

The Effect of Sedentary Behaviors in Mid-Life Population and Subsequent Cardiometabolic Diseases as Consequences of Inactivity: A Review of Prospective Studies

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Abstract

This literature review focuses on mechanisms that are involved in the phenomenon of “sedentary behavior” such as television viewing and work sitting, considering its impact on susceptibility to cardiovascular diseases and type 2 diabetes. As such the review tries to provide information on how the physical inactivity may be responsible for the development of chronic diseases. “Inactivity” is a term that can be used to describe the time that people spend not doing exercise. In terms of physical movement, “inactivity” can be determined as a minimal movement that the body implements. In terms of metabolic consumption, “inactivity” symbolizes a dimension in which the energy expenditure is equivalent to a resting metabolic trend. However, the study on the behaviour of sedentary can provide a wider spectrum of factors that concur to the development of diseases and a statement of the energy expenditure in sedentary actions. In sedentary behaviors are included reading, television viewing, work sitting, driving, or commuting, meditation or eating, talking with friends or on the telephone or other actions that do not include physical exercise. During the past decades many efforts have been made to try to determinate and quantify the physical activity in terms of validity and reliability estimation, and its incidence on morbidity. Since the past centuries until today it was noticed a general decrease in human energy expenditure and an increase in the sedentary lifestyle. Investigations have been also carried out on the alleged effects of the activity on morbidity. Clearly there is a need to review the research findings over the past years to provide an overview of the current state of knowledge on the underlying mechanisms governing the phenomenon of inactivity observed during prolonged period.

Physical Activity Fundamental to Preventing Diseases

This review paper focuses on mechanisms that are involved in the phenomenon of “sedentary activity” such as television viewing or work sitting for long period, taking into consideration the influence that this could have on the generation of cardiovascular diseases and type 2 diabetes. This literature review tries to provide information on how the physical inactivity may influence the development of chronic diseases. “Sedentary behaviour” is a term to describe the time that the individual spends inactive. Inactivity can be defined as a state in which bodily movement is minimal. In terms of energy expenditure, inactivity represents a state or behaviour for which energy expenditure approximates resting metabolic rate.

Common sedentary behaviors comprehend reading, television viewing, work sitting, driving, eating or other actions that do not include physical exercise [1]. Hill and colleagues [2] pointed out that in the past generations, people spent less amount of time sitting compare to people of new generation who spend increased time of period in environment in which physical activity is more limited and sitting time is more requested. In comparison to our family and grandparents, the new generation of people spend a greater amount of time in environments that unfortunately limit physical activity and require a lot of inactivity.

Important data shows that between 1989 and 2009, a greater number of households have a computer and access to internet. These data showed that the increase of households was from 15% to 69% [3]. Schools, public spaces, homes, and work places have been and continue to be designed in such a way that reduces the physical activity of people. These changes have had a multiple effect on human being behaviour: people spend more time sitting and less time to exercise. From another view, the human being was designed to move and this is basically important in terms of subsistence for the human species. Since the past centuries until today it was noticed a general increase in the sedentary lifestyle and a decrease in human energy expenditure. Historically, efforts have been made to try to determinate and quantify the physical activity in terms of validity and reliability estimation, and its incidence on morbidity. Investigations have been also carried out on the alleged effects of the activity on morbidity.

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Human motion is an intricate behaviour which is affected by different elements such as: personal stimulation, health status, genetical factors, mobility problems, and social conditions in which people live. All these factors doubtless operate a control on the desire to be more involved in sedentary behaviour rather than in physical activity.

Sedentary Behaviors Increase Cardiometabolic Risk

A study by Warren *et al* [4]. Confirmed that, sedentary behaviors such as: spend time riding in a car, TV viewing, sitting time and other sedentary activities, are strongly associated with cardiovascular risks and high mortality rate. The purpose of the study by Warren was to evaluate the relationship between two very common sedentary behaviors, spend time riding in a car and TV viewing, with cardiovascular mortality rate in men. Further results from this study showed that men who were physical active, older, with no pressure problems, in normal body weight had lower risks of cardiovascular mortality.

