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Exercize and Mental Health : A Clinical Review

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ABSTRACT

Psychiatric disorders are of major public health significance. It has been claimed that vigorous physical activity has positive effects on mental health in both clinical and nonclinical populations. This paper reviews the evidence for this claim and provides recommendations for future studies. The strongest evidence suggests that physical activity and exercise probably alleviate some symptoms associated with mild to moderate depression. The evidence also suggests that physical activity and exercise might provide a beneficial adjunct for
alcoholism and substance abuse programs; improve self-image, social skills, and cognitive functioning; reduce the symptoms of anxiety; and alter aspects of coronary-prone (Type A) behavior and physiological response to stressors. The effects of physical activity and exercise on mental disorders, such as schizophrenia, and other aspects of mental health are not known. Negative psychological effects from exercise have also been reported. Recommendations forfurther research on the effects of physical activity and exercise on mental health are made.

Introduction
A large number of studies have confirmed the fact that regular physical activity brings benefit to individuals with depressive and anxiety symptoms.[1-11 I]t also shown to be beneficial in other conditions like peripheral vascular diseases, fibromyalgia, menopause and nicotine withdrawal.12-15 Besides these physical activity also causes improvement in other aspects like self esteem, vitality, general well being and satisfaction with physical appearance.16-18 Mood of healthy individuals who exercise regularly is altered immediately after a short period of vigorous exercise i.e. they become less anxious, depressed or angry and even may feel euphoric.19-22

There are three main types of exercise [23] focusing on three important aspects :

- Aerobic exercise : For aerobic endurance.
- Anaerobic exercise : For anaerobic endurance.
- Yoga : For Flexibility, co-ordination and relaxation.

Aerobic exercise is mostly associated with the so called endurance sports such as swimming, rowing, canoeing, cycling and long distance running. In this type, an individual is subjected to physical work sustained for long period primarily intended to increase the efficiency of the oxygen transport system. Anaerobic exercise deals with high intensity work sustained for a very short period primarily intended to increase muscular strength (eg. weight lifting or sprinting).[23]

For individuals in general , continuous and prolonged exercise that does not exceed the anaerobic threshold (submaximal endurance) is sufficient to achieve physiological adaptation required to improve aerobic fitness.24 But for elite athletes an increase in quantity of this type of training does not improve their aerobic fitness.25-26

They require high intensity interval training which normally lasts 4-8 months, divided into 3 different training periods : 1) the beginning of the session during which increasing quantities of mainly sub maximal endurance training are employed ; 2) In this period sessions of a large quantity of sub maximal endurance training are intercalated with sessions of high intensity interval training separated by short period of inactivity or of low intensity exercise, which permits partial, but not complete recovery of athletes to facilitate "super adaptation"(adaptation of the physiological system at a level higher than previously reached by the athlete intended to improve performance27-30; 3) It is the period close to the competition during which training sessions are fewer and comprise lower intensity exercise to allow the athlete to rest so that he/she can reach his/her maximum potential at the time of competition.30-31 This article reviews the role of exercise in regulating mental health.

Theories and mechanisms of the interface of physical exercise and mental health

A large number of hypotheses have been postulated to explain the beneficial effects of exercise on mental health. Some of the hypotheses are discussed herein :

The Distraction Hypothesis : According to the distraction hypothesis , physical hypothesis causes diversion from unfavorable stimuli which leads to an improved mood during and after stimuli.1

The Self Efficacy Hypothesis : The self efficacy hypothesis believes that physical exercise is a challenging activity, hence the ability to get involved in it in a regularly manner might lead to improved mood and self confidence.14

The Social Interaction Hypothesis : The social interaction hypothesis states that, the mutual support that develops amongst individuals involved in exercise helps them further strengthen their social relationships which plays an important role in the effects of exercise on mental health.6

The Physiological Hypothesis : One of the most important mechanisms by which anti depressive drugs function is by the synaptic transmission of monoamines.32-34 According to the physiological hypothesis, physical activity increase the synaptic transmission of monoamines and also causes release of endogenous opioids (endorphins), basically -endorphins.33 The inhibitory effect of these substances on CNS are responsible for sensation of calm and improved mood experienced after exercise.34-35 However these effects needs further confirmation and more studies are needed to support it. It has been observed that, physically active individuals when withdrawn from exercise and in the state of endorphin abstinence have increases irritability, restlessness, nervousness and feelings of frustration.36

