REVIEW OF LITERATURE

2.1 GENERAL INTRODUCTION

Significant progress in the study of ‘Physical activity and Diabetes’ which can be noticed today, is a result of decades of efforts undertaken by researchers in close succession. Whenever human beings are confronted with some problem they seek guidance from the experience, knowledge and wisdom of other researches.

The significance of such related literature is indispensable for seeking guidance, knowledge and wisdom for any new study. In order to conduct a successful scientific study, review of previous studies on similar topics is a preliminary requirement, as it prevents duplication of the study, adds new ideas, helps in verification of theories and also provides guidance for making hypothesis.

Taking above facts into consideration, extensive effort has been put to collect articles, papers, documents and reports related to study. In this section an attempt has been made to evaluate research methodologies and relate the findings of the previous studies. This section will stress upon background of current topic and will highlight key findings of study. This chapter focuses upon current state of diabetes, research evidences regarding epidemiology of T2DM, current state of diabetes and role & effectiveness of physical activity in prevention and management of T2DM. It also offers guidance to T2DM patients on methods to improve physical activity.

2.2 REVIEW OF LITERATURE

For study, literature review was gathered from the following places:

- Bhai Gurdas Library, Guru Nanak Dev University, Amritsar.
- National Medical library, AIIMS, New Delhi.
- www.google.co.in
- www.medline.com
- www.pubmed.com
2.3 EPIDEMIOLOGY OF DIABETES MELLITUS

In this section, past literature of diabetes was reviewed, focusing on past, present and future state of diabetes in developed and developing countries. It describes the changing epidemiology of diabetes and its causes. Extensive research has been done to explore the epidemiology of DM.

Diabetes has become a major worldwide threat to developing as well as developed world. Increasing magnitude of T2DM can be attributed to factors like “population ageing, unplanned urbanization and globalization of trade and marketing” (Alwan et al., 2010). Globalisation, urbanization and evolving dynamic trends of eating habits are leading to burgeoning global numbers of T2DM. Diabetes thus, has developed as a key health challenge for developed as well as developing countries of the 21st century (Global Diabetes Plan 2011-2021). This part of review has been divided into three sections.

a. Studies reporting the status of DM worldwide.

b. Studies reporting the status of DM in developing countries.

c. Studies reporting the prevalence of DM in India.

a. Diabetes Mellitus Worldwide

In this section, we intend to focus on the “worldwide predictions of the diabetes epidemic” and the factors influencing the development of diabetes. The continuing rise in the globalization and urbanization has resulted into massive increase in the epidemic of T2DM. According to International diabetes federation (IDF) 2013, “85% to 95% of all diabetics are T2DM in high income nations and this percentage is further high in low and middle income countries”. (Figure 2.1)
Diabetes ranks in the top 10 causes of “disability worldwide” and “undermines productivity and human development” (IDF Global Diabetes Plan 2011-2021). Physiological and psychological implications of diabetes worsen the quality of life of a diabetic, eventually leading to decreased productivity.

Wild et al., (2004) estimated the global spread of diabetes for the year 2000 and projected its worldwide prevalence for year 2030. This prevalence was estimated to be 2.8% in 2000 beefing up to 4.4 % in 2030. Prevalence of diabetes was found to be “higher in men than in women”. (Figure 2.2)
Though men contribute more to diabetes numbers worldwide compared to women but this difference is not very striking and same can also be attributed to demographic structure of world population. More striking and worrisome are the projected numbers of diabetics across the world. Wild et al., (2004) estimated a twofold rise in urban population of developing countries between 2000 and 2030. This increase will be a result of factors like growth of population; ageing, urbanization & increasing prevalence of obesity. India will contribute biggest absolute increase (31.7 Millions in 2000 to 79.4 Millions in 2030) in number of people with diabetes as revealed by this study.

Another study estimated a twofold increase in number of people worldwide with diabetes in next 20 years due to increasing obesity and longevity (Ekoë et al., 2001). This study also highlighted physical inactivity and poor diet as the main risk factors for diabetes. Herman., (2006) analysed various studies and projected that increase in number of adults with diabetes by 42 % in developed countries, from “51 million to 72 million” and 170 % in developing countries, from “mere 84 million to 288 million”. Factors like ageing, urbanization and population growth allowed them to project
worldwide increase in number of adults with diabetes by “122 % from 135 million to 300 million by the year 2025”.

Figures reported by IDF of 382 million in 2013 are expected to rise up to 552 million by 2030 & 80% of this increasing number of people with diabetes live in low and middle income countries (Figure 2.3). Age of majority of this 382 million people with diabetes is between 40-59 years, according to IDF 6th edition (2013) and out of this 382 million, 46% i.e. 175 million people are undiagnosed. Studies mentioned above display that diabetes is a global epidemic which is growing at burgeoning pace every year. It threatens the health of millions worldwide. Though, growth of T2DM can be observed globally but it’s still skewed towards middle income and low income countries as 80% of people with diabetes live in such countries. Changing dietary habits, economic prosperity and fast urbanization in developing nations are the factors eventually leading to a shift towards sedentary lifestyle patterns and eventually inviting T2DM.

