Phonophoresis Versus Ultrasound in the Treatment of Soft Tissues Injuries in the Sprinters and Hurdling Athletes

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ABSTRACT

The purpose of this study was to compare the efficacy of phonophoresis (PH) versus ultrasound (US) in the treatment of soft tissues injuries (hamstring muscle injuries) in sprinters and hurdling athletes. Sixty subjects with a mean age of 18.9±3.7 years 52 males and 8 females with a mean body mass index (BMI) of 21.8±1.6 and the onset of trauma ranged between 2-8 days. Subjects were randomly assigned to PH, US or placebo groups. Continuous US waves of 1 MHz frequency and 1.5 watt/cm2 power were applied for 5 minutes to the target area, of daily settings for 2 weeks for a total of 10 sessions applied for the PH and US group, placebo group revived sham US treatment. For the PH group a gel containing an anti-inflammatory-analgesic gel (Ketoprofen) was used as a coupling agent. An identical acoustic gel was used for the US group and placebo group without any active pharmacological agent. Athletes were subjected to the following subjective and functional pre-and post treatment program evaluations: indicated their pain level by a visual analog scale (VAS), finger floor distance (FFD), triple jump test (TJT), vertical jump (VJ), hamstrings muscle strength (HS), 20 meters walking time. At the end of treatment, although both groups (PH and US group) combined showed a significant decrease in pain level and an increase in functional activity (P<0.05), the PH group showed a significant differences in the pain level at the end of the second week compared to the US group (P<0.05). Placebo group did not show any significant difference for pain level, 20 m T and HS at the end of the study (P>0.05). It is concluded that US results in decreased pain and increased functional capacity in sprinters and hurdling athletes with hamstring muscle injuries. The addition of PH with Ketoprofen augments the benefits of the US therapy.

INTRODUCTION

Ultrasounds have been widely used for more than 40 years in the treatment of musculoskeletal disorders. Us converts electrical energy into an acoustic waveform, which is then converted into heat as it passes through tissues of varying resistance[1].

In PH, in addition to deep heating, US is used to enhance percutaneous absorption of drugs. This technique also has been used successfully to deliver anti-inflammatory medication to inflamed subcutaneous tissues[2]. The possibility of delivering nonsteroidal anti-inflammatory drugs (NSAIDs) through the skin for either local or systemic effects is being investigated increasingly in the management of pain and inflammation in musculoskeletal conditions in sports medicine and orthopedic rehabilitation such as epicondylitis, tendinitis, tenosynovitis, bursitis and OA[3,4]. PH is believed to accelerate functional recovery by decreasing pain and promoting healing[5,6]. The technique is non-invasive, well tolerated and involves minimal risk of hepatic and renal injury[1]. Despite extensive clinical experience, there is controversy regarding the efficacy of PH[2].

Gastrointestinal upset and local pain commonly limits the use of oral nonsteroidal anti-inflammatory drugs and corticosteroid

injection as treatments for musculoskeletal disorders. Transdermal administration of an anti-inflammatory drug could avoid these adverse effects[7].

The hamstrings was the most common site of strain, accounting for 41% of sprinters and hurdling injuries, 15% to 25% of all time lost to injury and 30% of all retirements of sprinters and hurdling athletes[8].

The aim of this study was to evaluate the short-term effectiveness of Ketoprofen PH versus continuous US therapy in patients with soft tissues injuries.

SUBJECTS AND METHODS

This study included sixty sprinters and hurdling athletes from the Faculty of Physical Education, Zagazig University. They were 52 males and 8 females with a mean age of 18.9±3.7 years, the mean body mass index (BMI) of 21.8±1.6 and the onset of trauma ranged between 2-8 days. All of the sprinters and hurdling players with mild to moderate acute hamstrings muscle tear injuries were included. Players with severe muscle injury, multiple injuries, subjects who sustained a chronic trauma for more than 3 months, or who had used anti-inflammatory drugs at the onset of injury or within 30 days prior to the test, and subjects with skin problems (Eczema or Ketoprofen allergy) or recent wounds in the treated areas were excluded from this study. Concomitant use of NSAIDs or analgesics was not permitted throughout the study.

