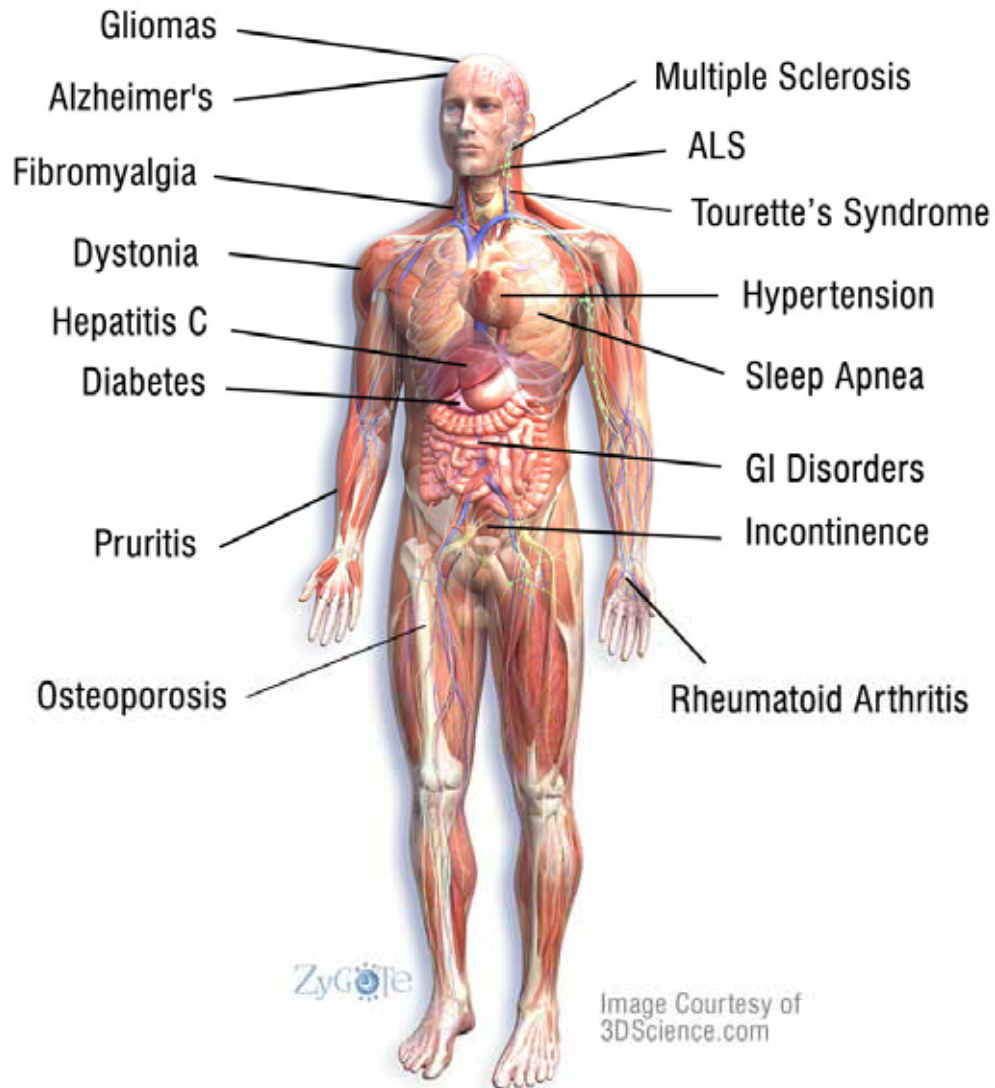


Emerging Clinical Applications for Cannabis and Cannabinoids:

A Review of the Recent Scientific Literature, 2000 – 2006



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Introduction

Despite continued political debates regarding the legality of medicinal marijuana, clinical investigations of the therapeutic use of cannabinoids are now more prevalent than at any time in history. A search of the National Library of Medicine's PubMed website quantifies this fact. A keyword search using the terms "cannabinoids, 1996" reveals just 258 scientific journal articles published on the subject for that year. Perform this same search for the year 2006, and one will find close to 1,000 published scientific studies.

While much of the renewed interest in cannabinoid therapeutics is a result of the discovery of the endocannabinoid regulatory system, some of this increased attention is also due to the growing body of testimonials from medicinal cannabis patients and their physicians. Nevertheless, despite this influx of anecdotal reports, much of the modern investigation of medicinal cannabis remains limited to preclinical (animal) studies of individual cannabinoids (e.g. THC or cannabidiol) and/or synthetic cannabinoid agonists (e.g., dronabinol or WIN 55,212-2) rather than clinical trial investigations involving whole plant material. Predictably, because of the US government's strong public policy stance against any use of cannabis, the bulk of this modern cannabinoid research is taking place outside the United States.

As clinical research into the therapeutic value of cannabinoids has proliferated exponentially, so too has investigators' understanding of cannabis' remarkable capability to combat disease. Whereas researchers in the 1970s, 80s, and 90s primarily assessed cannabis' ability to temporarily alleviate various disease symptoms — such as the nausea associated with cancer chemotherapy — scientists today are exploring the potential role of cannabinoids to alter disease progression. Of particular interest, scientists are investigating cannabinoids' capacity to moderate autoimmune disorders such as multiple sclerosis, rheumatoid arthritis, and inflammatory bowel disease, as well as their role in the treatment of neurological disorders such as Alzheimer's disease and amyotrophic lateral sclerosis (a.k.a. Lou Gehrig's disease.)

Investigators are also studying the anti-cancer activities of cannabis, as a growing body of preclinical and clinical data concludes that cannabinoids can reduce the spread of specific cancer cells via apoptosis (programmed cell death) and by the inhibition of angiogenesis (the formation of new blood vessels). Arguably, these latter trends represent far broader and more significant applications for cannabinoid therapeutics than researchers could have imagined some thirty or even twenty years ago.