Work conducted in the past by Morris and Crawford [5] showed that there was a positive relationship between men who had a sedentary job and the incidence of cardiovascular disease. From this study, it was seen that the London bus drivers were 1.8 times more likely to get into coronary diseases than bus conductors. Though the time spent driving the bus has not been calculated, it can be presumed that the bus drivers spent more hours per week driving than the bus conductors. Research point out that physical activity can help prevent cardiovascular diseases and mortality [6], and it was showed that people less active than other people have a higher index association of diabetes [7], hypertension [8], and cancer [9], becoming part of that group of individuals who have higher mortality risk [10].

Recently new researches work is starting to highlight relevant physiological processes which could explain the health risks nature in people and how these risks appear to be correlated to sedentary behaviors. Some of the main physiological processes may include: glucose homeostasis, alterations to cardiac functioning, lipid metabolism [7]. Recent papers show that physiological processes associated with extreme sedentary behaviors are different in nature than physiological processes which are activated by the body during a regular physical activity. In fact, during the physical activity, in terms of physiological mechanisms, the body will get benefits from the exercise itself [7]. This could clarify why men who were physically active and manifest high percentage of sedentary behavior at the same time, showed in this study, to have elevated risk of cardiovascular mortality [7].

The importance of the relationship between sedentary behaviour aspects and cardiovascular risk factors pointed out in the study by Warren and colleagues⁴ is scientifically considerable. In this study, a large number of human subjects were tested (7,744 men). Participants who spent more than 10 hours per week riding in a car or spent more than 23 hours per week in sedentary behaviors reported strongly higher risks of cardiovascular mortality. However, it is recommended that men should increase their physical activity levels and decrease their sedentary behaviors in order to reduce the probability to develop risks of cardiovascular mortality. Emerging evidence presented by Hamilton *et al* [11]. On the deleterious effects of sedentary behaviour, as it is underpinned by the unique physiology

of inactivity, are witness to the fact that exhortations on reducing sedentary behaviors in people of different age should be expanded to give an efficiency public health system using necessary information to improve their efficacy in promoting physical activity. Hamilton approaches the topic on the fact that it is time to consider excessive sitting a serious health hazard, with the potential for ultimately giving consideration to the inclusion of too much sitting (or too few breaks from sitting) in physical activity and health guidelines [11].

It was observed a strong increase in the rate of Type 2 Diabetes Mellitus (T2DM). From the beginning T2DM was seen as a disease of older people, despite this T2DM presently is also found in children and young people and between 1998 and 2005 was noted in the United Kingdom that the T2DM was eight times higher in young adults [12]. It was showed that younger people with T2DM have a greater probability of being obese, have family members who have diabetes, conduct a sedentary life, be of poor ethnicity and low social extraction [13]. People affected by diabetes showed to be influenced also by other malfunctions of the body. One on five young adults with T2DM showed to have kidney function problems. Four on five young adults with T2DM showed to have lipids metabolism problems, and half of them showed to have hypertension problems [14].

These malfunctions reported above can be easily converted into an increased risk of disease and mortality; for instance, the risk of developing a heart attack in early type T2DM (< 45 years) in people is four times higher compare to late type T2DM (> 45 years), and fourteen times higher compare to people who do not have diabetes T2DM [15]. From the view point of a future vision, the bang of so many people who are developing T2DM in so a short time could be very harmful for the social economic status (workforce) and for the health system. It is very important that effective measures regarding the lifestyle of people are taken and used in order to prevent the development of diabetes especially among young adults who are most at risk.

Dunstan *et al* [16]. Showed interesting evidence on correlations of TV watching, practice of physical activity, and metabolic syndrome in a group of Australian people. From this study was observed that a large sample of Australian adults, who spent a lot of time in sedentary behaviour, was correlated with a higher incidence of metabolic syndrome in people, related to the amount of physical activity that they were practicing. According to the physical activity guidelines provided by the public health system, physical activity was considered as responsible for a decreased incidence of factors of metabolic syndrome in people. The study by Dunstan *et al* [16]. Confirmed that a positive relationship pointed out between TV watching and metabolic syndrome factors is relevant. Other studies also affirm an indirectly proportional relationship between physical activity and factors responsible for the development of the metabolic syndrome, and a linear association between physical activity and the metabolic syndrome risk factors [17].

