EDITORIAL

Too much Sitting: A Potential Health Hazard and a Global Call to Action

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The rapid evolution and conversion of societies towards technology savvy urban lifestyle is adversely affecting the general health of modern humans with majority of them unaware of the potential insidious hazards of sitting too much. The prolonged sitting behavior has popped into our daily lives in a big way *via* rapid technology advancements and evolution of workplace, home, community, transport and business. Too much sitting, also termed as sedentary behavior, is characterized by very low-energy expenditure and is associated mostly with television (TV) viewing, desk-bound office work, screen-based work/viewing, studies, and use of transport. However, sedentary physiology is separate and distinct from exercise physiology (Figure **1**) [1]. The studies conducted during the last decade have clearly demonstrated that sedentary behavior is associated with adverse health outcomes such as premature mortality, and increased risk of type 2 diabetes, cancer, obesity and cardiovascular disease (CVD) and other metabolic disorders [2] (Figure **2**). It also effects the psychosocial and cardiometabolic health [1]. The recent studies further suggest that prolonged sitting adversely affects the cardiovascular and metabolic health of adults, irrespective of whether they meet the physical activity guidelines [3] (Figure **3**). Another study has further demonstrated that the time spent sitting is independently associated with total mortality, regardless of the level of physical activity [4, 5]. The association was consistent across the sexes, age groups and body mass index categories [5]. These detrimental effects are sustained in subjects even though they spend their leisure time in physical activity. Therefore, too much sitting is a global health hazard that is making the population more prone to debilitating and life-threatening chronic diseases. It is seriously impacting the work performance of employees. The sedentary lifestyle and its physiological and health implications has been intensively reviewed by many researchers during the last few years [6-9].

The assessment of sedentary behavior can be done by International Physical Activity Questionnaire [10] or by accelerometers [11, 12]. The accelerometer counts of <100 cpm are characteristic of the sedentary behavior, whereas counts of >100 cpm are considered as active state or a break of sedentary behavior. Several prospective studies and trials have been conducted to look into the biomolecular mechanisms pertaining to the adverse effects of prolonged sitting on the general health of the population. The AusDiab study employed the accelerometer-based measurement of the time spent in sedentary, light-intensity physical activity and moderate-vigorous physical activity in Australian adults [13]. It was observed that an adult spends half to two-thirds of her/his waking hours as sedentary, which may lead to uncharacterized biomolecular mechanisms that result into deleterious health consequences. The TV viewing time was associated with increased risk of all-cause and CVD mortality [13]. A typical adult can have sitting opportunities of about 15.5 h that can account for more than 95% of the waking hours, as shown in a recent report [14] (Figure **4**). The US National Health and Nutrition Examination Survey has reported similar findings that US adults spend more than 10.2 h in sedentary lifestyle and about 4.1 h in light-intensity activity [15] (Figure **5**). The breaking up of sedentary time has been found to be beneficial as demonstrated by the effects on metabolic biomarkers, high density lipoprotein (HDL)-cholesterol, C-reactive protein, insulin, homeostasis model assessment of steady state

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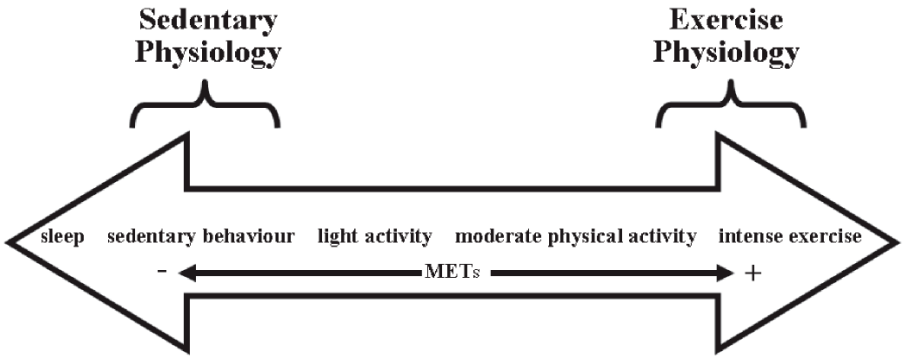

Figure 1: The movement continuum, illustrating the varying focus of sedentary physiology and exercise physiology [1]. METs are the metabolic equivalent tasks. Reproduced with permission from NRC Research Press.