HOW TO USE THIS REPORT

As states continue to approve legislation enabling the physician-supervised use of medicinal

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marijuana, more patients with varying disease types are exploring the use of therapeutic cannabis. Many of these patients and their physicians are now discussing this issue for the first time, and are seeking guidance on whether the therapeutic use of cannabis may or may not be appropriate. This report seeks to provide this guidance by summarizing the most recently published scientific research (2000-2006) on the therapeutic use of cannabis and cannabinoids for 16 separate clinical indications:

- * Alzheimer's disease
- * Amyotrophic lateral sclerosis
- * Diabetes mellitus
- * Dystonia
- * Fibromyalgia
- * Gliomas
- * Gastrointestinal disorders
- * Hepatitis C
- * Hypertension
- * Incontinence
- * Multiple sclerosis
- * Osteoporosis
- * Pruritis
- * Rheumatoid arthritis
- * Sleep apnea
- * Tourette's syndrome

In some of these cases, modern science is now affirming longtime anecdotal reports of medicinal cannabis users (e.g., the use of cannabis to alleviate GI disorders). In other cases, this research is highlighting entirely new potential clinical utilities for cannabinoids (e.g., the use of cannabinoids to modify the progression of diabetes.)

The diseases profiled in this report were chosen because patients frequently inquire about the therapeutic use of cannabis to treat these disorders. In addition, many of the indications included in this report may be moderated by cannabis therapy. In several cases, preclinical data indicates that cannabinoids may halt the progression of these diseases in a more efficacious manner than available pharmaceuticals. In virtually all cases, this report is the most thorough and comprehensive review of the recent scientific literature regarding the therapeutic use of cannabis and cannabinoids.

For patients and their physicians, let this report serve as a primer for those who are considering using or recommending medicinal cannabis. For others, let this report serve as an introduction to the broad range of emerging clinical applications for cannabis and its various compounds.



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Forward

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Marijuana is a colloquial term used to refer to the dried flowers of the female *Cannabis Sativa* and *Cannabis Indica* plants. Marijuana, or cannabis, as it is more appropriately called, has been part of humanity's medicine chest for almost as long as history has been recorded.

All forms of cannabis plants are quite complex, containing over 400 chemicals. Approximately 60 of these chemicals are classified as cannabinoids. Among the most psychoactive of the cannabinoids is delta-9-tetrahydrocannabinol (THC), the active ingredient in the prescription medications dronabinol (Marinol) and naboline (Cesamet). Other major cannabinoids include cannabidiol (CBD) and cannabitol (CBN), both of which are non-psychoactive but possess distinct pharmacological effects.

Cannabis was formally introduced to the United States Pharmacopoeia (USP) in 1854, though written references regarding the plant's therapeutic use date back as far as 2800 B.C. By 1900, cannabis was the third leading active ingredient, behind alcohol and opiates, in patent medicines for sale in America. However, following the Mexican Revolution of 1910, Mexican immigrants flooded into the United States, introducing to American culture the recreational use of marijuana. Anti-drug campaigners warned against the encroaching, so-called "Marijuana Menace," and alleged that the drug's use was responsible for a wave of serious, violent criminal activity. In 1937, after testimony from Harry Anslinger -- a strong opponent of marijuana and head of the Federal Bureau of Narcotics in the 1930s -- and against the advice of the American Medical Association, the Marijuana Tax Act was pushed through Congress, effectively outlawing all possession and use of the drug.

At the time of the law's passage, there were no fewer than 28 patented medicines containing cannabis available in American drug stores with a physician's prescription. These cannabis-based medicines were produced by reputable drug companies like Squibb, Merck, and Eli Lilly, and were used safely by tens of thousands of American citizens. The enactment of the Marijuana Tax Act abruptly ended the production and use of medicinal cannabis in the United States, and by 1942 cannabis was officially removed from the *Physician's Desk Reference*.

Fortunately, over the past few decades there has been a significant rebirth of interest in the viable medicinal uses of cannabis. Much of the renewed interest in cannabis as a medicine lies not only in the drug's effectiveness, but also because of its remarkably low toxicity. Lethal doses in humans have not been described. This degree of safety is very rare among modern medicines, including most over-the-counter medications. As a result, the National Institutes of Health (NIH), the National

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Academy of Sciences Institute of Medicine, and even the US Food and Drug Administration have all issued statements calling for further investigation into the therapeutic use of cannabis and cannabinoids.

The discovery of an endogenous cannabinoid system, with specific receptors and ligands, has progressed our understanding of the therapeutic actions of cannabis from folklore to valid science. It now appears that the cannabinoid system evolved with our species and is intricately involved in normal human physiology -- specifically in the control of movement, pain, reproduction, memory, and appetite, among other biological functions. In addition, the prevalence of cannabinoid receptors in the brain and peripheral tissues suggests that the cannabinoid system represents a previously unrecognized ubiquitous network in the nervous system.

Cannabinoid receptor sites are now known to exist in the nervous systems of all animals more advanced than hydra and mollusks. This is a result of at least 500 million years of evolution. The human body's neurological, circulatory, endocrine, digestive, and musculoskeletal systems have now all been shown to possess cannabinoid receptor sites. Indeed, even cartilage tissue has cannabinoid receptors, which makes cannabis a prime therapeutic agent to treat osteoarthritis. Cannabinoids have been shown to produce an anti-inflammatory effect by inhibiting the production and action of tumor necrosis factor (TNF) and other acute phase cytokines, which also makes them ideal compounds to treat the autoimmune forms of arthritis. It is now suggested by some researchers that these widely spread cannabinoid receptor systems are the mechanisms by which the body maintains homeostasis (the regulation of cell function), allowing the body's tissues to communicate with one another in this intricate cellular dance we call "life." With this knowledge of the widespread action of cannabinoids within all these bodily systems, it becomes much more easy to conceptualize how the various forms of cannabinoids might have a potentially therapeutic effect on diseases ranging from osteoarthritis to amyotrophic lateral sclerosis (ALS).

Another one of the exciting therapeutic areas that cannabis may impact is chronic pain. Cannabinoids produce analgesia by modulating rostral ventromedial medulla neuronal activity in a manner similar to, but pharmacologically distinct from, that of morphine. This analgesic effect is also exerted by some endogenous cannabinoids (anandamide) and synthetic cannabinoids (methanandamide). Ideally, cannabinoids could be used alone or in conjunction with opioids to treat people with chronic pain, improve their quality of life, and allow them to return to being a productive citizen.

