Acupuncture – from Empiricism to Science: Functional Background to Acupuncture Effects in Pain and Disease

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Abstract — Acupuncture is part of Traditional Chinese Medicine, a system with an empirical basis which has been used in the treatment and prevention of disease for centuries. A lack of scientific studies to prove or disprove its claimed effects led to rejection by many of the western scientific community. Now that the mechanisms can be partly explained in terms of endogenous pain inhibitory systems, the integration of acupuncture with conventional medicine may be possible. Its use for pain relief has been supported by clinical trials and this has facilitated its acceptance in pain clinics in most countries. Acupuncture effects must devolve from physiological and/or psychological mechanisms with biological foundations, and needle stimulation could represent the artificial activation of systems obtained by natural biological effects in functional situations. Acupuncture and some other forms of sensory stimulation elicit similar effects in man and other mammals, suggesting that they bring about fundamental physiological changes. Acupuncture excites receptors or nerve fibres in the stimulated tissue which are also physiologically activated by strong muscle contractions and the effects on certain organ functions are similar to those obtained by protracted exercise. Both exercise and acupuncture produce rhythmic discharges in nerve fibres, and cause the release of endogenous opioids and oxytocin essential to the induction of functional changes in different organ systems. Beta-endorphin levels, important in pain control as well as in the regulation of blood pressure and body temperature, have been observed to rise in the brain tissue of animals after both acupuncture and strong exercise. Experimental and clinical evidence suggest that acupuncture may affect the sympathetic system via mechanisms at the hypothalamic and brainstem levels, and that the hypothalamic beta-endorphinergic system has inhibitory effects on the vasomotorcenter, VMC. Post-stimulatory sympathetic inhibition which proceeds to a maximum after a few hours and can be sustained for more than 12 hours, has been demonstrated in both man and animals. Experimental and clinical studies suggest that afferent input in somatic nerve fibres has a significant effect on autonomic functions. Hypothetically, the physiological counterpart lies in physical exercise, and the effect can be artificially reproduced via various types of electrical or manual stimulation of certain nerve fibres.

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Biological background to acupuncture effects

In recent years, many publications have explored the effects of acupuncture. The underlying mechanisms, e.g. pain relief, are often discussed relative to traditional Chinese Medicine (TCM) but surprisingly few penetrating discussions have dealt with the physiological background. The paradigm of TCM with its balancing of energy may, in its way, explain diseases or disturbances, but it is a philosophical rather than biological approach. Specific diagnoses based on the pathology of individual organs are not used, and the treatment aims at correcting a disturbed energy balance. The knowledge of biological phenomena was for a long period insufficient to allow an understanding of the endogenous systems which are able to transform sensory inputs into modification of functions. The ideas of TCM were not enhanced as our scientific understanding of disease processes was extended, but the effects of needle manipulation became explicable in western biological terms; yet few, if any, attempts have been made to give an explanation to the totality of acupuncture. It should be recognized that any acupuncture effects must rest on physiological and/or psychological mechanisms and should have a biological meaning. Needle manipulation or the stimulation of cutaneous or subcutaneous tissue should obtain their effects from the artificial activation of systems which receive a similar stimulation from biological effects in functional situations.

The use of acupuncture as a pain relieving method in western medicine is based on a large number of clinical trials, and there is no doubt that it has a powerful and sustained effect in the treatment of musculoskeletal (nociceptive) pain, although there is little or no effect on neurogenic or idopathic pain. Acupuncture has been accepted for pain relief in most countries and is commonly used in general practice and pain clinics as a complement to conventional treatment. Recognition was facilitated by the discovery of the spinal gate mechanism (1) and of endogenous opioids (2). There were logical explanations for the effects on pain sensitivity but not so far, for its physiological mechanisms.