Excessive time spent watching television may be also related to incorrect eating behaviors [18], despite this, the study conducted by Dunstan *et al* [16] highlighted that the correlation between time spent watching television and the metabolic syndrome was not related to the food eaten. Lately, it was showed that certain types of enzymes, such as the lipoprotein lipase enzyme, may be led by the continuous process of physical activity, and these enzymes may be very sensitive

to physical inactivity changing their functioning [19]. This highlights the assumption that independent sedentary activity metabolic effects might exist (as showed by watching television).

Dunstan *et al* [16]. Reported relevant evidences on the relationship between TV viewing time and important physiological mechanisms such as dyslipidaemia and insulin resistance in men. This study discovered that a correlation between these factors was showed by waist circumference. Contrarily, relations with dyslipidaemia and insulin resistance in women stayed relevant despite modifications for the waist circumferences, indicating that other processes than those linked to the obesity may concur to increase the risks factors for the metabolic syndrome in women who will spend long time in watching television. Jakes *et al* [20]. Hypothesized that an inversely proportional relationship between physical activity and Blood Pressure (BP) may be exist. It has recently been shown that, a positive relationship between physical activity and hypertension, after modifications for the waist circumferences exist in men [16]. Cross-sectional study provides evidences that the blood pressure decreases the risks responsible for the hypertension condition [21].

Other cross-sectional studies conducted in young people (24-25 years) by Sharabi *et al* [22] from Israel, demonstrated that a positive relationship between physical activity and hypertension exist in men, but a non-relevant positive relationship between these two factors was significantly seen in women. It is conceivable that during that daily activity, women dedicate higher amount of time doing light to moderate activity, rather than men who dedicate higher amount of time doing vigorous activity. This concept is well standing by Dunstan [16] who stated that though the physical activity (including also vigorous physical activity) seemed to have a positive relationship with the metabolic syndrome factors in men, it was also noticed that this relationship became negative (there was no correlation anymore between physical activity and metabolic syndrome components) when the vigorous physical activity was not practiced. Results by Dunstan [16] also highlighted that, when moderate physical activity and walking were not practiced, the reduction in risk of the metabolic syndrome (in relation to vigorous activity) was more pronounced, and this occurred more in women than in men.

Dunstan *et al* [16] also reported that the relationship between the metabolic syndrome and TV watching time resulted to be higher in women than in men. An alleged explanation for this report could be that women may spend more time in sedentary behaviors, and this could interpret the fact that the association between physical activity, TV watching time and the metabolic syndrome components has been found to be most significant in women than in men.

ActivPAL™: A New Perspective to Monitor Physical Activity

Attainable measures of physical activity are requested in order to investigate the activity levels of people, to examine the relation with diseases, and to consider which interventions by the public health would be more suitable to take for the population [23]. Recently, new technologies have been discovered. These new technologies appeared be able to improve the physical activity assessments. The newer accelerometers are composed by specific sensitive microsensors which are able to distinguish dynamic accelerations and static accelerations, and thanks to this the accelerometer will be able to recognize also different postures (sitting, standing, stepping, lying)

in people who are wearing the device. These accelerometers can recognize the inclination of the legs to catalogue the times that the subject is spending sitting, stepping, standing, or lying.

The ActivPAL™ physical activity logger is a new accelerometer which can provide specific information on step rates. It is composed by single unit, and it is uniaxial. The ActivPAL™ can collect in real time a maximum of seven days of information. A study by Harrington *et al* [24]. Confirmed that starting from the point that new accelerometer devices now are available to measure posture and leg inclinations, scientists have evidenced the comfort ability of using the ActivPAL to determine and quantify sedentary behaviour levels in people.

As a part of the investigation described by Harrington [24] sedentary levels of adolescent females during 24 daily hours on days spent in the weekend and days spent in the week were taken into consideration during the entire day of school. However, an important evidence is that, data by Harrington [24] showed that the female students spent more time in sedentary behaviour during the weekdays than the weekend days. Results from this study indicate that may be necessary to develop new school interventions in order to reduce the inactivity bouts during the time spent in school [24].

