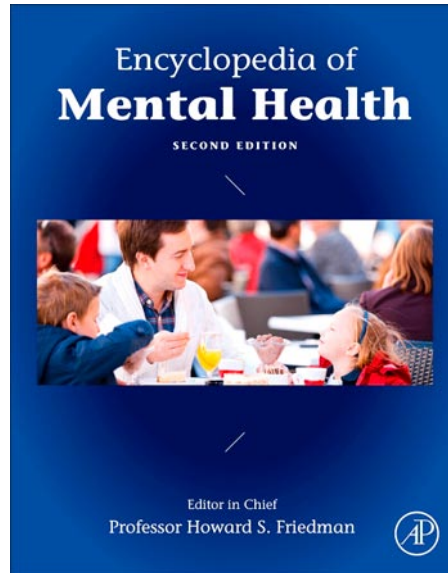


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Exercise, Physical Activity, and Mental Health

ML Kern, University of Melbourne, Melbourne, Vic., Australia

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Glossary

Endorphins Naturally occurring opioids produced in the body that bind to neuroreceptors in the brain, and act on the nervous system to alleviate pain and produce feelings of euphoria and well-being.

Exercise A subtype of physical activity that is planned, structured, repetitive, and performed to increase fitness.

Flow Extremely high psychological engagement in an activity that involves intense concentration, absorption, and focus.

Humors Distinct bodily fluids believed to influence health and personality, popular in ancient Indian, Greek, and Roman Medicine.

Monoamines A type of neurotransmitter that contains a single amino group, such as serotonin, epinephrine, or dopamine.

Physical activity Any bodily movement that results in energy expenditure.

Sports A specific type of physical activity that is structured, competitive, and rule governed.

Introduction

Accumulating evidence supports the benefits of physical activity and exercise across physical, mental, cognitive, and social realms. Federal recommendations indicate that people of all ages, genders, and sociodemographic backgrounds can improve their health and quality of life by regularly including moderate amounts of physical activity in their lives (U.S. Department of Health and Human Services (USDHHS), 2008). Current recommendations suggest that adults should engage in at least 150 min (2 h and 30 min) per week of accumulated moderate intensity activity (e.g., brisk walking, gardening, and swimming), with additional benefits occurring with more activity (either greater intensity or longer durations). Children and adolescents should engage in at least one hour of physical activity daily, including aerobic, muscle-strengthening, and bone-strengthening activities.

Physically, there is clear evidence that exercise can both prevent and help manage chronic illnesses and disease, including diabetes, heart disease, osteoarthritis, asthma, and many other conditions (Pedersen and Saltin, 2006). Activity predicts lower risk of mortality, although it may be the cumulative pattern of physical activity over time that results in health benefits (DiPietro, 2001; Kern 2010). Conversely, numerous studies document the burden of inactivity, ranging from increased risk of chronic conditions and illness to early mortality (Penedo and Dahn, 2005). Despite these health benefits, less than half of US adults and only half of US youth meet physical activity standards (CDC, 2011; Iannotti and Wang, 2013).

The current focus and impetus for increasing physical activity levels in the US stems from the physical health benefits of activity and the disease burdens associated with inactivity. Yet how are activity, exercise, and mental health connected? This article provides an overview, beginning with definitions of physical activity and exercise, continuing with a journey through the history of exercise and health, highlighting empirical evidence regarding activity and mental health relationships, and providing implications for clinicians, researchers, and public policy.

Defining and Measuring Physical Activity

The words 'physical activity' and 'exercise' are often used interchangeably, describing anything from movement that an individual performs during the day to intricately designed exercise programs. Formally, physical activity refers to any body movements that result in energy expenditure, ranging from very low (e.g., typing on a computer) to very high (e.g., sprinting 100 m) (Caspersen *et al.*, 1985). It occurs in multiple domains, including leisure time, occupations, household tasks, and even sleep. Exercise is a subset of physical activity that is structured, repetitive, and purposeful (e.g., going for a run or lifting weights), and is performed specifically to increase fitness. Exercise ranges from none to extreme amounts. Sports (e.g., basketball) are a specific type of physical activity that is structured, rule governed, and often competitive (Biddle and Ekkekakis, 2006). Federal recommendations regarding increasing physical activity primarily focus on leisure time activities and exercises performed specifically for health benefits (Kahn *et al.*, 2002).