In TCM, acupuncture is commonly used in the treatment of a variety of diseases. Research suggests that somatic sensory stimulation may have a variety of effects which could at least partly explain the results of these treatments in certain diseases. Many different mechanisms are perhaps involved and similar results may be obtained with other types of functional therapy also. A common feature in many methods used to relieve pain or treat diseases is the activation of somatic afferents seen, for example, in transcutaneous electrical nerve stimulation (TENS), vibratory stimulation and massage (3), where receptors or nerve fibres are excited in the stimulated tissue. TENS and acupuncture with manual or electrical stimulation are effective in initiating nerve impulses. According to TCM, the needle stimulation should give rise to a specific sensation (called 'de qi' in Chinese) which is experienced as numbness, heaviness and radiating paraesthesia, a sensation close to deep muscle pain, and is a sign of the activation of thin myelinated A-delta nerve fibres. Low-frequency electrical stimulation of sufficient intensity causes muscle contractions activating mechanoreceptors with high and low thresholds in muscles and other tissues. Particular significance has been given to a group of receptors in the skeletal muscles, which have a high threshold for mechanical stimulation and are innervated by A-delta fibres and possibly C-fibres also. Physiologically they are activated by strong muscle contractions (4–6) and have been denoted ergoreceptors which can be functionally excited by vigorous movements. It can be argued that acupuncture and physical exercise with repetitive muscle contractions similarly activate these receptors and the afferent fibre fibres. The functional modulation as well as the therapeutic effects which have been attributed to acupuncture, can also be noted during muscle exercise.

Both acupuncture and muscle exercise release endogenous opioids and oxytocin which seem to be essential in the induction of functional changes of different organ systems. Endorphins exert effects by binding to opioid receptors, and several types of endogenous opioids have been identified and found to have affinities to different opioid receptors. Particular interest has been given to β-endorphin which has high affinity to the µ-receptor and is important in pain control as well as in the regulation of blood pressure and body temperature (7–9). The substance is released via two different systems. One includes the hypothalamus and a neuronal network which projects to the midbrain and brainstem nuclei and, via this route, may influence pain sensitivity as well as autonomic functions (10–13). There is evidence that hypothalamic nuclei have a central role in the mediating effect of acupuncture. Lesions in the nucleus arcuatus eliminate the analgesic effects of low-, but not of high-frequency electro-acupuncture (14). Low-frequency electrical stimulation of the deep peroneal nerve induces circulatory changes in various tissues. These effects are eliminated after hypothalamic lesions. An increase in the beta-endorphin level has been observed in brain tissue of animals both after acupuncture and muscle exercise. Although details are still unknown, experimental and clinical evidence suggests that acupuncture can also affect the sympathetic system via mechanisms at hypothalamic and brainstem levels.
It has been suggested that the hypothalamic β-endorphinergic system has inhibitory effects on the vasomotor center (VMC). A decreased sympathetic tone is elicited during exercise or nerve stimulation, with vasodilatation and a decreased drive on the heart following the initial excitation of VMC.

β-endorphin is released to the blood via another system. Pro-opiomelanocortin in the hypophysis produces equimolar amounts of β-endorphin and ACTH (15) following muscle exercise, and most likely after acupuncture also. These substances reach different target organs. The two β-endorphinergic systems probably operate independently but both can be stimulated by afferent nerve activity. It has been shown that stress may cause increased levels of β-endorphin and ACTH in the blood (16) independent of its increase in the brain (17). Since the blood–brain barrier is relatively impermeable to circulating peptides, the β-endorphin level in the plasma may not have any relevance to the opioid receptors in the brain.

The central effects of endorphins are important, since endorphins are released in both acupuncture and muscle exercise and may induce similar changes, as has been suggested by administration of morphine, an agonist, or naloxone, an antagonist to β-endorphin. Administration of opiates in certain conditions can cause bradycardia and a lowered blood pressure through a change in balance between the parasympathetic and the sympathetic systems (8). Sympathetic reflexes induced by pressure or depressor stimuli can be diminished by morphine and potentiated by naloxone (18,19). The cardiovascular system in normal subjects (animal or human) does not change significantly after the administration of opioid receptor agonists or antagonists: the effect is evident only when the normal homeostasis is disturbed, e.g. by blood pressure outside the normal range (20,21). No change in blood pressure or heart frequency has been observed in normotensive animals administered large amounts of naloxone, but naloxone can increase the blood pressure in hypotension, an effect perhaps mediated via endorphins (22). Prolonged exercise (23) increases β-endorphin levels in the brain and CSF of rats for several days (24), whereas short-lasting exercise does not. The changes may be very complex: in addition to those due to the release of endorphin there is interaction, for example, between central commands and impulses from peripheral receptors, release of other neurotransmitters (25) and hormonal and metabolic changes.

