HOW MUCH EXERCISE IS ENOUGH?

As the first in this new six-part series, **Dr Paul Batman** poses the question we've all asked ourselves: how much exercise do we actually need for greater longevity and quality of life?

As society embraces a more sedentary lifestyle and increasing weight gain, there follows an increase in metabolic and cardiovascular diseases. From the earliest beginnings, our bodies evolved to store excess energy when additional energy was available and used these storage facilities when there wasn't enough energy to fuel our existence.

Physical activity is capable of reducing metabolic disease by controlling hypertension, insulin resistance, glucose intolerance, decreasing levels of HDL and elevating levels of LDL and atherosclerosis. What is lacking is how much the risk decreases when increasing the total amount of work per day/week rather than just focusing on the intensity of the activity[1].

In physical activity epidemiology, workloads are expressed as a combination of intensity in METs and duration measured in minutes, expressed as MET Minutes. METs are a measure of resting energy expenditure with 1 MET (3.5ml/kg/min-1) at rest, while physical activities are expressed as multiples of 1 MET. For example, brisk walking at 4 METs (4 x 3.5 = 14ml/kg/min-1) completed in 30 minutes = 120 MET Minutes per day.

Epidemiology studies recommend a range of 500-1,000 MET Minutes per week for significant health benefits, met by selecting physical activities of different combinations of intensity and duration[2].

While 75-150 minutes of moderate- to vigorous-intensity exercise has been the cornerstone to reducing mortality rates and cardiovascular disease, some studies quantify specific doses to reduce risk factors of many chronic diseases, such as breast cancer, colon cancer, diabetes and ischemic heart disease.

Most exercise programmes focus on exercise during leisure time and not what occurs during the rest of the day. To motivate groups, the minimum amount of exercise for the minimum benefit has been prescribed.

The healthcare focus should be on identifying the optimum workload to gain the maximum benefit.

The World Health Organization (WHO) recommends 600 MET Minutes per week for minimal health benefits, equivalent to 150 minutes of moderate-intensity activity (4 METs) or 75 minutes (7.5 METs) per week of vigorous activity[2].

Higher doses of physical activity appear to be needed to control many chronic diseases. The new WHO guidelines suggest that significant benefits can be gained by workloads in excess of 300 minutes per week at 4 METs, equaling 1,200 MET Minutes per week.

A major review of 174 research articles reported major risk reductions across all chronic diseases occurring between 3,000 and 5,000 MET Minutes per week, which is five or six times more than the current guidelines recommend[1].

As it is not possible to meet the MET Minutes with additional high-intensity activities, other types of physical activity should be prescribed to increase physical activity levels at low to moderate levels of intensity. For example, a 2% risk reduction was reported in diabetic patients who completed 600 MET Minutes per week. If the workload was increased from 600 to 3,000 MET Minutes per week, there was a combined risk reduction of 14%.

> "Those in the lowest fitness group who can reach the 50th percentile of fitness will receive the greatest improvements in health and fitness"

The relative risk of breast cancer was reduced by 3% at 600 MET Minutes, 6% at 600 to 3,900 MET Minutes and a combined

14% >8,000 MET minutes per week. Colon cancer risk was reduced by 10% at 600 to 3,900 MET Minutes and a combined 17% at 4,000 to 7,900 MET Minutes. The risk of ischemic heart disease was reduced by 16% at 600 to 3,900 MET Minutes and 23% at 3,900 to 7,900 MET Minutes[1].

This suggests that 3,000 to 5,000 MET Minutes per week should be recommended to reduce the relative risk across the spectrum of many chronic diseases. To reach these MET Minute goals, it is necessary to combine different levels of intensity and duration across the day. An example of meeting a 3,000 to 4,000 MET Minutes per week goal could be climbing stairs for 10 minutes, vacuuming for 15 minutes, running for 20 minutes, gardening for 20 minutes and walking or cycling for 25 minutes per day.

People who do meet the current guidelines of 150 minutes of moderate-intensity exercise per week (600 MET Minutes) enjoy greater longevity and reduced mortality by approximately 20%, while 450 minutes per week (1,800 MET Minutes) can decrease the risk by 39%.

In an AusDiab project, individuals who exercised for at least 150 minutes of moderate-intensity activity per week still watched significant amounts of TV. This group presented with an increase in waist circumference, systolic blood pressure, plasma glucose and precursors of metabolic diseases, suggesting that prolonged sitting has its own unique metabolic side effects that are not countered by 150 minutes of MVPA per week.

While it is not in dispute that 150 minutes per day of MVPA physical activity is a critical factor in improving health and fitness, it is possible that, when combined with high sedentary time, the significant responses gained could be potentially diluted. Those who exercise for 30 minutes per day and sit for fewer than four hours still have a 1-15% increased risk of mortality and heart disease, four to six hours a 15-30% increased risk and greater than six hours a 15-30% increased risk[3].

Alternatively, it is also possible that MVPA of 60-75 minutes per day can produce specific cardiovascular changes irrespective of the amount of sedentary time, with a <5% increased risk in all-cause mortality and cardiovascular disease. This translates into 240 to 300 MET Minutes of moderate intensity at 4 METs per day, which is 1,200 to 1,500 MET Minutes per week – two to three times the national recommendation[4].

A 2015 study of 154,614 subjects aged between 50 and 71 years, which compared sedentary time with physical activity time over a seven-year period, reported that sitting time was associated with a 20-40% increased risk of death from all causes and a 40-55% greater risk of cardiovascular mortality. When inactive subjects replaced 60 minutes of sitting with physical activity, mortality rates decreased significantly[4].

Not to be confused, to gain a higher level of fitness, a more intense effort is required, while metabolic health requires more volume and more frequent contraction of skeletal muscles. High-intensity interval training results in superior improvements in cardiovascular health as expressed as an improvement in VO_2max compared to low to moderate activities.

However, it is not necessary to get to the highest fitness level to receive health benefits that will increase longevity and quality of life. These top fitness levels are the domain of the 'would-be' athlete searching for an improvement in performance or extreme fitness, not necessarily an improvement in general health and wellbeing. Those in the lowest fitness group who can reach the 50th percentile of fitness will receive the greatest improvements in health and fitness. To improve from the 50th percentile requires an increase in intensity in return for a much smaller improvement, with the best health results being in those who have moved their fitness level from the bottom 20% to the 20-40% level, bearing in mind this is still below the average fitness category. The risk can be further lowered by moving into the 40-60% or average category and then again into the 60-80% or above average category. The closer we get to the higher, fittest group, the smaller the gains in health given the increased workload required.

Evidence suggests that prolonged sedentary time (>8 hours) and/or a reduced step count (<3,500 steps) can hinder metabolic adaptations even in people meeting the National Physical Activity Guidelines[6]. fp

DR PAUL BATMAN
has been involved in health and fitness for more than 40 years as a university lecturer, vocational educator, author, researcher, international conference presenter and workshop facilitator. Over the last 18 years, Paul has built, owned, operated and sold two leading health and fitness vocational training institutes, and has received a Lifetime Achievement award for his services to the Australian fitness industry. Paul originally contributed to our *Network* articles back in the 1990s.
www.neatfitcoaching.com

LOSING IT:
A NEW APPROACH TO WEIGHT LOSS

In **PART TWO** of his exercise physiology series, **Dr Paul Batman** presents new thoughts on long-term sustainable weight loss for overweight and obese clients.

Bodyweight increases throughout the developing world have occurred every year for the past 20 years, with the obesity epidemic now being reported in underdeveloped countries. Increased weight gain has resulted in increased weight-loss attempts, with 34.3% of US adults reportedly attempting to lose weight between 1999 and 2000, increasing to 66.5% in 2018 to 2019.

