

Beneficial Effect of Physical Activity in Hemodialysis Patients

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Abstract Hemodialysis patients are significantly less active than healthy, sedentary individuals and a low intrinsic motivation has been identified as a major barrier to prescribing exercise. Regular physical activity is associated with enhanced health and well being. World Health Organisation (WHO) revealed that regular physical activity is widely recognized as a mean of preventing the occurrence of many chronic diseases and reduced risk of all-cause mortality. Physical activity during illness results in improvement in physical function. Physical activity helps dialysis patients to improve their well-being. The association of decreasing levels of leisure-time physical activity with increased mortality risk is less certain in ESRD patients than in the general population. Studies have shown that hemodialysis patients physically being active had efficient clearance of urea during dialysis compared to physically inactive patients. Yoga and exercise in hemodialysis patient increases the quality of life through reduced stress level. In our country there is lack of awareness of potential benefits of physical activity in hemodialysis patients and there are no facilities available in in-centre hemodialysis centre to implicate the exercise programme during dialysis compared to Western hemodialysis centres. So there is the great need to impart the knowledge among the patients to obtain the complete standard of living with daily physical activity during on and off dialysis days.

Keywords Hemodialysis, Physical Activity, Dialysis Adequacy

1. Introduction

Regular physical activity is associated with enhanced health and well being. World Health Organisation [1] revealed that regular physical activity is widely recognized as a mean of preventing the occurrence of many chronic diseases and reduced risk of all-cause mortality. Physical activity during illness results in improvement in physical

function [2].

Numerous health-related benefits derived from engaging in appropriately structured exercise regimens have been documented extensively with sedentary adults, frail elderly persons, and individuals with a wide array of chronic illnesses. Chronic kidney disease is associated with dyslipidemia, which persist as kidney failure progresses and continues to affect clinical outcomes in patients on hemodialysis [3]. Hemodialysis patients are at increased risk of heart disease due to abnormalities in atherogenic lipids and apolipoproteins [4]. Physical functioning in patients with end-stage renal disease treated with dialysis is less, measured using objective laboratory measures, self-reported measures or physical performance testing [5]. Regular assessment of physical functioning and encouragement of increased physical activity are still given minimal attention within the nephrology community [6]. Rehabilitation interventions are most frequently discussed in relation to dialysis patients mostly ESRD patients along with rehabilitation programs for persons who have a kidney transplant [7-8].

2. Physical Activity Level in Hemodialysis Patient- Global Scenario

Hemodialysis patients are significantly less active than healthy, sedentary individuals [9] and a low intrinsic motivation has been identified as a major barrier to prescribing exercise in this cohort. Approximately 3.2 million people die each year due to lack of physical activity. People who are physically inactive have a 20% to 30% increased risk of mortality. Regular physical activity reduces the risk of cardiovascular disease including high blood pressure, diabetes mellitus, breast cancer, colon cancer, stress and depression. Insufficient physical activities are more prevalent in high-income countries and very high levels of physical inactivity are now seen in some middle-income countries especially among women. Patients with end-stage renal disease (ESRD) on dialysis have

physical activity levels which are 20%-50% lower than age- and sex-matched sedentary population controls [9-10]. The reduced physical activity in hemodialysis patients was assessed by flexibility test and found that depression played a major role in preventing the hemodialysis subjects to be physically active [11]. In India hemodialysis patients are physically inactive because of their poor health condition and lack of awareness about the health benefits of being physically active.

3. Benefits of Physical Activity in Hemodialysis

Physical activity helps dialysis patients to improve their well-being [12]. The association of decreasing levels of leisure-time physical activity with increased mortality risk is less certain in ESRD patients than in the general population [13]. It is therefore plausible that exercise may also lead to a corresponding decrease in morbidity and mortality rates in individuals with ESRD. An intervention with such an effect would be welcomed in the ESRD population, which is known to have high mortality rates and burden of cardiovascular disease [14].

3.1. Exercise and Clearance

Recent renewed interest in activity and exercise as an important component of dialysis treatment is encouraging. The positive impact of dialysis exercise programmes on people's physical functions was recently demonstrated [15]. Parson [16] reported that exercises during dialysis enhanced dialysate urea removal but not serum urea clearance. Alterations in the timing of exercise during dialysis and modality may be required to elicit increases in serum urea clearance. It is recommended that mild exercise during dialysis should be performed during the first two hours of dialysis.