All participants were subjected to the following subjective and functional pre-and post treatment program tests: Pain perception intensity, maximal hamstring free pain length by the finger floor distance (FFD), the triple jump test (TJT), vertical jump (VJ), hamstrings muscle strength, 20 meters walking time. Each subject performed three trials of each tests.

Athletes were randomly assigned into 3 equal groups, group I (PH group) and group II (US group), group III (placebo group).

The tests of subjective assessments and functional performance were performed as follows: pain perception intensity which was measured and represented by a line scaled from 0 position which means no pain to 10 position which means unbearable pain, athletes were asked to mark at a point which refer to the degree of pain he/she feels. Maximal hamstring free pain length was measured by the FFD by asking the athlete to bend forward maximally, keeping the knees fully extended while standing erect with the spine in fullest flexion, the distance between the fingers tips and the earth was measured in centimeters, for the TJT, the subjects were instructed to stand on their injured leg and to jump three times along a straight line and the total distances was measured in centimeters, VJ was performed with the subject standing erect, quickly performing a counter movement jump for maximal height with each leg on a wall scale in centimeters. hamstrings muscle strength were measured with the subjects in the prone position and asking the subjects to forcibly bend their knees by a dynamometer measured in Newton, 20 meters walking time “as fast as possible” was measured with stopwatch and reported in seconds. Measurements and assessments were recorded pre-and post-treatment program.

Intervention

The physiotherapy programme was conducted five times a week for two weeks, for a total of 10 sessions, while patients in a prone position and the area to be treated (about 8 cm^2) was marked after detecting it by the clinical examination. In the US and placebo

group the skin was coated with an acoustic gel without any active pharmacologically substance. In the PH group, an 8 cm long strip of gel containing 2.5% Ketoprofen was applied from the tube over the target thigh. US were then applied to the affected parts of the hamstring muscle over the gel by the same therapist stroking the applicator in small, continuous, circular movements at right angles to ensure maximum absorption of the US energy in a standardized way for all subjects. After the US treatment, the gel was removed from the affected area.

Continuous ultrasonic waves with 1 MHz frequency and 1.5 w/cm2 power were applied with a 4 cm diameter applicator (Sonopuls 590 Enraf-Nonus BV, AV Delft, Netherlands) for both treatment groups, placebo group received sham US treatment. US therapy lasted 5 minutes in each session. Total energy (in joules) was calculated as watts per square centimeter (applicator size (in square centimeters) (time (in seconds). Energy density = Total energy (in joules)/area treated[9].

The skin was pretreated with US, moistening or shaving in order to maximize clinical effectiveness. To avoid the influence of superficial heat on our results, outcome data were collected two days after the completion of therapy sessions.

Statistical analysis

All statistical analysis was carried out using SPSS 9.0 for Windows package program. All data are expressed as mean ± standard deviation. Paired t-test was used to compare the pre-and post-treatment changes in each group, ANOVA was used to compare the results of the three groups, and LSD test was used to prove the significant difference between groups. Also chi squared (X2) was used in quantitative variables. P considered significant at P value <0.05.

RESULTS

Baseline characteristics of the patients showed no significant differences with respect to age, gender, body mass index (BMI), onset of trauma (OT).

Comparing all groups for the pre-measurements values it revealed no statistically significant differences in baseline measurements between all groups (P >0.05).