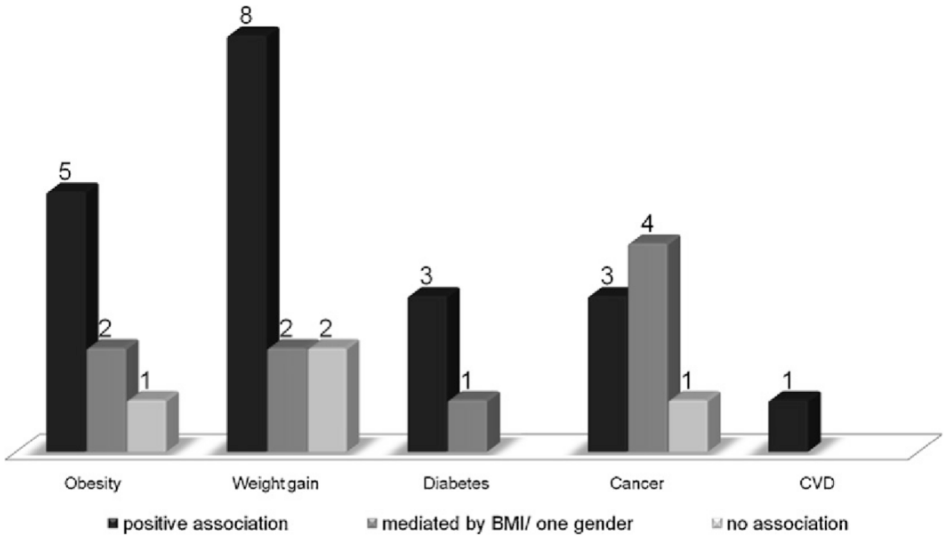

Figure 2: Summary view of the evidence from prospective studies conducted from 1996 to January 2011 demonstrating the associations of sedentary time with deleterious health outcomes [8]. The numbers in the graph are the number of studies. Reproduced with permission from Elsevier Inc.

beta cell function (HOMA-%B) and insulin sensitivity (HOMA-%S), waist circumference, triglycerides, body mass index, 2 h plasma glucose and mortality [7, 16-18]. The simple approach of 'Stand Up, Sit Less and Move More' is effective in critically reducing the occupational sitting time [19]. Another strategy based on the use of Sit-Stand workstations (Figure **6**) is also an effective way of reducing the occupational sitting time [20]. The use of point-of-choice prompting software on the computer at work has also been demonstrated to be useful in breaking up the sedentary time [21]. The Take-a-Stand Project 2011 in Minnesota, USA also demonstrated that a simple intervention using a sit-stand device can significantly reduce the sitting time by 66 min per day and lead to improved health outcomes in terms of reduced upper back and neck pain, and improved mood [22]. Therefore, sedentary behavior is a modifiable health risk that can be effectively managed by simple or light activity-based lifestyle interventions.

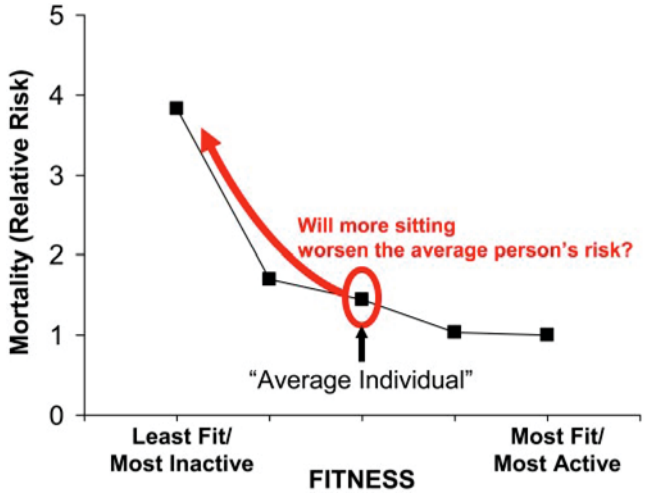

Figure 3: A major question raised by the inactivity physiology paradigm is whether the typical person who already does not perform structured exercise regularly will have increased risks of metabolic diseases in the coming years as a result of too much sitting. The red circle shadows the median of 13,344 middle-aged men and women [26]. Reproduced with permission from the American Medical Association.