Bennet [17] proposed the formula to determine the Dialysis Exercise Adequacy (DEA) that takes into account the frequency (F) and duration (T) of the exercise in hours and the age (A) of the person in years; thus $DEA = FTA/100$. A minimum DEA "target" could be established (for example 1.0) that considers the amount and frequency of exercise relative to the age of the person. Few studies have measured the acute or long-term effects of intradialytic exercise on urea removal and dialysis efficacy in vivo. In response to a single bout of exercise, dialysis efficacy has been shown to increase between 15% and 25% [18-19].

Cycling exercise before or during dialysis is an option in some treatment centers. Training of exercise during dialysis treatments may improve solute removal by increasing blood flow to muscle and efflux of urea and other toxins into the vascular compartment where they can be removed [20]. Moreover there is a possibility of reduced exercise tolerance during dialysis resulting from electrolyte and fluid shifts and exercise could lead to dialysis-associated hypotension [21].

It appears; however, that exercise is generally well tolerated within the first 1-2 hours of a hemodialysis (HD) session [22]. Also, the decrease in C - reactive protein (CRP) is an interesting finding. CRP is connected to residual renal function [23]. The reduced inflammatory process in the dialysis patients becomes better after six months of repeated cycle training and this might be an adequate prescription to be followed by every patient on hemodialysis.

Zaluska [24] reported a 16% improvement in dialysis efficacy in 10 hemodialysis patients who cycled for 30 minutes during the first hour of dialysis over 6 months; however, some of this improvement may have been related to a significant increase in protein catabolic rate, which would augment urea clearance. So far no study has demonstrated the effectiveness of intradialytic exercise program can result in improved serum urea clearance to determine dialysis efficacy [25].

3.2. Physiological Benefits of Exercise for Hemodialysis Patients

Studies had shown that dialysis patients are debilitated due to anemic condition. Hemodialysis patients reported low levels of physical activity which was determined using questionnaire. Muscle defect due to uremic condition, hyperparathyroidism, hormonal imbalance, resistance to growth hormone and muscle atrophy may be the reason for reduced physical activity. Exercise training in ESRD has lessened the impact of ramifications by the attenuation of uremic neuropathies and myopathies, improved cardiac function, reduced blood pressure, increased physical work capacity, and overall enhancement in health related quality of life [26]. Although most exercise programs have been instituted between dialysis sessions, recent investigations have promoted the concept of intradialytic exercise as a convenient intervention to improve compliance, provide motivation in a structured environment, and facilitate the medical monitoring of the exercising patient [27-28].

A large research literature documents a variety of potential benefits that ESRD patients may achieve from exercise training [21]. Kutner [29] quoted the evidence from other studies that exercise training for ESRD patients helps the improvement in arterial stiffness [30], decrease in pulse pressure [16], increased aerobic capacity [21], reduced need for antihypertensive medications [31], increase in concentration of hemoglobin and hematocrit levels and improved lipid metabolism [32]. Dialysis patients at rest do not show significant differences in their muscle blood flow compared to control subjects; nevertheless, their muscle blood flow rises significantly less than in control subjects during both submaximal and maximal exercise [33]. In a systematic review of 29 clinical trials, it was shown that physical condition was significantly improved following the use of aerobic training [34].

Trisha *et al.* [25] reported that intradialytic exercise from a physiologic perspective with the hypothesis that the increased muscle blood flow and greater amount of open

capillary surface area in working muscles will result in a greater flux of urea and associated toxins from the tissue to the vascular compartment for subsequent removal at the dialyser. Goldberg *et al* [32] examined the metabolic effects of exercise training in hemodialysis patients and reported that training lowered triglycerides and increased HDL cholesterol. Numerous studies in both the general and dialysis population lend circumstantial evidence and point to plausible physiological mechanisms for a morbidity and survival benefit with improved physical fitness and function and increasing physical activity levels in patients with ESRD [35]. The exercise increases the insulin sensitivity in the skeletal muscle and decreases the insulin in the blood which suggests less adiposities and healthy lipid profile with increased HDL-cholesterol and decreased triglycerides. Due to this, testosterone levels have been found to increase and androgen receptors which increase the effect of testosterone [36].