When discussing the therapeutic use of cannabis and cannabinoids, opponents inevitably respond that patients should not smoke their medicine. Patients no longer have to. Medicinal cannabis patients who desire the rapid onset of action associated with inhalation, but who are concerned about the potential harms of noxious smoke can dramatically cut down on their intake of carcinogenic compounds by engaging in vaporization rather than smoking. Cannabis vaporization

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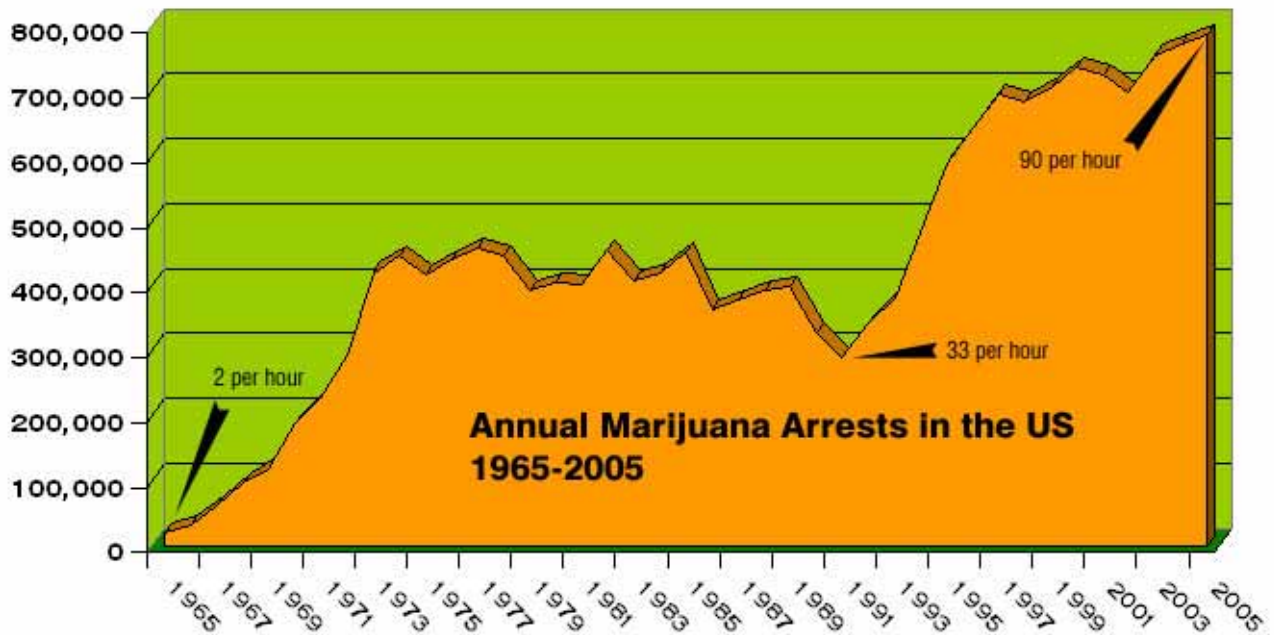
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limits respiratory toxins by heating cannabis to a temperature where cannabinoid vapors form (typically around 180-190 degrees Celsius), but below the point of combustion where noxious smoke and associated toxins (e.g., carcinogenic hydrocarbons) are produced (near 230 degrees Celsius). This eliminates the inhalation of any particulate matter and removes the health hazards of smoking. In clinical trials, vaporization has been shown to safely and effectively deliver pharmacologically active, aerosolized cannabinoids deeply into the lungs, where the rich vascular bed will rapidly deliver them to tissues throughout the body.

The following report summarizes the most recently published scientific research on the therapeutic use of cannabis and cannabinoids for more than a dozen diseases, including Alzheimer's, amyotrophic lateral sclerosis, diabetes, hepatitis C, multiple sclerosis, rheumatoid arthritis, and Tourette's syndrome. It is my hope that readers of this report will come away with a fair and balanced view of cannabis -- a view that is substantiated by scientific studies and not by anecdotal opinion or paranoia. Cannabis is neither a miracle compound nor the answer to everyone's ills. However, it does appear to have remarkable therapeutic benefits that are there for the taking if the governmental barriers for more intensive scientific study are removed.

The cannabis plant does not warrant the tremendous legal and societal commotion that has occurred over it. Over the past 30 years, the United States has spent billions in an effort to stem the use of illicit drugs, particularly marijuana, with limited success. Many very ill people have had to fight long court battles to defend themselves for the use of a compound that has helped them. Rational minds need to take over the war on drugs, separating myth from fact, right from wrong, and responsible, medicinal use from other less compelling behavior.

The medicinal marijuana user should not be considered a criminal in any state. Most major medical groups, including the Institute of Medicine, agree that cannabis is a compound with significant therapeutic potential whose "adverse effects ... are within the range of effects tolerated for other medications." Over a decade ago, the Drug Enforcement Administration (DEA) studied the medicinal properties of cannabis. After considerable study, DEA Administrative Law Judge Francis L. Young concluded: "The evidence clearly shows that marijuana is capable of relieving the distress of great numbers of very ill people, and doing so with safety under medical supervision. ... It would be unreasonable, arbitrary and capricious for the DEA to continue to stand between those sufferers and the benefits of this substance."



Despite this conclusion, over a decade later the DEA and the rest of the federal government persist in their policy of total prohibition. Nevertheless, the scientific process continues to evaluate the therapeutic effects of cannabis through ongoing research and assessment of available data. With regard to the medicinal use of cannabis, our legal system should take a similar approach, using science and logic as the basis of policy making rather than relying on political rhetoric and false perceptions regarding the alleged harmful effects of recreational marijuana use.

Alzheimer's Disease

Alzheimer's disease (AD) is a neurological disorder of unknown origin that is characterized by a progressive loss of memory and learned behavior. Patients with Alzheimer's are also likely to experience depression, agitation, and appetite loss, among other symptoms. Over 4.5 million Americans are estimated to be afflicted with the disease. No approved treatments or medications are available to stop the progression of AD, and few pharmaceuticals have been FDA-approved to treat symptoms of the disease.

A review of the recent scientific literature indicates that cannabinoid therapy may provide symptomatic relief to patients afflicted with AD while also moderating the progression of the disease.