Neurobiological changes and exercize
Acute changes in lumbar cerebro-spinal (CSF) monoamines with exercise have been demonstrated in depressed patients by researchers. It was found that CSF 5-Hydroxyindoleacetic acid (5-HIAA) and vanyl-mandelic acid (VMA) were significantly higher after 4 hours hyperactivity than in same patients after

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bed rest.37-38 Brown placed rats on an exercise programme which consisted of 30 min of treadmill running for 5 days a week over 8 weeks. After completion of the programme the rats were sacrificed and it was found that the nor-adrenaline and serotonin brain concentrations were significantly greater in comparison to sedentary controls.39-40 The result was similar to the overall neurobiological effect seen with antidepressant drugs and ECT.41

The role of opioid peptides in normal mood states or in mental illness is less clear than the monoamines.42 By using an antagonist drug or a PET scan with an opiate labeled ligand evidence of central opiate activity can be gained.43-44 In a double blind cross over trial researchers, studied 12 long distance runners on 2 occasions. On day 1, they received 2 i.v injections of 0.8 gm naloxone at 20 min interval following a 6 mile run .On the other day they were given two equal volume injection of normal saline. It was observed that the ratings of mood elevations were reversed by naloxone where as under the saline treatment ischemic pain and discriminability of thermal stimuli were reduced post run.22

Low dose of toxins and/or radiations can exert beneficial effects in organisms.45 It has been postulated that the beneficial effects of exercise are partly based on its ability to generate reactive oxygen species (ROS). Exercise induced ROS generates antioxidants, proteins, degrading enzymes and causes DNA repair which decreases the incidence of stress related disorders.46-47 Further, exercise may also upregulate anti-inflammatory cytokines and with time increase the immune threshold for stress.48 It is observed that exercise increases the release and synthesis of several neurotrophic factors like Brain derived neurotrophic factor (BDNF), Insulin like growth factor (IGF-1) which are related to better cognitive functioning, neurogenesis, angiogenesis, and plasticity. It has been proved by animal studies that BDNF is essential for hippocampal functioning, synaptic plasticity, learning and modulation of depression.49-50 Exercise is shown to elevate the level of BDNF in rat hippocampus which is the similar mechanism by which antidepressants work.51 An increase in the level of BDNF was found in humans running at high intensity.52

IGF-1 plays an important role in neurogenesis and cognitive improvement .Elderly people with diminished IGF-1 levels have a poor cognitive performance which can be improved by exercise, as exercise is shown to elevate IGF-1 levels.53 Some authors feel strength training has more advantage than cardiovascular training as it increases testosterone and IGF-1 levels. After 6 months of strength training in a group of elderly authors observed an increase in IGF-1 levels and improvement in cognitive function.54 IGF-1 is inversely related to levels and hence it plays an important role in regulation of amyloid level.

Exercise also regulates the expression of vascular endothelial growth factor (VEGF) which regulates endothelial cell proliferation and angiogenesis. It is also shown to have neuroprotective, neurotrophic and neurogenic effects Exercise induced angiogenesis is associated with increase in brain VEGF.50 On the basis of an increase in cerebral blood volume in the adult dentate gyrus authors55 observed an in vivo correlation of exercise induced angiogenesis and neurogenesis in that particular area. Exercise and antidepressants reverse the effects of stress, depression and aging by increasing neurotrophic expression and neurogenesis in brain. In an experiment, it was observed that exercise enhanced neurogenesis in the dentate gyrus of an adult mouse.57 According to researchers neurogenesis in adult hippocampus might improve cognitive processes and can treat several psychiatric diseases (eg., depression).58