Physical activity can be characterized by type (what activity is performed), intensity (how much energy is expended), frequency (how often activity is done), duration (how long movement lasts), or some combination (Welk, 2002). Activity is often assessed through self-reported measures, asking for instance how often a person engages in light (e.g., card playing, reading, cooking, playing video games), moderate (e.g., brisk walking, light calisthenics, gardening, golfing, recreational swimming, actively playing with children), and vigorous activities (e.g., jogging/running, most competitive sports, heavy yard work, lap swimming, cross-country skiing). Self-reported measures can be affected by self-presentation, poor recall, question context (e.g., movement in general, leisure time activity, or specific exercises), and individual perceptions of activity. For example, a farmer may report complete leisure time inactivity, yet is quite active in his or her occupation.

Physiologically based tools can determine exact energy expenditures. Traditionally, such assessments could only be conducted in laboratories at great expense. However, technology – such as smart phones with energy expenditure

indicators, accelerometers, pedometers, and heart rate monitors – is quickly making such assessments cheaper and easier. Each type of measure has strengths and weaknesses, and the optimal method depends on the purpose. An epidemiologist studying general trends in activity might rely on self-reported questionnaires, a neuroscientist studying mechanisms linking exercise and brain activity might rely on carefully controlled laboratory measures, a doctor might ask a few simple questions of her patients, and an athlete might use a heart rate monitor during training to monitor performance and recovery.

A Historical Perspective

The focus on physical activity in general and exercise in particular has existed for thousands of years (MacAuley, 1994; Tipton, 2008). The social standing and prestige surrounding sports and athleticism apparent in today's culture reflects a prestige that has appeared in numerous cultures across time.

Around 2500 BC, sports and games, including running, rowing, wrestling, boxing, jumping, and dancing, were an important part of the Egyptian culture. In fact, all future Pharaohs were expected to excel in a 33.3 km race. Homer's writings reflect admiration of athletic skills and warrior ability, with official competitive events occurring as early as 1370 BC. In the Spartan civilization (ca. 600 BC), the warrior held the highest status. Fitness was emphasized for both males and females, as fit women mothered warrior children. Greek youth were encouraged to participate in sports and exercise, and the Pan-Hellenic games, the root of the modern day Olympic Games, became the birthplace of the professional athlete. In the Roman era, gladiatorial contests, consisting of intense combat, running, jumping, and charging, were extremely popular.

Interestingly enough, even as athletes and warriors have been exalted by laypersons, there has also been longstanding debate over the amount of exercise required for physical and mental benefit. Many have argued for the value of moderate exercise. Early texts from the Indus Valley (India) suggested that the body was controlled and regulated by three humors, and disease occurred when these humors were displaced. The Indian doctors Susruta (ca. 600 BC) and Charaka (ca. 200 BC) advocated that a regimen of diet, exercise, and medication could restore and maintain balance in the body.

Health as a balance of elements also appeared in ancient Greek and Roman medicine. Pythagoras and his students believed that physical health resulted from the balance of four humors, and diet and daily exercise were needed to maintain equilibrium. Hippocrates and his followers viewed light to moderate exercise, combined with a nutritious diet, as important contributors to health attainment and disease prevention. Galen recognized the benefits of moderate exercise to promote health of body and intellect. These Greek doctors had little regard for the excessiveness of trainers and athletes.

Plato directly applied physical activity to mental health and illness. He advocated for moderate exercise to influence not only the health of the body, but also the mind and soul. He too was critical of excessive exercise. Although the harsh regimens demonstrated short-term success, Plato believed that excessive training hardened the athletes' minds, such that

athletes were prone to disease when their harsh regimens could no longer be sustained. Exercise and activity were meant to promote natural function and stability between the body and mind, and excessiveness destroyed that balance.

After the Roman Empire fell, the church became the dominant influence, and the focus on the body and the use of exercise for physical and mental benefits was pushed aside. Sports formally appeared again in the nineteenth century as rowing developed formalized rules in the United Kingdom. With the rise of modern medicine, the value of exercise and activity became an empirical question studied by physicians, public health officials, epidemiologists, and others, resulting in convincing evidence of the health benefits of physical activity. Yet the question of excessiveness versus sufficiency has remained across the centuries, and continues to be a source of debate today.

Benefits of Physical Activity and Exercise

Over the past century, clear evidence has documented the benefits of exercise to prevent and help treat numerous physical conditions (Pedersen and Saltin, 2006). Further, growing evidence finds that living an active and socially integrated lifestyle may have cognitive benefits (Colcombe and Kramer, 2003; Fratiglioni *et al.*, 2004; Hillman *et al.*, 2008; Ratey, 2008). Although less attention has been given to mental health effects, both cross-sectional and longitudinal studies have demonstrated clear positive associations between physical activity and mental health (Morgan *et al.*, 2013).