To interpret the effect of afferent nerve impulses on the cardiovascular system, normotensive and spontaneously hypertensive rats (SHR) have been studied in various situations. Electrical stimulation of the sciatic nerve of alert rats at an intensity which activates A-delta fibres gives a naloxone-reversible increase of the pain threshold lasting for about 60 minutes after the discontinuation of stimulation (26,27). Yao et al (21,28) observed that sciatic nerve stimulation at low frequency (2 Hz) induced a long-lasting (>10 hours) post-stimulatory decrease in blood pressure in parallel with a pain threshold increase. Such stimulation in normotensive rats similarly decreased pain sensitivity but caused only a small reduction in blood pressure. In another set of experiments, direct electrical stimulation of the gastrocnemius muscle at a low frequency (3 Hz), with sufficient intensity to excite A-delta fibres, induced muscle contractions and resulted in an even longer-lasting post-stimulatory blood pressure reduction. The pain threshold increased following direct muscle stimulation as with sciatic nerve stimulation, but its duration was even more prolonged. The involvement of endogenous opioids was suggested by the reversal of both effects following the administration of naloxone. The pain threshold increase was reversed by small doses (1 mg/kg), but a large amount (10 mg/kg) was required to reverse the blood pressure effects. It is suggested that muscle afferents contribute significantly to both the autonomic and the analgesic effects of peripheral afferent stimulation. Reversibility by naloxone further suggests that endorphinergic mechanisms are involved.

The effects of both vigorous muscle exercise and afferent nerve stimulation fall into two phases. First, there is excitation of the sympathetic system with increased heart rate, increased cardiac output and regional vasoconstriction together with increased blood pressure, resulting in a more effective perfusion of the muscles while the blood flow in visceral organs and the skin may decrease. These actions are adequate to give optimal adaptation to a heavy load on the muscles. Provided that the stimulation of the muscle receptors by muscle exercise or artificial afferent nerve stimulation, continues for a sufficient length of time, endogenous opioids are released to give a central inhibition of the autonomic outflow (29). This sympathetic inhibition is not evident during the ongoing activation, due to excitatory input via certain afferent somatic fibres (flexion reflex afferents) and metabolic effects on chemoceptors (30), but appears via opioid mechanisms after the termination of exercise or stimulation.

Post-stimulatory sympathetic inhibition has been demonstrated in both animals and man. Initially, blood pressure and sympathetic activity increase. After a period of sciatic nerve stimulation at low frequency (2 Hz) the fall in blood pressure correlates to a marked decrease in sympathetic activity. The sympathetic inhibition attains its maximum after a few hours and can have a total duration of more than 12 hours. Indirect evidence of the decreased sympathetic activity is the
absence of an increase in heart rate during the period of reduced blood pressure.

Using a microneurographic technique to analyze the sympathetic activity in the nerve to M. soleus in man, Moriyama (31) found an initial increase in activity during acupuncture. During prolonged acupuncture and in the post-stimulatory period, the sympathetic activity decreased, recovering only gradually. Sympathetic inhibition could be elicited at several acupuncture points, suggesting a general post-stimulatory inhibition. Similar results have been reported by Cao et al (32), measuring changes in skin temperature and resistance by the finger plethysmographic technique to investigate correlations between the analgesic effect of acupuncture and changes in galvanic skin response, skin temperature and blood flow. A high correlation between increased temperature in the palm of the hand, blood flow and analgesia was found. The galvanic skin response elicited by sound or light stimuli decreased markedly following acupuncture but the changes did not correlate with the degrees of analgesia.

Hypothetically, acupuncture activates the same types of afferent nerve fibres as do repetitive muscle contractions. A characteristic feature of both exercise and acupuncture (electrical nerve stimulation at 2 Hz) seen in man, is an initial increase in blood pressure which decreases gradually and remains at a lower level, particularly after the finish (33). Both nerve stimulation and extended regular exercise can give a sustained reduction in blood pressure (34,35) which may be more pronounced in hypertensive than in normotensive patients (33). The blood pressure decrease may last for several hours after muscle exercise (36,37).

Physical activity is reported to lower the blood pressure in humans with borderline hypertension. Running for 45 minutes lowered the systolic blood pressure in 7 out of 9 persons with a mean of 13 mmHg (38). Microneurographic recordings from sympathetic fibres in the peroneal nerve one hour after exercise showed decreased activity with reduced blood pressure in all patients. In a control situation without muscle exercise, no change in either sympathetic activity or blood pressure was observed. Administration of nitroprusside, which gives a similar decrease of the systolic blood pressure was observed. The blood pressure decrease may last for several hours after muscle exercise (36,37).