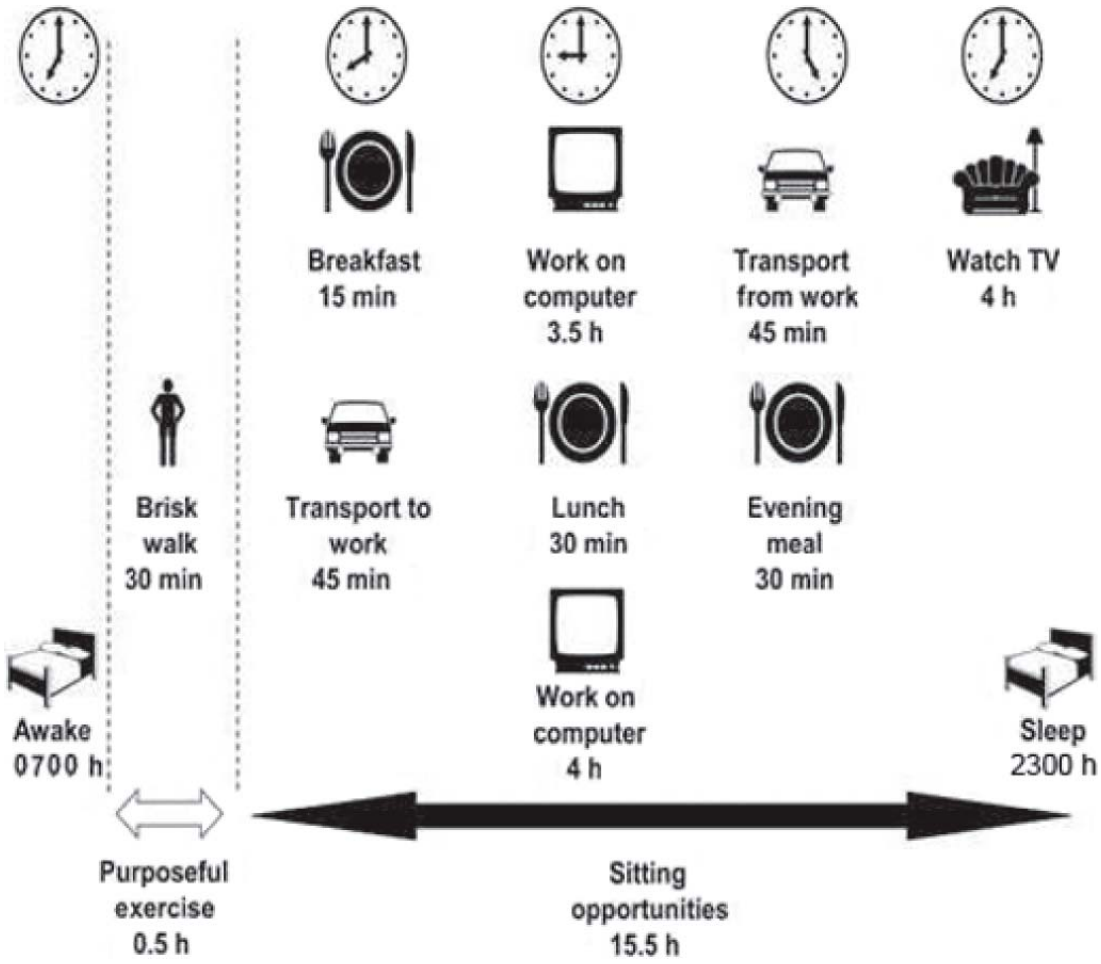

Figure 4: Major contexts for sedentary behavior and their distribution over a typical adult's waking hours [14]. Reproduced with permission from Touch Medical Media, European Endrocrinology.