All of the enrolled subjects completed the study and none were excluded from analysis. Comparing all groups at the end of 2 week of treatment, there was a significant difference (P<0.05) between groups. Comparing the results of both treatment groups with that of the placebo group, both groups showed a statistically significant differences for all functional tests measurements and pain evaluations (P<0.05). Comparing the pain evaluations of both treatment groups, it showed a statistically significant differences in favour of the PH group (P<0.05) (table 1). Comparing the post-program results of all groups, the two treatments groups showed a statistically significant differences for all functional tests measurements and pain evaluations (P<0.05), the placebo group showed no significant differences for the pain, 20 m T, and HS (P>0.05), but FFD, VJ and TJT showed a statistically significant differences (P<0.05) (table 2).

Comparing the percentage of change at the post-program measurements, the PH group showed the highest improvement in all the parameters studded compared to the two other groups. The US group showed more improvement compared to the placebo group (Figure 1). TJT and VJ showed the highest change at the end of study, HS and 20 m T showed a smaller change. No local or systemic

side effects were observed in the study population during the treatment.

DISCUSSION

In this study, marked improvements in clinical parameters were obtained with Ketoprofen PH or therapeutic US in athletes with soft tissues injuries, and both modality were found to be superior to the placebo. Therapeutic US is frequently used in physical therapy clinics to treat various musculoskeletal disorders[9]. Although the exact mechanism of action is unknown, heating is the most important effect. It encourages regional blood flow and increases connective tissue extensibility. Non-thermal effects are less understood and include molecular vibration, which increases cell membrane permeability and thereby enhances metabolic product transport[10].

Although ultrasound has been used for PH with a variety of techniques and settings, the most commonly used ultrasound method, corresponds to therapeutic ultrasound (frequency in the range of 1–3 MHz and intensity in the range of 1–2 W/cm2)[12].

Table (1): Significant deference between 3 groups (PH, US, and Placebo.) in Post-program measurements.

Variables	Groups	Mean	±SD	US	Placebo.	L.S.D 0.05
VAS	PH	3.1	1.37	0.8	2.2	0.66
	US	3.9	1.83		1.4	
	Placebo.	5.3	2.24			
FFD	PH	2.4	1.51	0.3	7.3	0.70
	US	2.7	1.68		7	
	Placebo.	9.7	2.01			
20.mT	PH	4.4	0.31	0.1	1.9	0.74
	US	4.5	0.41		1.8	
	Placebo.	6.3	2.24			
HS	PH	74.4	7.65	1.6	10.8	1.75
	US	72.8	8.21		9.2	
	Placebo.	63.6	6.33			
VJ	PH	44.6	5.71	0.6	15	0.74
	US	44	5.64		14.4	
	Placebo.	29.6	6.54			
TJT	PH	274	48.56	3.00	78	0.74
	US	271	46.97		75	
	Placebo.	196	32.54			

Table (2): Comparison between the Pre-to-post program measurements for 3 groups (PH, US, and Placebo.).

Variables	Groups	Pre-program		Post-program		t	Changed %
		Mean	±SD	Mean	±SD		
VAS	PH	6.8	2.00	3.1	1.37	2.98 s	54.41
	US	6.9	1.90	3.9	1.83	3.02 s	43.48
	Placebo.	6.7	1.81	5.3	2.24	1.28 ns	20.90
FFD	PH	15.4	3.64	2.4	1.51	6.53 Hs	84.42
	US	15.8	3.72	2.7	1.68	7.21 Hs	82.91
	Placebo.	15.7	3.25	13.7	2.01	1.02 Hs	38.22
20.mT	PH	7.4	2.39	4.4	0.31	3.11 s	40.54
	US	7.3	2.10	4.5	0.41	3.42 s	38.36
	Placebo.	7.2	2.45	6.3	2.24	1.24 ns	12.50
HS	PH	52.9	5.64	74.4	7.65	4.25 Hs	40.64
	US	54.2	4.91	72.8	8.21	5.67 Hs	34.32
	Placebo.	54.0	5.31	63.6	6.33	2.18 ns	17.78
VJ	PH	9.6	3.53	44.6	5.71	12.25 Hs	364.58
	US	9.7	3.71	44	5.64	10.58 Hs	353.61
	Placebo.	9.4	3.25	29.6	6.54	7.21 Hs	214.89
TJT	PH	75.8	9.75	274	48.56	15.28 Hs	261.48
	US	77.2	8.92	271	46.97	13.24 Hs	251.04
	Placebo.	75.9	9.26	196	32.54	10.64 Hs	158.23