Experimental and clinical studies suggest that afferent input in somatic nerve fibres has a significant effect on autonomic functions. Hypothetically, the effect has its physiological counterpart in physical exercise, and the effect can be reproduced artificially via various types of electrical or manual stimulation of certain nerve fibres. According to Chinese tradition, acupuncture should have little or no effect on normal functions. Only in dysfunction does the 'balancing mechanism' produce clear effects. The described findings with regard to the cardiovascular system support the idea that acupuncture is most effective when a function is disturbed. The neuronal and biochemical bases for such effects are largely unknown.

**Acupuncture and the treatment of diseases**

Acupuncture is used in TCM to treat many different symptoms and diseases. It is practised in many countries and is probably most popular in developing countries. Several conferences have discussed indications for the use of acupuncture. In 1979, a WHO inter-regional seminar drew up a provisional list, based on clinical experience and not necessarily on controlled clinical research, of diseases which lend themselves to acupuncture treatment. The inclusion of specific diseases was not meant to indicate the extent of efficacy in treatment. A large number of diseases are contained, and may be summarized into the following groups:-

1. Acute infections and inflammation;
2. Dysfunction of autonomic nervous system;
3. Pain;
4. Peripheral and central nervous diseases.

There are many clinical reports dealing with acupuncture effects in various diseases. Those in Chinese are sometimes available for western readers only as abstracts. General problems include the small number
of patients, the absence of placebo controls and the large variation in acupuncture technique. It is difficult to find reliable scientific proof of a specific effect on any condition. Experimental evidence from animals and man is sometimes supportive. Some diseases are discussed below on the basis of clinical reports, and with mechanisms which possibly can explain the effects.

Cardiovascular effects

Treatments with sensory nerve stimulation (acupuncture – TENS) have been found beneficial in various localized peripheral conditions.

Xerostomia can be caused by various diseases associated with the impairment of salivary gland function. Primary Sjögren's syndrome (SS) is a chronic inflammatory autoimmune disease characterized by lymphocytic infiltration of the salivary glands. It can occur together with other autoimmune disorders, such as rheumatic diseases, and then it is termed secondary SS. Few standard treatments for dry mouth give more than short-term relief, but 2 reports on the use of acupuncture for SS (39,40) demonstrate an increase in salivary flow rates after treatment. These findings are supported by experimental studies showing that acupuncture may affect the immune (41) as well as the circulatory (42) system. Blom et al in 1992 (43) compared the effects of acupuncture and placebo needling on 21 patients with severe xerostomia from various causes. All showed improvement during treatment, but only the 11 who underwent real acupuncture maintained the improvement through the observational year. In a further study (44) to investigate the effects of sensory stimulation on SS using 4 different forms of acupuncture, Blom et al observed significant increases in blood flux during and after manual stimulation and low frequency (2 Hz) electro-acupuncture compared with the effects of superficial needling, though the changes due to high frequency (80 Hz) were not significant. The increases were accompanied by increased salivary flow. However, patients with extremely little or no salivary secretion, or who were in the acute stage of their illness, generally showed no change or even a decrease in blood flux during or after treatment. In 1982, Kaada (45) reported that acupuncture-like stimuli produced a generalized increase in temperature and microcirculation in the skin. Since the effects were not blocked by naloxone or any pharmacological antagonist to adrenergic, cholinergic, histaminergic, purinergic or dopaminergic mechanisms, Kaada proposed they were due to a release of vasoactive intestinal polypeptide (VIP). That the effects of sensory stimulation are related to a release of vaso-dilatory neuropeptides is further supported by a study (46) showing blood flux increase after acupuncture and increased levels of VIP and calcitonin gene-related peptide (CGRP) in saliva during the treatment.

