

Review Article

Extracorporeal Shock Wave Therapy for Children and Adolescents Diagnosed with Osgood Schlatter Disease to Reduce Knee Pain: Systematic Review

Mohammad E. Tamboosi¹, Hashim T. Alharthi¹, Abdulaziz A. Bukhari¹, Abdulrahman M. Alsulami¹, Waleed A. Hawari¹, Yazeed K. Alahmadi², Rayan S. Alshahrani³, Rayan A Alshamrani⁴

¹Department of Physical Therapy and Rehabilitation, King Abdulaziz Medical City, National Guard Health Affairs

²Department of Physical Therapy, Faculty of Medical Rehabilitation Sciences, King Abdulaziz University

³Department of Physical Therapy, College of Applied Medical Science, Taif University.

⁴Department of Physical Therapy, College of Applied Medical Science, University of Tabuk

Abstract:

AIM: The current systematic review aimed to investigate the effectiveness of ESWT on children and adolescents diagnosed with OSD to reduce their knee pain.

METHODS: An electronic search for studies about ESWT on patients with OSD that were published in English in different databases (CINAHL, PubMed, MEDLINE, Scopus, and PEDro). National Heart, Lung, and Blood Institute's Quality assessment tool was used to evaluate the included studies.

RESULTS: According to the search strategy, from 2807 articles, only 2 studies (retrospective cohort and RCT) were selected for the current review, with a total of 34 subjects (20 Males and 14 Females) diagnosed with OSD participated to be treated with ESWT. They were aged between 12 to 29 years old. all participants were suffering from pain due to OSD.

CONCLUSION: The available evidence suggests that there is a promising effect of using ESWT for patients diagnosed with OSD to reduce their pain. However, the paucity of evidence prevents drawing firm conclusions, necessitating more studies to be conducted for a definite conclusion.

Keywords:

Extracorporeal Shock Wave Therapy; Rehabilitation; Pain; Adolescents; Children.

Introduction

Osgood Schlatter Disease (OSD) is a common condition that affects the knee joint in children and adolescents between the age of 10 to 15 years old, 10 to 12 in girls and 12 to 15 in boys. OSD occurs in male more than female with 9.8% [11.4% in males, 8.3% in females] of prevalence [1]. The incidence of OSD range from 12.4 to 22.5 per 1000 athletic adolescents [2]. This condition is a type of overuse injury that occurs due to repetitive

stress on the patellar tendon, it is characterized by pain and swelling in the bony prominent of proximal tibia just below the knee cap, which known as tibial tubercle [3]. The tibial tubercle starts to swell as a secondary ossification center that attaches the patellar tendon. The swelling minimize the flexibility of muscles and tendons around the knee joint specially the quadriceps [4]. OSD can be exacerbated due to activities that require repetitive extensor mechanism such as running, jumping, or squatting. Different sport activities can cause the repetitive extensor mechanism such as

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Address for correspondence:

Mohammad E. Tamboosi
Department of Physical therapy and rehabilitation,
King Abdulaziz Medical City,
National guard hospital
P. O. Box 9515
Jeddah 21423
E-mail:
tamboosimo@ngha.med.sa

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running, jumping, or squatting. Different sport activities can cause the repetitive extensor mechanism such as basketball, volleyball, sprinters, gymnastics, and football [1]. While OSD is a self-limiting condition that typically resolves on its own within a few months to a year, it can cause significant discomfort and limitations in physical activity during that time. In some cases, the condition may persist into adulthood or lead to chronic pain and muscles weakness [5]. Additionally, OSD may also lead to long-term complications such as pseudo-arthrodesis, genu recurvatum, patella alta, fragmentation-migration of bone fragments, and reduced knee flexion [6].

Diagnosis of OSD is typically based on a combination of clinical examination, imaging studies, and assessment of the patient's medical history and physical activity [5]. The main symptom of OSD is pain with a variety of intensity which worsens when the location is pressed especially in postures like kneeling [7]. Furthermore, the anterior tibial tuberosity, where the patellar tendon enters, frequently exhibits inflammation and hypersensitivity. This is especially noticeable during physical and sports practice and may seem as limping. In the acute stage, symptoms often progress progressively from mild and infrequent to severe and ongoing pain [8].

