THE EFFECTS OF RADIAL SHOCKWAVE THERAPY ON CHRONIC CALF MUSCLE STRAIN INJURIES IN RUNNERS

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INTRODUCTION

The popularity of running has been increasing over the last few decades, with an estimated 10.5 million people in the UK participating in the sport (SMS-Inc, 2014).

Running has a higher associated risk rate of overuse injuries than other forms of aerobic exercises when compared to cycling, swimming and walking (Francis *et al*, 2019).They also looked at the anatomical locations and occurrence of running related injuries and found that 70% of injuries occur at or below the knee, this agrees with previous studies (Dabholkar *et al*, 2014; Kluitenberg *et al*, 2015; Lopes *et al*, 2012).

Calf muscle strain injuries (CMSI) are common across running sports involving high speed or high volume loads, especially during fatiguing conditions (Green & Pizzari, 2017). Vitez *et al* (2017) found as high as 12% of all running injuries were from the calf complex.

The first recorded influences of shockwaves on tissue date back to world war one from the effects of exploding bombs on soldiers, with the first investigations of its use in medicine in the 1950's (Shrivastava & Kailash, 2005). These investigations ultimately lead to the use of shockwave in urology (lithotripsy) to disintegrate urolithiasis (bladder stones), whereas shockwave in orthopaedics (orthotripsy) is not used to disintegrate tissues, rather to induce tissue repair and regeneration (Wang, 2012).

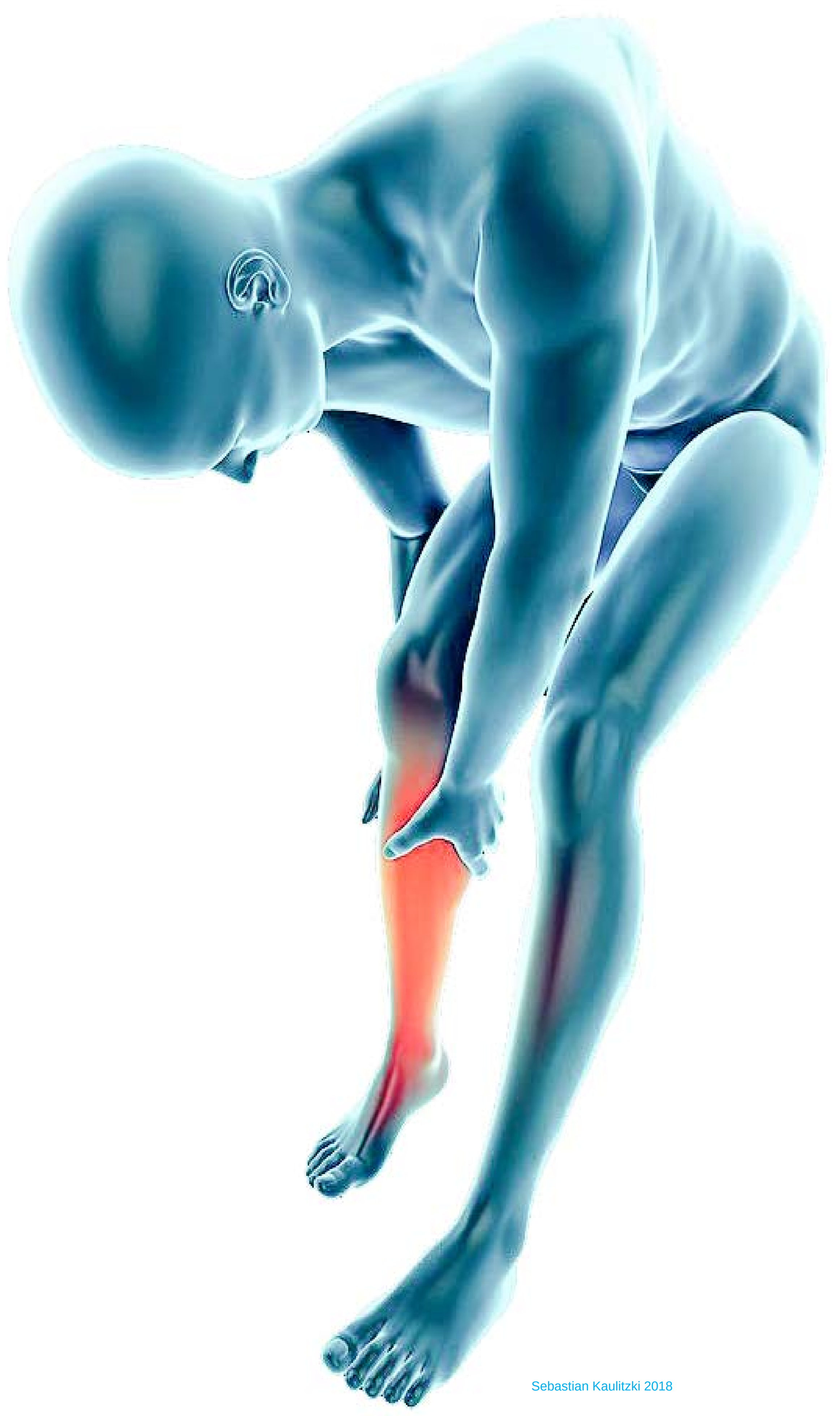
Extracorporeal shockwave therapy (ESWT) has been used in the treatment of soft tissue and bone related musculoskeletal disorders for over 20 years (Speed, 2014). It is most commonly used in the treatment of sports related over-use tendinopathies such as proximal plantar fasciitis of the heel, lateral epicondylitis of the elbow, calcific or non-calcific tendonitis of the shoulder and patellar tendinopathy (Wang, 2012).

