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**ABSTRACT**

Ahmedov, S. Ergogenic effect of acupuncture in sport and exercise: A brief review. *J Strength Cond Res* 24(5): 1421–1427, 2010—Acupuncture is one of the most popular alternative methods applied in Western medical practice. In addition to its curative properties in various chronic conditions, demonstrated by the number of clinical trials, acupuncture has been recently applied as an enhancer of sports performance. Reviewed studies of published literature on the use of acupuncture in resistance and endurance sports activities demonstrated the association of traditional acupuncture protocol with increase of muscular strength and power. In cases regarding endurance activities, acupuncture treatment improved hemodynamic parameters of participants but not their aerobic performance. Further methodologically strong studies with inclusion of both biomedical and traditional Chinese theories are needed to assess the usefulness of acupuncture in enhancement of sports performance.

**KEY WORDS** alternative therapy, traditional Chinese medicine, performance

**INTRODUCTION**

Ergogenic aid is defined as method, apart from training, that improves athletic performance (41). The use of ergogenics continues to grow, and sportsmen comprise a substantial portion of its customers (13,26,29,55). Among various nutritional, environmental, pharmacologic, and other ergogenic modalities, acupuncture has recently emerged as alternative medical enhancer of human physical performance.

Acupuncture is the most familiar of Western medicine complementary and alternative therapy. This treatment modality originated about 2,500 years ago in China and is still applied in its original form (25). The use of acupuncture occurs in the frame of traditional Chinese medicine (TCM), the core theory of which considers a healthy condition to be the result of a balance between so-called yin and yang—featured characteristics of various events within the body with free movement of vital energy, known as Qi. Imbalance between yin and yang disrupts the free flow of Qi and leads to low physical performance, illness, or both (49).

Vital energy Qi flows through special body pathways, called meridians. The latter have extensions on the skin with bioactive points (i.e., acupuncture points) on them. Insertion of acupuncture needles into these points facilitates free flow of Qi in the body, which was recently attributed to the piezoelectric effect of acupuncture (35).

The idea to try acupuncture as an ergogenic aid in sport was derived from its ability to resolve many health problems, including sport-related injuries (31,32,39,43,57). Histomorphological investigation of muscle structure in animal studies (42) has shown that even denervated skeletal muscle was able to regenerate and start the reinnervation process after acupuncture.

A previous review paper, published in the *Journal of Strength and Conditioning Research* in 2001 (38), summarized several preliminary studies on the use of acupuncture as an ergogenic modality in sport. The authors discussed clinical trials related to acupuncture’s impact on strength, aerobic conditioning, and flexibility. In conclusion, researchers indicated a controversial role of acupuncture in enhancement of sport performance and need for standard acupuncture protocols (38). Interest in acupuncture continues to grow, and a number of various studies, aiming to assess ergogenic properties of acupuncture in sports, followed the aforementioned publication.

The purpose of this review was to evaluate available information on ergogenic potency of acupuncture, to understand the reason for conflicting results, and to find the way to solve them.

**METHOD**

**Study Selection**

The Near East University (Yakin Dogu Universitesi) Ovid-LWW, Sciedirect, PubMed, and EBSCO online databases were used to search for relevant articles and abstracts on ergogenic use of acupuncture in sport and exercise. Acupuncture and performance were used as key words during the search. Mainly human and a limited number of animal studies published or accepted for publication in the English language between 1950 and November 2008 were included in this report.

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Data Analysis
Physical performance takes many forms and in human studies it usually acquired as psychomotor vigilance, influenced by seasonal and circadian conditions (1,44,52). Thus, the point of interest in each observed study was the presence or absence of enhancement or improvement in physical or mental condition, respectively, after acupuncture treatment. Propensity of various sports events to use mainly either anaerobic or aerobic energy systems (17) allowed the assessment of studies on acupuncture effect in sport performance separately for resistance and endurance activities, respectively.

RESULT
Acupuncture and Type of Resistance Activity
Resistence or anaerobic type of activity is characterized by high intensity and short duration of series of muscle contractions, expressing muscular strength and power. Various biomechanical and biochemical parameters, pain tolerance and ability to complete special tests for chosen muscle groups were used for assessment of ergogenic properties of acupuncture aimed to increase muscular power/strength and relieve muscle soreness.