Palpable thickening of the patellar tendon insertion is frequently accompanied by discomfort, especially while performing counter-resisted flexions or resisted knee extensions, as well as the quadriceps and hamstring muscles loss of flexibility can be detected during examining the flexibility of the knee muscles [9]. OSD should be confirmed by complementary radiological tests such as X-ray, MRI, and Ultrasound to differentiate and to rule out other diagnosis such as fractures, tumors, infections, tendinitis, or Hoffa's disease [10].

In a recent study, OSD patients had great success rates (80% at 12 weeks and 90% at 12 months), with 16% returning to sport after 12 weeks and 67% after 6 months [11]. Another study reported that 90% of OSD patients who had conservative care such as decreased in physical activities, ice application, pressure application, orthosis, warm-up and cool-down exercise, and stretching exercise for quadriceps, hamstring, gastrocnemius, and iliotibial band had entirely healed from their symptoms in about a year, although the strength and functioning deficiencies could persist over time [12–17]. Furthermore, the repetitive stress activities should be replaced with other activities that does not require a stress on the patellar tubercle such as swimming and pedaling, which not cause any load to the tendon [18]. Core muscles stabilization and strengthening is recommended to improve knee functions [19].

Medical intervention such as non-steroidal anti-inflammatory drugs (NSAID) can be efficient for OSD to minimize the pain and improve the symptoms [1]. Despite taking the drugs may enhance in decreasing the symptoms, but they would not shorten the course of OSD [20]. Surgical intervention by removing the ossicle and adjacent bursae, smoothing the bump, and repairing the patellar tending to bone would be the best solution for unresolved OSD with a rate of 100% of success [21,22].

On the other hand, Extracorporeal Shock Wave Therapy (ESWT) is an option for alternative therapies to treat OSD, which does not require a surgeries and cause tissue damage [23]. Recent study reported that ESWT is a safe and promising intervention for patients with OSD [23]. ESWT is a non-invasive intervention used to treat a variety of injuries and painful conditions. The waves are created by compressed air to the affected region produce energy that promotes regeneration and reparative processes of the bones, tendons and other soft tissues [24].

The current study aims to investigate the effectiveness of ESWT to enhance minimizing the symptoms of OSD by assessing and synthesizing the studies that applied ESWT for children and adolescents with OSD, which include the effective parameters of ESWT that should be applied for OSD, and the outcome measures used to assess the symptoms whether minimized nor not.

Materials and Methods

Study Design:

Systematic review; the current study was conducted according to the Preferred Reporting Item for Systematic reviews and Meta-Analysis (PRISMA) statement [25].

Search Strategy

The following databases were used to conduct an electronic search for studies about ESWT on patients with OSD that were published in English, every set search contained subject heading (MeSH) that were combined by “AND” in CINAHL, PubMed, MEDLINE, Scopus, and PEDro from 2010 to 2023. A summary of the search procedure is provided in (Table 1). A flow diagram was included to demonstrate how the information from the collected data flowed.

Inclusion Criteria:

The following inclusion criteria were established using the PICOS framework [Population, Intervention, Comparison/Control, and Study Design]: Patients were diagnosed with OSD who aged from 6 to 29 years old [P]; Interventions included ESWT as a treatment for OSD

whether a primary treatment or secondary treatment [I]; ESWT compared with a further intervention or no treatment if applicable [C]; Evaluation of at least one of the following results: pain or discomfort, the length of the symptoms, function (such as the ability to kneel), range of motion, muscle flexibility, or sport activity [O]; the selected study design was an experimental or observational study design either a prospective or retrospective cohort studies, a case study or case series, or a randomized control study were selected to be included in this project [S] [26].

Database	Keywords
PubMed	<ul style="list-style-type: none"> Osgood Schlatter AND Shock Wave
CINAHL	<ul style="list-style-type: none"> Osgood Schlatter AND Extracorporeal
MEDLINE	Shock Wave Therapy
Scopus	<ul style="list-style-type: none"> Osgood Schlatter AND Rehabilitation Osgood Schlatter AND Physiotherapy
PEDro	<ul style="list-style-type: none"> Osgood Schlatter* Shock Wave* Osgood Schlatter* Extracorporeal Shock Wave Therapy* Osgood Schlatter* Rehabilitation* Osgood Schlatter* Physiotherapy*

Table 1: Keywords/terms used for electronic database search

Exclusion Criteria:

Only records that written in English were included, any other languages were excluded. Further, animal studies, assessment or diagnostic studies, studies that focused in other outcomes such as cost-effectiveness of the intervention, and studies that published prior to 2010 were also excluded.