Shockwaves have changed medical therapy substantially in the last few decades, with the advantages of ESWT being a non-surgical safe and effective treatment. In their recent study Liao *et al* (2018) found no clinically relevant adverse events, side effects, or severe complications after ESWT. In comparison to open surgery, the cost of the ESWT is very reasonable (Shrivastava & Kailash, 2005).

RATIONALE

Although there are no official NICE guidelines for the treatment of CMSI, individual hospitals have produced their own local guidelines. Typical recovery treatment recommendations from the NHS involve rest, ice, compression and elevation (RICE). This is followed by some strength and stretching exercises, with typical recovery times between 2 and 8 weeks before return to play (RTP) (NHS, 2014; 2018). With patient adherence levels to prescribed exercise being as low as 22% for full compliance (Room *et al*, 2017) it may be beneficial to look at additional modalities of treatment that may help improve the outcome of CMSI.

It is believed that shockwave therapy improves blood supply to the tissue thus initiating repairs of the chronically inflamed tissues by tissue regeneration, however more research and development in the methods and applications of extracorporeal shockwave technology are needed (Wang, 2012).



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AIM

The aim of this study is to look at the effects of radial shockwave therapy on chronic calf muscle strain injuries (CMSI) in runners.

OBJECTIVE

The objective is to evaluate if a course of radial extracorporeal shockwave therapy (rESWT) is an effective treatment modality for the reduction of pain and symptoms of CMSI within a 6 week time frame.

SUMMARY OF LITERATURE

Calf strain muscle injury (CSMI) is one of the four most frequently injured muscles in the sporting population (Vitez et al, 2017). The posterior compartment of the leg consists of three main muscles which are the gastrocnemius, soleus and plantaris, the collection of these is known as the calf muscle or triceps surae (Prakash et al, 2018). The gastrocnemius is the most superficial muscle and possesses the greater proportion of type 2 fast twitch muscles used in rapid locomotion such as running and jumping. It is during these activities that too much strain and force is applied to the muscle causing the strain injury (Garrett, 1996). Muscle strain injuries most often occur during eccentric contractions, as a higher force generation of 25-50% can be produced in this way (Schoenfeld et al, 2017). The damage caused by the strain is a tearing of individual muscle fibres producing a haematoma, fibre disruption and muscle oedema (Thierfelder et al, 2019). The strain injury sustained are typically graded into one of three levels depending upon the severity during a clinical examination, with grade 3 being the most severe (Nsitem, 2013).

Conventional treatment aims are to initially reduce pain by limitation of activities, protection of the injury, rest, ice, compression and elevation (PRICE) (Nsitem, 2013). Following this, the focus moves onto restoring flexibility by passive and active stretching, with the use of massage and electrical stimulation useful as part of the treatment plan (Bryan Dixon, 2009). Although Tiidus (2015) states "that the effectiveness of massage on influencing muscle recovery from more severe injury cannot yet be made due to a lack of experimental evidence".

In the final phase of recovery, the addition of isometric, isotonic and dynamic training exercises are introduced. Finally general conditioning exercises, closed-chain exercises, and sport-specific exercises are used to help the patient gain strength and agility enabling a successful return to play (Bryan Dixon, 2009).

