Designing work for 21st Century bodies and lifestyles

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Abstract

Ergonomics developed in the middle of the 20th century with a physical focus on avoiding fatigue and overexertion, which suited the status of bodies and lifestyles at the time. Contemporary bodies in affluent communities are fat and unfit with inactive lifestyles. Contemporary work often demands sustained sedentary behaviour and is thus an important contributor to not only musculoskeletal disorders but also the substantial burdens associated with inactivity related disorders such as obesity, diabetes and cardiovascular disease. Public health responses to the growing burden from inactivity related disorders have to date focussed on leisure time exercise and transport to and from work. Ergonomics has an excellent opportunity to make a substantial contribution to population health by using its expertise in workplace interventions and postural variation. However physical ergonomics needs to change its paradigm to design work to increase, rather than decrease, physical loads at work through the minimisation of sustained sedentary behaviour and encouragement of activity.

Introduction

Ergonomics developed as a discipline in the middle of the 20th century. Its focus was on issues of prominence at that time; these issues were determined by the status of people and the demands of their lives. Physical ergonomics therefore initially focussed on avoiding whole body physiological fatigue and local biomechanical overexertion. Its approach to risk reduction followed the threshold limit value approach prominent in occupational hygiene. Thus recommendations were made for the threshold limits of the intensity of work – both whole body energy expenditure and biomechanical loading. For example, 50% of maximal oxygen uptake was suggested as the limit for an 8 hour workday in 1960 and this was subsequently revised down to 40% (Astrand 1967) and later to 30% (Frings-Dresen et al. 1995). Within the context of work typically requiring heavy physical labour, this was an appropriate approach to reducing physical risks.

However, the physical status of people and their lifestyles in affluent countries is now substantially different to the mid 20th century, and thus the focus of physical ergonomics perhaps needs to change also.

21st Century Bodies

Contemporary bodies in affluent communities have developed in a very different environment in terms of nutrition and activity than that of the mid 20th century, and indeed than that ever experienced by homo sapiens. Contemporary Australian diets are now characterised by an over intake of energy dense foods and an under intake of nutrient rich fruits and vegetables. For example, only 8% of adult females and 5% of adult males met daily intake recommendations of 2 fruit and 5 vegetable serves (ABS 2009). The median self-reported daily energy intake for Australian adults is 11,050kJ for males and 7,481kJ for females (ABS 1998) which is close to the estimated energy requirements of adults with moderate activity levels (NHMRC 2006). Healthcare is substantially improved, with increased life expectancy. Australian life expectancy at birth is now around 83.5 years for females and 78.7 years for males (ABS 2011a). The combined effect of these and other societal changes is that 21st century bodies are quite different to mid 20th century bodies.

Fat bodies

Whilst there is some evidence that the rising rate of overweight (>25BMI) and obesity (>30BMI) in Australian children has plateaued (Olds et al. 2010), the high rate (around 25%, ABS 2009) is substantially different to the rest of human history. For Australian adults, the rates are even higher (around 61%, ABS 2009), with no evidence of a plateau to date. Thus in contemporary society, ‘normal’ weight is actually overweight, with only 37% of adults at a healthy weight.

Unfit bodies

An international review has reported that aerobic fitness, as assessed by the shuttle run test, declined in children by 0.43% per year from 1980 to 2000 (Tomkinson et al. 2003). Recent UK data on aerobic fitness assessed by step test has shown that 32% of men and 60% women were not fit enough to sustain walking at a brisk pace on a slight incline (NHS 2009). National Canadian data show a decline not only in aerobic fitness (shuttle run) but also in muscle strength (grip strength) over the 1981 to 2008 period for children (Tremblay et al. 2010). Grip strength for Canadian adults also declined over the same period (Shields et al. 2010).

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Old bodies

Australian Bureau of Statistics data shows the aging of the population (ABS 2008). In 1901 45.1% of the population was under 20 years of age, but by 1950 this declined to 33.4% and by 2000 it had declined to 27.6%. In contrast the population aged 50 and over increased from 11.9% in 1901 to 22.8% in 1950 and 28.2% in 2000. This trend is expected to continue this century.

Impaired bodies

Whilst it is unclear whether the prevalence rates for a broad range of disabilities has increased in Australia over the last half century, there has been a substantial increase in the number of Australians living with a disability. From 1981 to 2003 the number of Australians with a disability increased from 1.9million to 3.9million (AIHW 2008). Disability related to musculoskeletal disorders, as well as cardiovascular disorders and diabetes is expected to increase substantially over the next few decades. For example, health costs associated with the treatment of diabetes is expected to increase from $1.6billion pa in 2003 to $8.6 billion by 2033 – due to not only population growth and aging but also an increase in the prevalence rate associated with higher rates of obesity (Goss 2008).

Bodies with musculoskeletal and other health disorders

The total health burden in Australia was estimated at 2,632,770 disability-adjusted life years (DALYs) in 2003 (Begg et al. 2007). The health burden to Australia of musculoskeletal disorders was 105,508 DALYs (4.0% of total burden) – which is substantial and a worthy issue for physical ergonomics to attempt to improve. Within musculoskeletal disorders, back pain contributed 35,778 DALYs (1.4% of total) and occupational overuse syndrome contributed 4,953 DALYs (0.2%). (Interestingly, other traditional ergonomics targets were estimated to be responsible for similarly small proportions of health burden: falls (26,386, 1.0%) and machinery accidents (5,095, 0.2%). However, the health burden to Australia of inactivity related disorders such as diabetes (218,518, 8.3%), stroke (118,462, 4.5%), ischemic heart disease (263,497, 10.0%), colorectal cancer (63,605, 2.4%) and breast cancer (60,654, 2.3%) is even greater, and physical ergonomics could make a substantial contribution by reducing occupational inactivity.