**Figure 2.3: Diabetes population type split (2013 and 2035).**

According to 3rd National Health and Nutrition Examination Survey (NHANES III), 5.1% of US adults were estimated with T2DM during 1988-1994 and it increased to 6.3% in 2002 (Harris *et al.*,1998). In US, in year 2007, 1.6 million new cases were diagnosed among adults aged 20 years or older (Freeman *et al.*, 2010). Prevalence in Australia of known diabetes was 3.7%, when combined with newly diagnosed diabetes the total was 7.4% (Dunstan *et al.*, 2002).
<table>
<thead>
<tr>
<th>Country</th>
<th>Author</th>
<th>Journal</th>
<th>Total Diabetes (n)</th>
<th>KDM (n)</th>
<th>KDM Proportion of total diabetes (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Africa</td>
<td>Erasmus et al., 2001</td>
<td>South African Medical Journal</td>
<td>9</td>
<td>1</td>
<td>11</td>
</tr>
<tr>
<td>South Africa</td>
<td>Levitt et al., 1993</td>
<td>Diabetes Care</td>
<td>46</td>
<td>24</td>
<td>52</td>
</tr>
<tr>
<td>South Africa</td>
<td>Omar et al., 1993</td>
<td>South African Medical Journal</td>
<td>20</td>
<td>12</td>
<td>60</td>
</tr>
<tr>
<td>South Africa</td>
<td>Motala et al., 2008</td>
<td>Diabetes Care</td>
<td>46</td>
<td>7</td>
<td>15</td>
</tr>
<tr>
<td>Denmark</td>
<td>Glumer et al., 2003</td>
<td>Diabetes Care</td>
<td>404</td>
<td>139</td>
<td>34</td>
</tr>
<tr>
<td>France</td>
<td>Gourdy et al., 2001</td>
<td>Diabetes and Metabolism</td>
<td>238</td>
<td>129</td>
<td>53</td>
</tr>
<tr>
<td>Germany</td>
<td>Leconte et al., 2002</td>
<td>Diabetes and Metabolism</td>
<td>1,675</td>
<td>993</td>
<td>59</td>
</tr>
<tr>
<td>Germany</td>
<td>Rathmann et al., 2003</td>
<td>Diabetologia</td>
<td>253</td>
<td>128</td>
<td>51</td>
</tr>
<tr>
<td>Greece</td>
<td>Panagiotakos et al., 2005</td>
<td>Diabetic Medicine</td>
<td>210</td>
<td>154</td>
<td>73</td>
</tr>
<tr>
<td>Italy</td>
<td>Garancini et al., 1995</td>
<td>Diabetologia</td>
<td>476</td>
<td>213</td>
<td>45</td>
</tr>
<tr>
<td>Netherlands</td>
<td>Mooy et al., 1995</td>
<td>Diabetes Care</td>
<td>184</td>
<td>78</td>
<td>42</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>Forrest et al., 1986</td>
<td>Diabetic Medicine</td>
<td>NA</td>
<td>NA</td>
<td>45</td>
</tr>
<tr>
<td>Egypt</td>
<td>Herman et al., 1995</td>
<td>Diabetic Medicine</td>
<td>NA</td>
<td>NA</td>
<td>57</td>
</tr>
<tr>
<td>Pakistan</td>
<td>Shera et al., 1999</td>
<td>Journal of the Pakistan Medical Association</td>
<td>115</td>
<td>42</td>
<td>37</td>
</tr>
<tr>
<td>UAE</td>
<td>Saadi et al., 2007</td>
<td>Diabetes Research and Clinical Practice</td>
<td>412</td>
<td>250</td>
<td>61</td>
</tr>
<tr>
<td>United States of America</td>
<td>Cowie et al., 2009</td>
<td>Diabetes Care</td>
<td>410</td>
<td>246</td>
<td>60</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Rahim et al., 2007</td>
<td>Diabetes Research and Clinical Practice</td>
<td>270</td>
<td>27</td>
<td>10</td>
</tr>
<tr>
<td>India</td>
<td>Ramachandran et al. (large cities), 2001</td>
<td>Diabetologia</td>
<td>1,684</td>
<td>1,175</td>
<td>70</td>
</tr>
<tr>
<td>India</td>
<td>Sadikot et al. (urban), 2004</td>
<td>Diabetes Research and Clinical Practice</td>
<td>624</td>
<td>199</td>
<td>32</td>
</tr>
<tr>
<td>India</td>
<td>Sadikot et al. (rural), 2004</td>
<td>Diabetes Research and Clinical Practice</td>
<td>193</td>
<td>37</td>
<td>19</td>
</tr>
<tr>
<td>Mauritius</td>
<td>Soderberg et al., 2005</td>
<td>Diabetic Medicine</td>
<td>1,317</td>
<td>671</td>
<td>51</td>
</tr>
</tbody>
</table>
The overall prevalence in Italians above 45 years of age from Health District of Cremona, Italy had a slightly lower rate of 7.7% compared to Dutch (Garancini et al., 1995). It has been a consistent finding from the above mentioned studies that there is a global epidemic of T2DM. Table 1 shows the percentage of known DM in total diabetes population in various studies. The study from Ramachandran et al., 2001 showed that India reported high proportion of known diabetes. Across all the surveys, around 50% of people with diabetes were left un-diagnosed.

b. Diabetes Mellitus in Developing Countries

This section will emphasize on the status of DM in developing countries. Though, burden of diabetes is overwhelming globally but pie of distribution shows a significant growth towards developing world.

Figure 2.4: Number of people with diabetes in millions (20-79 years, 2013). (Source: IDF, 2013)

As stated in 6th edition of the IDF, Diabetes Atlas (2013), South-East Asia Region contributes to almost one-fifth of the world’s adult diabetic population. Rapid changes
Review of Literature

In lifestyle, ageing population and transforming environments in developing countries contribute significantly to the dramatic pace of this epidemic. Out of 8.3% of the adult population or 71.4 million people having diabetes in 2011, 61.3 million are in India. And this number is set to increase to 120.9 million by 2030, or 10.2% of the adult population. 99% of these numbers in this region is contributed by India, Bangladesh and Sri Lanka (IDF, Diabetes Atlas, 2013)

According to the World Health Organization (WHO) Ad Hoc Diabetes Report (1993), age – standardized prevalence rates of diabetes were as high as 14% to 20% in Asian Indian migrants, Latin American and Chinese populations, whereas prevalence is about 3% to 10% in European populations (King et al., 1993). They described population of developing countries, minority groups and disadvantaged communities in industrialized countries as greater risk areas leading to growth in adult diabetic population. Another study by King et al., (1998) showed the projection, numerical estimates and prevalence globally for the year 1995-2025. In his study he estimated that over 75% of all people with diabetes by the year 2025, will be in the developing countries, as compared to number of 62% in 1995. One of the worst hit countries will be India with an increase of 195%, from 19 million to 57 million. They also estimated 82% increase in the adult population, 170% increase in the number of people with diabetes in developing countries and 48% increase in the prevalence of adult diabetes.

According to Ramachandran et al., (2012) more that 80% of T2DM cases occur in developing countries. Further emphasis was given to present trends estimating that more than 60% of the world’s diabetic population will be in Asia. Emphasis was given on trend of growth of T2DM in Asian youth population with China showing 88% increase in 35-44 age groups within 6 years. Also southern India has shown a growth trend in diabetes for population under 44 years as numbers have increased from 25% of in 2000 to 36% in 2006. Asians have also displayed lower thresholds for the environmental risk factors keeping them more prone to getting T2DM. Thus, Indians
develop diabetes at a younger age and at a lower body mass index compared with the Western population.