Writing in the February 2005 issue of the *Journal of Neuroscience*, investigators at Madrid's Complutense University and the Cajal Institute in Spain reported that the intracerebroventricular administration of the synthetic cannabinoid WIN 55,212-2 prevented cognitive impairment and decreased neurotoxicity in rats injected with amyloid-beta peptide (a protein believed to induce Alzheimer's). Additional cannabinoids were also found to reduce the inflammation associated with Alzheimer's disease in human brain tissue in culture. "Our results indicate that ... cannabinoids succeed in preventing the neurodegenerative process occurring in the disease," investigators concluded.[1]

More recently, investigators at The Scripps Research Institute in California reported that THC inhibits the enzyme responsible for the aggregation of amyloid plaque — the primary marker for Alzheimer's disease — in a manner "considerably superior" to approved Alzheimer's drugs such as donepezil and tacrine. "Our results provide a mechanism whereby the THC molecule can directly impact Alzheimer's disease pathology," researchers concluded. "THC and its analogues may provide an improved therapeutic [option] for Alzheimer's disease [by]... simultaneously treating both the symptoms and the progression of [the] disease."[2]

Previous preclinical studies have demonstrated that cannabinoids can prevent cell death by anti-oxidation.[3] Some experts believe that cannabinoids' neuroprotective properties could also play a role in moderating AD.[4]

In addition to potentially modifying the progression of AD, clinical trials also indicate that cannabinoid therapy can reduce agitation and stimulate weight gain in patients with the disease. Most recently, investigators at Berlin Germany's Charite Universitatmedizin, Department of Psychiatry and Psychotherapy, reported that the daily administration of 2.5 mg of synthetic THC over a two-week period reduced nocturnal motor activity and agitation in AD patients in an open-label pilot study.[5]

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Clinical data presented at the 2003 annual meeting of the International Psychogeriatric Association previously reported that the oral administration of up to 10 mg of synthetic THC reduced agitation and stimulated weight gain in late-stage Alzheimer's patients in an open-label clinical trial.[6] Improved weight gain and a decrease in negative feelings among AD patients administered cannabinoids were previously reported by investigators in the *International Journal of Geriatric Psychiatry* in 1997.[7] Additional study of the use of cannabinoids and Alzheimer's would appear to be warranted.

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Amyotrophic Lateral Sclerosis

Amyotrophic lateral sclerosis (ALS), also known as Lou Gehrig's Disease, is a fatal neurodegenerative disorder that is characterized by the selective loss of motor neurons in the spinal cord, brain stem, and motor cortex. An estimated 30,000 Americans are living with ALS, which often arises spontaneously and afflicts otherwise healthy adults. More than half of ALS patients die within 2.5 years following the onset of symptoms.

A review of the scientific literature reveals an absence of clinical trials investigating the use of cannabinoids for ALS treatment. However, recent preclinical findings indicate that cannabinoids can delay ALS progression, lending support to anecdotal reports by patients that cannabinoids may be efficacious in moderating the disease's development and in alleviating certain ALS-related symptoms such as pain, appetite loss, depression and drooling.[1]

Writing in the March 2004 issue of the journal *Amyotrophic Lateral Sclerosis & Other Motor Neuron Disorders*, investigators at the California Pacific Medical Center in San Francisco reported that the administration of THC both before and after the onset of ALS symptoms staved disease progression and prolonged survival in animals compared to untreated controls.[2]

Additional trials in animal models of ALS have shown that the administration of other naturally occurring and synthetic cannabinoids can also moderate ALS progression, but not necessarily impact survival.[3-4] One recent study demonstrated that blocking the CB1 cannabinoid receptor did extend life span in an ALS mouse model, suggesting that cannabinoids' beneficial effects on ALS may be mediated by non-CB1 receptor mechanisms.[5]

Preclinical data has also shown that cannabinoids are neuroprotective against oxidative damage both *in vitro*[6] and in animals.[7] Cannabinoids' neuroprotective action may be able to play a role in moderating ALS, which is characterized by excessive glutamate activity in the spinal cord.[8] At least one cannabinoid, delta-9-THC, has been shown to protect cultured mouse spinal neurons against excitotoxicity.[9]

As a result, some experts now recommend that "marijuana ... be considered in the pharmacological management of ALS,"[10] and they believe that "further investigation into the usefulness of marijuana and synthetic ... cannabinoid receptor agonists is warranted." [11]

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Diabetes Mellitus

Diabetes mellitus is a group of autoimmune diseases characterized by defects in insulin secretion resulting in hyperglycemia (an abnormally high concentration of glucose in the blood). There are two primary types of diabetes. Individuals diagnosed with type 1 diabetes (also known as juvenile diabetes) are incapable of producing pancreatic insulin and must rely on insulin medication for survival. Individuals diagnosed with type 2 diabetes (also known as adult onset diabetes) produce inadequate amounts of insulin. Type 2 diabetes is a less serious condition that typically is controlled by diet. Over time, diabetes can lead to blindness, kidney failure, nerve damage, hardening of the arteries, and death. The disease is the third leading cause of death in the United States after heart disease and cancer.

A search of the scientific literature reveals no clinical investigations of cannabis for the treatment of diabetes, but does identify a small number of preclinical studies indicating that cannabinoids may modify the disease's progression and provide symptomatic relief to those suffering from it.[1-2] Most recently, a study published in the journal *Autoimmunity* reported that injections of 5 mg per day of the non-psychoactive cannabinoid CBD significantly reduced the incidence of diabetes in mice. Investigators reported that 86% of untreated control mice in the study developed diabetes. By contrast, only 30% of CBD-treated mice developed the disease.[3] In a separate experiment, investigators reported that control mice all developed diabetes at a median of 17 weeks (range 15-20 weeks), while a majority (60 percent) of CBD-treated mice remained diabetes-free at 26 weeks.[4]

Investigators also found that CBD significantly lowered plasma levels of the pro-inflammatory cytokines (proteins) INF-gamma and TNF-alpha and significantly reduced the severity of insulinitis (an infiltration of white blood cells resulting in swelling) compared to non-treated controls. "Our results indicate that CBD can inhibit and delay destructive insulinitis and inflammatory ... cytokine production in ... mice resulting in decreased incidence of diabetes," authors concluded.

Other preclinical trials have demonstrated cannabinoids to possess additional beneficial effects in animal models of diabetes. Writing in the March 2006 issue of the *American Journal of Pathology*, researchers at the Medical College of Virginia reported that rats treated with CBD for periods of one to four weeks experienced significant protection from diabetic retinopathy.[5] This condition, which is characterized by retinal oxygen deprivation and a breakdown of the blood-retinal barrier, is the leading cause of blindness in working-age adults.

Cannabinoids have also been shown to alleviate neuropathic pain associated with the disease. A pair of studies published in the journal *Neuroscience Letters* in 2004 reported that mice administered a cannabis receptor agonist experienced a reduction in diabetic-related tactile allodynia (pain resulting from non-injurious stimulus to the skin) compared to non-treated controls.[6-7] The

findings suggest that “cannabinoids have a potential beneficial effect on experimental diabetic neuropathic pain.”

