



## The Correlation between Knee Flexion Lower Range of Motion and Osgood-Schlatter's Syndrome among Adolescent Soccer Players

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### Authors' contributions

This work was carried out in collaboration between all authors. Authors AT, LL, MY and IK designed the study and wrote the protocol. Author AT wrote the first draft of the manuscript and managed the literature searches. The study analyses performed by author LK. All authors read and approved the final manuscript.

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### ABSTRACT

**Aims:** To evaluate the association between knee flexion range of motion (ROM) and Osgood-Schlatter syndrome among adolescent soccer players.

**Study Design:** Observational case-control study.

**Methodology:** A study group of 20 male soccer players, mean age 13.4 years (13.4±0.7) diagnosed with Osgood-Schlatter syndrome and a control group of 21 healthy soccer players, mean age 13.5 years (13.5±0.9) were enrolled. The knee flexion ROM was bilaterally measured in a prone position by the Ely's test and using a digital inclinometer for angle measurement.

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**Results:** No significant difference between groups was found as to age, height, weight and dominant leg. Body mass index (BMI) was significantly higher ( $t = 2.249$ ;  $P = .03$ ) in the study group ( $18.97 \pm 1.61 \text{ kg/m}^2$ ) compared to the controls ( $17.79 \pm 1.71 \text{ kg/m}^2$ ). A statistically significant ( $t = -2.701$ ;  $P = .01$ ) difference was found in knee flexion ROM between the symptomatic leg in the study group and the dominant leg in the controls, with a lower ROM in the study group ( $132.52 \pm 12.40$ ) and ( $141.40 \pm 8.35$ ) in the controls. In a logistic regression analysis, BMI and knee flexion ROM both showed a significant association with the presence of symptoms (BMI:  $P = .014$ ; ROM:  $P = .013$ ).

**Conclusions:** Proper training including stretching regime to the quadriceps muscles, with focus on the rectus femoris muscle, during the growth phase of adolescent soccer players should be considered in order to reduce OSS symptoms or even trying to prevent them.

*Keywords: Osgood-schlatter syndrome; range of motion; rectus femoris; soccer players.*

## 1. INTRODUCTION

In recent years there has been a constant increase in children participating in sports and recreational activities. In the U.S. for example, the estimated number of children participating in organized sports programs is between 30-40 million [1-3]. These sports activities usually take place during the age of sexual development, in which the adolescents are still skeletally immature and may be more prone to growth-plate injuries when the epiphyseal physes are still open [4]. These athletes may also be at increased risk of injury due to imbalances among strength, flexibility and neuromuscular control [5-7]. In many cases, these sports are not coached in an appropriate way or are insufficiently supervised, which contributes to problems in the musculoskeletal system [8-10]. Non-traumatic knee pain is one of the most common complaints among young athletes [1].

One example of such a complaint is due to Osgood-Schlatter's Syndrome.

Osgood-Schlatter Syndrome (OSS), first described in 1903, is one of the most prevalent causes of knee pain in physically active young athletes and the most common syndrome of traction apophysitis [11,12]. OSS is an inflammatory response generated by micro avulsion injuries of the tibial tuberosity due to traction forces generated by the knee extension mechanism, mainly by the quadriceps muscle. OSS is characterized by pain over the tibial tuberosity, painful active knee extension, swelling, sensitivity and an osseous bump over the tibial tuberosity at late or advanced stages. Bilateral involvement has been described in 20-30% of patients [10,13,14].

OSS is very common among adolescents involved in sports which entail jumping, such as soccer, basketball and volleyball. The incidence of the syndrome among adolescents involved in sports is around 13% compared to 6.7% in the general population [15-19]. OSS usually presents between the ages of 8-13 among females and ages 10-15 among males [20-22]. Incidence of the syndrome among male adolescent elite skaters was found higher (14.2%) compared to female peers (8.9%) [16]. In another study, OSS incidence was almost 4 times higher ( $P = .014$ ) in males than female adolescents [23].