Cardiovascular Risk Factors in Youth People

Cardiovascular diseases continue to be one of the major causes of death in people. As seen so far in the past recent experimental studies showed that risk of cardiometabolic disease in adults such as hypertension, insulin-resistance, and dyslipidaemias begin in childhood and continue into adulthood [25,26]. Further research by Eisenmann [27], confirmed that cardiovascular risk in adolescent and children increased in recent years, and studies related to this phenomena showed that as a causative factor of cardiovascular risks is the obesity preponderance which has reached very high levels in the population.

Martínez-Gómez *et al* [28]. Have shown interesting evidence on the relationship between the abdominal and general adiposity with cardiometabolic risk factors in a group. The other purpose of this study was to assess the correlation between periods of time spent in sedentary activity by estimating various cardiovascular risk factors in young people. Results by Martínez-Gomez [28] indicate that the periods of time that young people spent in sedentary activity everyday was correlated with greater probability of cardiovascular risk. In fact, adolescents who were more involved every day in inactive behaviors demonstrated upper levels in some of the risk factors examined such as glucose, Triglycerides (TG), and Systolic Blood Pressure (SBP). Rates of cardiovascular risk index that was used showed to be worse as well.

Though TV watching time can appear a relevant portion of the time that adolescents invested in sedentary activities, it will need a long step before being a suitable indicator of the everyday quantity of time implied in the global sedentary activities. Findings achieved in the study by Martínez-Gomez [28] suggest that periods of time spent in inactivity behaviour can be in part responsible for the increase of the cardiovascular risk during the youth, though it was not find any correlations between obesity and sedentary lifestyle. Martínez-Gomez [28] indicates that it is very important to consider the reduction in sedentary lifestyle as a tactics in the preservation of the growth of cardiovascular risk in youth, as well as the improvement of physical activity and habits of eating.

There are specific organizations that have promoted plans of recommendations concerning the reduction of sedentary behaviour in adolescents and children. However, these recommendations are often referred to the use of the “screen time” on the computer, television, and videogames screen. Anyhow, the time of inactivity in adolescents can last much longer than that inserted in “screen time”. The investigation by Martínez-Gomez²⁸ suggests overall the necessity to forward instructions on the reduction of the global quantity of time that adolescents employ sedentary, and not only a decrease in screen time.

Additionally, Martínez-Gomez and colleagues [28] focuses on mechanisms that are involved in the associations between adiposity indicators and cardiovascular risk. In this regard, different values have been collected in groups of people considering their individual adiposity levels. Skin folds and waist perimeter were both used as indicators of abdominal and general adiposity state. Results from this research stated that the obesity prevalence, especially the abdominal fat level, is involved in the development of cardiovascular risk in youth people. Thanks to the relevant association that was found in this study [28] between the adiposity prevalence with cardiovascular risk and the time spent in sedentary behaviour, it can be asserted that youth people with greater rate of sedentary behaviour and adiposity have a greater prevalence of cardiovascular risk respectively.

Data collected in this study [28] indicate that a rise in sedentary behaviour can concur to increase cardiovascular risk in the most obese populations; while the sedentary behaviour in adolescents was measuring using an accelerometer as a standard procedure.

Television Viewing and Cardiometabolic Risk Factors

Factors such as dietary, smoking, and physical inactivity was established that these are not the only factors associated with risk factors of cardiovascular disease, type 2 diabetes, and all-cause mortality. TV viewing is considered one of the most sedentary behaviors among all, and therefore it is of considerable importance to quantify its independent association with risk of health. A study by Grontved and Hu [29] investigated the relationship between TV viewing and health risk response to that.

Results from this study [29] reported that TV viewing were associated with cardiovascular disease, all-cause mortality, and risk of type 2 diabetes. It appeared that these risks were higher when associated with TV viewing behaviors. Considering the rates of incidence in U.S.A, it was assessed (in a range of cases of 100.000 individuals per year) that the difference of absolute risk considering two hours of TV viewing per day was represented by 176 cases for type 2 diabetes, 104 cases for cause mortality, and 38 cases for cardiovascular disease. The data analysis reported a directly proportional increase between the TV viewing hour's number per day and both risk factors type 2 diabetes and cardiovascular disease. The relationship between TV viewing and cause mortality risk appeared to be stronger when the TV viewing hours number were higher than three hours per day.