Much research has been devoted to exploring the mechanisms of surgical flap survival and preventing or reversing resulting ischaemia. Kjartansson et al in 1988 (47,48) and Jansen et al in 1989 (49) demonstrated in experimental studies on ischaemic flaps in rats that increased blood flux and flap survival could be obtained by different modes of sensory stimulation. The mechanisms are as yet unknown but two possibilities have been suggested: 1) inhibition of sympathetic vaso-constrictor fibres and/or 2) release of vasodilator sensory neurotransmitters. Kjartansson's results suggest that sensory nerve stimulation shows a greater affinity with the effects of injecting the neurotransmitters SP and CGRP into the flap than blocking the sympathetic vasoconstrictor neurons, and could be of clinical use in reconstructive surgery. In clinical studies (41,50), patients who had treatment with TENS following surgery showed an increased blood flux which correlated well with the long-term survival of cutaneous or fasciocutaneous flaps. When used in the treatment of chronic diabetic ulcers TENS was found to significantly enhance the healing (51), although the recommended length and intensity of treatment varied (52–54). Barker et al 1982 (55) report the acceleration of wound epithelialization with sensory stimulation possibly by the release of sensory neuropeptides. Thus, the healing of wounds may be promoted by sensory stimulation which, through neuropeptide release, influences the proliferative and functional capacity of fibroblasts, leading to increased collagen synthesis and increased receptor levels of transforming growth factor-B.

Alterations in blood pressure and heart rate are general results of sympathetic tone changes. Patients with essential hypertension showed reductions in blood pressure when treated with acupuncture (56,57). In most patients, the decrease in systolic and diastolic pressure is small (5–10 mmHg) and the effect seems related to the cause of hypertension. Blood pressure may be lowered in cases of borderline and essential hypertension, an effect also seen in rats with high sympathetic activity (SHR), where cardiovascular depression is reported after both low frequency (2 Hz) nerve stimulation and exercise. Hypertension due to ligation of the renal artery is not reduced by electrical stimulation of the sciatic nerve (58). The importance of the involvement of the sympathetic system in the depressive effect of acupuncture is at least partly mediated via the pressure sensitivity of the carotid sinus baroreceptor reflex (59). Acupuncture seems to modulate the receptor sensitivity via the sympathetic innervation.
Sympathetic inhibition results in skin vasodilatation with a rise in temperature. Kaada (45,60) reported increased skin temperature and decreased pain in patients with Raynaud’s disease as a result of transcutaneous electrical stimulation of the hands. The temperature increased 7–10°C in the affected extremities but the changes were small in regions with normal temperature (0.5–2°C). Chronic ischaemia with ulcerations of the legs was also affected by low frequency hand stimulation and the ulcers healed with treatment in 3–9 weeks.

Ischaemic heart diseases have been treated with transcutaneous nerve stimulation or acupuncture. Richter et al (61) compared the effects of acupuncture and placebo in 21 patients with acute and stable angina pectoris. Treatment was given thrice weekly for 4 weeks. The number of pain attacks decreased significantly with acupuncture compared with placebo, working capacity increased and the pain at maximal load during ergometer bicycling decreased significantly (p < 0.01). The patients also reported a significant improvement in the quality of life. Similar results were obtained by Ballegaard et al (62,63) who investigated groups of patients with stable angina pectoris and also observed significant change in working capacity, decreased number of anginal pain attacks with a reduction in nitroglycerine consumption and a decrease in ECG pathology. Mannheimer et al (64,65) investigated the effect of transcutaneous electrical nerve-stimulation in patients with severe angina pectoris. Electrical stimulation (70 Hz) in skin areas of referred cardiac pain increased the tolerance for pacing, decreased the lactate metabolism and reduced the ST-segment decrease at maximal work load.

The mechanisms of the reported effects on the heart are speculative. Central control of the sympathetic system seems to be important. Cardiac ischaemia was induced in rabbits by ligating the left ventricle coronary artery for 10 minutes. The ECG recovery was compared with and without acupuncture and was significantly faster in the acupuncture group. After hypothalamic lesions (nucleus arcuatus) the faster recovery following acupuncture was eliminated and there was no significant difference between the groups receiving acupuncture and those not. Possibly the segmental reflex between the nociceptive afferent activity from the ischaemic heart to the sympathetic output to the heart is modified via descending systems from hypothalamic/brainstem levels or via input from somatic afferents in the relevant segment, i.e. by stimulation in areas of referred cardiac pain.