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During a 10km run, each calf muscles absorbs up to 1.68 million kg of force. (Summit Therapy, 2019)

The importance of treatment timings in the post injury phases need to be aligned with the biological principles of the tissue repair process (Zissler et al, 2018). This process occurs in three distinct overlapping phases, inflammation, proliferation, and finally the remodelling phase (Maxson et al, 2012). Issues occurring in any of these three phases of muscle repair can then develop into a chronic condition that can prolong and inhibit a full recovery (Davis et al, 2009). Shock waves are acoustic pulses characterised by high positive pressure amplitudes with a steep pressure increase compared to the ambient pressure (Gleitz, 2019). In modern therapy there are two forms of shockwave currently being used, focused extracorporeal shockwave therapy (fESWT) and radial extracorporeal shockwave therapy (rESWT) (Speed, 2014). Focused shockwaves are classified as a true shockwave as they produce a single positive pressure pulse that is followed by a smaller negative pressure pulse that causes cavitation at the tissue interface, with the formation of tiny air bubbles that subsequently implode at high speeds (van der Worp et al, 2013). Radial shockwaves are not classed as a true shockwave but instead a pressure wave as they lack the characteristic physical features of a true shockwave such as a short rise time and a high peak pressure (Cleveland et al, 2007). The term focused arrives from the fact that the pulse energy is focused on a single small point like a laser beam, while radial is the greatest energy radiated outwards from the end of the device like a torch (Woledge, 2019).

Further research is needed into rESWT and its use for the treatment of calf muscle strain injuries to evaluate its effectiveness a suitable modality.

Recently ESWT has been used in musculoskeletal disorders and is primarily used in the treatment of sports related over-use chronic tendinopathies, with success rates ranging from 65% to 91% (Wang, 2012). It is under these chronic circumstances that the main objective of using ESWT is to bring the chronic condition back into a more responsive acute state, thus escaping the vicious inflammatory cycle and triggering the self-repair mechanisms of the body (Koksal et al, 2015). It's use in chronic injuries of the lower limb has been found to be a cost-effective, non-invasive method of treatment for the healing of problematic soft tissue injuries (Haake et al, 2001).

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Studies have found that ESWT as a means to accelerate tissue repair and regeneration for various muscular and skin wounds (Davis et al, 2009; Hayashi et al, 2012; Mittermayr et al, 2012). Clinical studies on rats have shown that ESWT enhances blood flow in muscle tissues immediately after application with repetitive applications prolonging the effect observed (Kisch et al, 2016). The additional benefits of ESWT are in localised pain reduction by the production of free radicals resulting in pain inhibiting chemicals in the vicinity of the cells, while also stimulating the nociceptors to fire nerve impulses which are blocked according to the pain control theory (Wess, 2008).

Not much is known about the benefits of rESWT treatments applied to muscle injuries. Astur et al (2015) found improvements in lower limb muscular injuries treated with fESWT with reduced pain and muscular strength gains after six weeks. Although their study used fESWT, the treatments were only given twice, initially then on the third week.

Further research is needed into rESWT and its use for the treatment of calf muscle strain injuries to evaluate its effectiveness a suitable modality.

METHOD

6 week experimental, randomised sham-controlled between subject's design

- All participants will be runners over 18 years, with a chronic (greater than 3 weeks) calf injury.
- The sample size for the study is 34 participants using an effect size of 0.8 to give an 80% power with a significance level of 5% (Dhand & Khatkar, 2014).
- All participants are to be informed of any side effects and contraindications both written and orally.
- Participants will be randomly placed into two groups using a block randomisation technique (Suresh, 2011) provided by GraphPad (2018).
- Treatment will be given at the point of maximum pain of the CMSI.
- The ESWT group will receive 3000 shocks per session once a week for a total of 6 sessions (Müller-Ehrenberg et al, 2017).
- Treatment will be with a MP100 radial shockwave device (Storz Medical, Tagerwilen Switzerland) using ultrasound gel as a coupling agent.
- The sham group will receive their treatment using a special sham tube provided by the manufacturer fitted to the hand piece prior to treatment.
- The ESWT treatment will be applied by a qualified and experienced clinician.
- The pain score is taken prior to the treatments using a 10cm length visual analogue pain scale (VAS), then 1 week and 1 month after the final treatment.
- Confirmation of any other treatments not being received will be sought prior to each treatment.
- All results will be analysed using IBM SPSS software package (SPSS for Windows version 23.0; SPSS, Chicago, IL, USA).
- The study will evaluate if there is a significant difference between pain VAS scores of the ESWT group and the VAS score of the sham group for a significant difference ($p = < 0.05$) using an independent T – test. A paired T – test will be used for intergroup evaluation.
- To compare the treatment effects between groups against time, a repeated measure analysis of variance (ANOVA) will be used. If the ANOVA is significant, a post hoc Bonferroni test will be performed. A value of $P < 0.05$ will be taken to indicate statistical significance.