Studies of the effects of exercise on VO₂ peak have provided important information because they showed that patients with kidney disease could respond physiologically to exercise training in a manner that is similar to other patient groups. However, qualified success of severe aerobic exercise training that is designed to increase VO₂ peak should be considered. The patients who are active have generally been the healthiest individuals who receive hemodialysis, usually a small percent of available patients [37], and it is not clear that more typical (*i.e.*, less healthy) patients with kidney disease will be willing or able to undergo vigorous exercise training. Orti [38] reported that moderate evidence exists on the improvement on capacity of exercise on aerobic training, combined or isolated with strength training. Strength training improves health related quality of life and has positive effect on functional capacity and improves lower limb strength.

3.3. Psychological Benefits of Physical Activity in Hemodialysis Patients

Mental health needs, especially debilitating levels of depressed mood and clinical depression, are prevalent among renal patients especially those who are underdialysis [39]. Antidepressants are frequently advised, but negative side effect and drug interactions of antidepressants are of concern [40]. Yaghmayi [41] quoted that chronic renal failure has mutual effects on physical, psychological and functional status of individuals which causes types of deprivation and lifestyle changes including financial problems, unemployment, change in familial roles, restriction in fluid intake and diet and reduction in achieving long term goals. Stress is directly associated with the risk of chronic renal failure such as hypertension. Further-more, other studies have pointed out that stress is correlated with low socioeconomic status and such conditions can be a risk factor for progression of chronic renal disease through association with other socio-mental factors and behaviors such as alcohol consumption, smoking and drug use [42].

Exercise training may have positive benefits on other factors that are important clinical issues in dialysis patients, including oxidative stress, cardiovascular risk profile and inflammation [5]. Nancy *et al* [43] reported that screening and management of depressive symptoms and support for increased activity level may facilitate patients' opportunity for continued employment after initiation of dialysis and improving their quality of life.

Fatouros *et al* [44] implies that hemodialysis patient demonstrate higher elevated oxidative stress levels and a lower antioxidant status than healthy controls at rest and following exercise. Acute exercise appears to exacerbate elevated oxidative stress response in hemodialyzed patients probably due to diminished defence by antioxidants. However, increased aerobic capacity helps to decrease oxidative stress in this population.

Tayyebi *et al*. [45] in reported that implementation of yoga exercise, especially Hatha yoga as a combination of breathing, positional, and relaxing exercises, along with music as well as Quranic and religious recitation left significant impact on these patients. These effects have each been approved in various studies; in a study by Hojjat *et al*. [46] to investigate the effect of music and sounds of Quran on dialysis adequacy among hemodialysis patients, the mean dialysis adequacy was significantly increased, and more interestingly, the sounds of Quran played more effective role in such an augmentation [46]. NCD (National Cooperative Dialysis) study has also proved that the more the adequacy of dialysis is, the less the effects of uremia on body different systems and patients mortality will be decreased [47]. The close relationship between mind and body has long been clear and the goal of yoga as an Eastern philosophy of life was to bring the balance between the two, which affects the overall sense of health and augments the quality of life through enhancing the compatibility of psychological, neurological, immune, and cognitive systems and modulating the immune system [48].

4. Conclusion

Bennett *et al*. [17] recently reviewed the literature to identify elements needed to sustain inclusion of exercise in routine care and/or as a normal part of the individual's daily life, whether performed on or off dialysis. In India, most of the hemodialysis centres do not include exercise as the part of the treatment compared to Western hemodialysis centres. Since the hemodialysis patients are both physiologically and psychologically ill, knowledge on physical activity helps in improving their overall well being. Health care workers such as physicians, technician, Renal Dietician, nurses should play a major role in educating the patients on importance of physical activity.

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ROLE OF PHYTOMEDICINES AND NUTRACEUTICALS IN THE PREVENTION OF CHRONIC DISEASES

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ABSTRACT: The past decade has witnessed intense interest in nutraceuticals in which phytochemical constituents have long-term health promoting or medicinal qualities. Secondary products have a variety of functions in plants; it is likely that their ecological function have some potential medicinal effects for humans. Between 1990 and 2020, deaths from non-communicable diseases and injury are expected to rise from 33 million to 58 million, with a similar proportional increase in mortality. It's been estimated that by 2020, chronic diseases will account for almost three-fourths of all deaths. World Health Organization encourages the addition of secondary metabolites of plants in life saving drugs. Disorders like hypertension, diabetes mellitus, cardio vascular diseases, stroke, cancer, kidney disease and other diseases of unknown etiology are increasing due to poor diet pattern, stress, loss of physical activity, toxic substance in foods etc. Nutraceuticals and phytomedicines in the plant help in preventing these metabolic diseases without any side effects. Identification of these phytomedicines and Nutraceuticals and regular incorporation into the diet helps to increase the longevity of life and prevent synthetic drug induced physiological damage.