Rapid growth of urban population in developing world further catalyzes the pace of diabetes growth. Table 2 depicts that by 2030, all 10 listed countries will show remarkable growth of T2DM; however India and China will dominate these growth statistics, as T2DM numbers in India and China will get more than doubled by 2030. The global increase in numbers of T2DM is now a worldwide health epidemic.

**Table 2.2: List of countries with the highest number of estimated cases of diabetes for 2000 and 2030 (Source - Wild et al., 2004)**

<table>
<thead>
<tr>
<th>Ranking</th>
<th>2000</th>
<th>2030</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Country</td>
<td>People with diabetes (in millions)</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;</td>
<td>India</td>
<td>31.7</td>
</tr>
<tr>
<td>2&lt;sup&gt;nd&lt;/sup&gt;</td>
<td>China</td>
<td>20.8</td>
</tr>
<tr>
<td>3&lt;sup&gt;rd&lt;/sup&gt;</td>
<td>U.S.</td>
<td>17.7</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Indonesia</td>
<td>8.4</td>
</tr>
<tr>
<td>5&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Japan</td>
<td>6.8</td>
</tr>
<tr>
<td>6&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Pakistan</td>
<td>5.2</td>
</tr>
<tr>
<td>7&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Russian Federation</td>
<td>4.6</td>
</tr>
<tr>
<td>8&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Brazil</td>
<td>4.6</td>
</tr>
<tr>
<td>9&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Italy</td>
<td>4.3</td>
</tr>
<tr>
<td>10&lt;sup&gt;th&lt;/sup&gt;</td>
<td>Bangladesh</td>
<td>3.2</td>
</tr>
</tbody>
</table>
c. Diabetes Mellitus in India

It has been a consistent finding from the above studies that developing countries are facing the brunt of this epidemic and most of it is around India and China. This section contains prevalence estimates of DM in India.

One of the first data on spread of diabetes in India came from a multicenter study (Ahmedabad, Calcutta, Cuttack, Delhi, Trivandrum) conducted by the Indian Council of Medical Research (ICMR) in the early 1970s reporting a prevalence of 2.3% in the urban and 1.5% in the rural areas (Ahuja et al., 1979). The ICMR study (1972-1975) was the first systematic nationwide collaborative study on the prevalence of diabetes mellitus. It was carried out in 6 representative centres. 34,294 persons above the age of 14 years were included in this study & were screened by a post – 50gm glucose capillary blood test. Capillary blood glucose level of above 170 mg/dl was defined as diabetes. Based on this study, prevalence of diabetes was found to be “2.1% in urban and 1.5% in rural areas”.

The Daryaganj Diabetes Survey of known diabetes carried out in 1986 in an affluent urban Delhi population showed a much higher prevalence (3.1%) giving an estimated total prevalence of 6.2%, i.e. twice the known prevalence as compared to previous Indian surveys (Verma et al., 1986). In this survey no cases of known diabetes were found in people aged less than 30 years. The age specific prevalence reported in the Daryaganj study were strikingly similar to those found in South Asians in Southall and at least 5 times higher than in Europeans in Southall aged 40 to 64 years (Mather et al., 1985). For the first time, it was demonstrated that a high prevalence of diabetes may occur within India as well and study suggested that Indians have a high ethnic susceptibility to diabetes at a younger age.

A National Urban Diabetes Survey (NUDS) conducted among Indian urban subjects displayed age standardized prevalence of diabetes as 12.1% and the spread in the southern part of India was found to be higher i.e. 13.5% in Chennai, 12.4% in
Bangalore, and 16.6% in Hyderabad than in eastern India (11.7% in Kolkata), northern India (11.6% in New Delhi) and western India (9.3% in Mumbai). In this epidemiological study 11,216 subjects were studied and found that 69.8% of the diabetic patients were known cases with records of treatment. Subjects under the age of 40 years were found to be having a higher prevalence of impaired glucose tolerance (12.8%) than diabetes (4.6%) and this difference was statistically significant (Ramachandran et al., 2001).

A high percentage impaired glucose tolerance amongst young Indian population further adds to the pressure of high growth rate of diabetes in this part of world. India’s age demographics further aggravates the worry, as 25% of southern Indian population was under 44 years in 2000 that exceeds to 36% in 2006 (Ramachandran et al., 2012).

Mohan et al., (2007) have showed that India is leading the world with largest number of diabetes individuals and earns the distinction of being termed the “diabetes capital of the world”. According to the Diabetes Atlas 2006 published by the IDF, unless urgent preventive steps are taken the number of people with diabetes in India is expected to rise to “69.9 million by 2025”.

The major factor for this epidemic is rapid epidemiological transition associated with changes in dietary patterns and decreased physical activity. This is further evident from the higher numbers of diabetes individuals in the urban population. Gupta et al., (2012) further displayed that there were “40 million persons with diabetes in India (in 2007)” and this number is estimated to rise to almost “70 million people by 2025”. It is also quoted that every fifth person in world with diabetes will be Indian. Lifestyle modifications including weight loss, dietary changes & increased physical activity can prevent or delay the onset of diabetes as quoted by US Diabetes Prevention Program

With more than 1.1 billion Indians vulnerable to diabetes, this disease can bring further complications like blindness, amputation and heart failure. Early diagnosis and prevention measures can prevent diabetes and its complications by maintaining an ideal
body weight, blood pressure control and regular physical activity for 30 minutes, foot care and starting appropriate medication in the pre-diabetes stage itself.

The prevalence of diabetes in India study (PODIS), a random population survey in subjects aged 25 years and above was carried out in 40 urban and 37 rural centres. Fasting blood samples were taken after fast of 10-12 hours and 2 hours after 75 grams of oral glucose. The standardised prevalence rates for diabetes mellitus, in the total, urban and rural populations were 4.3, 5.9 and 2.7% respectively and also the corresponding impaired glucose tolerance rates in the three populations were 5.2%, 6.3% and 3.7% respectively. It was found by this study that prevalence of both diabetes mellitus and impaired glucose tolerance was quite high in the urban population compared to that of rural population (Sadikot et al., 2004).

Another study by Diamond (2011), documented, prevalence of diabetes as only 0.7% for non-obese, physically active, rural Indians. It reaches “11% for obese, sedentary, urban Indians; and it peaks at 20% in the Ernakulam district of Kerala”, one of India’s most urbanized states. Further, this prevalence of disease is higher among affluent, educated, urban Indians than among poor, uneducated, rural people. In 2004, prevalence of diabetes averaged “16% in urban India and only 3% in rural India”. He also reported that in Britain, the prevalence of T2DM is 14 times higher in Asian than European children.