Data Extraction:

The extracted data from the selected studies include the citation details, study design, participants characteristics [Number of participants, Age, Gender, and Condition], the concluded outcomes, and the parameters and the duration of the intervention, and the outcome measures used in the selected studies.

Quality Assessment:

The selected studies were assessed independently by 2 assessors [M.E.T and H.T.A] using the National Heart, Lungs, and Blood institute's quality assessment tool to assess the

quality of the selected studies. National Heart, Lungs, and Blood institute (NHLBI) created a set of specialized quality evaluation tools in 2013.

NHLBI provided a variety of quality assessment tools for different study designs. The tools were developed to screen for potential problems in the implementation or use of certain study designs. NHLBI offers the tools through the website [<https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools>].

Data Analysis:

A qualitative analysis was not applicable due to the heterogeneity of the included studies [e.g., various study designs, outcome measures, and data quality]. However, the data were synthesized in a narrative fashion.

Results

Literature Search and Screening Process:

The process search strategy and article screening procedure were performed in this review. 2807 articles were found after searching electronic databases. 2633 duplicates were removed, and 174 articles were screened. After evaluating the full texts of the relevant articles, only 2 studies met the criteria for eligibility requirements. [Figure 1] demonstrates the process of searching and screening strategy.

Characteristics of the included studies:

The included studies applied ESWT on OSD with a variety of parameters. 34 participants who participated in the included studies, as well as they were all diagnosed with OSD. The ages of the participants ranged between 12 to 29 years old. Both studies reported that there was an improvement while applying ESWT on OSD. [Table 2] summarizes the findings of the selected studies.

The study [23] reported that ESWT is a promising and safe intervention that can be used to improve the symptoms of OSD. Further, the study [27] reported in their findings that applying ESWT can minimize pain and improve the functions for cases diagnosed with OSD. The designs of the selected studies were pilot cohort study and Randomized Control Trial (RCT) respectively.

[27] compared ESWT to interferential current therapy for adolescents diagnosed with OSD, which also demonstrated an improvement in the range of motion (ROM) and the score of Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). However, they reported that there was a significant improvement in the mean value of total WOMAC measured in the group that received ESWT.