The biggest increases in obesity have occurred since 1980, while obesity rates from the 1920s to the 1970s were low and unimpressive. Obesity has doubled in the US since 1980, with no state in the US having less than 20% of its population classified as obese. Between 1980 and 2000, the average BMI increased by 2.5 points or a weight gain of approximately 8kg. Between 1980 and 2000, BMI values increased seven times faster than in the previous 100 years.

The increased weight gain is due to an obesogenic environment characterised by easy access to energy-dense palatable food, lack of easy access to exercise or movement, use of motorised transport, social facilitation of eating and lack of education with respect to food and movement choices, sleeping habits, smoking cessation and over-medication side-effects.

Exercise and weight-loss recommendations

The medical model of dose response exercise has been elevated as the main controller of bodyweight. The fitness industry has become a leader in weight loss through programmed exercise based on energy expenditure exceeding energy intake.

The American College of Sports Medicine recommends 150-250 minutes of moderate-intensity physical activity equivalent to an energy expenditure of between 1,200kcal/week-1 and 2,000kcal/week-1 for a total weight loss of 2-3kg. A further 250-420 minutes of moderate- to vigorous-intensity exercise is recommended for a 5-7.5kg weight loss, with further increases if diet restriction is modest.[1]

The National Weight Control Register reports that women who have been successful in long-term weight loss expend approximately 2,542kcal/week-1, while men expend approximately 3,293kcal/week-1, equivalent to at least 60 minutes of physical activity at moderate intensity per day (4 METs) or at least 300 minutes per week (1,200 MET Minutes).

The problem

The time and effort required to reach these energy deficits with dose response exercise alone is initially well beyond the capabilities, motivation and compliance abilities of most overweight or obese people, exposing them to potential failure. Compliance within a structured dose response exercise programme for weight loss is difficult to maintain, as it requires a major behavioural change, with existing behaviour replaced by a new, unfamiliar and sometimes threatening behaviour.

Physical activity used solely as an intervention for weight loss by burning more energy than is consumed has, at best, been disappointing, with weight loss rarely sustained for more than five years. Physical activity can be so much more than merely burning excess energy, as it plays a major role in regulating energy and macronutrients, improving health and fitness, decreasing waist circumference and increasing lean body mass independent of any weight loss.

> “Improving cardiorespiratory fitness before emphasising weight loss could be a stepping stone for those who have difficulty losing weight or sustaining it”

BMI controversy

In 2013 in the *Journal of the American Medical Association*, Dr Katherine Flegal controversially reported that people with a

BMI of 25-30kg/m² and classified as overweight or mildly obese had lower mortality rates than those in the normal or healthy weight category, suggesting that some people can be overweight or even mildly obese and still be healthy, challenging conventional wisdom.[2]

Cardiologists have reported that some patients who were overweight or moderately obese often lived longer after being diagnosed with an illness when compared to leaner patients. Researchers at the Cardiovascular Research Institute in Washington DC found that overweight patients when compared to leaner patients had approximately a 50% reduced risk of dying within 12 months after surgery for atherosclerosis. This was termed the "Obesity Paradox" and was found to be the case in many other chronic diseases.

According to a report by the Swedish Coronary Angiography and Angioplasty Register on 64,000 patients, BMI could have a U-shaped effect on health. Those in the underweight category <18.5kg/m² and those >40kg/m² are at the greatest risk of death. Those at the lowest risk are in the BMI range of 26.5-35kg/m² classified as overweight/moderately obese.

Importance of cardiovascular fitness

Dr Carl Lavie states that other confounding factors besides bodyweight, such as reduced muscle mass and a decline in cardiovascular fitness, contribute to high mortality rates, while moderate levels of physical activity increase cardiovascular fitness and provide strong cardio-protective effects, even in the absence of weight loss.[3]

People in the overweight and moderately obese categories who are aerobically fitter have a reduced mortality rate than the same unfit group, with the difference being cardiovascular fitness. Metabolic abnormalities are not just diagnosed in overweight people, with 25% of normal weight people suffering from metabolic disorders, while 50% of overweight people and more than 33% of obese people are regarded as healthy when classified as 'metabolically healthy obese'.

In the Veterans Exercise Testing Study, the annual healthcare costs for moderately fit obese males were $10,000-$27,000 less than the healthcare costs for low fit males with a normal BMI. Regardless of bodyweight, those who are metabolically healthy and have higher fitness levels could have a reduced chance of suffering from diabetes and/or high cholesterol.[4]

Overweight and obese people who are less active and have lower CRF levels would benefit by increases in physical activity levels and reducing sedentary time. Those in the lowest fitness levels who can improve to the average fitness levels receive the greatest health benefits. Obese adults can increase their VO_2max by >1 MET over eight weeks of training, even in the absence of weight loss. A 1 MET improvement can lower the risk of all-cause mortality by 14-29% and provide a 19% reduced risk for cardiovascular disease, improvements significantly greater than weight loss. A small[1] ml/kg/min increase in cardiovascular fitness can reduce all-cause mortality by 7-13%.[5]

A possible alternative

While it is not in dispute that weight loss is important for good health, it has been established that exercise training for weight loss in the long term for the obese and overweight has been largely ineffective. Perhaps a pivot to emphasise daily physical activity and reduce sedentary behaviour to initially improve cardiovascular fitness, increase exercise tolerance and decrease mortality rates could be a more successful segway into long-term weight loss.

The new approach of initially treating obesity-related conditions by improving cardiorespiratory fitness before emphasising weight loss could be a stepping stone for those who have difficulty losing weight or sustaining it. By changing the focus at the beginning of their weight-loss journey, it can allay fears of failure when weight loss is not achieved and prevent many unhealthy relationships with food and physical activity that can be obstacles to long-term success.

In the Danish Diabetes Prevention study, more than twice the number of subjects were able to sustain 150 minutes of MVPA per week than those who reached their weight-loss goal, indicating that initially improving cardiovascular fitness through increased physical activity was more sustainable in changing behaviour than focusing entirely on achieving weight-loss goals.[6]

Once there is a reduction in obesity-related diseases, an improvement in cardiorespiratory fitness and improved exercise tolerance, then a more exercise-driven weight-loss focus could be adopted.[7] fp

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FITNESS COULD START IN THE HOME

PART THREE of **Dr Paul Batman's** exercise physiology series discusses the impact that 'stay at home orders' during the pandemic have had on people's health and how simple activities in the home could be the first step to reverse the effects.

From the latest Active Lives study report, it was stated that "one million people in the UK became physically inactive between May 2020 and May 2021, while those who engage in at least 150 minutes of exercise per week fell by 700,000 people or 1.7%".[1]

These staggering numbers are the result of the government's 'stay at home orders' and strict quarantining rules placed on the general population to limit the transmission of COVID-19. The unprecedented increase in time spent at home and the closure of gyms, community fitness facilities, schools, sporting venues, etc. has led to a more online lifestyle while decreasing daily household activities.

Delving into the past reveals that between 1965 and 2010 there was also a significant decline in household activities such as cooking, shopping, housekeeping, home maintenance, laundry and general cleaning, etc. By the end of the 1990s, more time was spent on screen-based media, decreasing home activities by 12 hours per week, totalling approximately 360kcals per day or 2,518kcals per week. This was due to the increased use of technology and the advancement in food packaged microwaveable meals that reduced the time spent on sourcing, preparing and cooking food. In 1970, <1% of households had a microwave oven and <20% a dishwasher; by 2005, >90% of homes had a microwave and >60% had a dishwasher.[2]

Fast forward to 2020/2021 and, with the COVID pandemic and 'stay at home orders', household activities have declined even further. More time is spent at home but less energy is expended, with more opportunities to be sedentary due to conveniences such as drive-through restaurants and takeaway food, internet banking, streaming services, gaming, internet shopping, dishwashers, clothes dryers, internet food shopping and delivery, driving kids to and from school, mobile car services, auto car washes, 'hire a hubby' services, house cleaners and gardeners, etc. All these new services, combined with our new online way of life, have reduced the energy expenditure required to perform duties in the home, at work, transporting and during leisure time.