Muscular strength and power. A group of studies investigated direct impact of acupuncture on muscle strength during resistance exercise. In animal studies biochemical analysis of muscle changes during acute swimming exercise showed increased intramuscular enzyme activity in species under acupuncture, compared with controls, which demonstrated the ability of acupuncture to delay fatigue of exercising muscle (15). Lately, the same group of researchers used audiofrequency pulse-modulated wave for electrostimulation of acupoints in sportsmen (56). One hundred and fifty sportsmen were randomly assigned into 2 groups, experimental and control, and were tested for 30-m running, standing long jump, and Cybex isokinetic testing indexes. Acupoint treatment, based on traditional Chinese approach, significantly increased athletic performance and biomechanical indexes, maximal peak moment of force of sportsmen, their force moment accelerating energy, and average power. Results indicated an ability of acupoint stimulation to enhance rapid strength in sportsmen (56).

A different study design has been implemented in China, where 29 physically active nonsportsmen were randomly split into 2 groups: 1 group received 3 sessions per week of unilateral electroacupuncture of Zusanli (ST-36) and Xiajuxu (ST-39) acupoints for 4 weeks and the other did not receive any treatment (18). Participants in both groups continued their daily activities without any additional interventions through the whole period of experiment. By the end of the 1 month, there was a statistically significant increase in strength of relevant muscles in treatment group (n = 14) on 21.3% and 15.2% in unilateral and in contralateral legs, respectively, and no changes in the control group (n = 15).

Although improved strength in both stimulated and nonstimulated legs demonstrated the ability of acupuncture to improve anaerobic work in skeletal muscles, the study was unable to identify whether the increase in bilateral muscle strength after unilateral acupuncture was a result of a general or local effect of acupuncture (18).

Ozerkan et al (36) investigated the impact of acute ST36 acupuncture on isokinetic knee extension and flexion strength of 24 young soccer players and found a statistically significant increase of muscle strength in the acupuncture group.

In another study researchers evaluated the effect of acute transcutaneous electroacupoint stimulation (TEAS) on the recovery rate of muscle force after strenuous knee extension/flexion exercise (45). Four selected acupoints were Zusanli (ST36), Chenshan (BL57), Yanglingquan (GB34), and Sanyinjiao (SP6). After the first day of nonintervention for getting control values, all 17 healthy young participants underwent 15 minutes of acupuncture and sham acupuncture trials on the second and third days, respectively. TEAS had a significantly larger recovery effect on the rate of muscle force, compared to sham TEAS and control values. The absence of difference in lactate removal and muscle frequency restitution rate, however, made authors suggest that the plausible mechanism of effective TEAS protocol was its pain-controlling ability (45).

Assessment of immediate effect of standardized acupuncture treatment on muscular reactive strength in 12 sportsmen during a 1-legged drop vertical jumping performance failed to demonstrate a significant treatment effect of acupuncture on myoelectrical and kinematic parameters (3). There was only a relative decrease in the duration of ground contact in the acupuncture group compared to the sham and nonacupuncture groups (3).

Laris and Joao (27) also analyzed the immediate effect of acupuncture on muscular performance. Evaluation of electromyographic properties and isometric strength of tibialis anterior muscle in 30 healthy subjects also showed lack of ability of ST36 and RP9 acupoints, located around the knee, to increase muscle strength.

In one study, apart from using classic acupuncture for muscle stimulation, researchers utilized randomly selected places on stimulated muscle (51). Although the attempt to enhance muscle strength by the acute acupuncture needling of hand and leg muscles in 17 healthy men changed electromyographic responses in them compared to their nonstimulated muscles, the stimulation did not change muscular exercise performance (51).

Delayed-onset muscle soreness. Delayed-onset muscle soreness (DOMS) is the kind of muscle pain experienced by sportsmen about 2 days after dramatic increase in duration or intensity of training or competition. DOMS unfavorably affects performance of sportsmen, and health care professionals look for measures to shorten and smooth this undesirable event (40).
There is no effective contemporary measures for its prevention and treatment, and some of those scientists, who seek for alternative modalities, suggest that acupuncture may give positive results.

Treatment of DOMS in 48 healthy subjects demonstrated limited changes of cardinal signs and symptoms of muscle soreness in real acupuncture, compared to sham acupuncture, tender point acupuncture, and nonacupuncture groups (4).

Hübscher et al (21) investigated the impact of acupuncture on muscle function in exercise-induced DOMS in 22 healthy sport students. Participants were randomly assigned to classic acupuncture (n = 7), sham acupuncture (n = 8), and nonacupuncture (n = 7) groups. Acupuncture was applied immediately, 24, and 48 hours after DOMS induction. With an exception for pain perception, which was significantly lower in the acupuncture group, both mechanical pain threshold and maximum isometric voluntary force scores did not differ between groups after 72 hours (21).