The tendency to develop OSS at a young age may be attributed to the rapid growth and excessive pulling of the quadriceps muscle at the tibial tuberosity, leading to an overload at the tenoperiosteal junction and to decreased lower extremity control [5,10,24-29]. Periods of accelerated bony growth and loss of flexibility are also risk factors in for developing OSS [30-32]. Other intrinsic and extrinsic factors such as muscle strength, tightness, anatomical variants of the patella and its tendon, angular and rotational alternation of the knee, vascular insufficiency, improperly supervised sports activity, inadequate sports facilities, footwear and diverse playing surfaces have been mentioned as potential risk factors for developing OSS [15,16,21,23,32-36].

OSS is mainly diagnosed clinically. Symptoms may appear when direct contact is rendered on the tibial tuberosity, i.e. during jumping, landing, passive knee flexion and isometric contraction [10]. Plain radiographs of the knee are recommended in unilateral cases of OSS to rule out other conditions such as acute tibial apophyseal fractures, infection or tumor [4].

It was found [14,21,22,37-40] that the symptoms tend to favorably respond to conservative treatment and are likely to clinically improve within two years from initial onset with excellent prognosis in most cases. Sonographic signs of active disease were found two years after diagnosis in 50% of patients [41]. Discomfort while kneeling and limitation in sports due to pain over the tibial tuberosity was found in 60% and 18% of cases, respectively [39].

With the rising number of adolescents involved in sports and a higher incidence of OSS amongst them, it is important to identify potential risk factors. Two studies reported a significant association between decreased quadriceps length and OSS [15,20]. Additional studies are needed to confirm this association.

The aim of the present study was to evaluate the correlation between the knee flexion ROM and OSS. We hypothesized that the knee flexion ROM is lower in adolescent soccer players with OSS compared with their healthy peers.

## 2. METHODS

### 2.1 Design

Observational case-control study.

### 2.2 Subjects

The study group consisted of 20 male soccer players aged 12-15 ( $13.4 \pm 0.7$ ) years clinically diagnosed with OSS by an experienced board certified orthopedic surgeon. All subjects had symptoms for at least 6 weeks and were recruited by the author's request from the youth chief managers of their clubs for contact information of players suffering knee pain. The author contacted the player's legal guardians and asked for their interest. The diagnostic criteria were: pain on the tibial tuberosity upon applied pressure, pain during jumping, landing and resistance to knee extension. Exclusion criteria included a history of knee trauma, neurological abnormalities and musculoskeletal pain at the time of testing. The control group consisted of 21 soccer players, recruited in the same manner as the study group, aged 12-15 ( $13.5 \pm 0.9$ ) years who had experienced no pain in the knee area.

An explanation as to the study aims and procedures was given to all subjects and legal guardians who signed an informed consent form. The study was approved by the Ethical Committee, Recanati School for Community

Health Professions, Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer Sheva, Israel.

### 2.3 Outcome Measures

Demographic data (age, height, weight, dominant leg (leg that kicks the ball), number of workouts per week and duration of each workout) were collected using a self-reported questionnaire.

Body mass index (BMI) was calculated as weight (in kilograms) divided by height (in meters) squared.

The Ely's test was used to evaluate the knee flexion ROM [42] (Fig. 1).

The reliability of this test in assessing rectus femoris muscle length and knee joint ROM was previously examined using a goniometer with moderate intra-rater and inter-rater reliability (Inter Class Correlation (ICC) = 0.69 and 0.66 correspondingly) [42]. In the present study, we replaced the goniometer with the Saunders® Baseline digital inclinometer (Chaska, MN) which supplies measurements up to  $1^\circ$  (Fig. 2).

The use of the inclinometer was favored for two reasons: 1) a universal goniometer measurement requires the use of two hands for measurement; with the inclinometer, only one hand is needed; 2) the inclinometer has been demonstrated to have good to excellent inter-rater reliability and validity in numerous studies and measuring different joints (ICC: 83-97) [43-47]. To the best of our knowledge no previous study has evaluated the reliability and validity of the digital inclinometer using the Ely's test.

All ROM evaluations were performed by one examiner. Measurements were taken from both legs, totaling 82 examined knees. Prior to the test, subjects were given an explanation as to the nature of the test. They were also asked to refrain from athletic activity four hours before the evaluation. Prior to the test, all subjects performed a 5 minute walking warm-up. The subjects wore a shirt and shorts and were asked to relax their muscles and remain as passive as possible. The test was performed as previously described in Magee's Orthopedic Physical Assessment Textbook [48]. The subjects lay prone and the examiner passively flexed the subject's knee with one hand while placing the other hand under the anterior superior iliac spine in order to palpate when the spine rose from the bed. The examiner placed the inclinometer on

the tibial crest with its edge placed just below the tibial tuberosity. He then measured the angle without observing it and had an assistant record the obtained results. The test was repeated 3 times, 20 seconds apart, for each leg. The mean value of the 3 tests was used in further analyses. The examiner noted if pain was felt in the tibial tuberosity during measurement.