* HS: Highly significant P<0.001, * S: significant P<0.05

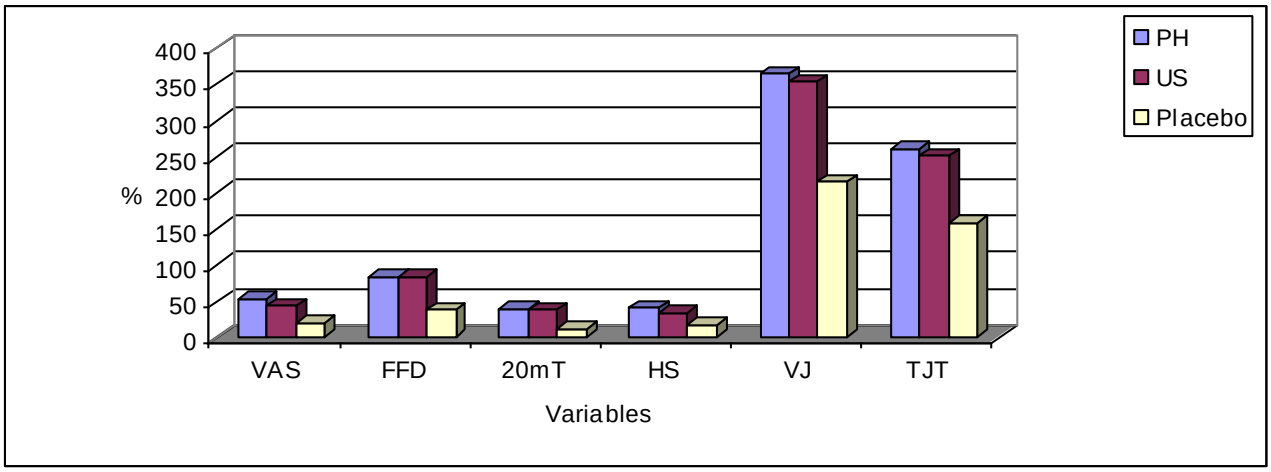

Fig. (1): The percentage increase of all the parameters studded for all groups.

In our study, a frequency of 1.5 MHz was used. Mitragotri et al.,[13] reported that the phonophoretic enhancement in the therapeutic frequency range varies inversely with ultrasound frequency. They found that 1-MHz ultrasound enhances transdermal transport of estuarial across human cadaver skin in vitro by 13-fold, but that 3-MHz ultrasound at the same intensity induces an enhancement of only 1.5-fold. They further hypothesized that the

observed inverse dependence of sonophoretic enhancement on ultrasound frequency occurs because cavitational effects, which are primarily responsible for phonophoresis, vary inversely with ultrasound frequency.

In this study, we proposed that penetration of Ketoprofen to the deeper sites is enhanced by PH, resulting in benefits additional to those of conventional therapeutic US. However, the two treatment modalities were found to be nearly equally effective. Although both groups (PH and US) revealed a significant reduction in the reported pain during various activities, the PH group showed more significant improvement in pain evaluations as the issues of specificity of PH treatment and reports in the literature[3,4,6]. Clinical studies of topical anesthetics, corticosteroids and phenyl-butazone have shown beneficial effects in the treatment of common musculoskeletal conditions (epicondylitis, tendinitis, and tenosynovitis) Cagnie et al.,[13] study results indicate that, in contrast to sham phonophoresis, ultrasound can increase the transdermal delivery of Ketoprofen in twenty-six patients with knee disorders.