Research on effect of acupuncture on relief of DOMS, carried out earlier in Japan, used standard acupuncture procedure for 1 leg and sham acupuncture for another in 6 athletes (50). DOMS was induced experimentally in both legs through heel raising exercise. At 48 hours after exercise, the only parameter that was significantly different in the real acupuncture site, compared to the sham acupuncture site, was the lesser pain on muscle stretching. The other parameters, such as ankle range of movement, maximal voluntary contraction, and 1-legged vertical jump, did not differ significantly between stimulated and nonstimulated sites (50).

The effect of acupuncture versus nonacupuncture on exercise-induced muscle soreness and serum creatine kinase activity in 20 nonsportsmen demonstrated a decrease of muscle soreness in acupuncture group (28). However, creatine kinase changes in groups was not significantly different.

Huguenin et al (19) used trigger point acupuncture of glutus muscle in 59 male athletes from football club members with posterior thigh pain. Participants received once either real or placebo acupuncture in random order. The assessment for possible improvement after 24 and 72 hours of treatment demonstrated unchanged test results for straight leg raise and hip internal rotation in both treatment and control groups. All participants from both groups admitted decreased pain and diminished gluteal tightness (19). The use of tender points instead of acupoints for analgesic purposes has given positive results in 30 participants with DOMSs caused by upper-extremity strength training exercises (22). Researchers suggested that acupuncture stimulation of tender points may activate their sensitized nociceptors, which lead to pain relief. Absence of such nociceptors at non tender points, however, made their stimulation ineffective. Based on these findings with mixed results, one could speculate that trigger/tender point acupuncture may be effective in the management of acute muscle soreness (22), whereas in cases with gradual onset of muscle pain, placebo stimulation of tender points may be equivalent to real acupuncture (19).

**Acupuncture and Endurance Activity**

An endurance or aerobic sport event is known as submaximal activity of low intensity and long duration. Aerobic activity highly depends on oxidative metabolism as a source of consumed energy, and cardiovascular response to sport-induced stress is one of the main mechanisms mostly involved in the process of energy supply. Consequently, parameters such as heart rate, blood pressure, exercise tolerance, maximal oxygen uptake, and rating of perceived exertion (RPE) were used by researchers for monitoring of acupuncture treatment in aerobic performance.

Ehrlich and Haber (12) analyzed effect of acupuncture on physical performance of 36 healthy men, randomly assigned into true acupuncture, sham acupuncture, and nonacupuncture groups. Performance was assessed through spiroergometry at the beginning and after 5 weeks (7 session per week) of acupuncture treatment. The results demonstrated functional improvement in the hemodynamics of acupuncture group and no changes in other groups.

Long-term acupuncture treatment (twice a week for 5 weeks) was applied in another study, carried out by Gentil et al (16). As in the case of previous observation, 31 sedentary subjects were divided into real acupuncture, sham acupuncture, and control groups and evaluated for their effect on physical performance in ergospirometry. Although acupuncture did not change maximal oxygen uptake in the real acupuncture group, participants from this group had lower heart rate and demonstrated higher velocity at their anaerobic threshold levels (16).

The capacity of acupuncture to improve physical performance in patients with a health problem was examined in 17 patients with heart failure (2). Long-term (10 sessions of 13 acupuncture) application of acupuncture in classic (n = 9) and sham (n = 8) forms partially improved autonomic function in terms of stable hemodynamics and improved exercise tolerance but not the quality of life (2).

Research on immediate ergogenic effect of single acupuncture treatment was carried on 10 healthy nonsportsmen during submaximal cycle ergometry (23). The result did not demonstrate any statistically significant differences for rating of perceived exertion, oxygen uptake, heart rate, respiratory exchange ratio, ventilation, and ventilatory equivalent for oxygen at submaximal workloads in acupuncture, sham acupuncture, and nonacupuncture groups during submaximal activity (23).

In another single-blinded, randomized controlled study researchers examined the ability of transcutaneous electrical nerve stimulation of PC-6 acupoint (Acu-TENS) to change the recovery heart rate of 27 healthy subjects after standard treadmill running exercise (9). A previous study showed that electrical acupuncture stimulation of that point in animals increased cardiac performance by 30% (47). Research with 27
healthy male participants (9) demonstrated that acute Acu-TENS on bilateral PC-6 reduced the recovery heart rate by 50%, but had nonequivocal changes of blood pressure in them, which indicated a need for further work on this topic.

Recent observation of the acute effect of acupuncture on 20-km cycling performance, presented by Dhillon (10), measured time to complete 20 km, RPE, and blood lactate concentration in 20 experienced male cyclists. The time difference was insignificant among repeated-measure protocols for acupuncture, sham acupuncture, and nonacupuncture. However, statistically significant higher RPE in the acupuncture group brought the meaning of clinical significance for the time reduction found in the acupuncture group (10). One researcher suggested that cycling-induced noxious muscle fiber damage, resulting in reduction of force output, was opposed by acupuncture-induced release of endogenous opiates.