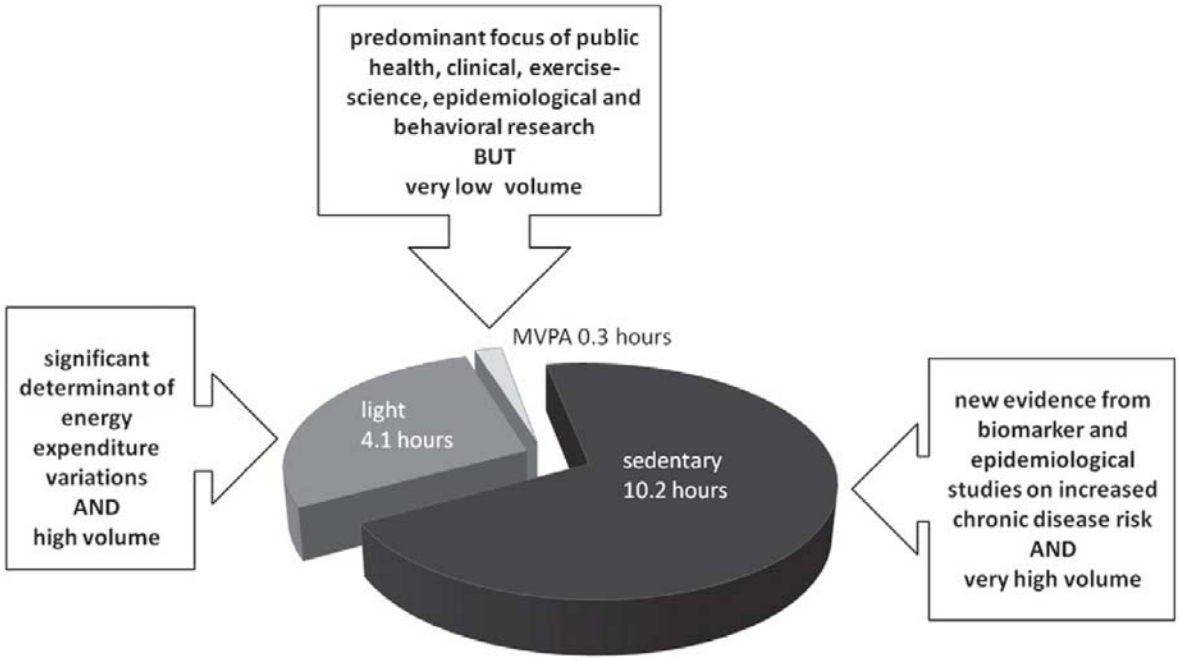

Figure 5: Accelerometer measured time spent in sedentary, light-intensity physical activity and moderate-vigorous physical activity in Australian adults (AusDiab) [27]. Reproduced with permission from Elsevier Inc.

Figure 6: Sit-stand devices used in the Take-a-Stand Project, Minneapolis, Minnesota, 2011 [22]. Reproduced with permission from PubMed Central.

However, the heterogeneity of the study designs, measures and findings of the studies conducted till date to demonstrate the relationship between occupational sitting and health risks has led to inconsistencies in results [9]. So they cannot be taken into account to draw definite conclusions about the association between sedentary behavior and adverse health risks. Therefore, there is a dire need to formulate the uniform set of guidelines that can be followed globally to study the effects of sedentary behavior and interventions (for breaking up the sedentary behavior) on the health of individuals. The biological mechanisms underlying the deleterious health outcomes of sedentary behavior further needs to be discerned *via* rigorous experimental studies. Moreover, there is a need to fully understand the determinants of sedentary behavior, such as environmental, social, occupational and personal factors.