INTRODUCTION: The greatest public health challenge of 21st century is chronic non communicable diseases ^{1, 2}. Approximately 36 million deaths were attributable to NCDs in the year 2008 were due to diabetes and cardiovascular diseases ³. Between 1990 and 2020, deaths from non-communicable diseases and injury are expected to rise from 33 million to 58 million annually, with a similar proportional increase in mortality ⁴.

It has been estimated that three-fourth of the death will be due to chronic diseases by 2020. 71 percent of deaths due to ischemic heart disease, 75 percent due to stroke and 70 percent due to diabetes will occur in developing countries. 60 percent of the burden of chronic diseases will occur in developing countries. CVD is now more numerous in India and China than in all economically developed countries in the world added together ⁵.

Excessive use of tobacco, decreased physical activity, unhealthy eating pattern and the harmful use of alcohol increase the risk of most NCDs. Tobacco accounts for almost 6 million deaths every year and are projected to increase to 8 million by 2030. About 3.2 million deaths annually can be attributed to insufficient physical activity.

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Nearly 1.7 million deaths are due to low fruit and vegetable consumption. Half of the 2.3² million annual deaths are from NCDs⁶.

The immune system is increasingly found to be involved in the development of several chronic illnesses, for which new modern medicines provides less tools for prevention and treatment. It is important to target the immune system in order to modulate the risk of certain chronic diseases. Phytomedicines and functional food (nutraceuticals) play a vital role in boosting the immune system in prevention of chronic diseases like diabetes, cancer, cardiovascular disease and stroke. World Health Organization nowadays encourages the addition of secondary metabolites of plants in to the lifesaving drugs.

This review helps in identifying some phytomedicines in treating and preventing these metabolic disorders in day to day life.

Phytomedicines and Cardiovascular disease: Several epidemiological studies show that intake of more plant foods reduce the incidence of diseases like cancer and arthrosclerosis. When normal

foods are fortified or enriched with some nutrients it shows some health benefits.

Phenolics are derivatives of benzene (cyclic derivatives in the case of polyphenols) with one or more hydroxyl groups associated with ring structure. They are classified into ten different groups depending on their chemical structure. The two main types of polyphenols are flavonoids and phenolic acids.

Flavonoids are distributed as flavones, flavonols, flavanols, flavanones, isoflavones, proanthocyanidins, and anthocyanins. Some of the most common flavonoids are quercetin, a flavonol found in onion, tea, and apple; catechin, a flavanol found in tea and several fruits; hesperetin, a flavanone present in citrus fruits, pigment anthocyanin in red fruits (tomatoes, blackcurrant, watermelon, raspberry, pomegranate, strawberry, etc.); daidzein, the main isoflavone in soybean; proanthocyanidins, common in many fruits, such as apple, grape, or cocoa and are responsible for their characteristic astringency or bitterness. **Figure 1**¹¹ shows different polyphenols and their source.