Over the past 20 years, the fitness industry has stepped up and substituted the decreased everyday activities with gym-based movement opportunities. Now that these fitness activities have been taken away, there is a reversion back to a more sedentary lifestyle that is significantly contributing to increases in bodyweight and obesity and all-cause mortality rates on a global basis.

While bodyweight increases in Thailand are substantial at 19%, it is still lower than many of its neighbours. From a study of over 70,000 Thai adults, there was a strong association between increases in obesity and leisure time, TV watching and computer gaming. Alternatively, there is an inverse relationship between obesity and the time spent in gardening and household activities. Those who were more involved in gardening and household activities had a 33% lower risk of being obese, while there was an 18% increase in the risk of being obese with every two hours of additional screen time.[3]

> "Women who did not participate in formal exercise but did perform significant household activities were at a 25-50% reduced risk for all-cause mortality diseases"

In the Shanghai Women's Study, 67,143 women were followed for 5.7 years in an

attempt to correlate mortality rates and physical activity levels (i.e., over 380,000 person years). There was a 20-40% reduction in risk factors in those women who were physically active by walking, stair climbing and household duties. Women who performed four hours of household activities per day significantly reduced their mortality risk compared to women who worked for two hours per day. The women who did not participate in formal exercise activities but did perform significant household activities were still at a 25-50% reduced risk for cardiovascular disease, cancer and other all-cause mortality diseases than those who did not.[4]

In rural Africa, females play a dominant role in collecting firewood, cleaning, fetching water, childcare, etc., as well as agricultural activities such as field preparation, weeding and harvesting. All of these activities require participation in low and high levels of physical activity, resulting in significant energy expenditure. The average rural African female is 155cm tall, weighs 53kg, has a BMI of 14-22m/kg² and a mean fat level of <27%, with fewer than 5% classified as obese.

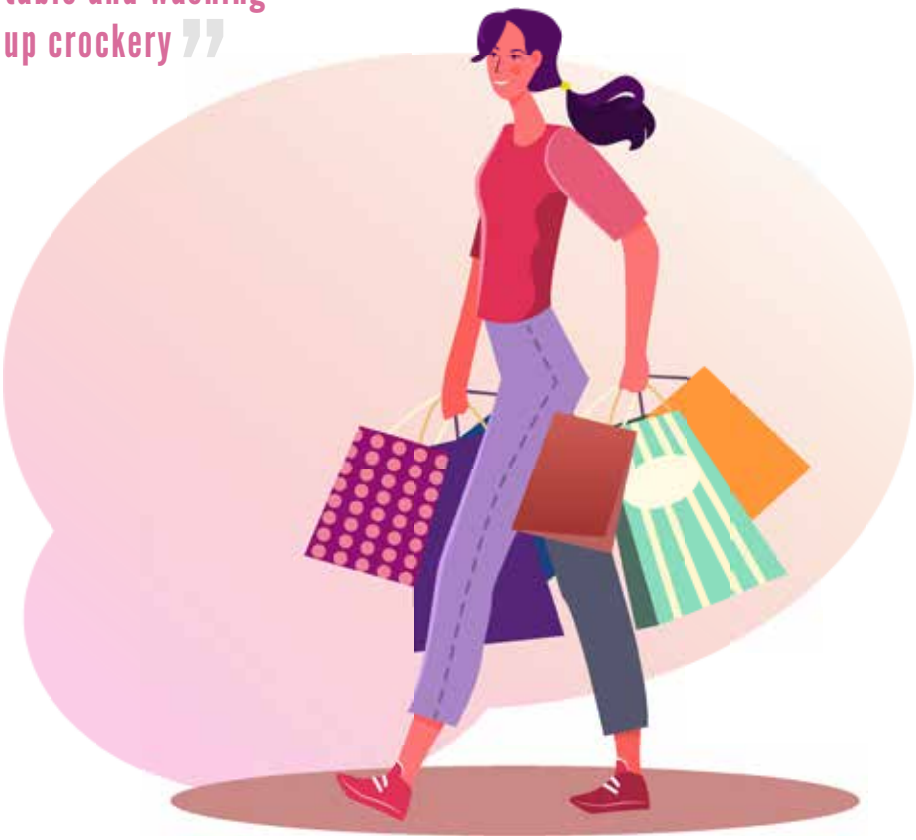
In rural India, the typical female weighs 40-50kg, is 150-160cm tall and has a body mass index of 18-22kg/m², classifying her as thin and lean. Their typical lifestyle includes daily activities >13 hours per day of moderately intense domestic activities and farming activities, combined with approximately nine to 10 hours of sleep. This increased daily energy expenditure of approximately 1,700-2,000kcal per day is barely able to keep pace with a very low energy intake.[5]

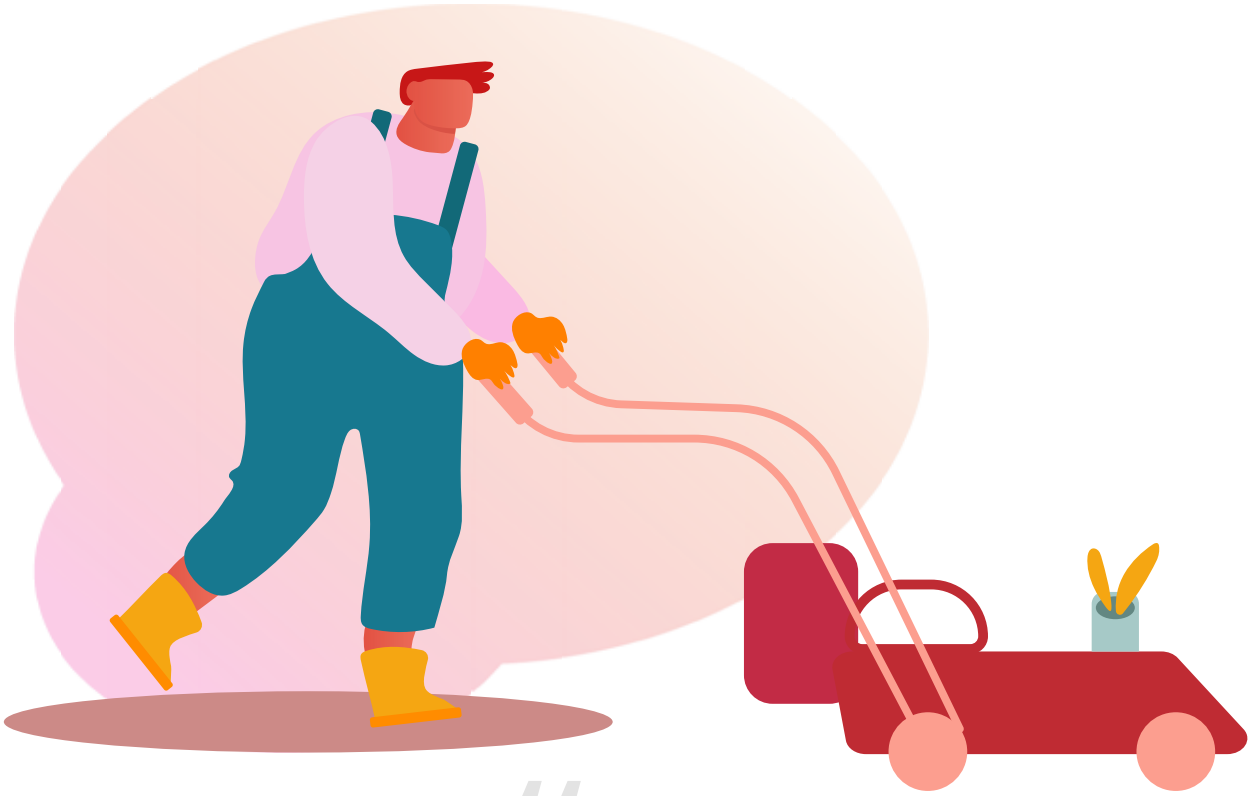
In a preliminary study, our team designed a new algorithm to correlate training heart rates with metabolic equivalents (METs) to measure workloads across all activities at all intensities. Using the new algorithm, I wanted to see what my workload in MET Minutes and energy expenditure was between Monday and Friday, as I took on the role of homeschool teacher (two grandchildren), domestic housekeeper, washer and dryer, cleaner and general dogsbody. My wife was recovering from spinal surgery and was unable to do any domestic duties and so I became the 'chief cook and housekeeper', with duties that included cleaning, vacuuming, laundry, food preparations, cleaning the table and washing up crockery, etc. My daily workload in the home was approximately 180 MET Minutes per hour (3 METS x 60 minutes) for four hours per day = 180 x 4 = 732 MET Minutes per day, which is three or four times the WHO physical activity recommendations for a day (100-200 MET Minutes of moderate-intensity physical activity per day)![6]