Despite this, clearly there is a need of more studies on cause mortality disease, in order to evaluate with consistent assurance, the being of the real relationship between TV viewing and all-cause mortality. Research studies, especially those that investigate the inactivity condition in people are difficult to execute in humans. Nevertheless, a study by Olsen *et al.*[30] was carried out on the

postprandial lipid metabolism and insulin sensitivity in subjects who significantly decreased their daily physical activity (daily steps) every day to 1500 steps from the range recommended for US adults of around 10.000 or from 6.000 steps. Subjects were invited to decrease daily activity in two weeks by taking the elevators instead of stairs and reading in cars instead of walking or bicycling. During the study procedure the dietary records were kept to ensure that habitual dietary intakes were maintained. The study showed changes in both, insulin sensitivity and postprandial lipid metabolism. In this time, the subjects developed metabolic changes showing a plasma insulin AUC Area Under The Curve increased, plasma C-peptide AUC and triglycerides increased as well. Also the intra-abdominal fat mass increased even if were no observed changes in total fat mass. Total fat-free mass and Body Mass Index (BMI) both decreased. These data suggest that in subjects occurred a decrease in insulin sensitivity and attenuation in postprandial lipid metabolism. These observations indicate that there might be a connection between reduced levels of physical activity and risk factors linked to progression of chronic disorders first and premature mortality afterwards.

A study by Robinson [31] based on 192 school children of 9 years old, underlined that when children reducing the hours of TV viewing and the time used to play videogames there was a slowdown in the increase of BMI and a decreases of meals number eaten in front of the television. This relationship was not linked to the individual physical activity level reported. Epstein and colleagues [32] have shown interesting evidence on BMI, TV viewing, computer time, and physical activity. The study was conducted on 70 children with BMI higher than the 75th percentile. The experiment demonstrated that decreasing computer time and TV viewing by 50% for two years also the BMI and the energy intake decreasing, levels of measured physical activity were not increased.

Another significant study by Otten *et al* [33] were carried out on 36 obese or overweight adults (BMI of 25 to 50) and contrary to study by Epstein [32], this showed that no greater changes were found in BMI and energy intake rate after reducing TV viewing time for three weeks and by the 50%; however, was observed an increase in the rate of the measured energy expended. This last observation states that reducing TV viewing by half was an adequate behavioural change to induce significant increase in energy expenditure of 119/kcal/d while there was a negative association with the energy balance of 244 kcal/d.

All these experiments mentioned so far are significant and each of them indicate that undoubtedly there is correlation between TV viewing and improvement in BMI, physical activity, and diet intake. Evidence from the studies seen so far, suggest that when the time spent watching television is reduced other factors such as physical activity, BMI, and diet intake may have a consequent improvement. A growing body of research is beginning to elucidate the pathways that contribute to explore if associations between TV viewing and BMI were controlled by diet, and it was noticed a reduction of the effect for type 2 diabetes and not for Cardiovascular Disease (CVD) and for all-cause mortality after collecting all the values estimated with supplementary adjustments made on the dietary plan.

Linear associations in TV viewing were viewed in Australian, U.S.A, and European population. They were dependent on quantity and type of food brought by television advertising, and it is not reliably believed that these positive associations are explained solely

by wrong eating habits proposed by the television advertising. In spite of everything, it was found that made some adjustment for the BMI reduced the positivity of the association between TV viewing and type 2 diabetes risks. Findings seen so far are indicative of a significant concept. More time spent watching television is linearly associated with greater risk of cardiovascular disease, all-cause mortality and type 2 diabetes. There is the need to state whether decreasing the time spent watching television can help to reduce chronic disease mortality and morbidity risk.