Physical well-being of sportsmen is critical for optimal athletic performance. Overtraining and heavy sports activity are known to stress neuroendocrine response (40) and immune status (46) in endurance sportsmen and lead to a decrease in overall performance. The use of acupuncture for support of physical well-being during endurance activities have been investigated to a limited extent. In 1 study the group of elite female soccer players was observed for effect of acupuncture vs. nonacupuncture on their neuroendocrine and mental responses during competition (48). The traditional Chinese approach of classic acupoints has been used for acupuncture after each game during the competitive period. The result demonstrated inhibition of an exercise-induced increase in cortisol and a decrease in immunoglobulin level after acupuncture treatment. In addition, acupuncture modulated the state of mood and improved subjective rating of fatigue in sportsmen after competition.

**DISCUSSION**

Sport-induced physical and mental stress disturbs metabolism, and body systems seek for the natural way to reestablish inner balance. Association of acupuncture with endogenous release of opioid peptides (6) is evidenced in favor of immunomodulating properties of this ancient treatment modality (7). Hutchison et al (20) investigated the effect of acupuncture on immune cells and found some changes in immune cells' status. Eight sessions of acupuncture treatment for 4 weeks did not significantly alter response of natural killer cells to a 60-minute bout of cycling, but they increased their degranulation at rest in 13 well-trained aerobic athletes (20). In another study researchers used manual acupuncture of Zusanli point (ST36) to manage pain in rats (59). Aside to more distinctive, compared to sham acupuncture, analgesic effect on ST36 stimulation, there was a higher degree of mast cell density and their degranulation at ST36 than at the sham acupoint (59). A recent review of studies on antiinflammatory properties of acupuncture also demonstrated that acupuncture fights against infection through meditation of the innate immune system (24). The ability of acupuncture to work for preservation of inner balance allowed thinking about acupuncture as a possible tool for enhancement of athletic performance.

From 23 studies, included in this review, 15 investigations dealt with resistance activities and 8 were concerned with endurance activities. The result of a review on the ergogenic effect of acupuncture in resistance exercises and sports activities indicated that acupuncture may be useful in enhancement of muscle strength and power. The majority of reviewed studies reported significant improvement of muscle performance under acupuncture treatment both in sportsmen and nonsportsmen (15,18,36,45,56). Despite differences among acupuncture protocols, common for all these studies was the use of more than 1 acupuncture session and utilization of traditional Chinese approach.

In cases in which acupuncture use did not bring an anticipated increase in muscular performance, researchers assessed the result of immediate acupuncture (3,27). The fact of single acupuncture session and differences in physical performance among sportsmen in these studies may contribute to the failure of acupuncture to achieve results.

A decrease in muscle performance is often associated with development of muscle fatigue or soreness (54). The development of DOMS reduces joint range of motion, alters muscular involvement into contraction, and causes unaccustomed stress on muscle tendons, which increases the risk of injury (8). Treatment of DOMS corrects muscular function and shortens the time of postexercise muscular soreness, both of which seem to improve damaged muscular performance. Attempts to manage the development of DOMS in sportsmen by acupuncture failed to demonstrate significant improvement in either biochemical and biomechanical parameters of muscle after acupuncture (4,21,28,50). However, pain perception in the acupuncture group was lower compared to the sham and control groups (21,28,50). These results demonstrated that relief of pain is not necessarily associated with improvement in muscular performance. Acupuncture treatment of tender/trigger points for analgesic purposes in sportsmen was effective both in cases of upper and lower extremities (19,22).

The majority of studies that used acupuncture for ergogenic purpose in endurance activities demonstrated either partial or complete improvement in main hemodynamic parameters of participants (2,9,12,16,47), and only a few of them were unsuccessful in verifying this favorable effect of acupuncture (10,23). One investigation attempted to evaluate both physical and mental well-being of sportsmen during competition (48) and clearly demonstrated a positive inhibiting impact of acupuncture on level of stress hormones and mood status of participants. None of these studies found improvement in aerobic performance of participants under acupuncture. The fact that all but 2 of the studies dealt with nonsportsmen and variations of acupuncture protocols
among them may be the reason for the mixed results found in use of acupuncture for direct enhancement of aerobic performance.