Taking into account that the deleterious effects of too much sitting has been well known, there is a urgent need to consider the sedentary behavior as a global health hazard and to implement public awareness programs and lifestyle intervention measures to counteract this modifiable health risk. This substantiates the need of a global call to action against sedentary behavior. The World Health Organisation and World Economic Forum has mentioned the workplace to be an important setting for health promotion action [23]. The coming years will witness prospective scientific findings and breakthroughs, and more effective interventions that will lead to increased understanding and prevention of the sedentary behavior. They will pave way to evidence-based public health strategies and implementation of highly effective population-wide large-scale interventions aimed at reducing the sedentary behavior. Further, there is an need to step up personalized mobile healthcare efforts *via* smartphones/gadgets [24, 25], which have become ubiquitous and can play a key role in assisting the large-scale global interventions aimed at reducing prolonged sitting. A smart application can also be installed in all such devices including smart TVs and smart watches, which can issue regular alerts to the users motivating them to do some light exercises or proven interventions for breaking up the sedentary behavior after regular time intervals. The benefits of increased physical activity on health are already well known to everyone. There might also be an option in near future that the desired interventions based on the use of light exercise devices can be interfaced with TV, computer or gadget. A lot of emerging healthcare companies such as iHealth and Runtastic have already started the pioneering trend towards the development and commercialization of wearable/portable devices interfaced with smartphones for personalized healthcare monitoring and management [24].

REFERENCES

[1] Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N. Physiological and health implications of a sedentary lifestyle. Appl Physiol Nutr Metab 2010; 35(6): 725-40. http://dx.doi.org/10.1139/H10-079

[2] Hamilton MT, Hamilton DG, Zderic TW. Role of low energy expenditure and sitting in obesity, metabolic syndrome, type 2 diabetes, and cardiovascular disease. Diabetes 2007; 56(11): 2655-67. http://dx.doi.org/10.2337/db07-0882

[3] Hamilton MT, Healy GN, Dunstan DW, Zderic TW, Owen N. Too Little Exercise and Too Much Sitting: Inactivity Physiology and the Need for New Recommendations on Sedentary Behavior. Curr Cardiovasc Risk Rep 2008; 2(4): 292-8. http://dx.doi.org/10.1007/s12170-008-0054-8

[4] Patel AV, Bernstein L, Deka A, Feigelson HS, Campbell PT, Gapstur SM, *et al*. Leisure time spent sitting in relation to total mortality in a prospective cohort of US adults. Am J Epidemiol 2010; 172(4): 419-29. http://dx.doi.org/10.1093/aje/kwq155

[5] van der Ploeg HP, Chey T, Korda RJ, Banks E, Bauman A. Sitting time and all-cause mortality risk in 222 497 Australian adults. Arch Intern Med 2012; 172(6): 494-500. http://dx.doi.org/10.1001/archinternmed.2011.2174

[6] Dunstan DW, Howard B, Healy GN, Owen N. Too much sitting--a health hazard. Diabetes Res Clin Pract 2012; 97(3): 368-76. http://dx.doi.org/10.1016/j.diabres.2012.05.020

[7] Owen N, Healy GN, Matthews CE, Dunstan DW. Too much sitting: the population health science of sedentary behavior. Exercise Sport Sci R 2010; 38(3): 105-13. http://dx.doi.org/10.1097/JES.0b013e3181e373a2

[8] Thorp AA, Owen N, Neuhaus M, Dunstan DW. Sedentary behaviors and subsequent health outcomes in adults a systematic review of longitudinal studies, 1996-2011. Am J Prev Med 2011; 41(2): 207-15. http://dx.doi.org/10.1016/j.amepre.2011.05.004

[9] van Uffelen JG, Wong J, Chau JY, van der Ploeg HP, Riphagen I, Gilson ND, *et al*. Occupational sitting and health risks: a systematic review. Am J Prev Med 2010; 39(4): 379-88. http://dx.doi.org/10.1016/j.amepre.2010.05.024

[10] Rosenberg DE, Bull FC, Marshall AL, Sallis JF, Bauman AE. Assessment of sedentary behavior with the International Physical Activity Questionnaire. J Phys Act Health 2008; 5 Suppl 1: S30-44.

[11] Healy GN, Clark BK, Winkler EA, Gardiner PA, Brown WJ, Matthews CE. Measurement of adults' sedentary time in population-based studies. Am J Prev Med 2011; 41(2): 216-27. http://dx.doi.org/10.1016/j.amepre.2011.05.005

[12] Healy GN, Matthews CE, Dunstan DW, Winkler EA, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. Eur Heart J 2011; 32(5): 590-7. http://dx.doi.org/10.1093/eurheartj/ehq451

[13] Dunstan DW, Barr EL, Healy GN, Salmon J, Shaw JE, Balkau B, *et al*. Television viewing time and mortality: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). Circulation 2010; 121(3): 384-91. http://dx.doi.org/10.1161/CIRCULATIONAHA.109.894824

[14] Dunstan D, Healy GN, Sugiyama T, Owen N. Too Much Sitting and Metabolic Risk - Has Modern Technology Caught Up with Us? Eur Endocrinol 2010; 6(1): 19-23.