It is observed that exercise causes an increase in cerebral blood flow at several cortical and subcortical areas.58 Forester proposed that circulating nucloetides particularly adenosine nucleotides (ATP : a potent vasodilator) play a major role in brain metabolism by regulation cerebral blood flow.59 Exercise also upregulates endothelial nitric oxide (NO) synthesis and improves angiogenesis and CBF.60 Several hormonal adaptations occurs after regular exercise which are mediated by Hypothalamus-Pitutary-Adrenal Axis. After an aerobic exercise programme there is smaller increase and faster recovery to the baseline of cortisol levels for the same workload and the same psychological stress.61-62

Exercise in various Neuro-Psychiatric Disorders
Depression
It is observed that the prevalence of depression in elderly population is approximately 22% and sedentary lifestyle is one of the major factor responsible for depression in elderly.63 A large number of studies have suggested that exercise is an effective treatment for depression.64-67 According to Griest68, running is advocated as a more effective antidote to depression than psychoanalysis. In a meta-analytic review69 it was found that exercise is suggested to improve depression by changing an individuals daily routine, increasing their interaction with other, helping them loose weight, participate in outdoor recreation and master difficult physical and psychological challenges. There was a difference between the effects of acute exercise (single session) and effects after an exercise programme. However, both were effective antidepressants. In this meta-analysis the authors analysed the effects of published and unpublished studies and the authors accounted for factors that may have produced the positive effects on depression attributed to exercise, e.g. source of participants, purpose of exercise, exercise location, group assignment of participants, age, gender and mode and duration of exercise.

There is an inverse relationship between aerobic and strength training and depression in elderly.70-77 It is found that aerobic exercise at an intensity consistent with public health recommendation can be regarded as an effective treatment of mild to moderate major depressive disorder whereas the effects of low intensity exercise are comparable to placebo effects.78 In one study70 patients with MDD were evaluated using different treatments, namely sertraline, placebo, home based exercise and supervised exercise. It was observed that remission rates was higher with sertraline (47%) and exercise (45%).The response rates in placebo was also high ,which suggested that the attention provided to the patient and to his/her own expectations regarding the treatment plays an important role in determining the therapeutic response.

Anxiety
To examine the effect of acute and chronic exercise on state (current) anxiety, trait(dispositional) anxiety and psychophysiological correlates of anxiety, Petruzzello et al79 conducted three metanalyses. It was observed that exercise produced a small effect on state anxiety (effect size : 0.24) . It was observed that chronic exercise had a better effect when compared with acute exercise, aerobic exercise was better than anaerobic exercise and high intensity exercise of 21- 30 min duration had a better effect than low intensity exercise shorter than 20 min or longer than 30 min. The effect size was largest in the pre-post within group design, in studies using matched controls , age of the participants between 31 and 45 and when anxiety was measured after 20 mins of exercise. However, when psychophysiological correlates of anxiety were the outcome measures, exercise had a fairly large effect on anxiety (effect sixe 0.56) overall. It was also observed that acute exercise was better than chronic exercise. The effect sizes were largest with lower intensity exercise of upto 20 min duration lasting 4-6 weeks, in the pre-post within groups design, studies using matched controls, age of the participants between 18 to 30 years and those with psychiatric illness.

The effect of exercise was moderate (effect size : 0.34) when trait anxiety was the outcome measure. The effect sizes were largest when high intensity aerobic exercise of more than 40 min duration, performed for more than 15 mins,age of the participants below 18 and people with psychiatric illnesses. Overall, exercise has a positive effect across all the three categories, however, the magnitude of effect differs. For instance, exercise produced the largest effect when the outcome was psychophysiological correlates of anxiety, especially skin measures. The effect on current anxiety was modest and in case of trait anxiety, the largest effect was seen in subjects with previous psychiatric illnesses. Exercise of at least 20 minutes was the minimum requirement for observing a reduction in anxiety irrespective of the way it was measured.