Increasing per capita incomes of middle class Indians, improved and comfortable lifestyle, improving literacy rates and shift from a rural economy to an urban economy are some of the key catalysts for unprecedented growth of diabetes in India.
Ahmad *et al.*, 2011 did study to determine the prevalence of DM in Kashmir. He found a rising trend of diabetes mellitus in Kashmir valley. The spread of Diabetes as per this study population was 6.05%, out of which 4.03% were known diabetic and 2.02% undiagnosed subjects. This difference was higher than previous studies because of increasing stress in valley due to turmoil, change in life style, and age composition of the selected population of earlier studies. They revealed that this spread of T2DM increases with age. In the target population of 20 years and above, the prevalence of DM increased with age from 3.02% in 20-40 year old through 5.80% in those aged 40-60 years and 16.66% in those aged > 60 years.

Though prevalence of DM is relatively lower in mid age group of 20-40 but this forms the biggest chunk of 34% of Indian population and previous studies have reported that a big number of this section is identified with impaired glucose tolerance which alarms the onset of diabetes.

Mohan *et al.*, (2013) did an observational study to determine the current glycaemic status and diabetes related complications among T2DM patients in India.
ICMR-INDIAB national study reported that there are “62.4 million people with T2DM” and “77 million people with pre-diabetes in India”. These numbers are further projected to increase to 101 million by the year 2030. Collating the results of various studies they also documented prevalence of diabetic retinopathy (DR) as 17.6%, coronary artery disease (CAD) as 21.4%, microalbuminuria in 26.9%, neuropathy as 26.1% and peripheral vascular disease (PVD) as 6.3%. They further concluded poor glycaemic control in Indians, resulting in higher prevalence of complications. This concludes that proper control of DM is urgently needed to reduce the risk of developing the complications of diabetes in Indian T2DM patients.

**Figure 2.6: Prevalence of diabetic complications (India). (Source: Mohan et al., 2007)**

A cross sectional study was conducted by Kumar et al., 2013 among police personnel in West Bengal to display the prevalence of diabetes, impaired fasting glucose (IFG) and impaired glucose tolerance (IGT). Results of their study shown that out of 1817 subjects, DM was found in 15%, 1.1% had IFG, and 5.7% had IGT. Almost 80% of the subjects were overweight or obese based on BMI and around 40% had abdominal obesity. Study reported a positive association of abdominal obesity with DM and IGT.
Currently, rapid economic and demographic transformation is taking place in India. Above studies have shown that diabetes in Asian Indians living in India is increasing rapidly in urban population compared to rural population. Adoption of a western lifestyle has resulted in populations changing to high saturated fat and sugar diets with the reduction in physical activity level.

2.4 PATHOPHYSIOLOGY OF T2DM

The “pathophysiology of T2DM is characterized by peripheral insulin resistance, impaired regulation of hepatic glucose production and declining β-cell function, eventually leading to β-cell failure” (Mahler et al., 1999).

Figure 2.7: Pathophysiological progression of T2DM as seen from pancreatic β cell function.

Source: Taken from Prof. Kohei Kaku Paper with permission via email, dated Nov 15, 2013 T2DM involves at least two primary pathogenic mechanisms

(1) Decline in pancreatic islet cell function leading to reduction in insulin secretion and inadequate suppression of glucagon secretion

(2) Peripheral insulin resistance resulting in a decrease in the metabolic responses to insulin (Spellman, 2010).

Beta-Cell dysfunction is initially characterized by “impairment in the first phase of insulin secretion during glucose stimulation” and may catalyse the onset of glucose intolerance in T2DM (Mahler et al., 1999). Progression of the deterioration of pancreatic β cell function subsequently causes permanent elevation of blood glucose ( 
Figure 2.8: Pathogenetic factors implicated in the progressive impairment in insulin secretion in T2DM. (Source: Taken from DeFronzo et al., 2004)
According to (Kaku., 2010) Insulin resistance develops and expands prior to disease onset. It is found in hypertension, hyperlipidemia and ischemic heart disease, entities commonly found in association with diabetes. This raises a question in as to whether insulin resistance results from different pathogenetic disease processes or is unique to the presence of T2DM (Mahler et al., 1999). In the basal state, the “hepatic insulin resistance is manifested by overproduction of glucose despite fasting hyperinsulinemia” and the increased rate of hepatic glucose output is the primary determinant of fasting plasma glucose concentration in T2DM individuals (DeFronzo, 2004). In insulin resistant individuals with overt hyperglycemia, for example, T2DM, a number of post-binding defects have been demonstrated, including reduced insulin receptor tyrosine kinase activity and altered insulin signal transduction, diminished glucose phosphorylation and impaired glycogen synthase activity (Abdul-Ghani et al., 2010).

2.5 EFFICACY OF PHYSICAL ACTIVITY IN DIABETES MELLITUS

This segment has considered the role of physical activity in both the prevention and treatment of obesity and T2DM. Extensive research evidences have been reviewed to understand the relationships between physical activity and T2DM. Past studies were remarkable for their consistent findings in the protective effects of physical activity in prevention and treatment of T2DM.

Kelly et al. (2001) did a systematic review to evaluate the effectiveness of physical activity in treatment and prevention of T2DM. In their review they documented large-scale, prospective studies that indicate relationship between higher levels of physical activity with lower incidence of T2DM. In their review they discussed about several important caveats to assess, whether physical activity improves glucose control in patients with T2DM. They noticed certain potential areas where exercise appears to have positive effects.

- First, insulin resistance of peripheral tissues seems to improve with exercise.
- Second, postprandial hyperglycemia was found to improve with exercise

- Third, very few studies suggest that exercise acutely lowers hepatic glucose production

- Fourth, studies of patterns of substrate utilization during exercise indicate similarity in the metabolism of glucose by peripheral tissues in both non diabetic and DM individuals

Indian population within age group of 20-40 years which makes almost 34% of total Indian population is prone to impaired glucose tolerance. A better physical activity in lifestyle of these Indians can help them to improve glucose tolerance and prevent the onset of T2DM.

A relationship of structured exercise training and physical activity advice on changes in HbA1c levels has been documented by Umpierre et al., (2011) for levels in patients with T2DM. It was concluded that physical training that including aerobic exercise, resistance training, or both combined is associated with HbA1c reduction in patients with T2DM. Physical structured training of more than “150 minutes per week is associated with greater HbA1c declines than that of 150 minutes or less per week”.