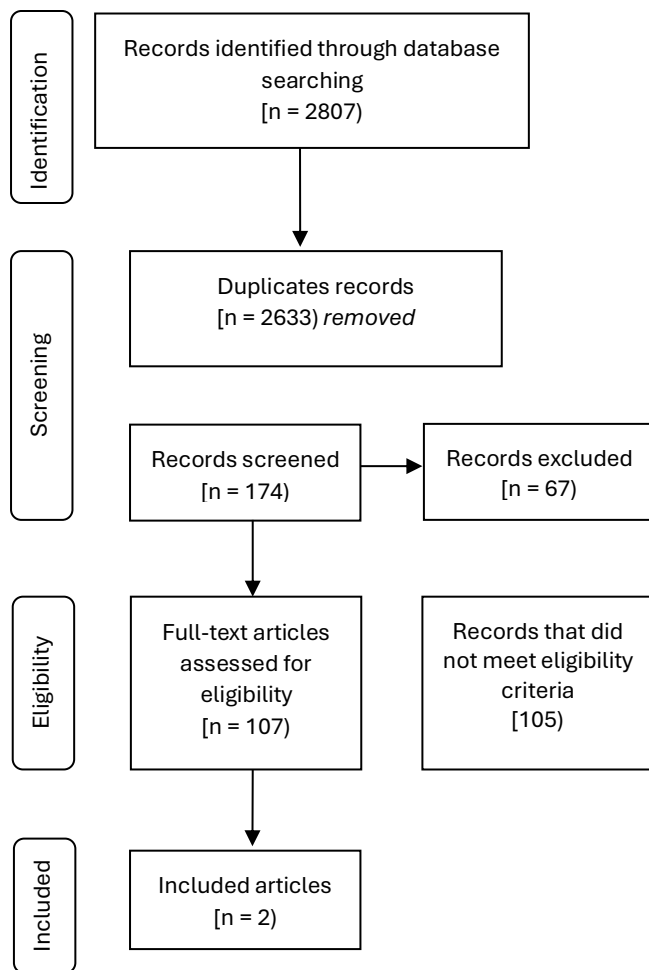


Figure 1: Flow diagram depicting search strategy and articles selection process

Application of Extracorporeal Shock Wave Therapy:

[23,27] applied different device model; Gymna ShockMaster 500, and DolorClast® Radial Shock Waves respectively. Furthermore, the working pressure was different (0.18mJ/mm²; 0.06 to 0.09 mJ/mm²), the contact pressure was “Medium” in both studies. Additionally, there was no analgesia in the treatment area and the pulse was from 1500 to 200 in both studies, while the frequency of the intervention was 160 pulses/min and 300 pulses/min respectively. The duration of the intervention varied between 3 to 8 weeks (Lohrer et al. applied the intervention for 3 to 7 weeks, and Gazya et al. applied it for 8 weeks). (Table 3) summarizes the application of ESWT in each study.

Outcome measures:

The study [27] selected visual Analog Scale [VAS] to measure the pain, and Western Ontario and McMaster Universities Osteoarthritis Index (WOMA)] to measure the functions. While [23] used Victorian institute of Sport Assessment Questionnaire (VISA-PG). The selected outcome measures were reviewed. Further, the psychometric properties such as validity and reliability were assessed.

Visual Analog Scale (VAS): The pain VAS is a unidimensional way to assess how much pain a person is experiencing. It may also be used to evaluate level of pain in individuals with comparable diseases. In several adult groups, VAS has been widely utilized [28]. Usually, VAS can assess patients with the age range between 18 to 65 years old. It showed an Adequate test re-test reliability (ICC=0.48) [29].

Table 2: Characteristics of the Included Studies

Reference	Year	Study Design	Participants Characteristics				Control Group	Outcomes	Outcome Measures	Findings
			N	Age	Gender	Condition				
Lohrer et al.	2012	Pilot Cohort Study	14	15 - 29 y	9 Male 5 Female	OSD	N/A	- Pain - Function	VISA-PG questionnaire	Adolescents with OSD have a safe and effective therapy option in ESWT
Gazya et al.	2014	RCT	40	12 – 14 y	22 Male 18 Female	OSD	Interferential Current Therapy N = 20	- Pain - Stiffness - Physical Function	- VAS - WOMAC	ESWT can be used to decrease pain of OSD

ESWT = Extracorporeal Shock Wave Therapy

N = Number of Participants

N/A = Not Applicable

OSD = Osgood Schlatter Disease

RCT = Randomized Control Trial

VAS = Visual Analog Scale

VISA-PG = Victorian institute of Sport Assessment Questionnaire

WOMAC = Western Ontario and McMaster Universities Osteoarthritis Index

(Table 3) Application of Extracorporeal Shock Wave Therapy

Reference	Device Model	Working Pressure	Contact Pressure	Analgesia	Pulses	Frequency	Duration
Gazya et al.	Gymna ShockMaster 500	0.18 mJ/mm2	Medium	No	2000 pulses	160 pulses/min	8 weeks
Lohrer et al.	DolorClast® Radial Shock Waves	0.06 to 0.09 mJ/mm2	Medium	No	1500 - 2000 Pulses	300 pulses/min	3-7 sessions, once/week

min = Minute

mJ/mm2 = Energy Flux Density

Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC): WOMAC index was created for hip and knee osteoarthritis. However, it has also been used to measure other rheumatic illnesses, including fibromyalgia, systemic lupus erythematosus, rheumatoid arthritis, and low back pain [30]. WOMAC showed an excellent test-retest reliability (ICC 0.77 – 0.94) and excellent negative construct validity with SF-36 physical function($r=0.73$) [31].