Sedentary Behaviors: Television Watching In Relation To Obesity And Type2 Diabetes Mellitus Risk in Women

For a long time the health campaign supported the theory that it is necessarily important to be focused on the enhancement of exercise levels in order to reduce type 2 diabetes and obesity, instead pay more attention to reducing sedentary behaviors. It was stated several times that TV viewing is the main sedentary behaviour in U.S.A. However, TV watching result more involved, in terms of risk factors for the health, in the growth of type 2 diabetes and obesity compared to others sedentary behaviour such as reading, sitting at work, and driving. The role of TV watching has still not been fully understood among people. This concept seems to have not been addressed well either about women in particular.

A study by Hu *et al* [34] considers the relationship between different sedentary behaviors and the rates of type 2 diabetes and obesity in a large women population. This study confirmed that women who spent more time watching television had a higher risk of smoking and drinking alcohol than women who practiced physical exercise. These same women also showed that they had a greater intake of general energy, red meat, total saturated fats, sweets, snacks, dessert, processed meat, and a lower intake of vegetables, fish, fruits, and whole grains. Part of the study attested have shown that in an experiment lasted six years, 3757 women who initially were not obese, had proven to become obese in 1998. In this circumstance was once again underlined the positive association between time spent watching television and risk of obesity in women.

Two other types of sedentary behaviors such as driving for long time and spent long time sitting when at work were seen as conditions significantly associated with an increased risk of obesity. In opposite time spent walking or standing around was seen as associated with less risk of obesity. Considering the observations so far met, we can conclude that women who spent more time watching television were on the right path to become obese from the baseline. During the duration of a six-year study, have been catalogued 1515 cases of type 2 diabetes. After arranged the subjects for age, the average of the time spent watching television was linearly associated with an increased risk of diabetes as well.

Hu *et al* [34] focuses more on a population of women, and it helps to give an important perspective about the concept of sedentary behaviour associated with health risk factors. Sedentary behaviors, especially watching television for a long time, were found in fact to be linearly associated with risk of diabetes and obesity. Often, sedentary jobs force the individual to spend the majority of their time sitting or standing at work and this have been associated with an increased risk of obesity, while light to moderate intensity activity such as walking

or lively it was seen to be strongly protective against the syndrome of diabetes [35].

There are two important likely mechanisms that might be responsible for the positive association between television viewing, obesity and diabetes risk [36]. Firstly, watching television for a long time divert physical activity and this undoubtedly reduces the energy consumed by the individual [37]. In the investigation described by Hu and colleagues [34], it was observed how women who spent more time watching television were inclined to do less physical activity, despite this, the effect of watching television and physical activity on the diabetes and obesity development resulted completely independent.

Secondly, TV viewing showed to be positively associated with an increase of food and energy intake because people are encouraged to eat more when are in front of the television despite their physical activity is maintained low³⁸. United States is a country where it has been noticed that the time devoted to the physical activity is low. There are not, however, results available indicating that recreational physical activity has decreased in recent years. The increased activity sedentary, especially watching television, may have taken part in the epidemic of obesity that has occurred in the United States. Considering the marked relationship emerged between sedentary behavior, diabetes, and obesity, the health campaigns, to help reduce the problem of diabetes and obesity, should not promote the enhance of the physical activity only, but also the decrease in sedentary behavior, in particular prolonged time spent watching television.

Benefits related to the health can be maintained by practicing light to moderate intensity physical activity such as walking during the day or doing some housework. Evidence reported by Hu [34], are not able to prove a causal relationship between time spent watching television and the risk of obesity because of the presumable relative relationship between TV viewing behaviour and obesity. In conclusion, results showed by Hu [34] support the idea that the main sedentary behaviour is when people spent time watching television and it is straight correlated to risk of diabetes and obesity. In opposite, taking into consideration studies discussed so far, it can be stated that exercise with light to moderate intensity reduces the diabetes and obesity risk in people.

Whereas these evidence provide some support to the guidelines that have as first duty to promote physical activity, these also recall the significance of decreasing sedentary behaviors in order to prevent both obesity and diabetes risk.