A scientific statement from American Heart Association, (Marwick et al., 2009) reported the effects of exercise training on T2DM. Data derived from high quality evidences showed favourable effects of exercise on metabolic, glycaemic and vascular profile. The review identified evidences that focussed on individualized exercise prescription. To prevent cardiovascular risk, it is recommended that “patients with T2DM participate in minimum of 150 minutes per week of at least moderate intensity and/or 90 minutes per week of vigorous intensity cardio respiratory exercise”. Studies comparing the combined effects of aerobic/or resistance training revealed that both forms of training were equally beneficial for glycaemic control, although aerobic training had a greater impact on body composition.
Zanuso et al., (2010) critically reviewed the literature to identify evidences on interrelationships between exercise and metabolic outcomes. They concluded that effects of aerobic exercises are well established and interventions with more vigorous aerobic exercise programs resulted in greater reductions in HbA1c and greater increase in insulin sensitivity.

In a meta-analysis done by Boule et al., (2002), reviewing exercise intervention of at least 8 weeks of supervised exercise in T2DM individuals, it was observed that regular aerobic exercise have a significant statistical and clinical effect on VO$_2$ max and glycaemic control having little effect on body weight. Post intervention HbA1c was significantly lower in supervised exercise groups than control groups.

Due to different physical activity protocols this part is further divided into 2 sections

a. Efficacy of Aerobic Exercise

b. Efficacy of Resistance Exercise

Thus from the above studies we can conclude that resistance and aerobic exercise are effective in improving glycaemic as well as metabolic profile of adults with T2DM. Evidences from the recent studies strengthen the importance of physical activity programs for the treatment and management of T2DM.

a. Studies Showing the Effects of Aerobic Exercise in T2DM

This section evaluates the research evidence regarding the role of aerobic exercise in the prevention and treatment of T2DM.

A randomized controlled trial was done by Praet and colleagues (2008) where they compared the clinical benefits of a 12-month exercise programme consisting of, brisk walking or a medical fitness programme in T2DM patients. The medical fitness programme consisted of three exercise sessions per week. They randomized 92 T2DM
patients (60±9 years old) to either three times a week of 60 min brisk walking (n=49) or medical fitness programme (n=43). Resistance type exercise consisted of a selection of eight different exercises targeting upper and lower body muscle groups. Endurance type exercise consisted of interval type exercise on a home trainer, elliptical trainer or rowing ergometer. It was a comparative study, which concluded that “prescription of group-based brisk walking represents an equally effective intervention to modulate glycaemic control” and cardiovascular risk profile in T2DM patients when compared with more individualised medical fitness programmes.

2-year impact of different increments in energy expenditure on several physiological and biochemical outcomes was performed by Loreto et al., (2005). Voluntary aerobic physical activity was performed in 179 T2DM patients followed for 2 years. Diabetic patients were advised to practice only aerobic activities at moderate intensity and most of them choose fitness walking. These patients were instructed to exercise at moderate intensity (40–60% of heart rate reserve) between 3 and 6 METs. It was concluded through this study that physical activity is an important cost-saving tool in the care of T2DM that confirms beneficial effects of exercise on cardiovascular risk factors. Effects of an aerobic physical exercise program in the treatment of a group of elderly patients with T2DM was studied by Tessier et al., (2000). Subjects entitled in this program were randomly assigned to either an experimental (n=19) or a control (n=20) group. After the completion of intervention, the experimental group showed a significant decrease of glucose excursion during the oral glucose tolerance test (OGTT) (area under the curve) (16.6±3.8 vs. 15.3±3.1, P<0.05) and an increase in total time on the treadmill (s) (423±207 vs. 471±230, P<0.05). Also, an improvement in DM was observed in the experimental group (P=0.01) but not in the control group.

Helmrich et al., (1991) investigated the effectiveness of physical activity in preventing NIDDM. Study concluded that, “Leisure-time physical activity, expressed in kilocalories expended per week in walking, stair climbing, and sports was inversely related to the development of NIDDM”.

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Another study assessed the association between “leisure time physical activity and mortality among patients with diabetes” (Hu et al., 2004). It was concluded by this study that moderate or high levels of physical activity helps in reducing total and cardiovascular disease mortality among patients with T2DM. It was also further provided as evidence that, not only leisure time physical activity but also occupational activity and daily walking or cycling to and from work are important components of a healthy lifestyle among diabetic patients.

Praet et al. (2009), reviewed patho-physiological problems associated with T2DM and discusses the benefits of exercise therapy on phenotype characteristics, glycaemic control and cardiovascular risk in T2DM. They concluded that “T2DM patients should be stimulated to participate in specifically designed exercise intervention programs”. “Endurance training may up regulate mitochondrial enzyme activity in skeletal muscle and subsequently improves whole-body oxygen uptake capacity”. When prescribing exercise as treatment for an individual diabetes patient, it is important to estimate “total energy expenditure that can be achieved through the recommended type of exercise”. Prolonged endurance type exercise training has been shown to improve insulin sensitivity in both young and elderly. Further this review provides high quality of evidence on the effectiveness of physical activity on T2DM.

Wallberg et al., (1998) investigated the role of exercise in the management of NIDDM. Exercise training also improves many other physiological and metabolic abnormalities that are associated with NIDDM such as lowering body fat, reducing blood pressure and normalizing dyslipoproteinaemia. “Physical activity exerts pronounced effects on substrate utilization and insulin sensitivity, which in turn potentially lowers blood glucose and lipid levels”.

Zoeller., (2007) stated that the “metabolic syndrome, a clustering of interrelated risk factors, is predictive of T2DM and cardiovascular disease and is prevalent in T2DM”. “Regular moderate to vigorous physical activity (150 minutes per week
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Moderate activity and/or 90 minutes per week vigorous activity) has been observed to reduce the risk of developing T2DM, even in high-risk individuals”. Exercise should be performed at least 3 days per week, with no more than 2 days between exercise bouts. “Strength training, alone or in combination with regular aerobic exercise, has been shown to improve glycaemic control, hypertension, and other T2DM-related risk factors”.

Davies et al., (2008) assessed the “effectiveness of a structured group education programme on biomedical, psychosocial, and lifestyle measures in people with newly diagnosed T2DM”. They reported that “structured group education programme resulted in greater improvements in weight loss, smoking cessation and positive improvements in beliefs about illness”. This structured group education programme of six hours delivered in a specific community, focussed on “lifestyle factors such as food choices, physical activity and cardiovascular risk factors”. Walker et al., (1999) examined the impact of a 12 week walking program on body composition and risk factors for cardiovascular disease in women with T2DM and in normoglycaemic women with first degree diabetic relatives. After 12 weeks, they reported that regular walking program, which is self paced but of relatively long duration, will improve the fitness and lipid profile in postmenopausal women who have or are at risk of T2DM.

