EFFECT OF PULSED ULTRASONIC THERAPY ON SKELETAL MUSCLE INJURY IN RABBITS

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INTRODUCTION

Skeletal muscle injury which comprises, a high proportion of sport injury, is associated with inflammation, transudation and fibrin deposition (Murray - Leslie, 1986). The injured muscle fibres, when relatively small, have the capacity for regeneration and repair and are again capable of contraction. With larger injury and/or presence of systemic diseases, there is a reduced capacity for regeneration and repair and the muscle fibers can ultimately be replaced by fat and/or fibrous tissue (Ambrosia, 1986). A modality able to enhance healing of such injury may facilitate restoration of the prior level of function. Low dose pulsed ultrasonic therapy was proved to be more effective than radiant heat, short-wave diathermy or paraffin baths in helping patients with sprained ankles to return to work (Middlemast, 1978). Various other researches including topics as surgical wounds, varicose ulcers and pressure sores, were in favor of the healing effect of pulsed ultrasound and support such an idea (McDiarmid et al., 1985 and Hong et al., 1988). Pulsed ultrasound can be applied safely during the early stages of healing without fear of bleeding due to its minimal thermal effect in comparison with the non thermal one (Dyson & Suckling, 1978; Partridge, 1987 and Lehman & DeLateur, 1989). Other contradictory results proved that low dosage of pulsed ultrasound impair healing when applied on freshly healing tendons in rabbits (Roberts, 1982). Despite these numerous experiments and the importance of early recovery after skeletal muscle injury, no study has been reported that examines the effect of ultrasound on the healing of muscle in-
the proportion of the regenerating fl-
(1987). Mild regeneration (grade 1) =
and Brown & Baker (1980) and Brown & Baker
determined according to Foster and
degree of muscle regeneraion was-
that were placed centrally (Figs. 2). The-
and normal appearing nuclei-
result of a loss of cytoplasm (Figs. 1-
sterilized with a ethylene oxide-
regeneration and regeneration (Brown and Baker)
degree of muscle fibre degeneration-
that were produced for the study of each-
20.25 cells were between 20.25 to 25-
hermetically and each (Lillie and Full-
mentation, sectioned and stained with-
embedded in paraffin by a standard-
method of Foster and Carlson (1980)
level of the skin over the belly-
method of Foster and Carlson (1980),

**MATERIAL AND METHODS**

Thus, this was therefore the basic

The central part of each gastrocnem-

Effect of pulsed ultrasonic therapy etc.

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bres was lesser than the degenerating fibres. Moderate regeneration (grade 2) = the proportion of the regenerating fibres was equal to the degenerating one. Marked regeneration (grade 3) = a few small patches of degenerated fibres existed, while the regenerated fibres with central nuclei occupied the major portion of the lesion. Excellent regeneration (grade 4) = the regenerating fibres occupied the whole site of lesion. The cytoplasmic staining and the size of the regenerating fibres were nearly the same as unaffected fibres (Fig. 4).

A t-test was performed to compare between the degree of improvement after the first and second week of treatment in both the insonated and mock-insonated groups. A probability level of 0.05 was considered to be significant.

RESULTS

- After one weak of ultrasonic irradiation (Table 1), the insonated muscles showed a more rapid grade of healing than of the control group. The insonated muscles showed mild regeneration in 3 muscles, moderate and marked regeneration in 7 and 2 muscles respectively. In the mock-insonated muscles mild and moderate regeneration were demonstrated in 8 and 4 muscles respectively while no marked regeneration was observed in any muscles (Fig.1, 2 and 3). The level of significance between the degree of improved regeneration in both the insonated and mock-insonated muscles reached a significant level (P<0.025).

- After two weeks of ultrasonic irradiation (Table 2), better degree of healing was observed in the insonated muscles in comparison with the mock insonated ones. Mild and moderate degrees of regeneration were demonstrated in no muscles & only in one muscle respectively in the insonated muscles, while they were demonstrated in 2 and 4 muscles respectively in the mock insonated muscles. Marked and excellent improvement in the tissues from insonated muscles was observed in 6 and 5 muscles respectively in comparison to 5 and one muscles in the mock-insonated group (Fig. 1, 2, 3 and 4). The level of significance between the degree of improved regeneration in both the insonated
The process of healing whenever a test cylinder of the basal lamina is called regeneration of mus. After muscle injury secondary to Xylo- 


speculate to the cause of injury (Hall

case of regeneration is similar to the

softer tissue injury; "the pro-

secondary to ischemia," but the pro-

method used greatest injury to the

and external of injury differs according

and muscle injury in animals. The severity

be in effective means for producing

each of these methods was found to

muscle: transplanthung whole muscles,

muscle; transplanthung whole muscles.

muscle; transplanthung whole muscles.

the process of healing is called


drug (Hall-Craggs, 1974; Foster &

and inducing a muscle with a myotoxic

muscle; transplanthung whole muscles.

muscle; transplanthung whole muscles.

muscle; transplanthung whole muscles.

muscle; transplanthung whole muscles.


discussion

(p < 0.01)

reach a more significant level

treatment. For two weeks of treatmen

and mock-ultrasound muscles at
er application and low dosage can produce the therapeutic effects of ultrasound inside the treated muscles, without any side effects (Lehman and DeLateur, 983).