Finally, a 2001 trial demonstrated that delta-9-THC could moderate an animal model of the disease by reducing artificially-elevated glucose levels and insulinitis in mice compared to non-treated controls.[8] With the incidence of diabetes steadily increasing in both the adult and juvenile population, it would appear that further cannabinoid research is warranted in the treatment of these diseases.

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Dystonia

Dystonia is a neurological movement disorder characterized by abnormal muscle tension and involuntary, painful muscle contractions. It is the third most common movement disorder after Parkinson's disease and tremor, affecting more than 300,000 people in North America.

A small number of case reports and preclinical studies investigating the use of cannabis and cannabinoids for symptoms of dystonia are referenced in the recent scientific literature. A 2002 case study published in the July issue of the *The Journal of Pain and Symptom Management* reported improved symptoms of dystonia after smoking cannabis in a 42-year-old chronic pain patient. Investigators reported that subject's subjective pain score fell from 9 to zero (on a zero-to-10 visual analog scale) following cannabis inhalation, and that the subject did not require any additional analgesic medication for the following 48 hours. "No other treatment intervention to date had resulted in such dramatic overall improvement in [the patient's] condition," investigators concluded.[1]

A second case study reporting "significant clinical improvement" following cannabis inhalation in a single 25-year-old patient with generalized dystonia due to Wilson's disease was documented by an Argentinian research team in the August 2004 issue of the journal *Movement Disorders*.[2]

Also in 2004, a German research team at the Hannover Medical School reported successful treatment of musician's dystonia in a 38-year-old professional pianist following administration of 5 mg of THC in a placebo-controlled single-dose trial.[3] Investigators reported "clear improvement of motor control" in the subject's affected hand, and noted, "[Two] hours after THC intake, the patient was able to play technically demanding literature, which had not been possible before treatment." Prior to cannabinoid treatment, the subject had been unresponsive to standard medications and was no longer performing publicly. "The results provide evidence that ... THC intake ... significantly improves [symptoms of] ... focal dystonia," investigators concluded.

By contrast, a 2002 randomized, placebo-controlled study investigating the use of the synthetic oral cannabinoid naboline (Cessamet) in 15 patients afflicted with generalized and segmental primary dystonia did not show a significant reduction in dystonic symptoms.[4] Investigators speculated that this result may have been dose-related, and that administration of a higher dosage may have yielded a different outcome.

At least one recent preclinical trial indicates that both synthetic cannabinoids as well as high doses of the natural non-psychoactive cannabinoid cannabidiol (CBD) could moderate the disease progression of dystonia in animals.[5] Limited references regarding the use of cannabinoids for dystonia in humans[6] and animals[7] in the 1980s and the 1990s also appear in the scientific

literature. It would appear that additional, larger clinical trials are warranted to investigate the use of cannabis and cannabinoids for this indication.

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Fibromyalgia

Fibromyalgia is a chronic pain syndrome of unknown etiology. The disease is characterized by widespread musculoskeletal pain, fatigue, and multiple tender points in the neck, spine, shoulders, and hips. An estimated 3 to 6 million Americans are afflicted by fibromyalgia, which is often poorly controlled by standard pain medications.

Fibromyalgia patients frequently self-report using cannabis therapeutically to treat symptoms of the disease,[1-2] and physicians – where legal to do so – often recommend the use of cannabis to treat musculoskeletal disorders.[3-4] To date however, only one clinical trial is available in the scientific literature assessing the use of cannabinoids to treat the disease.

Writing in the July 2006 issue of the journal *Current Medical Research and Opinion*, investigators at Germany's University of Heidelberg evaluated the analgesic effects of oral THC in nine patients with fibromyalgia over a 3-month period. Subjects in the trial were administered daily doses of 2.5 to 15 mg of THC, but received no other pain medication during the trial. Among those participants who completed the trial, all reported a significant reduction in daily recorded pain and electronically induced pain.[5]

Previous clinical and preclinical trials have shown that both naturally occurring and endogenous cannabinoids hold analgesic qualities,[6-7] particularly in the treatment of cancer pain [8] and neuropathic pain, [9] both of which are poorly treated by conventional opioids. As a result, some experts have suggested that cannabinoid agonists would be applicable for the treatment of chronic pain conditions unresponsive to opioid analgesics such as fibromyalgia, and they theorize that the disease may be associated with an underlying clinical deficiency of the endocannabinoid system.[10]

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Gliomas

Gliomas (tumors in the brain) are especially aggressive malignant forms of cancer, often resulting in the death of affected patients within one to two years following diagnosis. There is no cure for gliomas and most available treatments provide only minor symptomatic relief.

A review of the modern scientific literature reveals numerous preclinical studies and one pilot clinical study demonstrating cannabinoids' ability to act as antineoplastic agents, particularly on glioma cell lines.

Writing in the September 1998 issue of the journal *FEBS Letters*, investigators at Madrid's Complutense University, School of Biology, first reported that delta-9-THC induced apoptosis (programmed cell death) in glioma cells in culture.[1] Investigators followed up their initial findings in 2000, reporting that the administration of both THC and the synthetic cannabinoid agonist WIN 55,212-2 "induced a considerable regression of malignant gliomas" in animals.[2] Researchers again confirmed cannabinoids' ability to inhibit tumor growth in animals in 2003.[3]

That same year, Italian investigators at the University of Milan, Department of Pharmacology, Chemotherapy and Toxicology, reported that the non-psychoactive cannabinoid, cannabidiol (CBD), inhibited the growth of various human glioma cell lines *in vivo* and *in vitro* in a dose dependent manner. Writing in the November 2003 issue of the *Journal of Pharmacology and Experimental Therapeutics Fast Forward*, researchers concluded, "Non-psychoactive CBD ... produce[s] a significant anti-tumor activity both *in vitro* and *in vivo*, thus suggesting a possible application of CBD as an antineoplastic agent." [4]

In 2004, Guzman and colleagues reported that cannabinoids inhibited glioma tumor growth in animals and in human glioblastoma multiforme (GBM) tumor samples by altering blood vessel morphology (e.g., VEGF pathways). Writing in the August 2004 issue of *Cancer Research*, investigators concluded, "The present laboratory and clinical findings provide a novel pharmacological target for cannabinoid-based therapies." [5]