> "I became the 'chief cook and housekeeper', with duties that included cleaning, vacuuming, laundry, food preparations, cleaning the table and washing up crockery"

Over the five days I accumulated 3,660 MET Minutes (5 days x 732 MET Minutes) which is 3-4 times the new 2020 WHO guidelines. This is equivalent to running 8kph/4.8mph (8 METs) for 7.62 hours over the five days. Not only was my house cleaner than ever before, but I also reduced my mortality risk profile without going to the gym and expended an additional 4,995.9kcal over five days.

As a result of multiple lockdowns, more people are now food shopping online. I also found it very convenient to buy pre-prepared food and thought about continuing it even after lockdown, until I calculated the reduction in my energy expenditure by not physically shopping.





> By shopping online, my weekly energy expenditure was reduced by 854.88kcal, potentially increasing my bodyweight by 5.3kg per year

I normally shop two days per week – that includes driving to the shopping centre, parking the car as far away as is reasonable to get some additional steps, walking the aisles with a trolley and selecting the food, packing the food into my bags at the checkout counter, walking back to the car, usually while pushing a trolley, driving home and then carrying all the bags to the house, unpacking them and storing them in the cupboards and fridge/freezer, etc.

The workload for my shopping expedition of 90 minutes at 4 METs = 360 MET Minutes. My energy expenditure was = 0.0175kcal/kg/min x bodyweight (78kg) x METs (4) x duration (90 minutes) = 491kcal x two shopping days = 998.2kcal for the week.

My online shopping experience took 40 minutes of sitting at my computer at 1.5 METs and 15 minutes collecting it at the door and packing it away at 3 METs. My energy expenditure was 81.9kcal + 61.42kcal = 143.32kcal. I only shop online once per week.

The difference between my physical shopping experience and my online shopping experience was 998.2kcal – 143.32kcal = 854.88kcal per week. By shopping online, my weekly energy expenditure was reduced by 854.88kcal! That is 3,419.52kcal per month or 41,034.24kcal per year, potentially increasing my bodyweight by 5.3kg per year.

Lastly, I wanted to calculate my workload in MET Minutes and energy expenditure for the last five days of lockdown by working in my garden pruning, sacking leaves, weeding, cutting down old plants and replanting, etc.

My workload was 4 METs x 360 minutes or six hours = 1,440 MET Minutes per day, a workload equivalent to three x 60 minutes of vigorous to high-intensity indoor cycle classes per day or 15 sessions per week! The 7,200 MET minutes for five days is seven to 12 times more than the WHO recommendations of 500-1,000 MET Minutes per week for general health improvements. Not a gym to be seen and I expended an extra 9,828kcals over five days.

With rising inactivity levels and the difficulty in starting and maintaining an exercise programme for general health, gardening is a legitimate alternative that can improve health, cognitive functioning and community interaction. It is popular in many countries with older adults with surprising participation rates. In the UK, approximately 27 million people or 40% of the population garden in one form or another. In the US, 117 million people (33% of the population) participate in gardening activities, while in Japan 32 million people (25% of the population) garden as a hobby, significantly higher than fitness centre participation rates. The oxygen cost of the gardening activities varies according to the number of body parts moving and whether they are performed while weight bearing. Gardening activities that use both upper- and lower-body muscles, such as digging, raking, weeding, mowing and fertilising, generally have higher oxygen costs of between 3-4.5 METs, while gardening tasks that just use the upper body, such as pruning, planting seedlings, sowing and watering, are classified as low intensity, between 1.7-2.9 METs.

Given that gardening is regarded as a major leisure activity and has low to moderate MET values, it could be considered as a substitute for the universally recommended 150 minutes of moderate-intensity activity per week at 4 METs (600 MET Minutes) or as an intervention for prolonged sitting.

With the increase in sedentary time and inactivity levels and the need for an intervention that is convenient, not intimidating and low cost, simple everyday activities such as housekeeping, gardening and shopping that have been engineered out of everyday life could be reintroduced to start people moving and eventually be used as a stepping stone to more formal fitness activities. fp

DR PAUL BATMAN
has been involved in health and fitness for more than 40 years as a university lecturer, vocational educator, author, researcher, international conference presenter and workshop facilitator. Over the last 18 years, Paul has built, owned, operated and sold two leading health and fitness vocational training institutes, and has received a Lifetime Achievement award for his services to the Australian fitness industry. Paul originally contributed to our *Network* articles back in the 1990s.
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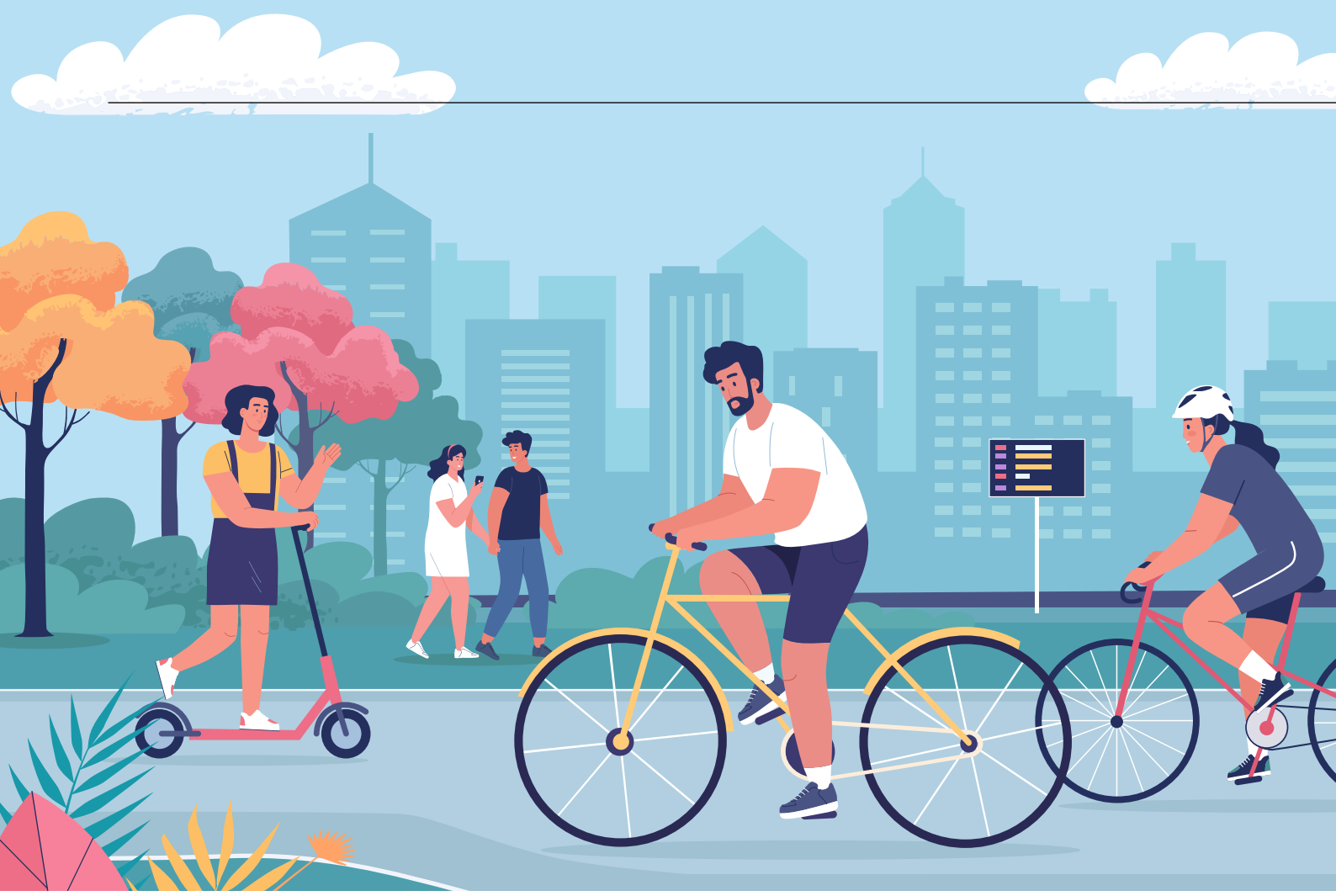