The pain relief achieved in this study was in line with that reported by Vlak[14] study on the effects of PH with diclofenac gel in treating 64 patients with painful shoulder syndrome has been found to be highly effective in reducing pain at rest and in motion. Our study confirms that topical applications of Ketoprofen with US attain high effects in pain relief. This finding is consistent with the results of Shin and Choi[15] in a double-blind, placebo-controlled randomly assigned study; indomethacin PH was used in the treatment of temporomandibular joint pain in 20 patients, and a significant pain relief was reported.

Those results lead one to expect that the PH group would demonstrate more functional benefits from the treatment program than would the two other groups. Regarding pain and functionality, the limited difference detected in this study between the two treatment groups suggested that PH are effective than the US in reducing pain and only a little more effective than the US in improving functionality.

A striking finding in this study is the absence of a significant difference in functional tests between the two treatment groups. Both groups (PH and US) demonstrated a significant increase in overall functionality, as measured by FFD, 20 m T, H S VJ and TJT tests used in this study. The number of subjects who could perform various tests without symptoms increased significantly for both groups (PH and US). Although the PH group showed a significant difference in the pain values, it did not reflected into significant functional difference, this may be due to the short treatment time (two weeks only) and the actual US advantages in the managements of soft tissues injuries which suggested that both treatments regimen are effective in the management of the soft tissues injuries in athletes. These observed success rate in the functional capacity of the US and PH treated groups in this study may indicate that US have a positive effects in the healing process and that the smaller improvements in the pain and muscle power may be reflected into improvement in functionality which are in consistence with previous findings in the literature concerning the effects of US in soft tissues injuries[16]. Gan et al.,[17] who found that US increase range of movement, advanced scar maturation and decreased amount of inflammatory infiltrate around the repair site in the surgically lacerated flexor tendons. The present study also goes in line with that

reported by Ramirez et al.,[18] who found that US stimulates collagen synthesis in tendon fibroblasts in response to an injury of the connective tissue matrix and that US stimulates cell division during periods of rapid cell proliferation. The present study also was in line with that of James and Harold[19] who reported improved force production after contraction-induced muscle injury after seven days of continuous therapeutic US on thirty-three rats. The Jussi et al.,[20] descriptive study followed the regeneration of contusion injury of the rat gastrocnemius muscle which revealed that US treatment increases the rate of repair of injured Achilles tendons of rats. The results are also consistent with an association between increased collagen synthesis and greater breaking strength during tendon repair.

BYl[4] reported that approximately 75% of the studies reviewed by them indicated some level of effectiveness of US as an enhancer of topically applied drugs. They attributed the physiological effects of US to the heating effects which increases the kinetic energy of the molecules in the drug and in the cell membrane, dilates points of entry such as the hair follicles and the sweat glands, and increases the circulation to the area sonicated. These physiological changes can enhance the opportunity for drug molecules to diffuse through the stratum corneum and be collected by the capillary network in the dermis.

In contrast, there are studies which have failed to show the efficacy of PH over US. Kozanoglu and his colleagues[21] failed to find any superior effects of ibuprofen PH over conventional US therapy in knee osteoarthritis. Bare et al.,[22]. Who investigated the phonophoretic delivery of 10% hydrocortisone in 16 healthy volunteers and failed to find a rise in serum cortisol concentrations, which appears to reflect absence of penetration through the epidermis into the underlying vasculature by PH. In a study by Klaiman et al.,[1] the efficacy of 0.05% fluocinonide PH versus US therapy was investigated in the treatment of 49 subjects with soft tissue injuries, and the authors found no difference in pain level and pressure tolerance between groups. This discrepancy may be attributed to: some authors used cream based PH that do not allow for adequate transmission of the acoustic wave, also the differences in the physiological properties of the drug used in PH can play a role, different frequencies and intensities used in the studies and a possible explanation for this is that none of our patients had a major long-standing soft tissues injuries.