More recently, investigators at the California Pacific Medical Center Research Institute reported that the administration of THC on human glioblastoma multiforme cell lines decreased the proliferation of malignant cells and induced cell death more rapidly than did the administration of WIN 55,212-2. Researchers also noted that THC selectively targeted malignant cells while ignoring healthy ones in a more profound manner than the synthetic alternative.[6]

Most recently, Guzman and colleagues reported that THC administration decreases recurrent glioblastoma multiforme tumor growth in patients diagnosed with recurrent GBM. In the first ever pilot clinical trial assessing the use of cannabinoids and GBM, investigators found that the

intratumoral administration of THC was associated with reduced tumor cell proliferation in two of nine subjects. "The fair safety profile of THC, together with its possible anti-proliferative action on tumor cells reported here and in other studies, may set the basis for future trials aimed at evaluating the potential antitumoral activity of cannabinoids," investigators concluded.[7]

In addition to cannabinoids' ability to moderate glioma cells, separate studies demonstrate that cannabinoids and endocannabinoids can also inhibit the proliferation of other various cancer cell lines, including breast carcinoma,[8-10] prostate carcinoma,[11-13] colorectal carcinoma,[14] gastric adenocarcinoma,[15] skin carcinoma,[16] leukemia cells,[17-18] neuroblastoma,[19] lung carcinoma,[20] uterus carcinoma,[21] thyroid epithelioma,[22] pancreatic adenocarcinoma,[23] and lymphoma. [24]

As a result, experts now believe that cannabinoids "may represent a new class of anticancer drugs that retard cancer growth, inhibit angiogenesis and the metastatic spreading of cancer cells,"[25] and have recommended that at least one cannabinoid, cannabidiol, now be utilized in cancer therapy.[26]

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Gastrointestinal Disorders

Gastrointestinal (GI) disorders, including functional bowel diseases such as irritable bowel syndrome (IBS) and inflammatory bowel diseases such as Crohn's disease and colitis, afflict more than one in five Americans, particularly women. While some GI disorders may be controlled by diet and pharmaceutical medications, others are poorly moderated by conventional treatments. Symptoms of GI disorders often include cramping, abdominal pain, inflammation of the lining of the large and/or small intestine, chronic diarrhea, rectal bleeding, and weight loss.

Although several anecdotal reports[1,2] and a handful of case reports[3,4] exist in the scientific literature supporting the use of cannabinoids to treat symptoms of GI disorders, virtually no clinical trial work has been performed in this area.

However, numerous preclinical studies demonstrate that activation of the CB1 and CB2 cannabinoid receptors exert biological functions on the gastrointestinal tract.[5] Effects of their activation in animals include suppression of gastrointestinal motility,[6] inhibition of intestinal secretion,[7] reduced acid reflux,[8] and protection from inflammation[9], as well as the promotion of epithelial wound healing in human tissue.[10] As a result, many experts now believe that cannabinoids and/or modulation of the endogenous cannabinoid system represents a novel therapeutic target for the treatment of numerous GI disorders — including inflammatory bowel diseases, functional bowel diseases, gastro-oesophageal reflux conditions, secretory diarrhea, gastric ulcers, and colon cancer.[11,12]

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Hepatitis C

Hepatitis C is a viral disease of the liver that afflicts an estimated 4 million Americans. Chronic hepatitis C is typically associated with fatigue, depression, joint pain and liver impairment, including cirrhosis and liver cancer.

Patients diagnosed with hepatitis C frequently report using cannabis to treat both symptoms of the disease as well as the nausea associated with antiviral therapy [1-2] Most recently, an observational study by investigators at the University of California at San Francisco (UCSF) found that hepatitis C patients who used cannabis were significantly more likely to adhere to their treatment regimen than patients who didn't use it. [3] Nevertheless, no clinical trials assessing the use of cannabinoids for this indication are available in the scientific literature.

Preclinical data indicates that the endocannabinoid system may moderate aspects of chronic liver disease[4-5] and that cannabinoids may reduce inflammation in experimental models of hepatitis.[6] However, a recent review of 270 untreated patients with chronic hepatitis C found that daily cannabis smoking was associated with fibrosis progression.[7]

Preclinical data demonstrates that the development of liver fibrosis may be regulated by cannabinoid receptors, with some studies indicating that an upregulation of CB1 receptors in certain liver cells may be positively associated with fibrosis.[8] By contrast, mice lacking CB1 receptors have been shown to develop experimental liver fibrosis at a decreased rate compared to normal mice.[9] Administration of the CB1 cannabis receptor antagonist SR 141716a (rimonabant) also inhibits fibrosis progression in animal models,[10] as does activation of the CB2 receptor.[11]

The role of the endocannabinoid system in liver disease, though not yet well understood, arguably warrants further investigation. However, experts at this time hold divergent opinions on the therapeutic use of cannabinoids for hepatitis C treatment. Writing in the October issue of the *European Journal of Gastroenterology*, investigators from Canada and Germany concluded that cannabis' "potential benefits of a higher likelihood of treatment success [for hepatitis c patients] appear to outweigh [its] risks." [12] By contrast, other experts advise that hepatitis C patients abstain from the regular use of cannabis until further studies are performed.[13-15]

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Hypertension

High blood pressure, or hypertension, afflicts an estimated 1 in 4 American adults. This condition puts a strain on the heart and blood vessels and greatly increases the risk of stroke and heart disease.

Emerging research indicates that the endogenous cannabinoid system plays a role in regulating blood pressure, though its mechanism of action is not well understood.[1] Animal studies demonstrate that anandamide and other endocannabinoids profoundly suppress cardiac contractility in hypertension and can normalize blood pressure,[2-3] leading some experts to speculate that the manipulation of the endocannabinoid system "may offer novel therapeutic approaches in a variety of cardiovascular disorders." [4]

The administration of natural cannabinoids has yielded conflicting cardiovascular effects on humans and laboratory animals.[5-9] The vascular response in humans administered cannabis in experimental conditions is typically characterized by a mild increase in heart rate and blood pressure. However, complete tolerance to these effects develops quickly and potential health risks appear minimal.[10-11]

In animals, cannabinoid administration in animals is typically associated with vasodilation, transient bradycardia and hypotension,[12] as well as an inhibition of atherosclerosis (hardening of the arteries) progression.[13-15] The administration of synthetic cannabinoids have also been shown to lower blood pressure in animals and have not been associated with cardiotoxicity in humans.[16]

At this time, research assessing the clinical use of cannabinoids for hypertension is in its infancy though further investigation appears warranted.[17]

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Incontinence

Urinary incontinence is defined as a loss of bladder control. Incontinence can result from several biological factors, including weak bladder muscles and inflammation, as well as from nerve damage associated with diseases such as multiple sclerosis (MS) and Parkinson's disease. More than one in ten Americans over age 65 is estimated to suffer from incontinence, particularly women.