Throughout the present study, it was found that the insonated muscles healed more rapidly than those of the mock-insonated muscles, as manifested by better grades of healing at any time during the regeneration process. This difference in the rate of healing between the insonated and non-insonated muscles was statistically significant after the first and second weeks of treatment (P< 0.025 and 0.01 respectively). The mechanism by which pulsed ultrasound stimulates healing is mostly due to the nonthermal effects and, to a lesser extent, to the thermal effect as well (Dyson & Pond, 1970 and Dyson, 1987). Of the nonthermal effects of ultrasound, cyclic and acoust streaming, it is the latter which seems to be most important (Madden & Smith, 1970). Cyclic effects relate to oscillatory movements accompanied by waves of pressure which are repeated at each wave cycle. They may induce a kind of "micromassage" which could facilitate tissue repair by reducing edema, but effect on tissue growth, per se, is not considered significant because the maximum displacement velocity produced at the ultrasound dosage giving maximal growth stimulation is too low to bring about the molecular interactions involved in growth (Madden and Smith, 1970). The acoustic streaming phenomena is observed mainly at interfaces such as the membrane of cells and organelles and it might be responsible for tissue repair (Webster et al., 1980). The acoustic streaming is thought to produce changes in diffusion rates and membrane permeability which might accelerate the rate of protein synthesis (Frieder et al., 1988). The mild degree of temperature elevation which may be produced as a result of pulsed ultrasound may enhance the healing brought about by non-thermal effects (Dyson, 1987). In this study, no complications as hemorrhage or progressive damage were noted during the period of treatment. Fortunately, if the proper equipment is used and a therapeutic dosage is applied with the proper technique, the destructive effect due to cavitation should not be observed under therapeutic conditions. Also there is no available study evaluating the healing effects of the the therapeutic ultrasound on muscle injury, the results of the present study support the effec-
SUMMARY

Improved outcome.

Skeletal muscle healing with resultant improved outcome observed during the early stage of skeletal muscle healing.

These results provide a foundation for the clinical therapy.

Weeks 0-4, 4-8, 8-12, and 12-24.

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were sacrificed after one week of treatment. The results revealed that

there were significant differences between the groups. The results revealed that

the treatment groups had a significantly better outcome than the control group.

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**Effect of Pulsed Ultrasound Therapy etc.**
Fig. 1: Section of a muscle after one week of mock-ultrasonic irradiation showing muscle cellular infiltration, their cells displayed missing nuclei and altered cytoplasmic staining (Hx. & E. stain X 100).

Fig. 2: Section of a muscle after one week of ultrasonic irradiation showing less cellular infiltration, with appearance of newly formed muscle fibres with central nuclei (Hx. & E. stain X 100).

Fig. 3: Section of a muscle after two weeks of mock-ultrasonic irradiation showing some cellular infiltration, their cells displayed missing nuclei and altered cytoplasmic staining with appearance of newly formed muscle fibres with central nuclei (Hx. & E. stain X 100).

Fig. 4: Section of a muscle after two weeks of ultrasonic irradiation showing no cellular infiltration, with appearance of normal peripheral nuclei and cytoplasmic staining (Hx. & E. stain X 100).

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Table 1: The reported degree of regeneration after one week in the mock-insonated and insonated gastrocnemius muscles.

<table>
<thead>
<tr>
<th>Number of Muscles</th>
<th>Degree of Improvement</th>
<th>S. D.</th>
<th>Mean Improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.66</td>
<td>&gt; 0.025</td>
<td>0.492</td>
<td></td>
</tr>
<tr>
<td>1.916</td>
<td>1.333</td>
<td></td>
<td>Marked</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td></td>
<td>Mild</td>
</tr>
</tbody>
</table>

- Marked
- Moderate
- Mild

- Statistical level of significance between the degree of regeneration in the mock-insonated and insonated muscles.

\[ p = 0.05 \]
الملخص العربي

تأثير العلاج بالموجات فوق الصوتية المنقطعة على إصابات العضلات الهيكلية في الأرانب

د. عاطف الغوطي د. نجوي هلال

يهدف هذا البحث إلى دراسة تأثير الموجات فوق الصوتية المنقطعة على التئام إصابات العضلات الهيكلية في الأرانب، حيث تم أحداث الإصابات بحقن دواء ضار بالعضلة (زيلوكاين) في منتصف العضلة ذات البطن للساق الأيمن والأيسر لأربعة وعشرين أرنبًا. وتم علاج الإصابة في العضلة اليمنى بواسطة الموجات فوق الصوتية المنقطعة (5). وبعد أسبوع واحد من العلاج تم فحص هستوپاتولوجي للعضلات المصابة في نصف الأرانب (عدد 12 أرنب) وتم الفحص في نصف الأرانب الثاني بعد أسبوعين. أوضح الفحص الهستوپاتولوجي للعضلات ذات البطن بعد أسبوع واسبوعين من العلاج أن الموجات فوق الصوتية المنقطعة قد ساعد على سرعة التئام إصابات العضلات بدرجة ذات دلالة إحصائية أكثر من تلك التي تركت بدون علاج فعال. وعلى ذلك بوصي باستخدام هذه الموجات في علاج إصابات العضلات الهيكلية.