BIKE, BUS OR BOOTS

THE BENEFITS OF ACTIVE TRANSPORTATION

In **PART FOUR** of his exercise physiology series, **Dr Paul Batman** discusses ditching the car for the bike, bus or walking boots and how this could reduce obesity levels.

Walking and cycling are low-cost options for increasing physical activity in the community. The number of people attending fitness centres is still quite small when expressed as a proportion of the general population, as some see the fitness experience as too expensive, intimidating and inaccessible.

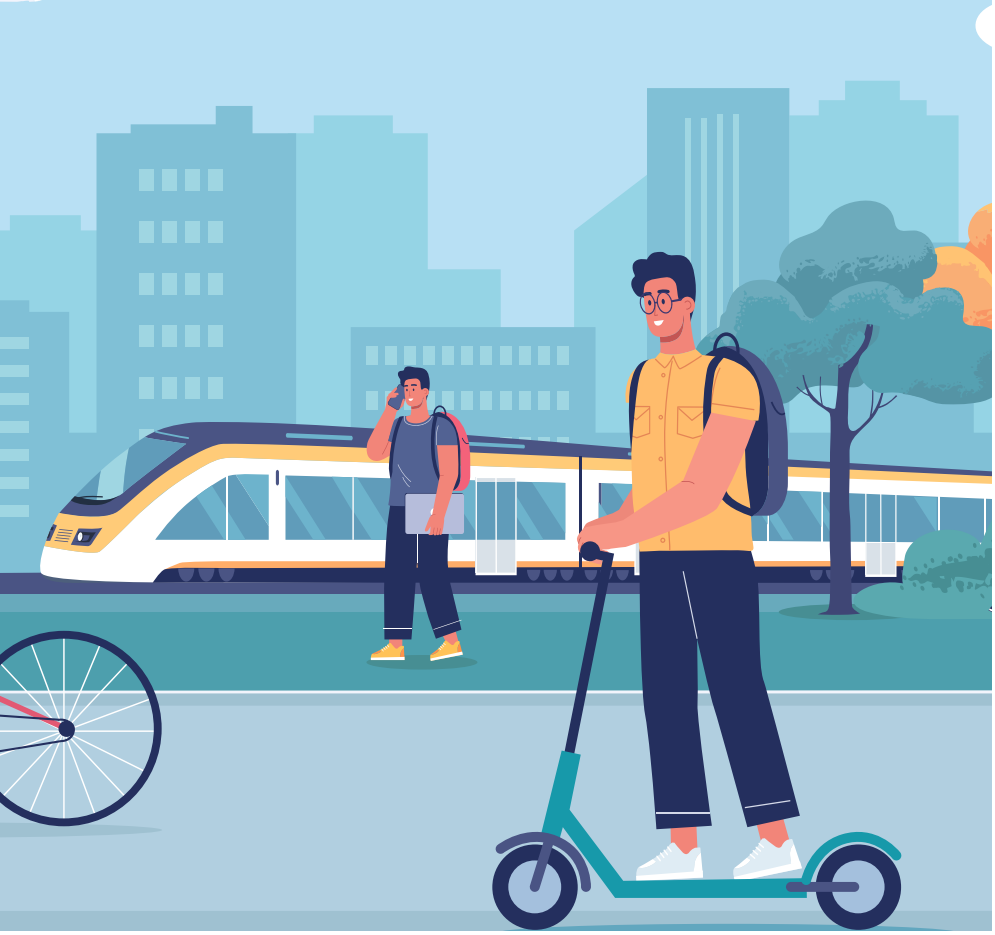
In Australia, more than 30% of the population is classified as sedentary, with no participation in any structured exercise or physical activity. The most common reasons for not exercising are generally lack of time and the cost. Incorporating physical activity into daily life at home, during travel time, at college or university, in the work environment and during leisure time makes physical activity a more realistic option for those unable to access a formal fitness service[1].

Active transportation can be defined as the volume of physical activity or general travel activities consisting of walking, cycling, wheeling or a combination, or even taking the stairs rather than elevators or escalators[2]. People using public transport daily present with decreases in cardiovascular risk factors, BMI, hypertension and % body fat than those who use motor vehicles. A Danish study reported positive changes in HDL cholesterol levels, reduced levels of LDL cholesterol, waist circumference and BMI in those who used active transport, with the best results in those who walked the furthest.

Scientists also report that, if every person in the US between the ages of four and 74 replaced 30 minutes of driving per day with walking, 24 billion litres of petrol could be saved, as well as a reduction of >6 million tons of petrol, 60 million tons of greenhouse gases and a loss of >6.5 million kilogrammes of weight![3]

One area where major changes have occurred is in the transportation of children to and from school. Some 30 years ago, over 60% of children walked or cycled to school. Now only 15% of children walk or ride to school, 25% catch the bus to school, while more than 50% arrive by car. Walking to work or school can increase energy expenditure by 120-150kcal per hour, compared to 60kcal for a passive transport commute[4].

The increased urbanisation of our cities is a significant contributor to the increase in sedentary behaviour, with the lack of green space, footpaths and inaccessible public transport all contributing to less active transportation. Alternatively, greater access to public transport can provide more



opportunities for physical activity, as most transit trips begin with and/or end with walking. Those who do walk to and from public transport can receive up to 19 minutes of additional physical activity per day, while up to 30% of transit walkers can achieve more than 30 minutes of daily physical activity, meeting the National Physical Activity guidelines.

Stair-climbing intervention programmes that encourage people to accumulate several two-minute bouts per day can potentially reduce all-cause mortality risk factors after only seven weeks. Potentially 11-12 minutes of stair climbing per day can have strong effects on aerobic capacity and a reduction in low-density lipoproteins. It has been estimated that a weight stable man of 80kg (all things being equal) who added two flights of stairs daily could lose 2.7kg per year if weight loss is based on energy in, compared to energy out.

The National Physical Activity guidelines for weight management recommend 60 minutes of moderate-intensity physical activity per day. Those walking to and from railway stations are more likely to walk for over 30 minutes per day when compared to those walking to the bus stop due to the limited number of railway stations available compared to the number of bus stops. Each hour spent driving increases the potential of gaining weight by 6%, while each additional kilometre walked per day is associated with a 5% reduction in weight[5].