## 2.4 Statistical Analysis

All statistical computations were performed using the SPSS 17.0 for Windows (SPSS, Chicago, IL, USA). A normal distribution of quantitative data was assessed by the Kolmogorov-Smirnov test  $P > .05$ . Statistical analyses were conducted at a 95% confidence level. A  $P$ -value of  $< .05$  was considered significant. Baseline features compared groups using independent t-tests for continuous data and  $\chi^2$  tests for categorical data.

Knee flexion ROM of dominant and non-dominant legs of controls was compared using the paired t-test. The comparison between the symptomatic leg knee ROM in the subjects and the dominant leg in the controls was performed using the independent t-test.

To evaluate the association between knee flexion ROM and basic anthropometrical characteristics, bivariate Pearson correlation analyses were used. Because presence of OSS was statistically significantly associated with BMI and knee flexion ROM, logistic regression analysis was performed (enter method, constant was not included in the model) where group belonging (presence of OSS) was a dependent variable and BMI and knee flexion ROM (in the

symptomatic leg, if symptoms were unilateral and the dominant leg if symptoms were bi-lateral) were independent predictors.

## 3. RESULTS

No significant difference between the two groups was found for age, height, weight and/or dominant leg (Table 1). BMI was significantly higher in the study group ( $18.97 \pm 1.61 \text{ kg/m}^2$ ) than in controls ( $17.79 \pm 1.71 \text{ kg/m}^2$ ), ( $t = 2.249$ ;  $P = .03$ ).

Six (30%) subjects experienced pain in the right and 3 (15%) in left leg; 11 (55%) had bilateral symptoms.

Comparisons of knee flexion ROM are shown in Table 2. No significant difference was found between the dominant and secondary legs in the control group ( $t = -1.892$ ,  $P = .073$ ) or in study group ( $t = 1.023$ ,  $P = .319$  (not presented in the table)).

However, the difference between the symptomatic leg in the study group and the dominant leg in the controls was statistically significant, with a lower ROM in the study group ( $132.52 \pm 12.40$ ) compared to controls ( $141.40 \pm 8.35$ ), ( $t = -2.701$ ;  $P = .01$ ).

Utilizing the results of our study, we performed a power analysis: 20 subjects in OSS group and 21 subjects in control group, type 1 error probability 0.05; the difference between experimental and control groups  $10^\circ$  and standard deviation approximately 10.0. Obtained probability of rejecting the null hypothesis (power) was 0.869, which is considered high.



Fig. 1. Ely's test evaluation of knee flexion ROM



Fig. 2. Ely's test, using Saunders® Baseline digital inclinometer

The results of the bivariate Pearson correlations between knee flexion ROM and basic anthropometrical characteristic are shown in Table 3.

No correlations between dominant leg knee flexion ROM and basic anthropometrical characteristics were found significant in the control group. In the study group, weight and BMI were significantly correlated ( $r = -0.475$ ,  $P = .034$  and  $r = -0.561$ ,  $P = .010$ , correspondingly) to the symptomatic leg (or dominant leg if symptoms

were bilateral) knee flexion ROM. Analyzing the Linear regression between ROM and BMI among the asymptomatic subjects (both dominant and secondary leg) shows lower results  $R^2 = 0.055$  and  $0.184$  correspondingly while among the symptomatic subjects (symptomatic or dominant leg in bilateral symptoms) the result was higher  $R^2 = 0.351$ . Fig. 3 shows a clearer and more visible image of the differences association between knee flexion ROM and BMI in subjects with and without OSS.