The results indicate that, in contrast to sham phonophoresis, ultrasound can increase the transdermal delivery of Ketoprofen.

CONCLUSION

Conventional therapeutic US application was effective in relieving the symptoms in athletes with a range of musculoskeletal injuries, pain or in promoting soft tissue healing. We conclude that US results in decreased pain and increased functionality in these selected soft tissue injuries. The addition of Ketoprofen gel will augment the benefits of US used alone.

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الملخص العربي

العلاج بطريقة إدخال المواد الكيميائية إلى الجسم عن طريق الجلد بواسطة الموجات فوق الصوتية مقابل العلاج بالموجات فوق الصوتية لعلاج حالات تمزق الأنسجة الرخوة للعدائين ولاعبي الحواجز

تهدف هذه الدراسة إلى المقارنة بين كفاءة كلا من العلاج بطريقة إدخال المواد الكيميائية إلى الجسم عن طريق الجلد بواسطة الموجات فوق الصوتية و العلاج بالموجات فوق الصوتية لعلاج حالات إصابات الأنسجة الرخوة (تمزق العضلة الفخذية الخلفية) للعدائين ولاعبي الحواجز. تم اختيار ستون حالة: 52 من الذكور و 8 من الإناث يبلغ متوسط أعمارهم 18.9±3.7 سنة ومتوسط كتلة الجسم 21.8±1.6 وعمر الإصابة 2-10 يوم. تم تقسيم الحالات عشوائيا إلى ثلاث مجموعات متساويات. المجموعة الأولى: مجموعة العلاج بطريقة إدخال المواد الكيميائية إلى الجسم عن طريق الجلد بواسطة الموجات فوق الصوتية، والمجموعة الثانية: مجموعة العلاج بالموجات فوق الصوتية والمجموعة الثالثة:المجموعة الضابطة. تم استخدام الموجات فوق الصوتية بقوة 1 ميجا هيرتز وتردد 1.5 وات/سم2 لمدة خمس دقائق يوميا على المنطقة المصابة لمدة عشرة أيام خلال أسبوعان للمجموعتان العلاجيتان بينما تلقت المجموعة الضابطة موجات فوق الصوتية زائفة. تم استخدام وسيط مائي يحتوى على مادة مضادة للالتهابات ومسكنة (كيتوبروفين) كوسيط موصل للموجات الصوتية للمجموعة الأولى، ووسيط مائي لا يحتوى على أي مواد كيميائية للمجموعتين الثانية والثالثة . تم إخضاع كافة المشاركين بالبحث لعدة اختبارات قبل وبعد البرنامج وهى قياس شدة الألم، أقصى مسافة للأصابع عن الأرض. الوثب الثلاثي للقدم المصابة، القفز العمودي بالقدم المصابة، قوة العضلة الفخذية الخلفية وزمن مشى 20 مترا. وقد أظهرت نتائج الدراسة انه وعلى الرغم من أن كلا من المجموعتين العلاجيتين قد أظهرتا تحسنا ذو دلالة إحصائية لمستوى الألم وكذلك القياسات الوظيفية الأخرى، فان المجموعة الأولى قد أظهرت تحسنا أفضل وذو دلالة إحصائية لمستوى الألم عن تلك للمجموعة الثانية. بينما لم تظهر المجموعة الضابطة أي تحسن ذو دلالة إحصائية لمقياس الألم أو مشى 20 مترا بالوقت أو قوة العضلة الفخذية الخلفية عند نهاية الدراسة . وقد استخلصت الدراسة أن الموجات فوق الصوتية تساعد في تقليل الألم وزيادة القدرة الوظيفية للعدائين ولاعبي الحواجز المصابين بتمزق بالعضلة العضلة الفخذية ، وإن إضافة المواد المضادة للالتهاب تزيد من كفاءة وفعالية العلاج بالموجات فوق الصوتية.