The lowest rates of obesity are found in Sweden (9.4%), Switzerland (8%) and Netherlands (8.1%) where active transport is the highest, with these countries also having the highest fitness centre penetration rates in the world[6]. In the Netherlands, there are >19,000km of bicycle paths and the average person cycles approximately 909km per year, 30% commute by bicycle, 18% walk, 5% use public transport, while 45% still use motorised transportation, with 9.1% more bicycles than people.

> "The evidence strongly supports a direct relationship between an active transport culture and lower obesity levels as measured by BMI"

Conversely, China has been developing an increased reliance on motor vehicles over the past 25 years, with over 14% of households now owning a motor vehicle. Chinese males who own a car report an average weight gain of 1.8kg after its purchase and are now twice as likely to become obese compared to those who do not own a motor vehicle.

The evidence strongly supports a direct relationship between an active transport culture and lower obesity levels as measured by BMI. The highest obesity rates found in the USA can be traced back to the lowest rates of active transport, with 75% of people reporting no active transportation within 30 days, while 55% did not engage in any leisure time walking and/or cycling in the previous 30 days[7].

Leisure time has been used extensively to increase physical activity levels. However, these programmes mainly attract the already health-conscious, better educated and more affluent sectors and have been largely ignored by chronically inactive people. While participation in leisure-time activities is lower in lower socio-economic groups, the reverse has been reported for active transport with lower sedentary and obesity levels. This is due to their lower disposable income and where the only method of transportation is walking, cycling or using public transport.

In the 2010 Australian census, 80% of people employed in the state of Victoria travelled to work by car. Only 4% reported they walked to work, while only 1% reported cycling as their main mode of transportation[1]. Conversely, in Switzerland, over 50% of trips are made by cycling. A further study in Australia reported that, if 10% of car users in Melbourne used active transport to commute daily, 89 lives could be saved and there would be 295 fewer cases of chronic disease. If this initiative was extended to the outer suburbs, there would be 272 fewer deaths and 903 fewer cases of heart attack, stroke, bowel cancer, breast cancer and diabetes[8].

Between 1990 and 2000, the number of US workers who commuted to and from work for 30 minutes or longer increased from 19.6% to 33.7%. Between 2000 and 2020, workers were living further away from their workplace due to increased rental costs, living expenses and increased urbanisation. In the US, 15% of all trips nationwide are to or from work, while 45% are for family-related purposes. Some 83% of all trips are by driving, 9% by walking and 8% by cycling. Short trips of approximately 500 metres are by motor vehicles 55% of the time, >1km 85% of the time and >90% for longer trips.

The COVID-19 pandemic has increased the number of people working from home, effectively reducing their commute time and limiting the potential for any additional active commuting and increasing sedentary time[9].

Given that many people have difficulty in starting or maintaining a formal exercise programme, it is possible that active transportation could conceivably meet the minimum recommended national physical activity guidelines and play an important role in reducing obesity levels. fp

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ESCAPING THE DESK TRAP

With the emerging discipline of inactivity physiology and the global acceptance of the harmful effects of prolonged sitting, the workplace is now a prime candidate for potential interventions to reduce employees' sedentary time, as **Dr Paul Batman** explains in **PART FIVE** of his exercise physiology series.

Office workers spend the bulk of their day either travelling to and from work or trapped behind a desk for at least eight hours. The modern office requires extensive use of computers, restricted movement and long periods of sitting, all in the relative isolation of a workstation.

There have been considerable differences reported in physical activity based on job classifications. In a study of over 25,000 Japanese workers spanning a number of different occupations, it was found that machine operators, skilled workers and labourers were the most physically active. Likewise, in New Zealand, blue-collar workers reportedly walk on average 10,300 steps, while university staff and administrative staff accumulate fewer than 5,000 steps per day.

The more sedentary occupations that have a high degree of sitting now provide little opportunity to move, reducing energy expenditure. The difference is the environment and people's interaction with this environment. For example, the mail delivery employee who delivered the mail by walking was more likely to increase energy expenditure compared to an employee who now delivers the mail on a motorcycle.

Stress-induced responses in occupational activities have been found to be an important risk factor for cardiovascular disease due to significant changes in technology (computers) industry structure and evolution of service delivery and knowledge industries, increased female labour force participation, labour relations (decreased union activity), work space reductions, emergences of contractual work, employment of consultants, part-time workers, family/work balance and, more recently, working from home.

The concept of occupational anomalies was first officially reported in the 1950s with the Dr Jeremy Morris London Bus Drivers and Conductors study. Dr Morris reported that bus conductors were less likely to have a heart attack because of their increased activity levels during their work shift than the more sedentary bus drivers who sat for the duration of their shift[1].

Over the years, this has been repeated several times with some variations. In a study of 14,677 Norwegians conducted in the 1970s, bus drivers still presented with a greater mortality risk as measured by cholesterol levels, systolic blood pressure and bodyweight.

From 1950 to 1985, Dr Ralph Paffenbarger examined the energy expenditure and risk of cardiovascular disease of longshoreman (wharf labourers) who unloaded and loaded cargo on the San Francisco docks. Some 40% of the workers performed occupational tasks requiring an energy cost of 5-7kcal per minute – about six METS (21ml/kg-1/min-1), which was less than our ancestors over 200,000 years ago. The less strenuous workers expended approximately 2,400kcal per day, equivalent to about 1,400 MET minutes per week. The workers who performed the vigorous tasks had a lower risk of heart attacks than those in lower energy tasks. Just as these studies were being published, vigorous activity was disappearing from the worksite[2].

> "The absence of necessary activity for daily living, starting in the 1960s, could be the greatest loss the new generations are experiencing"

Dr Paffenbarger studied the movement habits of 13,485 Harvard University alumni between 1915 and 1950 and reported a greater reduction in cardiovascular mortality rates amongst the more vigorous alumni (>6 METS) and those who performed moderate-intensity (between 3-6 METS) activity, although not as great. There was little cardiovascular immunity in light-intensity activities at <2 METS.

Between 1950 and 2000, active to non-active jobs doubled, while active jobs dropped by a third, not taking into account changes within the jobs.

In 1970, 20% of working Americans had jobs requiring light activity such as sitting, while 30% engaged in jobs that required a high-energy expenditure such as construction, farming or manufacturing. Thirty years later >40% of adults were engaged in light activity jobs, while 20% were engaged in the high-energy expenditure jobs. This shift, in combination with increased TV viewing times, computer usage, smart phones, tablets, surfing the internet and gaming, has further reduced daily energy expenditure.

Since 1960, there has been a huge increase in the emergence of service delivery industries such as health, education, finance, leisure and hospitality, while there has been a large decrease in manufacturing, mining and logging industries. These changes have morphed the world into ever increasing 'knowledge economies'. The absence of necessary activity for daily living, starting in the 1960s, could be the greatest loss the new generations are experiencing.

With the rise of service delivery industries and the demise of manufacturing and agricultural industries, moderate-intensity physical activity occupations have decreased from 48% in 1960 to 20% in 2008, decreasing energy expenditure by more than 150 calories per day, playing a significant role in bodyweight increases over the past 50 years, as time spent at work represents the largest time period during waking hours.[3]

An interesting variation on the physical performance of occupational activities is the role that expectation and attitude can also play in the results. In a study from Harvard University, 84 women who worked as housekeepers in a hotel were selected as subjects. Half the group was told to think of their occupation as a substitute for exercise and informed of the number of kcals they expended. The remaining 50% was told nothing about the potential health benefits. After four weeks, the group that was told of the health benefits improved blood pressure and lost 1kg of bodyweight, suggesting an awareness of the health benefits, regardless of where it is performed, can improve performance[4].

