

## THE EFFECT OF MICROWAVE THERAPY UPON MUSCLE BLOOD FLOW IN MAN

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### ABSTRACT

Muscle blood flow was measured using a radioactive tracer technique in five normal subjects. Flow values obtained during application of 2450 MHz microwave therapy were compared with resting values and in each case the treatment produced a significant increase; the mean values being 2.9 ml/100g/min at rest and 11.4 ml/100g/min during application of the microwave therapy. Comparison is made with previous studies using other therapeutic agents and it is concluded that the most significant effect on muscle blood flow is produced by microwave therapy.

#### Introduction

Previous studies have been concerned with the effect of infra-red irradiation, ice, short-wave diathermy, pulsed electromagnetic radiation and massage on muscle blood flow in man (McNiven et al 1974; Wyper and McNiven 1976). None of these agents were found to have a significant effect on muscle blood flow. However, several animal experiments suggested that microwave therapy may be more effective in producing an increased perfusion rate in muscle (Richardson 1954; Siems et al 1948). The purpose of this investigation was to study the effect of microwave therapy on muscle blood flow in man.

#### Method

Muscle blood flow was measured using the Xenon-133 (<sup>133</sup>Xe) clearance technique (Lassen et al 1964). Using a fine gauge needle, 200  $\mu$ Ci\* of <sup>133</sup>Xe dissolved in 0.1 ml of sterile isotonic saline was injected into the muscle. The use of a fine gauge needle is important as trauma resulting from the injection could produce hyperaemia in the muscle.

Blood flow was calculated from the rate of clearance of <sup>133</sup>Xe from tissue, this being measured by monitoring the count rate of the 80 Kev  $\gamma$ -rays emitted by the <sup>133</sup>Xe and detected by a scintillation counter which was set in a fixed position relative to the muscle (Fig. 1). The detector head was shielded using a lead collimator to exclude radiation other than that coming directly from the injection site.

Under steady state conditions an intramuscular injection of <sup>133</sup>Xe should result in a mono-exponential clear-

ance (Figure 2). From this  $T_{1/2}$  (the time taken for the count rate to half) can be measured, and muscle blood flow F can be calculated using the equation:

$$F = \frac{48.5}{T_{1/2}}$$

If  $T_{1/2}$  is measured in minutes, then the units of F will be ml/100g/min.

\* 1 Curie =  $3.7 \times 10^{10}$  disintegrations per second.

The presence of any hyperaemia following the injection would cause the clearance rate to be more rapid during the first few minutes. It is essential to wait until a mono-exponential clearance is obtained before measuring the resting value of muscle blood flow.

After obtaining a satisfactory measurement, microwave therapy was applied in the conventional way, the dose rate being adjusted to produce the maximum comfortable heating. The effect on the clearance rate of <sup>133</sup>Xe is shown in Figure 2. After a lapse of between 5 and 12 minutes a significant increase in the clearance rate and hence in the muscle blood flow was observed.

Five subjects were investigated (3 male and 2 female). All were in normal health and they were of varying athletic ability (a marathon runner, a hockey player, a rugby player and two non-athletes).

#### Results

As seen from Figure 3, there was a marked increase in muscle blood flow in all subjects at the end of microwave application. The mean resting value was 2.9

ml/100g/min and the mean value at the end of microwave application was 11.4 ml/100g/min.

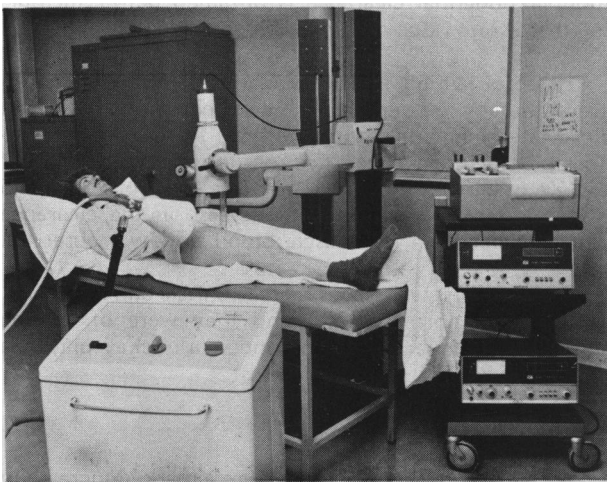
The time between the start of microwave application and an increase in blood flow varied from 5 to 12 minutes. There was no significant correlation between this time and blood flow values, neither was there any correlation between athletic fitness and resting blood flow or blood flow increase in these subjects.