General Populations and Mental Health

In the general population, evidence certainly supports positive associations between physical activity and self-reported well-being (Biddle, 2000; Biddle and Ekkekakis, 2006; Morgan *et al.*, 2013). People talk about the 'runner's high,' a feeling of flow or complete absorption that an athlete experiences during or after intense activity, which occurs when challenge and skill meet (Csikszentmihalyi, 1997). Testing emotions before and after exercise, studies have found a positive increase in affect, regardless of exercise intensity (Ekkekakis and Petruzzello, 1999). Indeed, ending exercise with a sense of enjoyment may be important for maintaining that activity (Biddle, 2000). Interestingly, this 'feel good' effect may not necessarily occur during the activity itself. For example, in a study with university students, when participants pushed into anaerobic levels (i.e., maximal intensity), negative affect rapidly increased (Hall *et al.*, 2002). But immediately after terminating the exercise, affect quickly improved. Similarly, endurance athletes often complain of intense struggle and discomfort during the event, yet later report a high sense of accomplishment and enjoyment.

Few studies have directly examined mental health and exercise in youth, but there is general agreement that activity is beneficial. A review of 20 studies found positive associations between physical activity and greater self-esteem, lower levels of reported stress, and less depression and anxiety (Calfas and Taylor, 1994). However, another review found inconsistent

associations for children and adolescents between activity and body image, self-esteem, self-efficacy, and perceived confidence in children (Sallis *et al.*, 2000). For youth, whether or not activity directly influences mental health may be less important than setting into place active trajectories that will provide both physical and mental health benefits as the youth become adults, as high fitness and activity is one of the best predictors of physical activity in adulthood (Tammelin, 2005). In the British Health and Lifestyle Study, maintaining exercise across a 7-year period alleviated trait-level mood instability, suggesting that consistent physical activity can actually modify negative personality characteristics (Bowen *et al.*, 2013). And as people age, the ability to stay active and function in life is important for maintaining a high quality of life (Gill *et al.*, 2013). Studies are needed that prospectively follow people over time, directly examining how activity and mental health might influence one another across development.

Clinical Populations and Mental Illness

Research has only recently begun to examine activity and mental health associations for individuals with mental illness. People with serious mental illness are significantly less active and in worse physical condition (in terms of muscle strength and aerobic fitness) than the general population. They are at a considerably greater risk of early mortality, in part due to high risk of suicide, but more often due to cardiovascular disease and other chronic conditions resulting from poor physical condition (Richardson *et al.*, 2005).

Most of the studies that have found relations between exercise, physical activity, and mental illness have focused on depression. In both clinical and nonclinical samples, meta-analyses and randomized control trials have demonstrated moderate to large associations between exercise and lower levels of depression, although few studies have investigated how to best optimize exercise as a treatment option (Morgan *et al.*, 2013). Clinical studies offer a clearer picture than non-clinical studies, which are extremely heterogeneous in terms of study design, types of participants, how activity and mental health is measured, and the intervention itself. Clinical studies suggest that for mild or moderate depressive symptoms, exercise may be as effective as other treatment modalities, with equal effectiveness for strength and aerobic exercises (Paluska and Schwenk, 2000). In fact, effects may be longer lasting than pharmaceuticals (Penedo and Dahn, 2005). Few studies have included severely depressed individuals, although one meta-analysis found particularly strong effects for exercise, compared to people in the control condition (Craft and Landers, 1998).

For anxiety, findings are less consistent than with depression. There are clear associations between exercise and lower levels of state anxiety; participants often report short-term improvements in quality of life. However, studies have failed to demonstrate conclusive associations between chronic exercise, fitness, and improvements in trait anxiety (Paluska and Schwenk, 2000). Also, some evidence finds that exercise might increase anxiety for individuals with panic disorder. It may be particularly important to identify and guide such individuals through anxiety provoking aspects of an activity.

Little guidance is available for other severe mental illnesses. With illnesses such as schizophrenia, exercise may be important for alleviating secondary symptoms, such as depression, low self-esteem, social withdrawal, and generally low fitness (Morgan *et al.*, 2013; Richardson *et al.*, 2005). Likewise, in bipolar disorder, studies suggest that physical activity can help alleviate symptoms, but studies have not examined the prospective effects of exercise or activity on mania (Van-campfort *et al.*, 2013). Notably, individuals with serious mental illnesses often face additional challenges and barriers that require guidance and support.