It has been observed that moderate intensity physical activity has been associated with mood improvement on a medium and a long term basis, whereas worsening of mood has been reported with high intensity exercise lasting for 10 days to some weeks.80-91 However majority of the studies reporting these mood disturbances have mainly monitored elite athletes from sports that requires high degree of aerobic fitness (endurance sports such as swimming, cycling, canoeing, rowing).85-89 These elite athletes are subjected to high intensity interval training divided into three different training periods. It was observed that, on an average for most of the athletes there was worsening of mood from the first to second training period, followed by improvement from second to third period. Hence, just before the competition an improvement in mood is seen when an increase in anxiety would be expected

Exercise and cognitive function
The beneficial effects of exercise on cognition has been demonstrated by a large number of studies.92-94 It was observed that exercise has the capacity to enhance learning and memory in a variety of conditions ranging from mental decline associated with aging to facilitating functional recovery in patients suffering from brain injury or disease.95-100 Exercise induced increase in BDNF in the hippocampus is one of the major mechanisms by which exercise causes an improvement in cognitive function.101-104 In an analysis of 18 longitudinal fitness training studies it was found that cardiovascular fitness training improves cognitive regardless of the task type.101 A study on rats, demonstrated that blocking BDNF action using specific immunoadhesive chimers abolished the ability of exercise to augment learning and memory.105

In a meta analysis of 18 previously published studies106 which reviewed studies which included exercise interventions like bicycle ergometry, walking and calisthenics, flex and stretch exercises, aerobic workouts of varying levels of intensity and duration and nonaerobic stretch and co-ordination exercise. It was observed that the impact of exercise on cognitive function is more pronounced in the elderly population, where it tends to produce a moderate benefit. Of the different types of exercise Yoga has been shown to have the greatest benefit in this particular population. Authors107 conducted meta- analysis of of 134 studies that investigated the effects of exercise on cognitive function. It was found the effect of exercise on the cognitive functioning of the general population is small yet significant. Also chronic exercise tends to produce more effects than acute exercise. However, no study till date examines the impact of the improvement in cognitive function that is attributable to exercise on longevity and quality of life.

Alzheimer's Dementia (AD)
A wide variety of environmental stimuli along with genetic factors are thought to influence the onset of AD. It is observed that exercise is one of the most important lifestyle changes associated with AD prevention.63 In one study it was observed that daily 30 min of physical training (aerobic, flexibility and strength) reduced the number of hospitalizations in 153 AD patients and also decreased depressive symptoms and improved their quality of life.108 After one year of exercise interventions in 134 patients109 it was demonstrated that the exercise group had improved quality of life as compared to the sedentary group. Williams And Tappen110 observed an antidepressant effect of exercise in severe AD. A large number of other studies have shown a significant improvement in older adults with AD.110-111

Parkinson's disease
Parkinson's Disease is a neurodegenerative disease associated with tremor, rigidity and hypokinesia as well as posture and balance changes.112 Exercise serves as a adjunctive treatment and plays an important role in prevention of PD.113-128 It is highly effective in the improvement of motor symptoms, gait and activities of daily living (ADLs).129-130 The intensity of exercise also influences the neuroprotective response. According to authors128 higher intensity of exercise would be positively related to protective factor, when compared to lower intensity. In a study130, it was observed that physical activity is significantly beneficial to PD patients by improving their quality of life, walking skills, and reducing neurological symptoms. Particularly, the strength and balance training plays a very important role in improving their functional capabilities which has a positive influence on their quality of life and independence. It was observed that parkinsonians who accomplished a 10 week strength and balance program developed strength and the number of falls were also reduced.131

Schizophrenia
Schizophrenia is one of the most disabling of all mental illnesses. Faulkner and Sparkes132 designed an ethnographic study – participant observation and interviews with participants and their keyworkers. They explored the therapeutic value of a 10 week exercise programme of twice weekly sessions for people living with schizophrenia.. It was observed that exercise reduced auditory hallucinations, raised their self esteem and improved their sleep patterns and general behavior. The major factor responsible for these benefits was that exercise provided distraction and social interaction. It was unclear from the study how exercise interacted with other interventions like medications which may have produced the outcome. However, the ethnographic design allowed the researchers to study intensively the participants and their key workers experiences. Hence the results of this study support the therapeutic value of exercise.