Asthma bronchiale

Most authors investigating the effects of acupuncture on asthma bronchiale report that acupuncture significantly decreases the airway resistance. However, many studies do not have adequate placebo controls and the number of patients included is often small. According to Chinese tradition acupuncture should be given repeatedly to asthmatic patients if the condition is to be improved. In some studies, only one or a few treatments have been given. Berger and Nolte (66) used plethysmographic measurements in 12 patients. Acupuncture in thoracic points in 9 of the patients gave a significant decrease in airway resistance compared with placebo one or two hours after the treatment. Virsiik et al (67) studied 20 patients who received acupuncture in the thoracic segments and placebo stimulation in the gluteal region. Acupuncture gave a significant increase in peak respiratory flow rate and vital capacity over placebo. Several studies compare pulmonary function after acupuncture treatment and the inhalation of sympathomimetic or anticholinergic drugs. The drugs had a more pronounced effect and, when given after acupuncture, improved respiration further, indicating that the bronchoconstriction was not fully counteracted. Tashkin et al (68) compared acupuncture in thoracic points with placebo acupuncture in a methacholine-induced asthma study. Here also, real acupuncture caused significant improvement of the respiration compared to placebo, but isoprenaline was more effective than either in decreasing the airway resistance. Takishima et al (69) report that a requirement for improved respiration with acupuncture is that the patients should react with decreased airway resistance to inhaling sympathomimetics. Tandon and Philips (70) compared real and placebo acupuncture in histamine-induced asthma and found neither had a significant effect on respiratory functions in this experimental condition.

Some studies used a series of acupuncture treatments. Patient groups who received acupuncture or placebo treatment twice weekly for 5 weeks (71) both showed improvement, but the improvement in the real acupuncture group was significantly better during the treatment period and the effects lasted for two weeks more. A similar finding was made by Jobst et al (72) in patients with disabling breathlessness. The effects of acupuncture and placebo were compared for the distance walked in 6 minutes, subjective experience and respiratory tests. Acupuncture or placebo treatment 13 times over 3 weeks increased the walking distance in the acupuncture group by 48% and 17% in the control group. The subjective improvement was significant in the acupuncture group but respiratory measurements were unchanged in both groups.

The main difference reported between placebo and real acupuncture suggests that acupuncture decreases the airway resistance in asthmatic patients. Most
studies demonstrate an immediate short-lasting effect following acupuncture but there is evidence that a longer-lasting effect is possible. More studies are needed, particularly concerning possible long-term effects. The autonomic control of the airways is presumably in part related to the segmental innervation of thoracic respiratory muscles. It seems reasonable that the stimulation of somatic afferents in these segments may influence output to the sympathetic chain and, further, to the lungs. Yet, it cannot be excluded that the effect of acupuncture on respiration is unspecific in regard to the area stimulated. Stimulation in the paravertebral muscles has been combined with other muscle points such as those between the thumb and index finger. As discussed previously, muscle points are effective in inducing endorphin release and possibly also the release of other neurotransmitters. Placebo stimulation is usually given in non-muscle points or superficially in the skin and these techniques are less effective in releasing such substances. Although there is no evidence that endorphins directly influence airway resistance, such an effect may occur via other routes. The changes in the central sympathetic control of the cardiovascular system could be paralleled by changes in the autonomic output to the airway. The facilitation of respiration following a period of exercise, one’s ‘second wind’, is well known among sports enthusiasts. If the hypothesis is correct that acupuncture induces functional changes similar to those of muscle exercise, a decrease in airway resistance could be expected. Another possibility could be the release of ACTH which is produced with β-endorphin in equimolar amounts from pro-opiomelanocortin in the hypophysis. ACTH stimulates the release of cortisol with secondary effects on inflammatory reactions. Yet another reason for decreased inflammatory reactions in the airways could be the production of calcitonin gene-related peptide (CGRP) in the region of acupuncture stimulation. Changes in the immune system also seem to occur after acupuncture and could influence the asthmatic condition.

Psychological factors may worsen or even induce asthmatic attacks. The relaxation and decrease in stress experienced by many patients during acupuncture, irrespective of the reason for treatment, may be an unspecific but important component (73), and the anxiety felt by many asthmatic patients may be lessened under its positive influence.