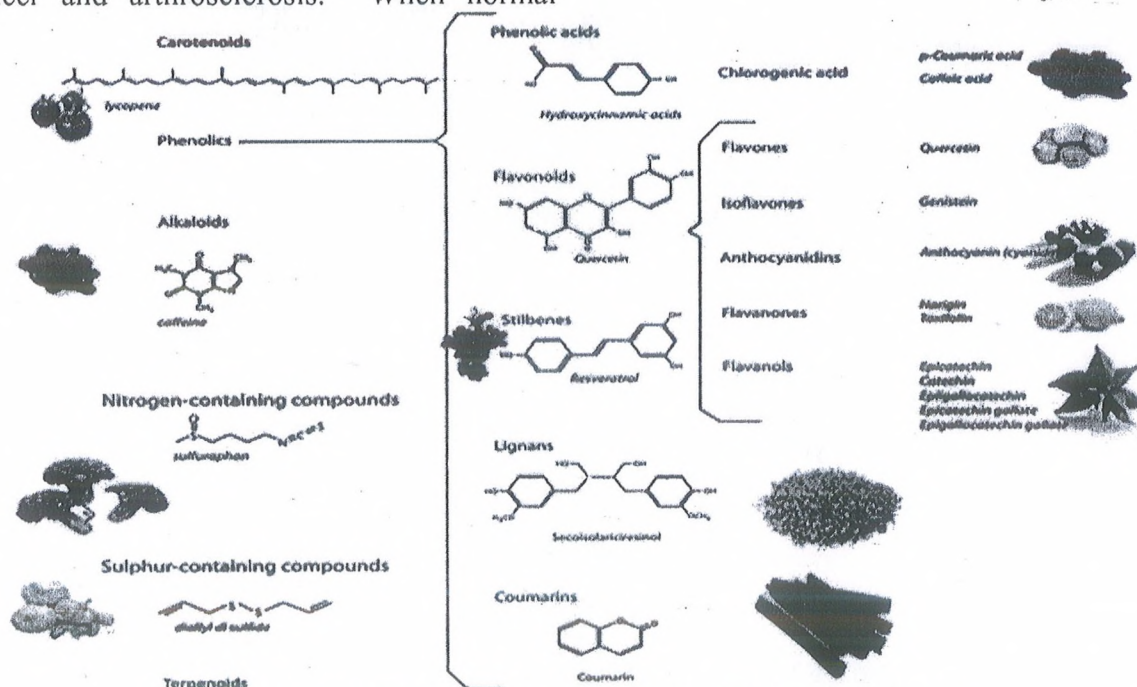


FIGURE 1: DIFFERENT POLYPHENOLS AND THEIR SOURCE

Phenolics play a vital role in plant physiology, providing to resistance to microbes, insects, pigments, odor and flavor. Polyphenolic compounds mainly flavonoids have potential therapeutic value as antioxidant and anti-

inflammatory agents for prevention of cardiovascular disease. Polyphenols helps in decreasing the oxidation of Low Density Lipoproteins (LDL), induce Nitric Oxide (NO) production, inhibit aggregation of platelets and down regulate expression of pro inflammatory mediators⁸.

A meta-analysis study including seven case-control and 10 cohort studies suggested a reduction of the risk of myocardial infarction of 11% upon consumption of three cups of tea per day⁹. When the source of polyphenols were consumed for three months, an increase in the plasma antioxidant capacity or in the concentration of antioxidants such as vitamin E, vitamin C, b-carotene and uric acid was observed in some studies, whereas no change were observed in other studies¹⁰.

Phytosterols are typical constituents of plants' cell walls. The plant kingdom contains a number of sterols that differ from cholesterol by having ethyl or methyl groups or unsaturation in the side chain. The major ones sitosterol, stigmasterol and campesterol can be present in Western diets in amounts almost equal to dietary cholesterol. When ingested with plant foods, phytosterols reduce cholesterol absorption from the stomach, due to its structural similarity with cholesterol. In the last decades, purified plant sterols/stanols have been

added to foods items to obtain functional foods with remarkable hypo cholesterolemic activity. A daily intake of 1.6-2g/day of plant sterols or stanols incorporated in foods helps to reduce cholesterol absorption from the stomach by about 30%, and plasma LDL cholesterol levels by 8-10%⁷.

Role of Phytochemicals and Nutraceuticals against cancer: Phytochemicals plays a vital role in preventing oxidative damage. Antioxidants defuse free radicals leading to limited risk of oxygen species and associated disorders. At cellular and molecular levels they inactivate ROS and under specific low concentration inhibit or delay oxidative processes by interrupting the radical chain reaction of lipid peroxidation¹². Phytochemicals with antioxidant capacity naturally present in food are of great interest due to their beneficial effects on human health as they offer protection against oxidative deterioration. **Figure 2** shows the mechanism of phytochemical in fighting against free radical damage¹³.