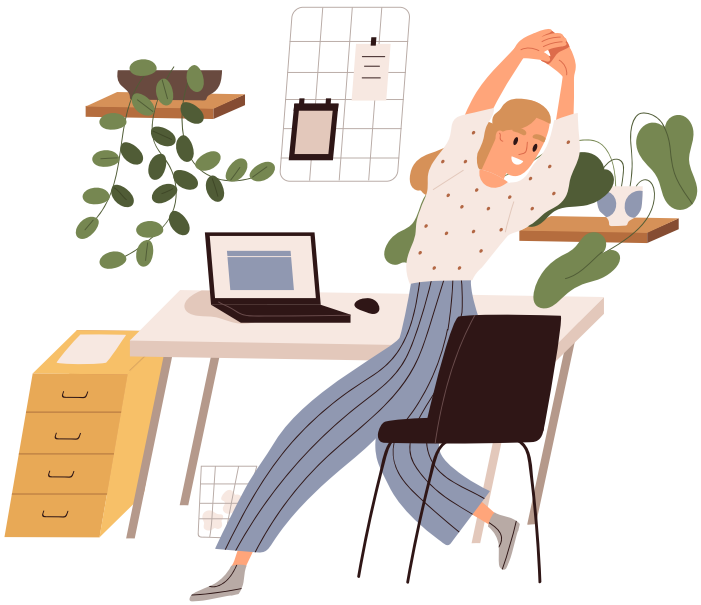
> **"An additional 2.5 hours of standing or moving per day could potentially translate into an additional 350kcal expended at work"**

A cohort of 1,100 call centre employees were also studied for over eight months. The average weight gain in both males and females over time was 5.1kg, while 68% had a weight gain of 7.5kg. Those employees who engaged in moderate to vigorous exercise during leisure time still reported an average weight gain of 3.7kg compared to their non-exercising colleagues. In other words, even though they were more active, they still gained weight, only less.

Given that employees who participated in moderate to vigorous exercise still increased their bodyweight would indicate that the current public exercise recommendations could be insufficient to prevent weight gain.

Dr James Levine reports that an additional 2.5 hours of standing or moving per day for all employees could potentially translate into an additional 350kcal expended during work hours. This could be achieved by standing at the computer every 30 minutes, taking breaks in sitting time in office meetings, standing to greet a visitor in the office, standing during phone calls, walking to a colleague's desk with a message, no emailing internally, drinking more water by walking to the water cooler, moving the bin away from the desk, using height-adjustable desks to either stand or sit during computer time, and conducting standing or walking meetings[5].

To combat prolonged sitting problems, it is important at the very least to reinforce 'sit, stand, move and repeat' on a regular basis. fp



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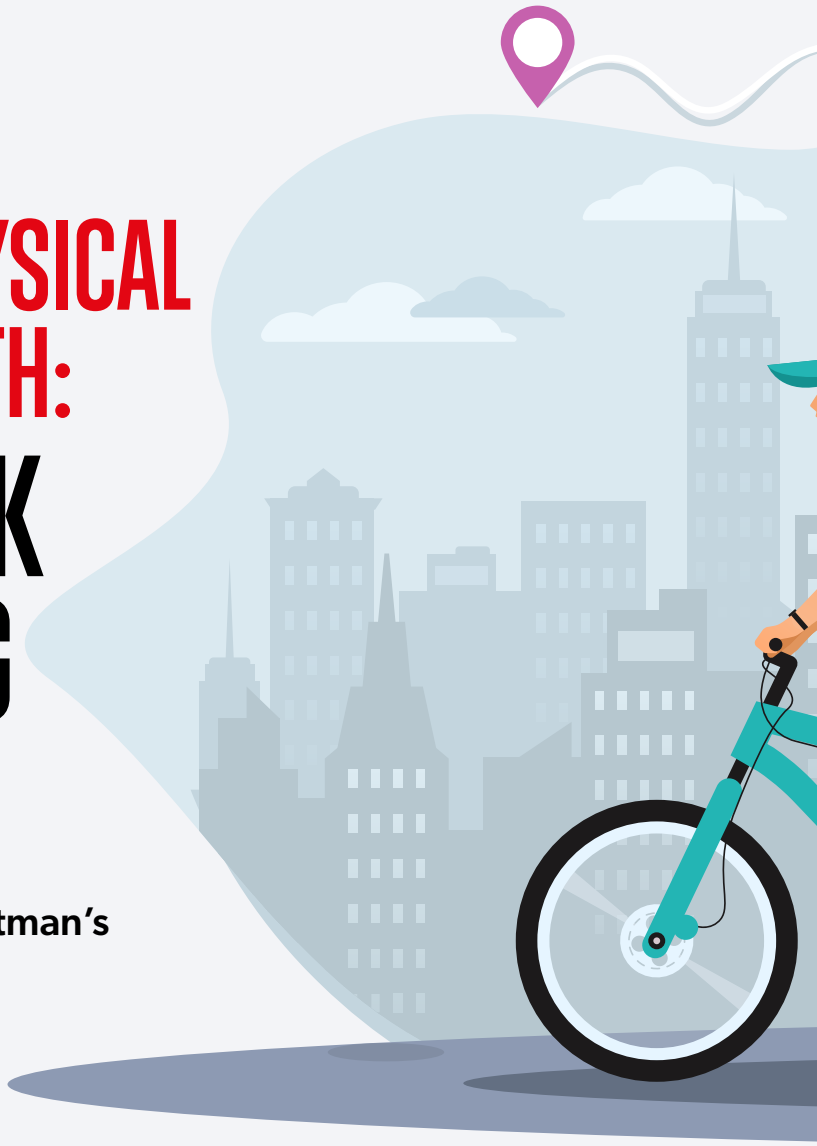
AIR POLLUTION, PHYSICAL ACTIVITY AND HEALTH:

IS THERE A RISK IN EXERCISING OUTDOORS?



PART SIX, the final part, of **Dr Paul Batman's** exercise physiology series looks at the risks of inhaling air pollution while exercising outdoors.

If the public were to be told there is an insidious problem within our community that kills 3,000 people per year, there would be outrage and a determination to do something about it. This problem is not about car fatalities, shark attacks, inactivity or drug overdoses. It is simply air pollution.

The Australian Institute of Health and Welfare estimated that urban air pollution is responsible for more than 3,000 premature deaths per year[1]. The *Sydney Morning Herald* in August 2014 reported: "Sydney's air kills more people than car accidents".

It has been reported that long-term city dwellers' lives could be potentially reduced by 72 days for men and 65 days for women as a result of continually breathing in fine particles from polluted air. This further supports the move to working from home and electric cars.

While over the past 15 years air quality has improved markedly, it could easily be reversed with the continual reliance on coal-fired power generation and the population growth so dependent on the increasing use of motor vehicles.

In a Scottish study, 30 healthy men who rode their bikes daily to and from work while exposed to diesel fuel emissions presented with constricted blood vessels and reduced action of an enzyme responsible for breaking blood clots in the heart[2].

In another study, competitive cyclists who were exposed to different levels of air pollution while exercising decreased their endurance by approximately 30% and their lung function by 22%, caused by haemoglobin having a greater affinity for carbon monoxide reducing the muscle's oxygen-carrying capacity.

A 2010 study in the Netherlands estimated that short daily trips cycling in polluted cities has the potential to reduce life expectancy by between 0.8 and 40 days[3].