Hamer et al., (2008) did a Cochrane review to “quantify the association between walking and the risk of cardiovascular disease and its effect on mortality in healthy men and women”. Cumulative evidences from 18 prospective cohort studies suggested an “inverse dose-response relationship between walking and these clinical endpoints”. This study found that “walking pace was a stronger independent predictor of overall risk compared with walking volume” (48% vs. 26% risk reduction).

In a systematic review, by Jeon et al., (2007), they evaluated various epidemiological evidences on association between physical activity of moderate intensity and risk of T2DM. They found inverse relationship between physical activity
of moderate intensity and risk of T2DM. However this review provided high quality of
evidences indicating that 30 min or more daily moderate intensity activity can
substantially reduce the risk of T2DM as compared with a sedentary lifestyle. Hu et al.
(1999) did a prospective cohort study to “examine the relationship of total physical
activity and incidence of T2DM in women and to compare the benefits of walking vs
vigorous activity as predictors of subsequent risk of T2DM”. In this study, author
depicted “comparable magnitudes of risk reduction with walking and vigorous activity,
when total energy expenditures were similar”. They also observed a strong inverse
association between walking score and risk of T2DM.

Tanasescu et al., (2003) did a prospective cohort study to “examine the
relationship of physical activity with risk of cardiovascular disease (CVD) and mortality
among men with T2DM”. However they found that “Walking was inversely associated
with total mortality and faster walking was inversely associated with CVD and total
mortality, independent of the time spent walking”. Furthermore, the findings of the
Finnish Diabetes Prevention Study (Laaka et al., 2007) showed that “increasing
physical activity may substantially reduce the incidence of T2DM in high risk
individuals”. They stated that “changes in lifestyle and low-intensity leisure time
physical activity (LTPA) can decrease the risk of diabetes independently.

Karstoft et al., (2013) did a Randomized controlled trial to “evaluate the
feasibility of free living walking training in T2DM patients and compared the effects of
interval walking training with continuous walking upon physical fitness, body
composition and glycaemic control”. They concluded that “walking exercise can be
implemented as a free living training method in T2DM patients”. Hansen et al. (2009)
also concluded that, “prolonged continuous low-to-moderate intensity endurance type
exercise training is equally effective as continuous moderate to high intensity training in
lowering blood glycosylated haemoglobin and increasing whole body and skeletal
muscle oxidative capacity in obese T2DM patients”.
Thus previous researches have reported substantial benefits of physical activity for the patients with type 2 diabetes. Data from recent studies support the importance of aerobic exercise programs in the treatment and prevention of T2DM. From the above literature, it is clear that low to moderate intensity exercise, such as walking has been shown to have significant benefits in T2DM individuals.

b. Studies Showing the Effects of Resistance Exercise in T2DM

In the following section, effect of resistance exercise for the management of diabetes would be discussed. More recently, several studies have demonstrated the “beneficial effects of resistance exercise in patients with diabetes”.

Misra et al., (2008) studied 30 patients with T2DM to investigate the role of “supervised progressive resistance exercise training (PRT) protocol on insulin sensitivity, glycaemia, lipids and body composition in Asian Indians”. They concluded that moderate-intensity progressive resistance training for 3 months was effective and shown significant improvement in “insulin sensitivity, glycaemia, lipids, truncal and peripheral subcutaneous adipose tissue compartments in patients with T2DM”. The result suggested that, “resistance training should be an integral part of exercise regimen in Asian Indians with T2DM”. Arora et al., (2009) analyzed the “effects of eight weeks of progressive resistance training (PRT) compared with aerobic exercise on glycaemic control, metabolic profile, cardiovascular fitness parameters and general well being in adults with T2DM”. They found that both progressive resistance training and aerobic exercise were helpful in improving the metabolic variables in adults with T2DM.

Hills et al., (2009) did a review to “address the importance of resistance training to obese adults with T2DM”. Evidences suggest that high level of cardio respiratory fitness does not require for the commencement of resistance training, therefore it represents an initial point in a weight management programme. They suggested that resistance training should be a basic component of exercise prescription for untrained, obese, diabetic individuals.
Sigal et al., (2006) evaluated the “effects of aerobic training alone, resistance training alone, and combined exercise training” on HbA1c values in 251 patients (aged between 39-70 yrs) with T2DM. He found that “combined exercise training resulted in an additional change in HbA1c value of -0.46 percentage point compared with aerobic training alone and -0.59 percentage point compared with resistance training alone”. They concluded that, either “aerobic or resistance training” alone improves glycaemic control in T2DM, but the improvements are greatest with “combined aerobic and resistance training”. They suggested that, people with T2DM should be encouraged to perform resistance exercise three times a week.

Extensive research has been carried out on the “effects of aerobic and resistance training” in T2DM individuals. Colberg et al., (2010) carried out another systematic review of exercise and T2DM. In this review they discussed post exercise glycaemic control of aerobic and resistance exercise and concluded that, both “aerobic and resistance training helps in the management of blood glucose levels, lipids, blood pressure, cardiovascular risk, mortality and quality of life”.

In the light of available evidences, it appears that aerobic training could be an effective intervention to assist glycaemic and metabolic control. Several prospective studies have shown that physical activity does play an important role in the prevention and management of T2DM. For most patients, the exercise program should include both aerobic and resistance exercises. In the absence of contraindications, patients with diabetes should be encouraged to perform resistance exercise three times a week, including all major muscle groups. The role of exercise in preventing the progression from insulin resistance to impaired glucose tolerance has been brought out by several studies in the recent years. It is evident that regular physical exercise can prevent and manage the glucose control in T2DM. Thus resistance and aerobic exercises have a useful role in the control of diabetes and prevention of its long term complications.
2.6  EFFICACY OF PEDOMETER BASED INTERVENTION IN T2DM

Large numbers of extensive studies have been conducted that have used pedometer as a motivational and measurement tool of tracking physical activity through walking. Apart from the above mentioned studies in this section, an attempt has been made to review all the available evidences to determine the effect of pedometer based intervention in reducing the risk for and manage T2DM.