Benefits of Physical Activity: Cautious Optimism

Altogether, there is considerable evidence supporting the value of physical activity for mental well-being. Although it might be tempting to say that physical activity will make a person happier or alleviate depression and other mental illnesses, care is needed before making any causal claims. For example, although several recent reviews found positive associations between exercise programs, better school performance, and better psychological and social well-being, they also noted the predominance of poor study quality and high risk of biased reports (Lubans *et al.*, 2012; Singh *et al.*, 2012). Studies often consist of small samples and only follow participants across a short period of time. A 6-week study might find that the treatment (exercise) group reports greater well-being than the control group at the end of the intervention. But the extent to which benefits extend a year or more beyond the intervention is unknown, and most likely depends on whether or not the person continues to exercise. Even with successful interventions, many participants drop out during the course of the study, such that the treatment works for those who stay with it, but not for those that need it the most.

Perhaps the clearest evidence of beneficial effects comes from animal studies (e.g., rats running on a wheel), but animals cannot report their own subjective well-being, and findings may not generalize to humans. Studies on preventive aspects of activity are inconclusive, and no experiment has shown that exercise prevents depression or other mental illnesses (Paluska and Schwenk, 2000). Still, there generally appears to be consistently positive associations between activity, exercise, and good mental health, and there is growing support for the possibility of using exercise as a complementary treatment to pharmaceuticals or psychotherapy. The question may be not whether exercise improves well-being, but rather whom it works for, under what conditions is exercise helpful or harmful, how to make exercise interventions more effective, and mechanisms that connect activity and mental health. These are important questions that future studies need to continue to explore.

Type and Dose

What type and amount of activity is necessary to provide benefit? Although most studies have focused on aerobic training, strength and resistance training appear to be equally

effective, and the optimal prescription may depend upon individual preferences.

Exercise dose can vary in terms of frequency, duration, and intensity, and there is little guidance in terms of what might be sufficient, optimal, or too much. Some evidence supports a dose-response relation, such that more physical activity and sport participation is related to reduced psychological distress (Hamer *et al.*, 2009). Studies on anxiety have found a non-linear relationship between the intensity of exercise and feelings of anxiety, such that little relief of anxiety-related symptoms is found until high exercise intensities are reached (Morgan *et al.*, 2013). Yet prescriptions of more intense exercise are a double-edged sword – exercise can quickly become too much, leading to additional anxiety, feelings of helplessness, and dropping exercise altogether.

The proper amount may also vary by age. Many older adults are able to do much more than they realize. For example, walking and resistance training have both been associated with improved mood in healthy older adults (Penedo and Dahn, 2005). Active individuals do need to be aware of natural age-related changes; if an individual does not adjust for natural declines that may occur with the aging process, he or she might experience disappointment, lowered self-worth, and injury, accompanied by depression and other mental health problems.

Individual differences also play a role. Some individuals have a natural inclination to be more active than others, and may be more or less prone to mental health versus illness. Moreover, the person exists within a social environment, which may be more or less supportive of an active lifestyle. The interaction of individual differences and social environments across extended periods of time are pivotal in influencing how active a person is, the mental health benefits derived, and the long-term health-related outcomes associated with different activity patterns.

As much of the US population struggles with being too sedentary, less attention has been given to overtraining and excessive exercise. However, supporting the claims by the ancient Greek and Roman doctors, activity can be just as detrimental when carried to an extreme. Overtraining represents a psychobiological disorder, with symptoms crossing both mental and physical domains, including irritability, psychological burnout, fatigue, injury, exhaustion, and depressive symptoms (Paluska and Schwenk, 2000).

Altogether, although strong research evidence is lacking, moderate activity appears to support good mental health. Interestingly enough, such recommendations return to the advice given by Hippocrates, Plato, Galen, and their contemporaries.

Mechanisms

Salutary effects on mental health may occur through physical, social, and psychological pathways, and a combination of direct and indirect influences. Notably, causal effects are most likely bidirectional, with activity impacting mental health and mental health impacting a person's desire and ability to exercise.

Physically, activity and exercise impact cardio-respiratory functioning, muscular and bone strength, stress response, and hormonal release and regulation. Muscles and fitness respond to use and atrophy with disuse, whereas physical training can increase muscular strength, even in older individuals (Hirvensalo *et al.*, 2000; Pedersen and Saltin, 2006). Purposeful activity or exercise may improve stress regulation; exercise temporarily stresses the physiological system, but when tempered by rest, the body builds reserves for dealing with subsequent stressors. Advances in animal studies and neuroscience suggest that exercise balances neurochemicals in the brain and potentially promotes the function and growth of neurons (Ratey, 2008). Exercise may increase the transmission of monoamines in the blood, which function similar to anti-depressive drugs, and exercise releases endorphins into the system, causing calmness and improved mood (Camero *et al.*, 2012; Monteiro-Peluso and Guerra de Andrade, 2005).