Immunological reactions

According to TCM, infectious diseases can be treated with acupuncture, but the idea should be treated with care, for the system also advocates the use of Rhino horn and seal’s testicles for impotence, and the existence of the tiger has been put at risk because of the use of tiger bone in ‘traditional’ Chinese drugs. However, it has been reported that acupuncture is as effective as antibiotics in the treatment of gastrointestinal infections (74). Most information is anecdotal and few controlled studies have been performed. Similarly, anecdotal reports claim that the immune defence system can be strengthened by muscle exercise, and many joggers believe that they will succumb to infections if they do not run regularly. Some scientific reports support this idea. Edwards (75) reported changes in human peripheral blood following physical exercise: the number of lymphocytes increased, as did the activity associated with natural killer cells. Enhancement of human natural killer cell activity related to enkephalins has been observed in vitro experiments (76), and a significant increase reported in natural killer cell activity from lymphocytes incubated with β-endorphin (77). Morphine produced no such effect. Natural killer cell activity was found to have increased significantly (p < 0.005) when spontaneously hypertensive rats running in a wheel were compared to sedentary controls.

Thus, there is some reported support for the stimulation of immunity responses by strong physical exercise. More documentation is needed in studies of immunological effects on large populations. If the preliminary results can be verified they may have important clinical application in the modulation of specific immune-mediated diseases.

Tinnitus

In TCM, acupuncture is recommended for the relief of tinnitus, although scientific documentation of its effect is lacking. During the last decade, a few studies have been carried out in western countries. Two placebo controlled trials (78,79) used acupuncture for tinnitus, but found no significant improvements nor significant differences between the groups. In both studies, some patients reported some improvement, but it was considered unspecific. Thomas et al (80) reported 40% of patients experiencing reduced tinnitus during acupuncture treatment, but within 3 months the tinnitus returned to original levels. Similarly (81), 46 patients with severe tinnitus underwent 10 treatments. Only 3 patients reported an improvement for at least 10 days after the treatment and one third reported a transient reduction lasting from several hours to a few days. Statistical analyses of the whole group showed no significant general treatment effects. In a study by Lindholm et al (82), acupuncture treatment was given twice-weekly for two months, 15 treatments in all for each of 57 patients. A significant improvement was reported for 56% whose tinnitus
was reduced or disappeared completely for an undefined period of time. In a cross-over placebo-controlled study, Axelsson et al (83) were not able to reproduce these positive effects. Some patients in both acupuncture and placebo groups experienced a small reduction in tinnitus but without any significant difference between them, and these effects lasted for a few hours or days only. Just one patient reported a marked and long-lasting improvement, and that after the first acupuncture treatment.

It is to be concluded that the specific effect of acupuncture on tinnitus is small or none. However, many patients experience positive side-effects such as improved sleep, a better acceptance of the disturbing noise leading to a better quality of life. Therefore, acupuncture's beneficial effects of general stress reduction and relaxation could be valuable and preferable to other treatment modalities which are also without specific effect on tinnitus, but which can have aversive instead of positive side effects.

**Drug abuse**

Acupuncture therapy for opiate-dependent persons was initiated in Hong Kong in 1973 and has since gained increasing popularity as a complement to other treatments in varying types of drug abuse. Needles are placed in the vagus-innervated part of the ear and stimulated manually, or at high frequency electrically, for 10–30 minutes. The method reduces withdrawal symptoms and facilitates other treatments. Several publications support the use of acupuncture in the treatment of opiate withdrawal (84–86). The levels of plasma ACTH and cortisol, elevated due to abstinence, decrease following acupuncture unlike with methadone treatment, allowing a fast narcotic detoxification in opiate addicted patients (84,87). Electro-acupuncture in the ear was combined with repeated small doses of naloxone (0.04 mg), and detoxification was claimed for one or two days with almost no abstinence symptoms.

Acupuncture is also used to treat alcohol abuse. Smith et al (88) reported that a combination of body and ear acupuncture gave valuable results. Treatment was given daily and 50% of those who continued to the end were free from the drug at least 6 months afterward. The most convincing results have been reported by Bullock et al (89), where 80 persons with severe alcoholism were divided equally into those given real acupuncture and those with placebo stimulation. Treatment was given over 8 weeks with increasing intervals between the treatments and 21 of 40 patients in the acupuncture group, but only 1 in the placebo group, completed the programme.