EXPECTED FINDINGS

The rESWT group will have a greater initial pain reduction supporting the findings of (Gerdesmeyer et al, 2008). The return to play (RTP) times for the experimental rESWT group may prove shorter due to increased healing process by supporting the findings of (Mattyasovszky et al, 2018).

LIMITATIONS

Due to timescales a shorter follow up period of one month will be used. This contradicts previous evidence suggesting that the effects of rESWT can be persistent at up to 90 days post last treatment (Oh et al, 2019).

REFERENCES

Astur, D. C., et al (2015) EXTRACORPOREAL SHOCKWAVE TERAPY TO TREAT CHRONIC MUSCLE INJURY, Acta ortopedica brasileira, 23(5), 247-250.

Bryan Dixon, J. (2009) Gastrocnemius vs. soleus strain: how to differentiate and deal with calf muscle injuries, Current reviews in musculoskeletal medicine, 2(2), 74-77.

Cleveland, R. O., Chitnis, P. V. & McClure, S. R. (2007) Acoustic Field of a Ballistic Shock Wave Therapy Device, Ultrasound in Medicine & Biology, 33(8), 1327-1335.

Dabholkar, A., Alva, T. & Yardi, S. (2014) Common Musculoskeletal Problems Faced by Recreational Runners, Indian Journal of Physiotherapy and Occupational Therapy, 8(1), 221-226.

Davis, T. A., et al (2009) Extracorporeal shock wave therapy suppresses the early proinflammatory immune response to a severe cutaneous burn injury, 6(1), 11-21.

Dhand, N. K. & Khatkar, M. S. (2014) Statulator: An online statistical calculator. Sample Size Calculator for Comparing Two Paired Means, 2014. Available at: http://statulator.com/SampleSize/ss2PM.html [Accessed:30 Apr].

Francis, P., et al (2019) The Proportion of Lower Limb Running Injuries by Gender, Anatomical Location and Specific Pathology: A Systematic Review, Journal of Sports Science & Medicine, 18(1), 21-31.

Garrett, W. E., Jr. (1996) Muscle strain injuries, Am J Sports Med, 24(6 Suppl), S2-8.

Gerdesmeyer, L., et al (2008) Radial extracorporeal shock wave therapy is safe and effective in the treatment of chronic recalcitrant plantar fasciitis: results of a confirmatory randomized placebo-controlled multicenter study, Am J Sports Med, 36(11), 2100-9.

Gleitz, M. (2019) Myofascial Syndromes and Triggerpoints. 2Level10 Buchverlag.

GraphPad (2018) QuickCalcs, 2018. Available at: https://www.graphpad.com/quickcalcs/randomize1/ [Accessed:05/11/2019].

Green, B. & Pizzari, T. (2017) Calf muscle strain injuries in sport: a systematic review of risk factors for injury, British Journal of Sports Medicine, 51(16), 1189.

Haake, M., Rautmann, M. & Wirth, T. (2001) ASSESSMENT OF THE TREATMENT COSTS OF EXTRACORPOREAL SHOCK WAVE THERAPY VERSUS SURGICAL TREATMENT FOR SHOULDER DISEASES, International Journal of Technology Assessment in Health Care, 17(4), 612-7.

Hayashi, D., et al (2012) Low-energy extracorporeal shock wave therapy enhances skin wound healing in diabetic mice: A critical role of endothelial nitric oxide synthase, Wound Repair & Regeneration, 20(6), 887-895.

Kisch, T., et al (2016) Repetitive shock wave therapy improves muscular microcirculation, Journal of Surgical Research, 201(2), 440-445.

Kluitenberg, B., et al (2015) What are the Differences in Injury Proportions Between Different Populations of Runners? A Systematic Review and Meta-Analysis, Sports Medicine, 45(8), 1143-1161.

Koksal, I., et al (2015) Comparison of extracorporeal shock wave therapy in acute and chronic lateral epicondylitis, Acta Orthop Traumatol Turc, 49(5), 465-70.

Liao, C.-D., et al (2018) Efficacy of extracorporeal shock wave therapy for knee tendinopathies and other soft tissue disorders: a meta-analysis of randomized controlled trials, BMC Musculoskeletal Disorders, 19(1), N.PAG-N.PAG.

Lopes, A. D., et al (2012) What are the Main Running-Related Musculoskeletal Injuries? , Sports Medicine, 42(10), 891-905.