Despite scientific evidence of usefulness of acupuncture in prevention and treatment of various health problems (11,14,30,33,34,53), there is still great discrepancy between its wide acceptance by the general population and its cautious interpretation by contemporary science. Previous research on acupuncture in human performance, summarized by Pelham et al (38), has drawn the conclusion, similar to that for clinical trials, that the results are inconsistent and more evidence-based trials are needed to make the situation clear. To do this, Western science assumes the following:

1. Participants of the same age and gender and similar sports experiences would have similar cardiovascular or respiratory (depending on study) reactions for the same acupuncture protocols.

2. Selected acupoints and the way of needle manipulation (either reduction or tonification) must be the same for all participants to be compared.

3. Acupuncture protocol, established at the start, is not impressed by changes in the sportsman's condition during the treatment and remains unchanged through the trial.

4. Results of experimental group are compared to those obtained from sham acupuncture.

Actually, utilization of these rules in acupuncture studies is an attempt to convey modern research (i.e., randomized, double-blind, controlled trials) with an ancient medical tool (i.e., acupuncture). However, this mixture of 2 different medical systems raised the following controversies, which must be solved.

First, traditional Chinese medicine deals with individuals, whereas conventional medical science concerns about health problems and medicines. Second, acupuncture is rooted in the traditional Chinese medical system and can not work appropriately if used without its theories. Acupuncture treatment occurs in accordance with its own rules, based on disease pattern approach. In terms of traditional Chinese medicine, low human performance is caused by an imbalance between yin and yang, and its identification is crucial for effective acupuncture. The sportsman's condition is not an exception for Chinese pattern discrimination. All people have similarities in general terms of biology, but chemically they are different. One can not expect that 2 sportsmen with similar quantitative cardiovascular parameters based on different hemodynamic background (i.e., yang-featured hyperdynamic vs. yin-featured hypodynamic) would equally benefit from the same stimulating-yang acupuncture protocol; it would be advantageous for the latter but disadvantageous for the former. Neglect of these individual patterns, especially in the case of endurance activities, may lead to misuse of acupuncture (e.g., tonification acupuncture procedure of yang-featured individuals) during research with potential for mixed results. Thus, the use of the pattern discrimination approach of the traditional Chinese medical system with individualized acupuncture prescription (58) would be fruitful for identification of ergogenic properties of acupuncture in sport and exercise. In cases with multiple sessions of traditional acupuncture diagnostic process aimed to get feedback from previous sessions is routinely implemented in each session, and further acupuncture protocol is tailored according to feedback result. In modern science, however, biomedical understanding is not changing the treatment through the trial (37). Thus, acupuncture is not just needling, but also the process of diagnosis (i.e., observation, interrogation, and touch) and treatment with needles of appropriately selected acupoints. Consequently, all participants experience everything, except real needle insertion, and in this case the result of sham stimulation would not represent a pure placebo effect of acupuncture (37).

**Practical Applications**

Traditional acupuncture protocol might be effective for enhancement of muscular strength and power. The use of several acupuncture sessions better contributes to enhancement of muscular performance in resistance exercises than does a single session. The Zusanli (ST36) is the most popular acupoint and is frequently used to increase muscular strength and power.

Uncertainty with the exact mechanism of DOMS development and variations in degrees of muscle damage among participants might contribute to controversy of results related to the ergogenic effect of acupuncture in sport through management of DOMS. Muscle pain relief was not always associated with improvement of muscle function, so other alternative modalities, such as exercise, might be added to overall management of DOMS. The use of trigger/tender points instead of classic acupoints demonstrated promising results in terms of acupuncture treatment of postexercise muscle soreness. Further research is required to analyze muscular function after treatment of DOMS by trigger/tender point acupuncture in participants with similar degrees of muscle damage.

Acupuncture use in endurance activity is associated with improvement of heart rate and blood pressure of participants but not with their aerobic performance. It is not apparent if participants in the presented studies represented a homogeneous population in terms of traditional Chinese medicine. Thus, the probable reason for failure of acupuncture to enhance aerobic performance might be invalid study design caused by the application of similar acupuncture protocols for all sportsmen without individualization.

A randomized clinical trial is not an ideal approach for studies exploring the ergogenic effect of acupuncture in sport. Thus, selection of participants in accordance with traditional Chinese medicine's principles would be more relevant to solve the aforementioned controversies between Western and Chinese medical systems. Consequently, pattern-tailored acupuncture instead of standard acupuncture protocol would
provide specialists with a more reasonable strategy to study ergonomic features of acupuncture. The problem with the placebo effect of sham acupuncture could be overcome by repeated application of real and sham acupuncture in the same group of subjects. Both biomedical and traditional Chinese theories must be included in further well-designed large sample studies aimed to critically explore the ergonomic effect of acupuncture in human performance.

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