Sedentary Behaviour in Mid-Life: Relationship Between Television Viewing/Sitting Work And Cardiometabolic Disease

As a part of the investigation conducted by Pereira *et al* [39] in a large study population cohort, an interesting assumption is about the associations between time spent sitting at work and time spent watching television, with cardiovascular disease and diabetes biomarkers in the middle of the adult age. First of all, greater levels of time spent watching television result in positive associations with almost all biomarkers of health. Whereas, associations related to the time spent sitting at work are less positive in terms of response for health biomarkers. Moreover, surprisingly, it has emerged from the study by Pereira [39] that there are differences in associations with

biomarkers of CDV and diabetes for the time spent sitting at work and the time spent watching television. In fact, it has been noticed that these indicators of sedentary behaviour (television viewing and work sitting), have different scheme of association with other factors connected to diabetes and CVD.

In general, it has been seen that there was a rate of opposed lifestyle and socio-demographic characteristics with an increase in time spent watching television. Moreover, a rate that goes in the opposite direction for time spent sitting indicates that these associations might be confused in other ways. So far, considering the associations examined for time spent sitting at work, the rate of association was similar to that for time spent watching television, also when they were analysed simultaneously, both associations showed independent reports.

Associations for time spent watching television and time spent sitting at work with health biomarkers were controlled by BMI. With regard to metabolic syndrome, eating regime did not control associations with any of these behaviors. The focus of the investigation by Pereira [39] also comprehends the range of information on the two main sedentary behaviors in individuals' everyday life (work and leisure), while the majority of other studies consider only the time spent watching television (domain of pleasure) as sedentary behaviour. A group of CVD and diabetes biomarkers including inflammatory blood markers, measurements of eating regime and BMI, lifestyle and socio-economic features, some relevant information inherent to the past stages of life, a randomised nationwide population are other important factors that should be taken into consideration when an investigation is carried out on sedentary behaviour matter. The research by Pereira and colleagues [39] take into consideration only the general population, though this is limited to those employed in a job, as expected by a research study focused on indicators of both sedentary behaviors, work and leisure.

Pereira [39] have shown interesting evidence through a cross-sectional study in a cohort of adulthood where subjects appear to spend more time in habitual sedentary behaviors during the last year of the follow-up. Time spent watching television is used as a gauge of sedentary behaviour, in this study as in other studies; it may be incorrect if subjects spend more time in other inactivity behaviors such as time spent using computer. Whereas, in the range of adult population taken into account, more than 75% used the computer for pleasure for a time longer than one hour. In future studies, especially those that will be conducted on young people, there might be the need to consider a more wide range of behaviors related to this pattern. Data on sedentary behaviour reported by ourselves could be considered as a limitation for the study.

Anyway, from data measured objectively alone, as for example using an accelerometer, it is not feasible to detect the state in which the behaviour occurs, and this is of great importance. In the study by Pereira [39] the time spent in television viewing and work sitting was estimated using questionnaires, although it had been used unlike formats. In fact, in order to calculate the time that participants spent sitting was estimated their total weekly hours (h/wk) in which they were exercising light work, while in order to calculate the time spent watching television they answered for it using predefined classes such as hours per day (h/d). Then it may be possible that the time spent watching television and time spent sitting at work, has not been measured with the same accuracy.

Though analysis had been adapted for the time activity of leisure, they had not been adapted for moderate to vigorous activity when at work. The moderate to vigorous activity is greater correlated (negatively) with the time spent sitting at work, and because of this, to take this factor into consideration may represent out-adaptation. In the investigation carried out by Pereira [39], it was not possible to calculate an estimate of the activity in different other situations such as the amount of activity that an individual is able to perform during his time spent at home. In spite of this, it was estimated the influence of transportation to work (this assessment was always estimated by comparing the use of motorized transports towards the use of the bicycle or walking).

Although it is doubtful that BMI and eating regime play a role as mediation factors, additions to patterns authorized an estimation of their impact on interesting associations, demonstrating consistent effects of BMI and no significant effects of nutrition. To reduce the number of variables mostly correlated to the eating regime in this analysis, were considered only three gauges in respective patterns. Findings about analysis of sensitivity that embraced extra eating regime factors were analogous to those findings indicated in this study [39].