**Table 1. Descriptive statistics of the studied sample**

Variables	Cases (n=20)	Controls (n=21)	Comparison t - test
	Mean±SD (range)		
Age (years)	13.45±0.78 (12-15)	13.55±0.93 (12-15)	t = -0.363; P = .719
Height (cm.)	159.35±8.27 (146-172)	159.14±11.11 (145-180)	t = .067; P = .947
Weight (kg.)	48.43±7.61 (36-68)	45.43±8.74 (34-65)	t = 1.168; P = .25
BMI (kg/m <sup>2</sup> )	18.97±1.61 (16.44-22.99)	17.79±1.71 (15.11-21.34)	t = 2.249; P = .03
Dominant leg (Right)	14 (70.0%)	16 (72.7%)	$\chi^2$ P = .655
Side of symptoms	Right	6 (30%)	-
	Left	3 (15%)	-
	Bilateral	11 (55%)	-

SD – Standard deviation; statistically significant difference  $P < .05$  marked in bold

**Table 2. Comparison of knee flexion ROM (degrees) (mean±standard deviation)**

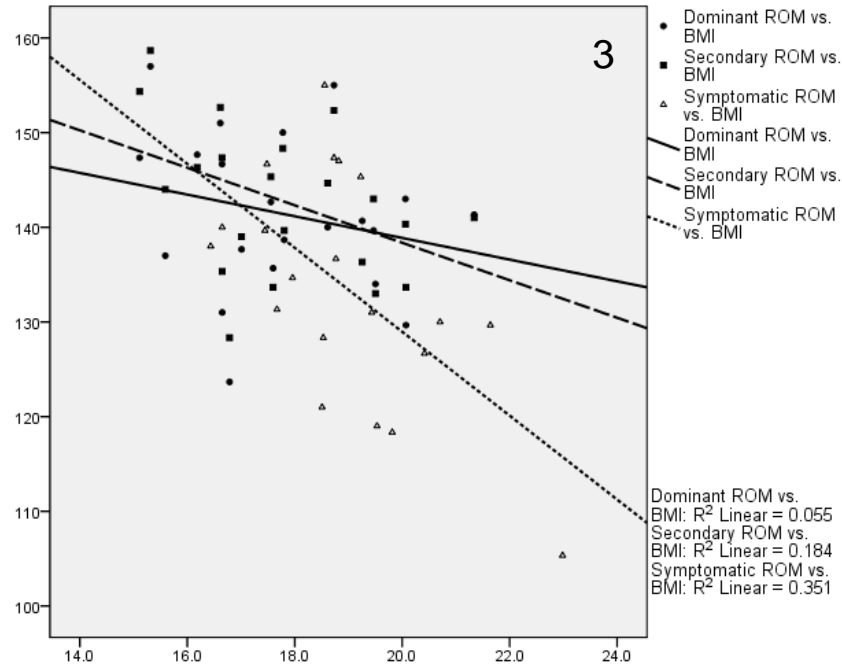
Cases*	Controls			Comparison between symptomatic leg in cases and dominant leg in the controls (t-test)
	Dominant leg	Secondary leg	Comparison between dominant and secondary leg (paired t-test)	
132.52±12.40	141.40±8.35	142.73±7.91	t = -1.892; P = .073	t = -2.701; P = .010

\*Symptomatic leg or dominant leg if symptoms are bilateral; statistically significant difference  $P < .05$  marked in bold

**Table 3. Bivariate pearson correlations between knee flexion ROM and basic anthropometrical characteristics**

	Symptomatic leg or dominant leg if symptoms are bilateral (cases)	Dominant leg (controls)
Age (years)	$r = -0.114$ , $P = .633$	$r = -0.193$ , $P = .403$
Height (cm.)	$r = -0.226$ , $P = .339$	$r = -0.300$ , $P = .187$
Weight (kg.)	$r = -0.475$ , $P = .034$	$r = -0.321$ , $P = .156$
BMI (kg/m <sup>2</sup> )	$r = -0.561$ , $P = .010$	$r = -0.235$ , $P = .305$

Statistically significant difference  $P < .05$  marked in bold



**Fig. 3. Scatterplot of the association between knee flexion ROM and BMI in subjects with (Symptomatic) and without (Dominant and Secondary legs) OSS**

In a logistic regression analysis (enter method, no constant included) where group belonging (presence of OSS symptoms) was a dependent variable and BMI and knee flexion ROM (in symptomatic leg, if symptoms were unilateral and dominant leg in the rest of subjects) were independent predictors, both BMI ( $B = -0.386$ ,  $P = .014$ , odds ratio (OR)=.68 (95% confidence interval (CI) for OR: .5 – .924) and ROM ( $B = .052$ ,  $P = .013$ , OR=1.053 (95% CI for OR: 1.011 – 1.097), showed a significant association with the symptoms. The design of the study is not allowing establishing of causal relationships between variables. Our speculation is that individuals with a higher BMI and lower ROM have a higher probability of experiencing symptoms of OSS.