Mattyasovszky, S. G., et al (2018) Exposure to radial extracorporeal shock waves modulates viability and gene expression of human skeletal muscle cells: a controlled in vitro study, J Orthop Surg Res, 13(1), 75.

Maxson, S., et al (2012) Concise Review: Role of Mesenchymal Stem Cells in Wound Repair, STEM CELLS Translational Medicine, 1(2), 142-149.

Mittermayr, R., et al (2012) Extracorporeal shock wave therapy (ESWT) for wound healing: Technology, mechanisms, and clinical efficacy, Wound Repair & Regeneration, 20(4), 456-465.

Müller-Ehrenberg, H., et al (2017) Importance of the Correct Use of Extracorporeal Shockwave Therapy, Archives of Physical Medicine and Rehabilitation, 98(10), 2100-2101.

NHS (2014) Calf Strain, 2014. Available at: https://www.ouh.nhs.uk/patient-guide/leaflets/files/10921Pcalfstrain.pdf [Accessed:05/11/2019].

NHS (2018) Sprains and strains, 2018. Available at: https://www.nhs.uk/conditions/sprains-and-strains/ [Accessed:05/11/2019].

Nsitem, V. B. D. C. F. M. (2013) Diagnosis and rehabilitation of gastrocnemius muscle tear: a case report, The Journal of the Canadian Chiropractic Association, 57(4), 327.

Oh, J. H., et al (2019) Duration of Treatment Effect of Extracorporeal Shock Wave on Spasticity and Subgroup-Analysis According to Number of Shocks and Application Site: A Meta-Analysis, Ann Rehabil Med, 43(2), 163-177.

Prakash, A., et al (2018) Connective tissue injury in calf muscle tears and return to play: MRI correlation, British Journal of Sports Medicine, 52(14), 929.

Room, J., et al (2017) What interventions are used to improve exercise adherence in older people and what behavioural techniques are they based on? A systematic review, BMJ Open, 7(12), e019221.

Schoenfeld, B. J., et al (2017) Hypertrophic Effects of Concentric vs. Eccentric Muscle Actions: A Systematic Review and Meta-analysis, J Strength Cond Res, 31 (9), 2599-2608.

Shrivastava, S. K. & Kailash (2005) Shock wave treatment in medicine, Journal of Biosciences, 30(2), 269-75.

SMS-Inc, S. (2014) UK'S RUNNING POPULATION 2014. Available at: https://www.sportsmarketingsurveysinc.com/uks-running-population-reaches-remarkable-10-5m-says-sports-marketing-surveys-inc/ [Accessed:Apr 2019].

Speed, C. (2014) A systematic review of shockwave therapies in soft tissue conditions: focusing on the evidence, British Journal of Sports Medicine, 48(21), 1538.

SummitTherapy (2019) Achilles load during a 10km run, 2019. Available at: https://www.facebook.com/summittherapy/photos/a.966808646794723/1284616468347271/?type=3&theater [Accessed:11/11/2019].

Suresh, K. (2011) An overview of randomization techniques: An unbiased assessment of outcome in clinical research, Journal of human reproductive sciences, 4 (1), 8-11.

Thierfelder, K. M., et al (2019) Imaging of hip and thigh muscle injury: a pictorial review, Insights into Imaging, 10(1), 1-9.

Tiidus, P. M. (2015) Alternative treatments for muscle injury: massage, cryotherapy, and hyperbaric oxygen, Current Reviews in Musculoskeletal Medicine, 8(2), 162-167.

Van der Worp, H., et al (2013) ESWT for tendinopathy: technology and clinical implications, Knee Surgery, Sports Traumatology, Arthroscopy, 21(6), 1451-8.

Vitez, L., et al (2017) Running injuries in the participants of Ljubljana Marathon, Zdravstveno Varstvo, 56(4), 196-202.

Wang, C.-J. (2012) Extracorporeal shockwave therapy in musculoskeletal disorders, Journal of Orthopaedic Surgery and Research, 7, 11.

Wess, O. J. (2008) A neural model for chronic pain and pain relief by extracorporeal shock wave treatment, 36(6), 327-334.

Woledge, J. (2019) Overview of Shockwave therapy in daily practice with guest expert Paul Hobrough, The Shockwave Therapy Podcast [Podcast]. 24/05/2019. Available online: https://theabbeyfieldsclinic.co.uk/feed/the-shockwave-therapy-podacst/ [Accessed 12/11/2019].

Zissler, A., et al (2018) Extracorporeal Shock Wave Therapy in Acute Injury Care: A Systematic Review, Rehabilitation Process and Outcome, 7, 1179572718765138.