**Discussion**

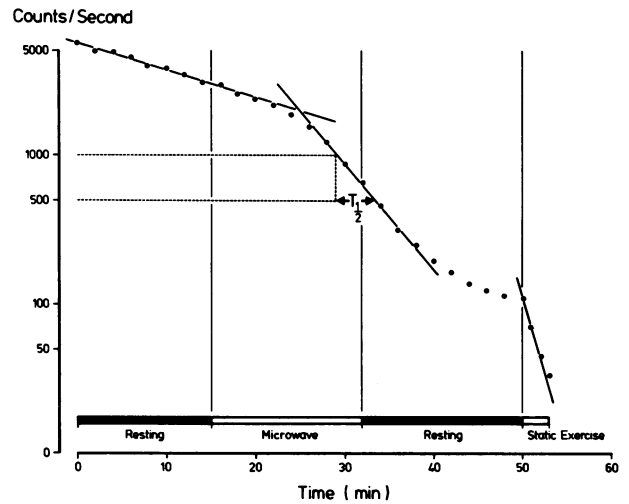
These results demonstrate by direct measurement that microwave therapy is effective in producing hyperaemia in human muscle and that there may be a delay of up to 12 minutes before this effect occurs. It is not possible to measure temperature in human muscle by an atraumatic technique during application of the microwave radiation, but it is probable that the hyperaemia is a result of local temperature increase in the muscle. The superiority of microwave compared with other agents investigated can be attributed to the greater penetration of 2450 MHz radiation. Kebbel et al (1964) have shown in tissue phantoms that the temperature increase in muscle compared with that in fat, bone and skin is superior with microwave fields than with other fields except a coil short wave field which is often difficult to apply and to direct.

**Conclusion**

Microwave therapy was found to produce, on average, a four-fold increase in muscle blood flow compared with the resting value. A delay of between 5 and 12 minutes from the commencement of application was observed before obtaining the maximum hyperaemia effect.

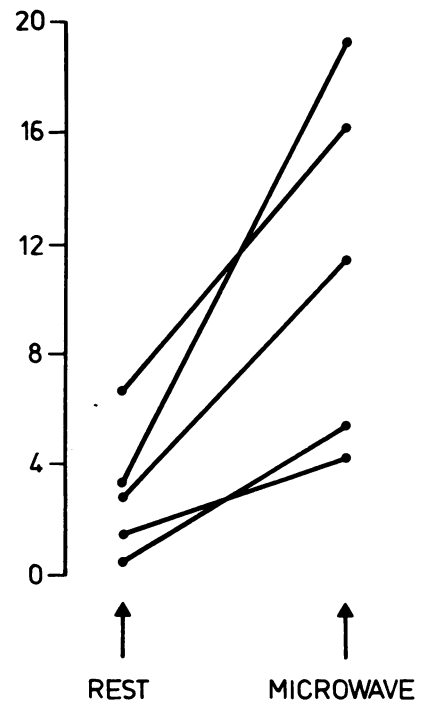


**Figure 1.** Muscle blood flow being measured during application of microwave therapy.



**Figure 2.** The clearance curve of xenon-133 obtained from a single intra-muscular injection. The initial resting part is mono-exponential. The values obtained for  $T_{1/2}$  are 16.7 mins for the initial resting period, 4.2 mins at the end of microwave application and 1.6 mins during static exercise. The corresponding muscle blood flow values are 2.9, 11.5 and 30.3 ml/100g/min respectively.

**MUSCLE BLOOD FLOW  
( ml /100g/min )**



**Figure 3.** The values of muscle blood flow during the initial resting period and at the end of microwave therapy in 5 subjects.

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