Victorian institute of Sport Assessment Questionnaire (VISA-PG): VISA-PG is a straightforward, useful questionnaire-based severity index that will aid in the study of jumper's knees and, consequently, therapeutic therapy. VISA-PG has excellent test-retest reliability (ICC=0.97). According to the construct validity, the differences between scores of the patients, healthy students, and basketball players were statistically significant: $P<0.001$ [32].

Quality assessment:

The selected studies were assessed using NHLBI quality assessment tool. Moreover, the quality assessment of both studies demonstrated a Good quality with a rate of 10 “YES” answers for [27] and 9 “YES” answers for [23]. The performance of quality assessment for [27] is demonstrated in (Table 4), as well as the performance of quality assessment for [23] is demonstrated in [Table 5]. Furthermore, both studies were assessed independently by 2 authors (M.E.T and H.T.A). The outcomes of the assessment by both assessors were similar.

Table 4: NHLBI Quality Assessment of Controlled Intervention Studies

Criteria	Yes	No	Other [CD, NR, NA] *
1. Was the study described as randomized, a randomized trial, a randomized clinical trial, or an RCT?	✓		
2. Was the method of randomization adequate [i.e., use of randomly generated assignment]?	✓		
3. Was the treatment allocation concealed [so that assignments could not be predicted]?		✓	
4. Were study participants and providers blinded to treatment group assignment?		✓	
5. Were the people assessing the outcomes blinded to the participants' group assignments?		✓	
6. Were the groups similar at baseline on important characteristics that could affect outcomes [e.g., demographics, risk factors, co-morbid conditions]?	✓		
7. Was the overall drop-out rate from the study at endpoint 20% or lower of the number allocated to treatment?	✓		
8. Was the differential drop-out rate [between treatment groups] at endpoint 15 percentage points or lower?	✓		
9. Was there high adherence to the intervention protocols for each treatment group?	✓		
10. Were other interventions avoided or similar in the groups [e.g., similar background treatments]?	✓		
11. Were outcomes assessed using valid and reliable measures, implemented consistently across all study participants?	✓		
12. Did the authors report that the sample size was sufficiently large to be able to detect a difference in the main outcome between groups with at least 80% power?		✓	
13. Were outcomes reported or subgroups analyzed prespecified [i.e., identified before analyses were conducted]?	✓		
14. Were all randomized participants analyzed in the group to which they were originally assigned, i.e., did they use an intention-to-treat analysis?	✓		

Table 5: NHLBI Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies

Criteria	Yes	No	Other [CD, NR, NA] *
1. Was the research question or objective in this paper clearly stated?	✓		
2. Was the study population clearly specified and defined?	✓		
3. Was the participation rate of eligible persons at least 50%?	✓		
4. Were all the subjects selected or recruited from the same or similar populations [including the same time period]? Were inclusion and exclusion criteria for being in the study prespecified and applied uniformly to all participants?		✓	
5. Was a sample size justification, power description, or variance and effect estimates provided?		✓	
6. For the analyses in this paper, were the exposure[s] of interest measured prior to the outcome[s] being measured?	✓		
7. Was the timeframe sufficient so that one could reasonably expect to see an association between exposure and outcome if it existed?	✓		
8. For exposures that can vary in amount or level, did the study examine different levels of the exposure as related to the outcome [e.g., categories of exposure, or exposure measured as continuous variable]?		✓	
9. Were the exposure measures [independent variables] clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
10. Was the exposure[s] assessed more than once over time?	✓		
11. Were the outcome measures [dependent variables] clearly defined, valid, reliable, and implemented consistently across all study participants?	✓		
12. Were the outcome assessors blinded to the exposure status of participants?		✓	
13. Was loss to follow-up after baseline 20% or less?	✓		
14. Were key potential confounding variables measured and adjusted statistically for their impact on the relationship between exposure[s] and outcome[s]?		✓	

Discussion

The current review aimed to investigate the effectiveness of ESWT for children and adolescents athletes diagnosed with OSD and to describe the ESWT characteristics that are used to treat the intended population.

The main findings of the selected studies showed that ESWT is an effective intervention for patients diagnosed with OSD. [23] concluded that ESWT considered as a safe and promising physiotherapy intervention to treat patients with OSD. However, the study design is pilot retrospective, the risk of bias is extremely possible for such designs specially with the absence of longitudinal nature of data as the study [33] mentioned in their paper.