Diedrich et al., (2010) did a pragmatic randomized control trial study on 53 T2DM patients to investigate the effect of self management program with or without pedometer. They found that levels of HbA1c and weight were significantly reduced in both the groups among 33 participants but diastolic blood pressure was decreased only in pedometer group. Authors concluded that pedometers are a helpful motivational tool for T2DM to make their lifestyle more active.

In 2001, Tudor-Locke et al., did a cross-sectional study and presented first normative data on “pedometer-determined ambulatory activity” in individuals with T2DM. They found distinct and consistent inverse relationship between steps/day and body mass index. Locke and colleagues also suggested “objective quantification of ambulatory activity” via simple and inexpensive pedometers that permits researchers and practitioners to easily screen for level of activity along a continuum. Later in 2004, Tudor-Locke and colleagues proposed the preliminary indices to classify pedometer-determined physical activity in healthy adults: (i) <5000 steps/day may be used as a ‘sedentary lifestyle index’ ; (ii) 5000-7499 steps/day includes daily activities excluding volitional sports/exercise and considered as ‘low active’ (iii) 7500-9999 likely includes some volitional activities and considered as ‘somewhat active’ and (iv) ≥ 10000 steps/day indicates the point that should be used to classify individuals as ‘active’. Individuals who take > 12 500 steps/day are likely to be classified as ‘highly active’. In 2004, a randomized control study by Tudor- Locke et al., where he compared the First Step Program (FSP)-(an intervention designed to physical activity in sedentary
individuals) with T2DM using goal setting and pedometers against controls. Authors conclude that, while no other changes were found between groups, “FSP was a practical intervention that elicits an immediate and profound change in walking behaviour”. It also constitutes an important first step towards increasing physical activity among T2DM. They are considered “valid and reliable tools with which to measure physical activity through walking” (Tudor-Locke et al., 2002) pedometers have been promoted as motivational tools.

Richardson et al., 2007 did a pilot randomized trial to compared two pedometer based protocols that used either lifestyle (steps/day) or structured (duration and intensity) goal setting to increase the intensity of physical activity. 35 T2DM were randomized and 30 patients completed the study. After 6 weeks both groups showed improvement, with no difference between groups other than the pedometer group demonstrated greater satisfaction with the intervention. They concluded that participants are more comfortable with pedometer based walking programs. Richardson et al., 2008 carried out a meta-analysis of pedometer based walking interventions and weight loss. In this meta-analysis, they searched 6 electronic databases and contacted pedometer experts to identify pedometer based walking studies without a dietary intervention that reported weight change as an outcome. Authors cited that on an average, participants lost 0.05 kg per week during the interventions. Results from 9 cohort studies showed consistent outcome with previous findings, that increasing moderate-intensity physical activity tends to result in a modest amount of weight loss but longer programs lead to more weight loss than shorter programs.

Johnson et al., (2005) conducted cohort study to investigate the use of pedometers and stopwatches to increase the intensity of physical activity. 11 individuals with T2DM were recruited and 8 participants completed 12 week pedometer based intervention and showed significant improvements in cardio respiratory fitness. They found that pedometers and stopwatches, when introduced within educational framework designed can serve to facilitate increased walking intensity for people with T2DM. In
another study Johnson et al., 2009 examined the impact of two different lifestyle programmes on “cardiovascular health and glycaemic control” among people with T2DM. The study protocol consisted of 2 phases that lasts for 24 weeks. Results for 37 subjects at 24 weeks showed significant improvement in weight, BMI and blood pressure (P<0.001) from baseline for both groups, suggesting that even a minimally intensive pedometer-based intervention can have positive effect on increasing physical activity in patients with T2DM..

Arazia et al., 2006 studied whether a recommendation to walk 10,000 steps per day would result in significant improvement in glycaemic control, insulin sensitivity and cardiovascular risk in patients with T2DM. Results at 6 weeks showed a significant improvement in physical activity among the pedometer group vs. control group. They concluded that pedometer may prove to be an effective tool for promoting health lifestyle changes.

Chan et al., 2003 investigated the cross-sectional relationship of pedometer-determined ambulatory activity on general indicators of health. Results of the study indicate that fewer steps/day are associated with increased BMI, waist circumference, diastolic blood pressure and components of the metabolic syndrome. Conclusions regarding pedometer determined activity and health outcomes are limited by cross-sectional design and small sample size in this study; so further studies were required to verify findings. A randomized controlled study on 29 T2DM men by Bjorgaas et al., (2005), investigated the relationship between pedometer registered activity, aerobic capacity and self reported activity with fitness before and after a 12 week exercise. Subjects were divided into exercise and control groups. Results showed positive correlation between pedometers registered activity and aerobic capacity.

Apart from above mentioned studies, some other evidences were also found which stated that pedometer does not enhance beneficial metabolic outcomes. Bjorgaas et al., 2008 did a systematic review to examine the effect of pedometer on T2DM or
those who were overweight/ or inactive. This review found that most studies do not
investigate pedometers effect in isolation that makes it difficult to associate outcomes to
pedometers. Authors concluded that, pedometer have thus far failed to show an effect
on physical activity in those who are overweight, inactive or have T2DM. However, this
review does not provide evidences to support previous literature and is contrary to the
meta-analysis by Richardson et al., (2008). Again in 2008 Bjorgaas et al., conducted a
study, where they randomized 70 T2DM patients to an exercise counselling intervention
with or without pedometers. Results from 48 patients at 6 months showed significant
benefits for all patients in the study from baseline, there were no significant benefits
achieved among those in the pedometer intervention group over the non pedometer
group. Conflicting results from these above mentioned systematic reviews leave the
practicing clinicians in a state of dilemma of choosing the best exercise protocol for
treating and preventing patients with T2DM. But still the school of thought narrating
benefits of pedometer based intervention for patients with T2DM overrides the contrary
school of thought.

A 2010 study by Geef et al., investigated the “benefits of a pedometer and a
cognitive behavioural group intervention for promoting physical activity in T2DM
patients”. Results of the study documented that combination of a “12-week cognitive-
behavioural intervention and a pedometer has a significant short term impact on daily
steps and sedentary behaviour” but the “effects on total physical activity and long term
effects were limited”. A 2010 Finnish study (Korkiakangas et al.) examined the
experiences of participants at high risk of T2DM who began using a pedometer. 74
patients were recruited and results showed a significant increase in those using the
pedometer regularly. Qualitative analysis indicated that perceived benefits of the
pedometers included continual feedback on patients’ activity levels and the ability to set
specific activity goals. While barriers to pedometer use were associated with functional
failures and inability of the pedometers to measure activity other than walking.
A 2011 U.S. study by Weinstock et al., determine the effects of the “Informatics for Diabetes Education and Telemedicine (IDEATel) intervention and pedometer use on physical activity and impairment in older adults” with T2DM. They concluded that “pedometer use played a significant mediating role in the reductions of physical activity and physical impairment in IDEATel telemedicine program for comprehensive diabetes management”.