Several recent clinical trials indicate that cannabinoid therapy may reduce incidents of incontinence. Writing in the February 2003 issue of the journal *Clinical Rehabilitation*, investigators at Oxford's Centre for Enablement in Britain reported that self-administered doses of whole-plant cannabinoid extracts improved bladder control compared to placebo in patients suffering from MS and spinal cord injury.[1]

Investigators at London's Institute for Neurology followed up these initial findings in an open-label pilot study of cannabis-based extracts for bladder dysfunction in 15 patients with advanced multiple sclerosis. Following cannabinoid therapy, "urinary urgency, the number of and volume of incontinence episodes, frequency and nocturia all decreased significantly," investigators determined. "Cannabis-based medicinal extracts are a safe and effective treatment for urinary and other problems in patients with advanced MS." [2]

These findings were confirmed in 2006 in a multi-center, randomized placebo-controlled trial involving 630 patients administered oral doses of cannabis extracts or THC. Researchers reported that subjects administered cannabis extracts experienced a 38 percent reduction in incontinence episodes from baseline to the end of treatment, while patients administered THC experienced a 33 percent reduction, suggesting a "clinical effect of cannabis on incontinence episodes." [3]

Most recently, preclinical data presented at the 2006 annual meeting of the American Urological Association indicated that cannabis analogs can reduce bladder inflammation and bladder over-activity in animals.[4]

In light of these findings, experts have recommended the use of cannabinoids as potential 'second-line' agents for treating incontinence.[5]

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Multiple Sclerosis

Multiple sclerosis (MS) is a chronic degenerative disease of the central nervous system that causes inflammation, muscular weakness, and a loss of motor coordination. Over time, MS patients typically become permanently disabled, and in some cases the disease can be fatal. According to the US National Multiple Sclerosis Society, about 200 people are diagnosed every week with the disease – often striking those 20 to 40 years of age.

Clinical and anecdotal reports of cannabinoids' ability to reduce MS-related symptoms such as pain, spasticity, depression, fatigue, and incontinence are plentiful in the scientific literature[1-12] – leading many MS-associated patient organizations, including the Multiple Sclerosis Societies of Britain and Canada, to take positions in favor of the drug's prescription use.[13] Recent clinical and preclinical studies also suggest that cannabinoids may inhibit MS progression.

Writing in the July 2003 issue of the journal *Brain*, investigators at the University College of London's Institute of Neurology reported that administration of the synthetic cannabinoid agonist WIN 55,212-2 provided "significant neuroprotection" in an animal model of multiple sclerosis. "The results of this study are important because they suggest that in addition to symptom management, ... cannabis may also slow the neurodegenerative processes that ultimately lead to chronic disability in multiple sclerosis and probably other disease," researchers concluded.[14]

Investigators at the Netherland's Vrije University Medical Center, Department of Neurology, also reported for the first time in 2003 that the administration of oral THC can boost immune function in patients with MS. "These results suggest pro-inflammatory disease-modifying potential of cannabinoids [for] MS," they concluded.[15]

Most recently, clinical data from an extended open-label study of 167 multiple sclerosis patients reported that use of whole plant cannabinoid extracts could relieve symptoms of pain, spasticity, and bladder incontinence for an extended period of treatment (mean duration of study participants was 434 days) without requiring subjects to increase their dose.[16] These results would be unlikely in patients suffering from a progressive disease like MS unless the cannabinoid therapy was halting its progression, investigators have suggested.

As a result, the British government is now sponsoring a three-year clinical trial to assess the long-term effects of cannabinoids on both MS-associated symptom management as well as disease progression. Health Canada also recently approved the prescription use of cannabis extracts for the treatment of MS-associated neuropathic pain.[17] Similar approval of cannabis extracts is pending in Britain and Europe.

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Osteoporosis

Osteoporosis is a degenerative skeletal disease characterized by a deterioration of bone tissue. Patients with osteoporosis are at risk for suffering multiple fractures and other serious disabilities. Approximately 10 million Americans over age 50 suffer from osteoporosis, according to the US Surgeon General's office, and another 34 million are at risk for developing the disease.

Initial references to the potential use of cannabinoids to protect against the onset of osteoporosis are available in the scientific literature beginning in the early 1990s.[1] To date, however, no clinical work has taken place investigating the use of cannabis for this indication.

Recently, investigators at the Bone Laboratory of the Hebrew University in Jerusalem reported in the *Proceedings of the National Academy of Sciences* that the administration of the synthetic cannabinoid agonist HU-308 slowed the development of osteoporosis, stimulated bone building, and reduced bone loss in animals. Investigators also reported that mice deficient in the CB2 cannabinoid receptor experienced age-accelerated bone loss reminiscent of human osteoporosis.[2] The findings conflict with previous preclinical research indicating that the administration of cannabinoid receptor antagonists inhibited bone loss in mice.[3]

Though the role of the endocannabinoid system in the regulation of bone mass is not well understood, experts are hopeful that cannabinoids and the cannabinoid receptor system may "offer a molecular target for the diagnosis and treatment of osteoporosis." [4]

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Pruritus

Itching (pruritus) is a common symptom associated with numerous skin diseases, as well as a secondary symptom of numerous serious conditions such as renal failure and liver disease. Itching, unlike other skin sensations, is generally a result of CNS activities, and typically goes untreated by standard medical therapies.

A review of the scientific literature reveals three clinical trials investigating the use of cannabinoids in the treatment of pruritus. Writing in the August 2002 issue of the *American Journal of Gastroenterology*, investigators from the University of Miami Department of Medicine reported successful treatment of pruritus with 5 mg of THC in three patients with cholestatic liver disease.[1] Prior to cannabinoid therapy, subjects had failed to respond to standard medications and had lost their ability to work. Following evening cannabinoid administration, all three patients reported a decrease in pruritus, as well as "marked improvement" in sleep and were eventually able to return to work. Resolution of depression was also reported in two out of three subjects. "Delta-9-tetrahydrocannabinol may be an effective alternative in patients with intractable cholestatic pruritus," investigators concluded.