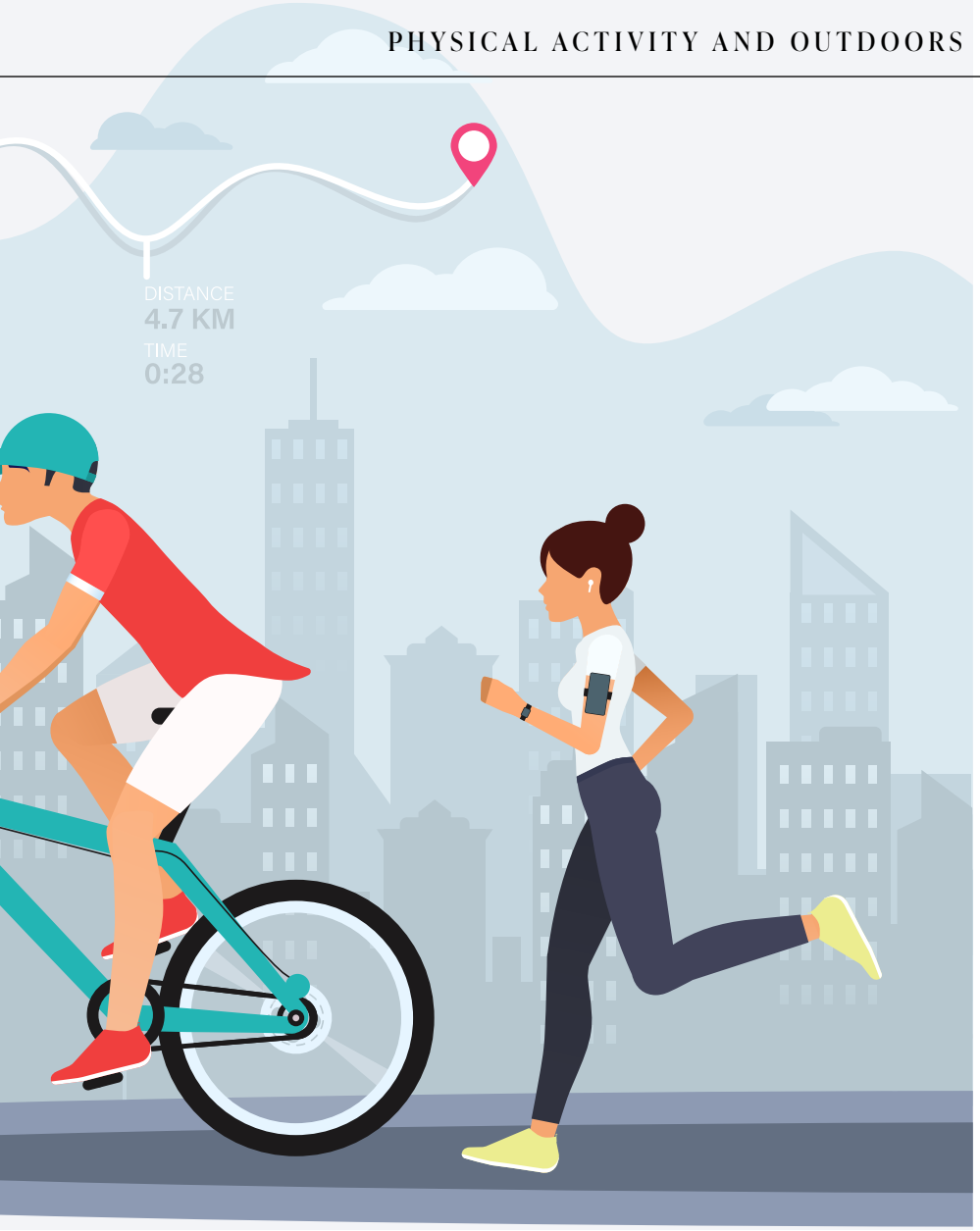
City air consists of two different types of air pollution: primary pollutants include carbon monoxide, sulphur oxide, nitrogen oxides, hydrocarbons and particles from dust, smoke and soot; secondary pollutants include those that come directly from the environment, including sunlight, moisture and other pollutants that react with the primary pollutants.

Outdoor pollution is strongly related to industry and population density, with the contributors to carbon monoxide including cars, buses, trucks, planes and the combustion of fossil fuels, with vehicle pollution accounting for approximately 70% of poor air quality.

> "Low levels of fitness and obesity further increase the potential risks from exercising in a polluted environment"

While car pollution has reduced over the past 20 years, there has been an increase in the use of diesel-powered vehicles in some countries. It is the tiny soot particles from these diesel exhausts that is reportedly causing some of the biggest problems by finding their way into the bloodstream, contributing to clot formation and hardening of the blood vessels.

As part of reducing sedentary behaviour and promoting physical activity, children and adults are encouraged to go outside and walk



more, cycle more and run more, either in a structured fitness session or in active transport, outdoor household activities or free-living activities.

Globally, 52% of people live in urban areas, increasing to 78% in developed countries, suggesting that exercising outdoors might increase exposure to urban air pollution that could affect the positive benefits of being physically active.

Different forms of active transport are also affected by exposure to air pollution. For example, cyclists travelling in the bike lane in major urban areas might be exposed to smaller particle matter than pedestrians, due to their proximity to the traffic. It is also possible that commuters in buses and cars in urban areas are also exposed to poorer air quality if they sit in sections with limited circulating ventilation.

Walkers, bikers and runners who exercise in urban environments before work, at lunchtime or after work could also be at risk given that, at the start of exercise, breathing increases up to 15 times more than at rest, which allows more fine polluting particles to progress deeper down the respiratory tree.

The effects of this exposure to air irritants while moving can be reduced by exercising at low to moderate intensities (2-4 METs). Overall physical performance and health will decrease, particularly while exercising at high intensities (>6 METs).

There are a number of physiological changes that occur when exercising in a polluted environment. When exercising at low intensities, there is a tendency to still breathe through the nose, which filters many of the air's irritants before it gets into the lungs.

Once the intensity increases, there is a rise in breathing through the mouth, increasing the pollutant dose into the lungs. The faster breathing rate increases the proportion of fine particles that move down the airways and are not exhaled easily. This can cause an inflammation of the lung tissue that can affect the airway antioxidant defences and increase airway resistance by constricting the air passages, making it harder to breathe.

At the beginning of exercise, breathing becomes faster and deeper and then, as a means of trying to protect the lungs, breathing becomes less, trapping gases in the airway dead space and setting up a potential competition for blood between the skeletal muscles and the muscles responsible for breathing. Air passages tighten and breathing becomes much more laboured.

The cardiovascular and respiratory systems start to strain in an attempt to feed the muscles with the required amount of oxygen they are demanding.

Carbon monoxide has a strong affinity for haemoglobin found in the red blood cells. Carbon monoxide has a 200-250 times greater affinity for haemoglobin than oxygen, reducing the oxygen-carrying capacity of the blood[4].

As oxygen is needed to burn fuel for the supply of energy, the heart must beat faster and with more blood (stroke volume) in order to transport the required amount of oxygen to the tissues. If the blood and the oxygen fail to reach the tissue, there is a chance of tissue hypoxia or lack of oxygen to the cells. When oxygen delivery to the cells is reduced, there is an increase in the production of free radicals, which causes the cells to become inflamed, impairing their basic functions as well as increasing the oxygen cost of the activity[5].

The effects of air pollution can last for hours, even after the exercise session has finished.

Short-term symptoms of pollution exposure include sore throat, coughing, scratchy throat, headache, chest pains and watery eyes. In those with existing coronary heart disease, exposure to air pollution can potentially contribute to myocardial infarctions and irregular heartbeats, as well as affecting the lining of the arteries.

Overall exposure to air pollution in an urban environment should always be a consideration when planning outdoor activities, particularly when the session is high intensity. Low levels of fitness and obesity further increase the potential risks from exercising in a polluted environment.

Risk management strategies include: being aware of the pollen count or pollution levels forecast on the day of exercise; pre-treatment for asthmatics to protect against the reduced oxygen levels; exercising in the morning and avoiding mid and late afternoon; exercising as far away from traffic or industry as possible; exercising close to trees, gardens and water areas; identifying those at risk; avoiding smoky areas; exercising indoors if the air quality is too poor; avoiding morning and afternoon rush hours; selecting the less-polluted days to exercise at a higher intensity (e.g., Sundays); exercising at low to moderate levels of intensity on poor air quality days; reducing the time outdoors and limiting exercise on polluted days.

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