A 2008 Polish study (Kempny et al.,) randomized 30 T2DM patients to an intervention group (Pedometer + Advice) intervention vs. control group (Advice only) to increase physical activity. Subjects in the experimental group achieved significantly higher level of physical activity after 1 and 5 weeks where as control group did not. They concluded that oral advice has small effect on time spent on walking among patients with T2DM. Providing a pedometer with internal memory makes such advice more effective. Regarding the efficacy of supervised walking program Negri et al. (2010) reported that, supervised walking may be beneficial as it induces favourable changes and increases functional capacity in diabetic subjects but compliance remains a crucial issue.

Croteau et al., (2007) assessed the effectiveness of a “12 week pedometer based intervention on the daily step counts of older adults” residing in community. They randomized 147 older adults to a pedometer intervention or usual care. Results at 12 weeks showed a significant increase in steps/day for the pedometer group compared to control group. Controlled group was enrolled in intervention after 12 weeks and at the end of 24 weeks a significant increase in steps/day was observed for both groups. Authors conclude that the use of pedometer was effective in increasing step counts of study participants. VanWormer et al., (2006) examined whether an online program of “10,000 Steps” with pedometer, could help a “large worksite population increase their walking and lose weight”. This was an 8 week pedometer program emphasized upon increased walking, to improve general health conditions related to physical activity. The results of this cohort study showed that 10,000 steps program was effective in
promoting a moderate increase in short term physical activity i.e. 1, 163 steps per day over 8 weeks. A 12 week randomized control trial using pedometer and text messaging to increase physical activity in adolescents with T1DM was evaluated by Newton et al., (2009). Result of the study stated that pedometers and weekly text messaging as motivational tool did not increase physical activity in adolescents with T1DM over 12 week period while the study was small and underpowered as adherence to pedometer use among this population was low.

A randomized controlled trial was conducted by Shenoy et al., (2010) in Indians to evaluate the effect of 8 week “aerobic walking using heart rate monitor and pedometer for monitoring exercise intensity” on glycaemic and cardiovascular parameters. 40 T2DM patients were randomized to a pedometer based intervention vs. control. Results of the study showed that pedometer based aerobic walking program is helpful in changing the values of glycaemic control, cardiovascular factors and general well being. A 2007 U.S. randomized control trial by Licht., 2007 compared a pedometer based physical activity intervention with goal setting vs. standard educational materials in 28 Africans-Americans and Hispanics aged above 55 with T2DM. After 6 months, intervention group increased their caloric output by twice than that of controls and also increased moderate intense physical activity by more than eight times. They concluded that giving pedometer to older T2DM patients with a goal to meet may be enough to get them moving.

Strycker et al., (2007) in their study attempted to document and compare “mean steps/day, demographic predictors of steps/day and reliability of pedometer in two longitudinal investigations”. Investigations were based on youth sample vs. postmenopausal women with T2DM. They reported mean steps/day as “10,365 steps in the youth sample and 4,352 steps in the sample of older women”. Results suggested that pedometers are user friendly and are “cost effective objective measure of walking” both young and older adult population. Pal et al., (2009) cited that, setting a step goal and the immediate feedback from pedometer acts as a key motivational factor for increasing
physical activity. Kobayashi and colleagues., 2006 carried out their study to clarify the effects of walking with a pedometer on metabolic parameters, including adiponectin (APN). They concluded that, walking with a pedometer is effective for improving metabolic profile parameters but is not significant to increase adiponectin levels.

Kim (2010) did a pilot study to determine the accuracy, reliability and validity of pedometer use by older adults living independently and suggested that pedometers can provide a reliable and valid measure of physical activity. A review of the literature conducted by Albright and Thompson, 2006 examine the effect of walking programs on cardiovascular risk in women with regard to pedometer. They concluded that, pedometer monitored walking has been found to be effective in improving risk factors of cardiovascular diseases in women. Using a pedometer as a set step goal is of great interest, as this method of exercise prescription does not involve an intensity recommendation and relies solely on increasing overall daily walking. This review has shown that pedometer monitored walking may also lead to better adherence in women because of the less regimented exercise routine, allowing them to fit it into their daily lifestyle. Cocker et al., (2009) examined whether “self selected pedometer use in the intervention sample was associated with individual characteristics (gender, age, education, employment status, self reported health, baseline step counts, baseline sitting time)” and “intervention exposure variables (hearing or seeing a physical activity promotion message, knowing the amount of physical activity required for health benefits and knowing about 10,000 steps)”. They reported that use of pedometer was like by older participants and by those who knows about “10,000 steps” campaign. However, it was suggested that “age and intervention” awareness were attributed by pedometer use, that turn into a significant predictor of step count increase.

The findings of the above studies support that the extensive self monitoring of physical activity can be an integral part of the management in T2DM individuals. Patients are often unaware of the importance of exercise and its relationship to glucose
control. Many studies have shown that a well designed exercise plan can improve the lifestyle in people with T2DM.

Engel and Lindner (2006), studied 57 overweight/obese T2DM patients to investigate the impact of physical activity coaching intervention with or without a pedometer. Results showed that, both groups significantly improved their weight, cardiovascular fitness and waist circumference from baseline to 6 months. Author concluded that a coaching intervention can improve physical activity for T2DM patients but using pedometer added no further benefits.

Any increase in physical activity is to be encouraged and positively reinforced in T2DM. Sustained increase in physical activity through walking with pedometer has also been shown to improve glucose control, metabolic control and cardiovascular fitness independently. Physical activity must also be targeted according to the need of individuals with appropriate guidance and support.

The review of literature presented in this chapter has been found to be quite useful in designing the present study. Both school of thoughts, one supporting pedometer based intervention and other denying the importance of pedometer based intervention were extensively studied before drafting current study.

Present study aims to bridge lacuna in literature by determining effectiveness of two different target setting approaches using “pedometer based walking program”;

1. Employing supervised exercise group with pedometer.

2. Employing self-reported group with pedometer.