The following year, British researchers reported in the June 2003 issue of the journal *Inflammation Research* that the peripheral administration of the synthetic cannabinoid agonist HU-211 significantly reduced experimentally-induced itch in 12 subjects.[2] Investigators had previously reported that topical application of HU-210 on human skin reduced experimentally-induced pain and acute burning sensations.[3]

Most recently, researchers at Wroclaw, Poland's University of Medicine, Department of Dermatology, reported that application of an endocannabinoid-based topical cream reduced uremic pruritus and xerosis (abnormal dryness of the skin) in hemodialysis patients.[4] Three weeks of twice-daily application of the cream "completely eliminated" pruritus in 38 percent of trial subjects and "significantly reduced" itching in others. Eighty-one percent of patients reported a "complete reduction" in xerosis following cannabinoid therapy.

In light of these encouraging preliminary results, some dermatology experts now believe that cannabinoids and the cannabinoid system may represent "promising new avenues for managing itch more effectively." [5]

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Rheumatoid Arthritis

Rheumatoid arthritis (RA) is an inflammatory disease of the joints characterized by pain, stiffness, and swelling, as well as an eventual loss of limb function. Rheumatoid arthritis is estimated to affect about one percent of the population, primarily women.

Use of cannabis to treat symptoms of RA is commonly self-reported by patients with the disease. In a 2005 anonymous questionnaire survey of medicinal cannabis patients in Australia, 25 percent reported using cannabinoids to treat RA.[1] A survey of British medicinal cannabis patients found that more than 20 percent of respondents reported using cannabis for symptoms of arthritis.[2] Nevertheless, few clinical trials investigating the use of cannabis for RA appear in the scientific literature.

In January 2006, investigators at the British Royal National Hospital for Rheumatic Disease reported successful treatment of arthritis with cannabinoids in the first-ever controlled trial assessing the efficacy of natural cannabis extracts on RA.[3] Investigators reported that administration of cannabis extracts over a five week period produced statistically significant improvements in pain on movement, pain at rest, quality of sleep, inflammation, and intensity of pain compared to placebo. No serious adverse effects were observed. Similar results had been reported in smaller, Phase II trials investigating the use of orally administered cannabis extracts on symptoms of RA.[4]

Preclinical data also indicates that cannabinoids can moderate the progression of RA. Writing in the August 2000 issue of the *Journal of the Proceedings of the National Academy of Sciences*, investigators at London's Kennedy Institute for Rheumatology reported that cannabidiol (CBD) administration suppressed progression of arthritis *in vitro* and in animals.[5] Administration of CBD after the onset of clinical symptoms protected joints against severe damage and "effectively blocked [the] progression of arthritis," investigators concluded. Daily administration of the synthetic cannabinoid agonist HU-320 has also been reported to protect joints from damage and to ameliorate arthritis in animals.[6]

Summarizing the available literature in the September 2005 issue of the *Journal of Neuroimmunology*, researchers at Tokyo's National Institute for Neuroscience concluded, "Cannabinoid therapy of RA could provide symptomatic relief of joint pain and swelling as well as suppressing joint destruction and disease progression." [7]

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Sleep Apnea

Sleep apnea is a medical disorder characterized by frequent interruptions in breathing of up to ten seconds or more during sleep. The condition is associated with numerous physiological disorders, including fatigue, headaches, high blood pressure, irregular heartbeat, heart attack and stroke. Though sleep apnea often goes undiagnosed, it is estimated that approximately four percent of men and two percent of women ages 30 to 60 years old suffer from the disease.

One preclinical study is cited in the scientific literature investigating the role of cannabinoids on sleep-related apnea. Writing in the June 2002 issue of the journal of the American Academy of Sleep Medicine, researchers at the University of Illinois (at Chicago) Department of Medicine reported "potent suppression" of sleep-related apnea in rats administered either exogenous or endogenous cannabinoids.[1] Investigators reported that doses of delta-9-THC and the endocannabinoid oleamide each stabilized respiration during sleep, and blocked serotonin-induced exacerbation of sleep apnea in a statistically significant manner. No follow up investigations have taken place assessing the use of cannabinoids to treat this indication. However, several recent preclinical and clinical trials have reported on the use of THC, natural cannabis extracts, and endocannabinoids to induce sleep[2,3] and/or improve sleep quality.[4]

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Tourette's Syndrome

Tourette's syndrome (TS) is a complex neuropsychiatric disorder of unknown etiology that is characterized by involuntary vocal tics. Severity of this condition varies widely among patients. Though there is no cure for Tourette's syndrome, the condition often improves with age. Experts estimate that 100,000 Americans are afflicted with TS.

A review of the scientific literature reveals several clinical trials investigating the use of cannabinoids for the treatment of TS. Writing in the March 1999 issue of the *American Journal of Psychiatry*, investigators at Germany's Medical School of Hanover, Department of Clinical Psychiatry and Psychotherapy, reported successful treatment of Tourette's syndrome with a single dose of 10 mg of delta-9-THC in a 25-year-old male patient in an uncontrolled open clinical trial.[1] Investigators reported that the subject's total tic severity score fell from 41 to 7 within two hours following cannabinoid therapy, and that improvement was observed for a total of seven hours. "For the first time, patients' subjective experiences when smoking marijuana were confirmed by using a valid and reliable rating scale," authors concluded.

Investigators again confirmed these preliminary results in a randomized double-blind placebo-controlled crossover single dose trial of THC in 12 adult TS patients. Researchers reported a "significant improvement of tics and obsessive-compulsive behavior (OCB) after treatment with delta-9-THC compared to placebo." [2] Investigators reported no cognitive impairment in subjects following THC administration [3] and concluded, "THC is effective and safe in treating tics and OCB in TS." [4]

Investigators confirmed these results in a second randomized double-blind placebo-controlled trial involving 24 patients administered daily doses of up to 10 mg of THC over a six-week period. Researchers reported that subjects experienced a significant reduction in tics following long-term cannabinoid treatment, [5] and suffered no detrimental effects on learning, recall or verbal memory. [6] A trend toward significant improvement of verbal memory span during and after therapy was also observed.

Summarizing their findings in the October 2003 issue of the journal *Expert Opinions in Pharmacotherapy*, investigators concluded that in adult TS patients, "Therapy with delta-9-THC should be tried ... if well established drugs either fail to improve tics or cause significant adverse effects." [7]

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