#### 4. DISCUSSION

The common hypothesis related to the etiology of OSS suggests an asynchronous development of bone and soft tissues, especially the rectus femoris muscle during the maturation stage [3,5,8,43]. These periods of accelerated bony growth might result in loss of flexibility which presents additional risk for developing OSS [31].

Accelerated bone growth may lead to an overload at the tenoperiosteal junction of the tibial tuberosity and consequently to developing OSS [10,24].

In the present study, we confirmed our hypothesis that the knee flexion ROM is lower in adolescent soccer players with OSS compared with their healthy peers. We demonstrated that there is a significant difference in knee flexion ROM between the dominant leg in the control group and the symptomatic leg in the study group ( $t = -2.701$ ;  $P = .01$ ). This is in agreement with a previous study [15] that found that rectus femoris muscle shortening is associated with OSS.

Muscle length in de Lucena et al's [15] study was measured dichotomously using the Thomas test. Despite the fact that this test evaluated the length of the rectus femoris, it is less precise and studies that have evaluated its validity and reliability are scarce and controversial [45,49]. In our study, on the other hand, we measured knee flexion in a prone position allowing for better control in the pelvic position and measuring the actual degree of knee flexion.

A pathophysiology explanation as to our findings can be found in several studies of human growth and lifestyle, suggesting that accelerated bone growth during puberty, accompanied by asymmetrical muscle tissue lengthening, may create an overload on the tenoperiosteal junction [50]. The area may become fibrotic, creating a lack of local osseous connection or a full osseous connection and an enlargement of the tibial tuberosity [20]. However, studies conducted on adolescent tennis players, employing ultrasound imaging, revealed that ossicles within hypoechoic cartilage are common and usually asymptomatic [51,52].

In light of our results and previous studies, [15,20] stretching of the quadriceps muscle, with emphasize on the rectus femoris muscle should be incorporated into a prevention program for OSS at a young age (before symptoms occur) in order to increase knee flexion ROM and therefore try to reduce the traction forces created by the quadriceps muscle on the tenoperiosteal junction. Studies designed to evaluate the efficacy of rectus femoris stretching in preventing OSS in adolescent sportsmen, should be conducted.

We also found that OSS subjects had a higher BMI than their pain free peers. The cross-sectional design of the study did not allow direct estimation of the causal relationship between BMI and OSS; however, all our participants were physically active and no one was obese (see BMI ranges in Table 1). It might be that higher BMI denotes subjects with a higher muscle mass or with accelerated body growth. This assumption is supported by a significant negative correlation between knee flexion ROM and weight ( $r = -0.475$ ;  $P = .034$ ) and BMI ( $r = -0.561$ ;  $P = .01$ ) in the study group. We can speculate that stronger muscles, especially if they are shortened produce more pulling forces on the tenoperiosteal junction, triggering OSS development.

Traditionally, decreased muscle length has been considered an important risk factor for lower extremity injury in athletes [19,53-60]. However, literature relating to adolescent soccer players is scarce and contradictory [53,56,58,61-63].

Therefore, in light of the increasing number of adolescents playing soccer and the physical demands characterized by overloading muscles and tendons, the need for medical care and preventive measures should be emphasized [8-10].

Prevention of sports injuries is the most desirable and most economically effective way to reduce these injuries. Not all injuries are inevitable and therefore, it is essential to encourage prevention of sports injuries as a complementary part of the process [64].

## 5. CONCLUSION

The symptoms of OSS differ from adolescent to adolescent. Therefore, we have to find the right individual way for each adolescent to cope with them.

Reduced intensity, impact forces and movement mechanisms which arouse the pain in addition to stretching regime, manual therapies and the use of external devices during the growth phase of adolescent soccer players should be consider to handle the symptoms or even trying to prevent them.

When improvements occur, gradually going back to full activity should be considered.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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