. Delahunt E, Kennelly C, McEntee BL, Coughlan GF, Green BS. The thigh adductor squeeze test: 45 of hip flexion as the optimal test position for eliciting adductor muscle activity and maximum pressure values. Man Ther. 2011;16(5):476-80.
18. Coughlan GF, Delahunt E, Caulfield BM, Forde C, Green BS. Normative adductor squeeze test values in elite junior rugby union players. Clin J Sport Med. 2014;24(4):315-9.
19. Delahunt E, Fitzpatrick H, Blake C. Pre-season adductor squeeze test and HAGOS function sport and recreation subscale scores predict groin injury in Gaelic football players. Phys Ther Sport. 2017;23:1-6.
20. Weir A, Jansen JA, Van de Port IG, Van de Sande HB, Tol JL, Backx FJ. Manual or exercise therapy for long-standing adductor-related groin pain: a randomised controlled clinical trial. Man. Ther. 2011;16(2):148-54.
21. Polat G, Çelik D, Çil H, Erdil M, Aşık M. Evidence for reliability, validity and responsiveness of Turkish version of Hip Outcome Score. Acta Orthop Traumatol Turc. 2017;51(4):319-24.
22. Martin RL, Kelly BT, Philippon MJ. Evidence of validity for the hip outcome score. Arthroscopy. 2006;22(12):1304-11.
23. Hinman RS, Dobson F, Takla A, O'Donnell J, Bennell KL. Which is the most useful patient-reported outcome in femoroacetabular impingement? Test–retest reliability of six questionnaires. Br J Sports Med. 2014;48(6):458-63.
24. Drew MK, Palsson TS, Izumi M, Hirata RP, Lovell G, Chiarelli P, et al. Resisted adduction in hip neutral is a superior provocation test to assess adductor longus pain: an experimental pain study Scand J Med Sci Sports. 2016;26(8):967-74.

25. Tucker K, Larsson AK, Oknelid S, Hodges P. Similar alteration of motor unit recruitment strategies during the anticipation and experience of pain. Pain. 2012;153(3):636-43.
26. Henriksen M, Graven‐Nielsen T, Aaboe J, Andriacchi TP, Bliddal H. Gait changes in patients with knee osteoarthritis are replicated by experimental knee pain. Arthritis Care Res (Hoboken). 2010;62(4):501-9.
27. Hodges PW, Tucker K. Moving differently in pain: a new theory to explain the adaptation to pain. Pain. 2011;152(Suppl 3):S90-S8.
28. Nielsen NP, Tucker K, Dorel S, Guével A, Hug F. Motor adaptations to local muscle pain during a bilateral cyclic task. Exp Brain Res. 2017;235(2):607-14.
29. Thorborg K, Branci S, Stensbirk F, Jensen J, Hölmich P. Copenhagen hip and groin outcome score (HAGOS) in male soccer: reference values for hip and groin injury-free players. Br J Sports Med. 2014;48(7):557-9.
30. Hölmich P, Larsen K, Krogsgaard K, Gluud C. Exercise program for prevention of groin pain in football players: a cluster‐randomized trial. Scand J Med Sci Sports. 2010;20(6):814-21.