On the other hand, [27] reported in their conclusion that ESWT can be used to treat patients with OSD to decrease pain and to restore functions. The design of their study was RCT. However, the risk of bias can be detected in this study, as the patients, assessors and the therapists were not blinded, and this factor might affect the results of their study negatively. The study [34] reported that lack of blinding leads to overestimated treatment effects.

Sports that requires requiring repetitive extensor movmenets like sprinting, leaping, or squatting might lead OSD worse [1], the participants in the selected studies were athletes from different sport activities such as football, tennis, hockey, discus throw, and figure skating.

In order to distinguish between OSD and other diagnoses like fractures, tumors, infections, tenderness, or Hoffa's disease, supplementary radiological studies like X-ray, MRI and Ultrasound should be used to confirm the diagnosis [10]. All participants in the selected studies confirmed the diagnosis of OSD using MRI.

Replacing the repetitive stress activities with ones that do not require stress on the patellar tubercle such as swimming and cycling. With the goal of improving knee functioning, stabilizing, and strengthening the core muscles is recommended [18,19]. The study [27] performed an additional exercises alongside the ESWT such as isometric exercise for Quadriceps and hamstrings, hip abductor dynamic strengthening exercise, free ROM exercise, and 15 minutes of hot pack. Further, participants were adviced to apply knee support while standing and walking and educated to perform the same exercises as home exercise program, as well as, they were adviced to avoid aggressive knee flexion such as cross sitting and squatting. While the study [23] reported that the exercises were paused and the stress were reduced for several weeks and sport shoes inserts were applied.

As seen in [Table 3], the parameters [Working Pressure, Contact pressure, Pulses, and frequency] and the duration of device application was somewhat comparatively similar to each other in both studies. Regardless the model of the devices and the designs of the studies, both studies reported a significant improvement in OSD symptoms. Applying ESWT with similar parameters and duration might be possible to demonstrate the same effect for such cases. The outcome measures used in the selected studies were reviewed. However, according to the results in the current review, the outcome measures used in the selected studies were valid and reliable outcome measures despite the excellence of the test-retest reliability of VAS. However, there was no evidence supports the psychometric properties of WOMAC for patients diagnosed with OSD. Also, VAS seems to be assessing patients who are older than 18 years old to confirm the validity. Regardless, it is not recommended to use VAS and WOMAC to measure the pain as WOMAC is an outcome measure designed to measure pain, stiffness and functional level.

The current review has some limitations. Due to the heterogeneity of the selected studies, the meta-analysis was impossible to be conducted. Furthermore, the selected studies were published in 2012 and 2014, in which those studies seems to be conducted for more than 5 years ago. Recent evidence investigating the effectiveness of the intended intervention for the intended population is missed. According to our knowledge and the searching process that conducted, there was no recent evidence found that applied ESWT to treat OSD and its symptoms. Moreover, the participants in both studies to some extent were slightly few with a total number of 44 participants, 20 of them were control group and received Interferential Current Therapy, which considered to be a very small sample size, the application of the same intervention for a bigger subject group might differ from the results found in the selected studies.

A considerable gap in the literature is noticed and need to be addressed. Therefore, conducting such studies with a bigger number of participants are necessary to be conducted to confirm the effectiveness of the intervention for the intended population. RCT design with blinding whether among the participants or the assessor is suggested.

Conclusion

Despite the lack of evidence investigating the effectiveness of ESWT on patients diagnosed with OSD, applying the device demonstrated a promising results to decrease the pain and to restore the functions; it is recommended to use the device in

the clinics with the mentioned parameters and durations. However, the lack of evidence prevents drawing firm conclusions, necessitating more studies to be conducted for a definite conclusion.

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Ethical approval statement

Not applicable

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Conflicts of interest

The authors declare that they have no conflicts of interest.