[15] Owen N. Sedentary behavior: understanding and influencing adults' prolonged sitting time. Prev Med 2012; 55(6): 535-9. http://dx.doi.org/10.1016/j.ypmed.2012.08.024

[16] Peddie MC, Bone JL, Rehrer NJ, Skeaff CM, Gray AR, Perry TL. Breaking prolonged sitting reduces postprandial glycemia in healthy, normal-weight adults: a randomized crossover trial. Am J Clin Nutr 2013; 98(2): 358-66. http://dx.doi.org/10.3945/ajcn.112.051763

[17] Dunstan DW, Kingwell BA, Larsen R, Healy GN, Cerin E, Hamilton MT, *et al*. Breaking up prolonged sitting reduces postprandial glucose and insulin responses. Diabetes Care 2012; 35(5): 976-83. http://dx.doi.org/10.2337/dc11-1931

[18] Healy GN, Dunstan DW, Salmon J, Cerin E, Shaw JE, Zimmet PZ, *et al*. Breaks in sedentary time: beneficial associations with metabolic risk. Diabetes Care 2008; 31(4): 661-6. http://dx.doi.org/10.2337/dc07-2046

[19] Healy GN, Eakin EG, Lamontagne AD, Owen N, Winkler EA, Wiesner G, *et al*. Reducing sitting time in office workers: short-term efficacy of a multicomponent intervention. Prev Med 2013; 57(1): 43-8. http://dx.doi.org/10.1016/j.ypmed.2013.04.004

[20] Alkhajah TA, Reeves MM, Eakin EG, Winkler EA, Owen N, Healy GN. Sit-stand workstations: a pilot intervention to reduce office sitting time. Am J Prev Med 2012; 43(3): 298-303. http://dx.doi.org/10.1016/j.amepre.2012.05.027

[21] Evans RE, Fawole HO, Sheriff SA, Dall PM, Grant PM, Ryan CG. Point-of-choice prompts to reduce sitting time at work: a randomized trial. Am J Prev Med 2012; 43(3): 293-7. http://dx.doi.org/10.1016/j.amepre.2012.05.010

[22] Pronk NP, Katz AS, Lowry M, Payfer JR. Peer Reviewed: Reducing Occupational Sitting Time and Improving Worker Health: The Take-a-Stand Project, 2011. Prev Chronic Dis 2012; 9.

[23] Preventing Noncommunicable Diseases in the Workplace through Diet and Physical Activity 2008. Available from: http://www.who.int/dietphysicalactivity/workplace/en/. (Accessed on 16.2.2015)

[24] Vashist SK, Schneider EM, Luong JHT. Commercial smartphone-based devices and smart applications for personalized healthcare monitoring and management. Diagnostics 2014; 4(3): 104-28. http://dx.doi.org/10.3390/diagnostics4030104

[25] Vashist SK, Mudanyali O, Schneider EM, Zengerle R, Ozcan A. Cellphone-based devices for bioanalytical sciences. Anal Bioanal Chem 2014; 406(14): 3263-77. http://dx.doi.org/10.1007/s00216-013-7473-1

[26] Blair SN, Kohl HW, Paffenbarger RS, Clark DG, Cooper KH, Gibbons LW. Physical fitness and all-cause mortality. A prospective study of healthy men and women. JAMA 1989; 262(17): 2395-401. http://dx.doi.org/10.1001/jama.1989.03430170057028

[27] Owen N, Sparling PB, Healy GN, Dunstan DW, Matthews CE, editors. Sedentary behavior: emerging evidence for a new health risk. Mayo Clin Proc; 2010: Elsevier.

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http://dx.doi.org/10.6000/1927-5129.2015.11.18