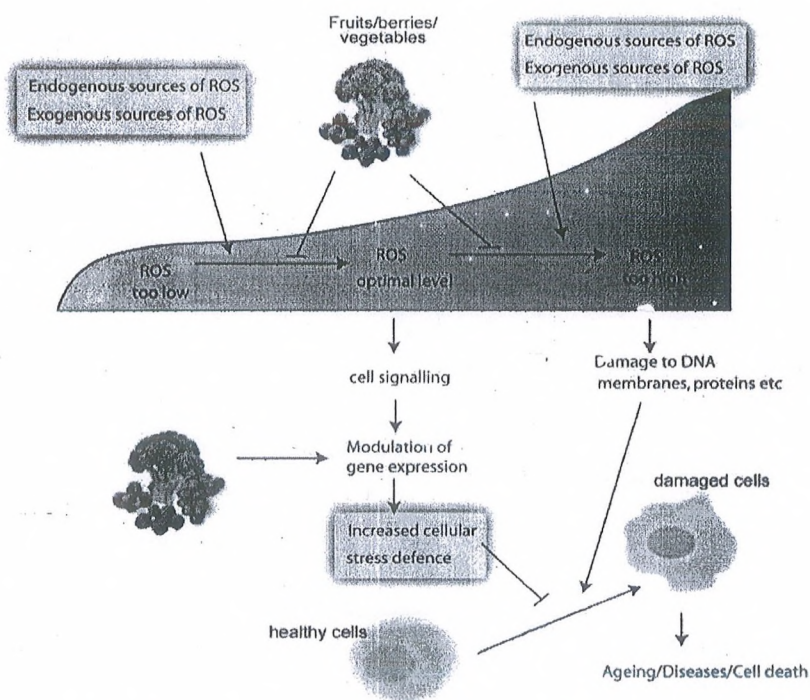


FIGURE 2: THE MECHANISM OF PHYTO CHEMICAL IN FIGHTING AGAINST FREE RADICAL DAMAGE

The occurrence of cancer is a slow process and the risk of developing cancer increases with age. Consumption diet which consists of beneficial phytochemicals can influence the balance and availability of dietary chemo preventive agents. Supplementation of foods that contain anti-cancer properties helps in preventing the deadly cancer.

Many phytochemicals are being investigated for anticarcinogenic properties. Evidence shows that Nutraceuticals are more active when they are administered earlier¹⁴.

Isoflavones are a group of phytochemicals that are predominantly present in soy-based diet. The three

major constituents of isoflavones that have remarkable influences in cancer prevention and therapy are genistein, diadzein, and glycitin¹⁵. They are collectively called as phytoestrogens which are weak estrogen-like activity and bind preferentially to ER- β receptors^{16,17}.

Evidence shows that antiproliferative activity of genistein *in vitro* stems from its ability to inhibit enzyme tyrosine kinase that is most often up regulated in cancer cells^{18,19}. Clinical study showed that treatment of patients with dietary supplements (82 mg/day aglycone equivalents) of isoflavone yielded a higher concentration of total isoflavones in the prostatic tissues than serum level.

Therefore, there is a possibility of increasing the concentration of isoflavones to anticarcinogenic levels in tissue¹⁸.

Curcumin is an orange-yellow crystalline powder practically insoluble in water and ether but soluble in ethanol, dimethylsulfoxide, and acetone. Curcumin was first isolated in 1815 by Vogel²⁰ and in 1870 and it was isolated in crystalline form and identified as 1, 6-heptadiene-3, 5-dione-1,7-bis(4-hydroxy-3-methoxyphenyl) (1E,6E) or diferuloylmethane²¹.

More than 1700 papers on curcumin have been published over the last five decades. Extensive investigation has indicated that curcumin reduces total blood cholesterol, prevents oxidation low-density lipoprotein, inhibit aggregation of platelets, suppression of thrombosis and myocardial infarction (MI) and reduces the symptoms associated with type II diabetes.

Vast number of literature suggesting that curcumin has potential in the prevention and treatment of a variety of cancers. D-Limonen from lemon has been shown to have anti-prostate carcinogenic effects at low dose concentrations. Combination of two compounds may have a plethora of positive antitumor functionalities. Treatment enhanced the sensitivity of DU145 prostate cancer cells that are known to be apoptotic resistant²².

Serum lycopene (a carotenoid) levels have been shown to have an inverse correlation with risk of prostate cancer. Studies show that higher levels of serum lycopene reduce prostate cancer risk. From

the data analysis it was found that lower serum lycopene levels in conjunction with β -carotene supplements were effective in lowering the risk of prostate cancer.

Resveratrol (trans-3, 5, 4'-trihydroxystilbene) is the parent compound of a family of molecules, existing in cis and trans forms in narrow range of spermatophytes of vines, peanuts and pines are the prime substance²³. Resveratrol is a polyphenolic compound found abundant in grape skin and grape products including wine, is found to have chemo preventive properties as supported by numerous *in vitro* and *in vivo* studies.