How so ever, the evaluation of the diet had been implemented before the measurement of the results obtained, and this could contribute to its little effect on the associations we are interested in examining in this investigation [39]. Likewise, other variables were estimated previous exposing and evaluating the results. However, it is improbable that this affects the results of the study given that factors such as class of employment and level of education lean to be steady over the three years term in middle adult age. In this research were implemented adjustments for chronic diseases that are limiting for daily physical activity because these could negatively influence both sedentary behaviors (television - viewing and work sitting) and biomarker results. However, also other conditions such as high blood pressure might be detected as a limiting factor. In the analysis of sensitivity, chronic diseases were excluded from the patterns considered and the outcomes were mostly similar to those presented in this study [39].

In this inspection were used two sedentary lifestyle gauges from different patterns. If work sitting and television-viewing needed both to understand the effects of sedentary behaviour solely, it is expected that both indicators will have mostly similar associations with biomarkers of Cardiovascular Disease (CVD) and diabetes [39]. This evidence was enough established by previous studies conducted on sedentary behaviour from different patterns in women [34,40]. One of the first authors, who have provided an important approach on the relationship between sedentary behaviour and cardiovascular disease/diabetes, was Hu *et al* [34]. In the Nurses' Health study by Hu [34] was shown that both work sitting and television-viewing were related to diabetes and obesity conditions, however the associations for television viewing were found to be more strong [40].

There are many reasons for the discrepancy between numerous studies conducted on sedentary behaviour. One of those is that, it is necessary to consider that there are differences in the metabolic cost, with a lesser energy cost for the time spent watching television than the time spent sitting at work⁴¹. Thus, positive associations for the time spent watching television may be caused by the lesser energy cost

due precisely to this behaviour. Another one is that, factors such as lifestyle and socio-demographic conditions associated with television viewing, suggesting that time spent watching television may reflect a general summary for aspects associated with ill health conditions.

Contrary to this, work sitting was negatively associated with factors such as lifestyle and socio-economic conditions, but work sitting showed to have just weak associations with less biomarker.

Despite the carefulness implemented to reduce the possibility to take mistakes, the true effect of diversifying associations with other factors related to cardiovascular disease and diabetes could be that work sitting underestimates and television viewing overestimates veritable associations of sedentary behaviors.

In the case of some biomarkers, a more consistent pathway by which sedentary behavior might influence the health status is the adiposity. Several studies on television viewing do not confront pathways without and with BMI/eating regime, and then pathways via BMI/eating regime cannot be evaluated. Jakes *et al* [20] from the EPIC-Norfolk study has also reported significant evidences on ill associations between sedentary behaviour of television viewing and triglycerides, Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), and total cholesterol after observed BMI.

It has not appeared easy to evaluate the mechanism of adiposity through the examination by Pereira *et al* [39] and the Epic Norfolk population possessing no information from the Epic Norfolk study on the lowering of the effect ratio due to changes for BMI. Similarly to Pereira [39], Fung and colleagues [42] in their study revealed a mitigation of the association between television viewing behaviour and cholesterol (HDL) in men after considering the BMI. Despite this, there was no evidence from this study of any association with cholesterol (LDL) that was minimally influenced by BMI. Pereira [39] highlights that the BMI controls the association between cardiovascular disease biomarkers and television viewing behaviour. Particularly, it was also indicated by other sources that a probable pathway may exist across the inactivity effect on the enzyme called Lipoprotein Lipase (LPL) which controls the triglycerides of plasma and cholesterol (HDL). Despite the fact that greater evidence is limited in human beings, the function of the enzyme lipase and the growth of triglycerides from skeletal muscle was lesser in rats that were inactive rather than in rats that were considered active because able to stand up [7].

In conclusion, the associations with markers of health in adult middle age were distinguished for television and work, indicating that the levels of sedentary behaviour can change depending on the domain from which they are generated. The two domains may also mediate different associations with other types of related diseases. Few associations were found in both domains of sedentary, although greater for television viewing, and lower for work sitting, and with demonstrations that BMI played a mediating role between them.

To conclude, the study of the relationship between physical activity and sedentary behaviors is complicated especially when it seems necessary to determine correlations between state of health and time of activity. So far, the physical activity can be considered as an important instrument available to examine the sedentary behaviour. Clearly there is a need to review the research findings over the past 10-15 years to provide an overview of the current state of knowledge on

the underlying mechanisms governing the phenomenon of sedentary behaviour observed in population.

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