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العلاج بالموجات الصادمة خارج الجسم للأطفال والمراهقين المصابين بمرض أوسغود

شلاتر لتقليل آلام الركبة: مراجعة منهجية

محمد الياس تمبوسي¹، هاشم ثامر الحارثي¹، عبدالعزيز عبدالله بخاري¹، عبدالرحمن محمد السلمي¹، وليد أيمن هوراي¹، يزيد خالد الأحمد²، ريان سعد الشهراني³، ريان علي الشمراني⁴

- 1- قسم العلاج الطبيعي والتأهيل، مدينة الملك عبدالعزيز الطبية، مستشفى الحرس الوطني
- 2- قسم العلاج الطبيعي، كلية علوم التأهيل الطبي، جامعة الملك عبد العزيز، جدة، المملكة العربية السعودية.
- 3- قسم العلاج الطبيعي، كلية العلوم الطبية التطبيقية، جامعة الطائف، الطائف، المملكة العربية السعودية.
- 4- قسم العلاج الطبيعي، كلية العلوم الطبية التطبيقية، جامعة تبوك، تبوك، المملكة العربية السعودية.

المستخلص:

المقدمة: يعتبر مرض التَّنَكُّس العَظْمِيُّ حالة شائعة تصيب مفصل الركبة لدى الأطفال والمراهقين الذين تتراوح أعمارهم بين 10 و 15 عامًا. يحدث هذا المرض بين 12.4 و 22.5 لكل 1000 من المراهقين الرياضيين. ينتج مرض التَّنَكُّس العَظْمِيُّ عن الإجهاد المتكرر في وتر الرضفة مثل الجري والقفز والجلوس القرفصاء؛ مما يسبب الألم والتورم في الدرنه الظنبوبية. قد يؤدي مرض التَّنَكُّس العَظْمِيُّ إلى عواقب طويلة الأمد مثل تقييد ثني الركبة، وتفتت وتنقل الشظية الظنبوبية، وتقوس الركبة، وارتفاع الرضفة. يمكن علاج التَّنَكُّس العَظْمِيُّ غير المُعالَج جراحياً. ومع ذلك، يمكن أن يكون العلاج بالموجات الصدمية خارج الجسم تدخلاً بديلاً لا يتطلب جراحة أو تلف الأنسجة.

الهدف: تهدف المراجعة المنهجية الحالية إلى التحقق في فعالية العلاج بالموجات الصدمية خارج الجسم على الأطفال والمراهقين المصابين بمرض التَّنَكُّس العَظْمِيُّ لتقليل آلام ركبتهم.

الطريقة: تم إجراء بحث إلكتروني عن الدراسات حول العلاج بالموجات الصدمية خارج الجسم على المرضى المصابين بالتَّنَكُّس العَظْمِيُّ المنشورة باللغة الإنجليزية في قواعد بيانات مختلفة (PEDro, Scopus, MEDLINE, PubMed, CINAHL) تم استخدام أداة تقييم الجودة من المعهد الوطني للقلب والرئة والدم لتقييم الدراسات المشمولة.

النتائج: وفقاً لاستراتيجية البحث، من بين 2807 مقالة، تم اختيار دراستين فقط (دراسة المجموعة الضابطة العكسية والدراسة العشوائية ذات الشواهد) للمراجعة المنهجية الحالية، بمشاركة إجمالي 34 مشارك (20 ذكرًا و 14 أنثى) تم تشخيص إصابتهم بمرض التَّنَكُّس العَظْمِيُّ. تراوحت أعمارهم بين 12 و 29 عامًا. جميع المشاركين يعانون من آلام ناتجة عن مرض التَّنَكُّس العَظْمِيُّ.

الاستنتاج: تشير الأدلة المتاحة إلى وجود تأثير واعد لاستخدام العلاج بالموجات الصدمية خارج الجسم (ESWT) للمرضى المصابين بمرض التَّنَكُّس العَظْمِيُّ لتقليل آلامهم. ومع ذلك، فإن قلة الأدلة تمنع استخلاص استنتاجات قاطعة، مما يستلزم إجراء المزيد من الدراسات للتوصل إلى استنتاج نهائي.

الباحث الرئيسي:

محمد الياس تمبوسي

قسم العلاج الطبيعي والتأهيل، مدينة الملك عبدالعزيز الطبية، مستشفى الحرس الوطني

صندوق البريد: 9515، جدة، 21423

البريد الإلكتروني: tamboosimo@mngaha.med.sa