Phytomedicines in prevention of Diabetes:

Diabetes mellitus is a complex metabolic disorder resulting from either insulin insufficiency or insulin dysfunction. Type I diabetes (insulin dependent) is caused due to insulin insufficiency. Type II diabetes (insulin independent) is due to immunological destruction of pancreatic β -cells leading to insulin deficiency. Type II diabetes is characterized with insulin resistance. It is the more common form of diabetes constituting 90% of the diabetic population.

Traditional herbal medicine has been used since ancient time in many parts of the world. The many side effects of insulin therapy and other oral hypoglycemic agents necessitate the use of more effective and safer antidiabetic drugs. Many medicinal plants have shown experimental or clinical antidiabetic activity and that have been used in traditional systems of medicine. Plants such as *M. charantia*, *Eugenia jambolana*, *Mucuna pruriens*, *Murraya koeingii* and *Brassica juncea* have found to have anti diabetic property²⁴.

All plants have shown varying degree of hypoglycemic and antihyperglycemic activity. In the recent years more than 500 herbal medicines have been reported to possess antidiabetic property²⁵. The principal antidiabetic plants included *Vernonia amygdalina*, *Morinda lucida*, *Carica papaya*, *Citrus aurantiifolia*, *Bidens pilosa*, *Ocimum gratissimum*, and *Momordica charantia*.

The positive effects of aloe are due to the presence of compounds such as polysaccharides, mannans, lectins and anthra-quinones²⁶. Consumption of *Aloe vera* helps to improve blood glucose levels in

diabetics²⁷ and lowered blood lipids in hyperlipidaemic patients²⁸. *Azadirachta indica* is commonly known as neem, margosa or Indian lilac. Three bitter compounds were extracted from neem oil, which were named nimbin, nimbinin, and nimbidin. The neem tree offers an opportunity to reduce insulin requirements with a safe and proven herb.

Momordica charantia, called bitter melon or bitter gourd in English belongs to family Cucurbitaceae, widely grown in Asia and Africa. The plants contain also bioactive glycosides (including momordin, charantin, charantosides, and momordicosides) and other terpenoid compounds (including momordicin-28, momordicin, momordenol and momordol)²⁹. Effect of *Momordica charantia* fruit powder on serum glucose level and body weight in Alloxan induced diabetic rats has been studied^{30,31}.

Momordica charantia has been found to increase insulin sensitivity³². *Gymnema sylvestre* found to have an antidiabetic and hypolipidemic activity on both alloxan induced diabetic rats and normal rats. From extract of the leaves were isolated gymnemic acids, which exhibit antisweet activity³³. *Gymnema sylvestre* may be useful as therapeutic agents for the stimulation of insulin secretion in individuals with type II diabetes³⁴. It can also help prevent adrenal hormones from stimulating the liver to produce glucose, thereby reducing blood sugar levels³⁵.

Anti-diabetic activity of *Holosstemma ada-kodien* Schults in alloxan induced diabetic rats was studied. Extracts of this plant possess antidiabetic properties such as reducing insulin requirements by enhancing endogenous insulin availability, improving blood glucose homeostasis, controlling of hyperlipidemia associated with diabetes, and reducing serum amylase activity.

Green tea and Kidney disease: Consumption of green tea helps kidneys to process toxins and waste products more efficiently. In the rats study, extracts of green tea increased antioxidant activity and improved antioxidant levels in the cells of kidneys. It also reduced signs of kidney damage and restored levels of creatinine and urea to normal. The researchs concluded that green tea could provide inexpensive and safe way to prevent kidney disease

and further research on humans to confirm the results of the preliminary animal study on green tea extracts³⁶.

Inclusion of green tea helps to prevent kidney cancer. In the study done by Mowafy *et al*³⁷ on laboratory animals, supplementation of 50 mg per kg body weight of epigallocatechin-gallate, an extract of green tea, reduced tumors by 92 percent. Green tea extract also helped in reduction of white blood cells levels, inflammatory C-reactive protein (CRP) and lipid peroxidation. An animal study showed that extracts of green tea protects the kidneys from toxicity that can lead to tumor formation.

CONCLUSION: This review highlights the importance of medicinal plant to in human health. The number of studies in this area is quite high although most of the studies have been done on the extract level but yet to be practiced in humans. Enormous numbers of studies are to be done in isolated antioxidant compounds on various diabetic models for better understanding of its mechanism of action.

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