Psychiatric disorders related to exercize
Disorders associated with excessive exercise
Many individuals show an exaggerated preoccupation with exercise and exercise training even in the presence of medically contraindicated conditions.133-135 For them physical activity becomes an obsession or rather an addiction.136-139 Since most individuals with exercise dependence have a good mental health and show no signs of diseases it is considered that excessive exercise is rarely pathologic.137-138

Muscle dysmorphia
In large number of bodybuilders and weight lifters it is found that physical activity is associated with a condition of alteration in body image in which an individual , although large and muscular, believe they are weak and skinny.139-145. This condition is denominated as "bigamerexia"140 and "reverse anorexia"141. Pope and others144 proposed a criteria based the DSM IV diagnostic criteria for the diagnosis of muscle dysmorphia.146 According to Pope the following features suggest body dysmorphic disorder : (1) Excessive preoccupation with the idea that their body is not sufficiently slim (in terms of a low fat content) and muscular ; (2) this preoccupation causes discomfort and significant impaired social functioning ; (3) this preoccupation cannot be explained by any other psychiatric disorder. Also there are evidences indicating a relationship between the presence of muscle dysmorphia and a history of mood and anxiety and eating disorders145, as well as use of anabolic androgenic steroids.

Anabolic- Androgenic steroid dependence
Most of the physically active individuals use anabolic-androgenic steroids and are in a state of dependence.147 These substances causes symptoms like increase in irritability, aggressiveness, mania, psychotic symptoms which might provoke the users to commit criminal acts.148 Also, abstinence from its use might lead to depressive symptoms.149-152

Overtraining Syndrome
Overtraining153, staleness83, overstress, overuse and burnout129, overwork, over fatigue , overstrain , chronic fatigue in athletes154, sport fatigue syndrome, unexplained underperformance syndrome155-156 etc are the different denominations used for this condition. It is estimated that per training session 7% to 20% of the athletes face this problem157-158

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and this prevalence is even higher in endurance sports and amongst elite athletes because of their extensive training programme.159 In this condition in order to reach the goal of improved performance the athlete overshoots his/her limits of physical capacity. They start presenting with complaints like sleep disturbances, loss of weight and appetite, reduced libido, irritability, heavy and painful musculature, emotional liability and even depression. In one study by Morgan et al it was found that its prevalence was higher than 60% along the career of elite runners and 38% amongst lower level runners. The milder or initial form of this condition is called as overreaching or distress.158 Its incidence was found to be 30% per training session in studies conducted on university swimmers.

Overtraining syndrome is considered when an athlete shows a decline in sports performance following or during period of intense training which does not improve with short term rest of 1 or 2 weeks. Along with symptoms of persistent fatigue, sleep disturbances, reduced appetite and libido, sensation of painful musculature and mood changes such as apathy, irritability and depression.159 Along with these symptoms there are physiological alterations like reduced maximum heart rate, altered lactate measurements such as lactate concentration at maximum performance or lactate threshold, reduced nocturnal epinephrine secretion, changes in testosterone: cortisol ratio, immunological alterations leading to infections of upper airway and changes in serum markers such as creatine kinase and urea.160-164 According to Eichner,161 overtraining syndrome is " depression with a new face". It is observed that athletes with overtraining syndrome generally show complete recovery after weeks or months.165 However, prolonged inactivity might lead to decrease in an individuals performance which might prevent their participation in competition, leading to loss of motivation, sponsorship, and even retirement. Hence, prevention of overtraining syndrome is the best way to deal with it. Since the reliability of physiological biomarkers is still questionable and do not permit early diagnosis166-168, changes in the mood states can be used to diagnose overtraining syndrome169. A decrease in training load of athletes presenting with initial signs of overtraining syndrome detected by monitoring of mood disturbances prevents the development of complete syndrome.170

Conclusions

For both psychiatric and nonclinical populations, physical activity and exercise would seem to offer some benefit. Yet despite the great public health importance of this potential benefit, surprisingly few studies meeting acceptable standards of methodology have been reported to help explain how physical activity and exercise might be useful (a) to reduce morbidity in psychiatric populations and (b) to prevent psychological problems and even improve mental health in nonclinical populations. Even the controlled studies have been short term, involving small samples, and few studies have addressed possible mechanisms. Our knowledge in the area can best be advanced through a variety of studies that both address a variety of populations and combine excellent psychological and physiological methodology with equally careful description and assessment of physical activity and exercise.

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