There is a common belief that acupuncture, particularly ear acupuncture, is a useful aid to renouncing smoking or reducing weight. Only few controlled studies have been performed to investigate these possibilities. Gillams et al (90) divided persons who wanted to stop smoking into 3 groups, one treated with ear acupuncture, another with placebo at the same points and the third attended group therapy sessions. The results showed no significant difference between any of the three in regard to the number of persons who stopped smoking. Clavell (91) compared effects among smokers randomized to acupuncture and nicotine gum. Both groups smoked less during the months of treatment in comparison with an untreated control group, but there was no difference in their tendency to resume smoking later. Similar results were obtained by Lamontagne et al (92) who relegated 75 heavy smokers randomly to three groups. One group received ear acupuncture for 20 minutes twice weekly, the second received acupuncture in other points assumed to give relaxation. Patients in the third group met a therapist for 20 minutes twice a week to talk about their smoking habits and receive encouragement to cease smoking. Results showed that the groups who received acupuncture had significantly less cigarette consumption than the third group fourteen days after the end of the treatment. Differences, however, were not significant 1, 3 and 6 months after treatment.

A few studies report acupuncture for the treatment of obesity. Mok (93) compared the effects in a group of 24 persons weighing 5–33% more than their ideal weight, observing them over 3 periods. During the first acupuncture was applied to influential points in one ear, during the second the same points were stimulated in both ears and during the third the needles were placed in different points supposed not to influence body weight. No significant effects on weight showed in any of the treatment periods.

Acupuncture may have some value in the treatment of opiate and alcohol addiction due to its ability to reduce abstinence symptoms, but the long-term effect is uncertain and the importance of psychosocial care following detoxification is emphasized. Acupuncture may be a complement in the treatment but alone does not give sustained results.

**Mood and behaviour**

Acupuncture induces in many patients an increased sense of well-being, calmness and improved sleep. Regular muscle exercise often decreases psychological tension, and promotes a sense of euphoria or joy. Exercise (94) and acupuncture (95,96) appear almost as effective as anti-depressant drugs in the treatment of some patients' anxiety and depression. Differing
behavioural effects may also be seen in animals both after electrical nerve stimulation and prolonged exercise. In a series of experiments, the motor activity of SHR rats was followed over a period of several weeks, where the test group only, had access to a wheel in their home cage. The runners showed significantly less spontaneous exploratory locomotor activity than the controls, but it was accompanied by a decrease in aggressive behavior, including marked aggression toward intruders. After 45 days, the wheels were locked to prevent running. Within a few days, the previous runners became significantly (p < 0.01) more aggressive than the controls, possibly as a reaction to their former behaviour.

GENERAL CONCLUSION

Changes in biological parameters occur as a result of somatic afferent stimulation whether from normal physical exercise, electrical stimulation of afferent nerve fibres or stimulation via acupuncture needles. The direction of change seems to be towards an optimal performance of different functions. The details of the underlying mechanisms are largely unknown, but most likely the autonomic system and hormonal controls are involved. In further research, the physiological mechanisms of physical exercise should also be helpful in understanding acupuncture mechanisms.

The human biological system has evolved over a very long period of time, yet remains adapted to a hunter–gatherer lifestyle where persistence in physical activity was of fundamental importance for survival. In modern society, psychosocial stress is high and motor activity frequently minimal, and the resulting emotional tension cannot be transformed into physical exercise in accordance with inherited biological needs. Instead, the stress-induced changes remain and can cause long-lasting disturbances in muscle tone and autonomous activity, resulting in pain and functional diseases. A contributing factor to health disturbances is probably limited physical exercise with insufficient afferent input for an optimal performance.

Regular physical exercise should be encouraged in order to promote physical and mental fitness. Some diseases or disabilities may prevent patients performing certain types of physical exercise. Acupuncture, TENS and other methods for afferent stimulation may provide a complement or alternative in such cases. This kind of stimulation releases neurotransmitters and hormones, partly mimicking the action of physical exercise. It is evident that sensory stimulation can only to a limited extent replace physical activity, which has many other positive components. The engagement of the patient is important in any method of disease treatment. The psychological factor becomes particularly important in methods which rely on the endogenous modulati on of various functions in which the psychological factors (often referred to as placebo) are integrated. No doubt all types of somatic sensory stimulation, and particularly acupuncture, have very strong placebo effects. Acupuncture is possibly an uniquely effective method in the activation of positive placebo effects. It must be realized that placebo is as physiological a mechanism as any other. Mental activity, conscious or unconscious, may modulate somatic mechanisms as effectively as any peripheral stimulus. The somatic and psychological factors must act in harmony to utilize endogenous mechanisms most effectively.

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