Social support, norms, the built environment, and other aspects of the social context correlate with and can influence physical activity (Bauman *et al.*, 2012). Social relationships may also increase mental well-being (Paluska and Schwenk, 2000). For example, there is growing interest in class-based programs at gyms, in which members mutually encourage one another during a workout. Many charity races are built on the idea of bringing people together to support a common cause. Friends can connect and share emotions and thoughts during a walk or exercise session. Depressed individuals often isolate themselves from others; exercising with others can break down feelings of loneliness. Still, many people experience mental benefits without a social component. Research is needed to distinguish when and how social relationships might lead to mental health benefits.

Psychological mechanisms may also link exercise and mental health. In some cases, exercise can divert attention away from negative stimuli, improving mood in the process. Self-efficacy is often considered an important determinant of exercise; cross-sectional studies find that self-efficacy predicts starting and maintaining vigorous activity (Paluska and Schwenk, 2000). Yet self-efficacy most likely also results from physical activity (French, 2013), as progressive improvements in fitness can build self-confidence for success in the future. Similarly, when mental illness is accompanied by a sense of helplessness, engaging in exercise can offer a mode to take control of one's actions, increasing mood as a byproduct. Further, exercise can provide achievable goals; a sense of mastery and control can develop as goals are reached that previously seemed impossible.

Implications

In terms of clinical implications, regular activity – be it aerobic or strength training – may indeed be important for alleviating symptoms of depression and anxiety, and in some cases may be as effective as psychotherapy or medication. At the same time, individuals with mental illness often face additional barriers, and professionals need to be mindful of these challenges. Self-monitoring and feedback is helpful, especially when incremental improvements can be captured and documented, but is also difficult to promote, and can easily lead to

discouragement and dropout (Richardson *et al.*, 2005). It may be helpful to take advantage of other elements in a person's life, such as social support and establishing routines, which may encourage activity to continue after the intervention ends.

In terms of research implications, a better empirical foundation is needed. A considerable number of studies have built strong evidence for the benefit of physical activity in preventing and managing many chronic physical conditions (Pedersen and Saltin, 2006); similar work is needed for mental health and illness. Specific attention should be given to minority and at-risk populations, who tend to be both less active and at higher risk of mental illness. Studies are needed that include both clinical and nonclinical populations with varying types and levels of mental illness severity, as are prospective studies following people over long time periods. For example, a study might randomly select a large group of people, including different ages, socioeconomic statuses, genders, and ethnicities, and randomly assign them to different levels and types of exercise (e.g., no exercise, aerobic activity, strength training, or personal preference). Tools such as smart phones could monitor adherence and actual activity levels. Changes in mental health could be tracked from baseline, through the trial, and for years beyond, determining who stays with the activity, who stops activity, and the long-term impact of each condition.

On the policy side, due to the many individual differences that impact physical activity, individually tailored programs may be the most promising outlet for successful interventions, but communities and public policy play an important role in creating environments that support physically active lifestyles. Environments can be designed to nudge people toward active lifestyles (e.g., Buettner, 2012). For example, community-based social support programs and schools that have focused their physical education curricula specifically on health and fitness have effectively increased activity levels (Kahn *et al.*, 2002). Such programs may further benefit from directly incorporating mental health elements, building not only physical but also emotional fitness. Public policy also plays an important role in building communities that are safe, attractive, and conducive to activity, exercise, and mental well-being as a whole.

Studies are needed that test the cost-effectiveness of exercise versus pharmaceutical and other treatment approaches, but if moderate activity can prevent mental illness from occurring, then it potentially will result in major economical and psychological benefits for individuals and society as a whole.

Conclusion

Returning to our historical roots, a balanced life involving moderate exercise and a healthy diet indeed may be protective, resulting in both physical and mental health outcomes. As Plato noted thousands of years ago, "lack of activity destroys the good condition of every human being, while movement and methodical physical exercise save it and preserve it."

See also: Adolescence. Anxiety, Panic, and Phobias. Burnout. Cognitive-Behavioral Psychotherapy. Depression. Disorders of

Negative Affect. Food, Nutrition, and Mental Health. Happiness and Subjective Well-Being. Medical Regimen Adherence. Mental Health and Aging. Psychotherapy. Schizophrenia. Self-Efficacy. Self-Esteem. Social Support and Mental Health. Sport and Mental Health. Stress

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