21st Century Lifestyles

Contemporary lifestyles are characterised by inactivity. Activity in the domains of occupation, leisure, transport and domestic chores is now characterised by prolonged periods of sedentary time and often complete absence of bouts of moderate to vigorous physical activity (Owen et al. 2010). The daily routine for many workers is sitting during a commute to work, followed by sitting at a computer at work, with occasional breaks sitting in the lunch room, followed by a commute home in sitting and then an evening sitting to eat dinner and watch TV. This is a stark contrast to the lifestyle of most workers a century ago.

Quantitative data on historical activity levels were not collected at the time, however estimates have been made. In an interesting study the daily physical activity levels of modern male workers was compared to the activity levels of male actors playing the roles of soldiers, convicts and settlers in a historical theme village (Egger et al. 2001). The historical lifestyles had greater physical activity – equivalent to walking 8km more each day. Over the past half century, more of the workforce in countries like Australia has shifted from manufacturing and primary industry to service industries, particularly computer based occupations. In the USA, from 1960 to 2010 the proportion of workers employed in occupations which required moderate energy expenditure fell from almost half to less than an quarter (Church et al. 2011).

Importance of moderate to vigorous activity

Mid 20th century Morris et al. conducted a study on London bus workers and found bus conductors had half the early mortality from coronary heart disease of bus drivers (Morris et al. 1953a). They proposed that the physical activity required of bus conductors provided a protective effect to maintain cardiovascular health. Over the subsequent half century substantial evidence has been accrued that moderate and vigorous physical activity is very beneficial to health (Haskell et al. 2007).

Evidence has also accrued that it is not just the overall accumulation of exposure to moderate to vigorous physical activity, but also the pattern of exposure is important. Sustained bouts of moderate to vigorous physical activity lasting at least 10 minutes in duration have been found to provide better health benefits (Strath 2008).

The public health response to this evidence has been to encourage leisure time moderate to vigorous physical activity. For example, Australian guidelines for young people recommend 60 minutes (and up to several hours) of moderate to vigorous physical activity every day (DHA 2004). Australian guidelines for adults recommend 30 minutes of moderate to vigorous physical activity every day in bouts of at least 10 minutes duration (DHA 1999).

Despite considerable investment by society in promoting leisure activity, compliance with guidelines is generally quite poor. Data from the National Health Survey 2007-2008 suggest only 38% of Australian adults meet the national physical activity guidelines of at least 30 minutes of moderate to vigorous activity on most days of the week (ABS 2011b). The health benefits of moderate to vigorous physical activity have mainly been championed in a context of leisure ‘exercise’ – defined as planned physical activity for the purpose of improving body function – although active transport has also been promoted. Health benefits of exercise have been reported for many aspects of physical and mental health with similar effect sizes as expensive pharmaceuticals but without adverse side effects (Sigal et al. 2006; Daley 2008). Indeed Exercise and Sport Science Australia has replicated the excellent approach of their American equivalent to promote exercise as a ‘medicine’ (see website http://exercisemedicine.org.au/).
Importance of sedentary behaviour

Something that has been overlooked for half a century in the Morris et al. study of London bus workers was that they proposed that there might have been two health risk mechanisms at work – a protective one for the conductors of moderate to vigorous physical activity and an injurious one for the drivers of sitting (Morris et al. 1953b). Over the last decade there has been a growing evidence base that sedentary exposure is an independent risk factor for health.

For example Katzmarzyk et al. (2009) found that mortality from all causes increased in a dose-response manner to daily sitting, with those who sat almost all of the time at 54% greater risk than those who sat none of the time. The increased risk with sitting was evident in those who were not physically active during leisure time as well as those who were, suggesting sedentariness is an independent risk factor to the lack of moderate to vigorous physical activity. Indeed Hamilton et al. (2007) have proposed that there are separate physiological mechanisms arising from exercise and sedentariness and has studied lipoprotein lipase as an example. Lipoprotein lipase is important to metabolic regulation and has been linked with metabolic syndrome – a cluster of risk factors for cardiovascular disease and type 2 diabetes including plasma triglycerides, cholesterol, plasma glucose, blood pressure and central adiposity. Whilst exercise increases lipoprotein lipase activity, especially in fast twitch muscle fibres, sedentariness reduces lipoprotein lipase activity, especially in slow twitch muscle fibres. It appears sedentariness influences physiological mechanisms at fundamental levels including gene transcription.

Similar to moderate to vigorous physical activity exposure, recent research has provided evidence that it is not just the total accumulated exposure to sedentariness but also the pattern of exposure is important.

For example, Healy et al. (2008) showed that breaks in sedentary time were beneficially associated with blood lipid and glucose levels as well as waist circumference, independent of total sedentary time and moderate to vigorous physical activity. Dunstan et al. (2012) showed that 2 minute bouts of light walking every 20 minutes lowered postprandial glucose and insulin levels in overweight adults in comparison to uninterrupted sitting.

Currently there are no Australian public health guidelines concerning sedentary behaviour exposure except for recommendations that children spend no more than 2 hours per day with screen based media (TV, electronic games, computers) for leisure purposes (DHA 2004).

Recently, researchers have been discussing the possibility of sedentary guidelines (Owens et al. 2009), and have cited ergonomics guidelines for appropriate use of computers.

It is estimated that physical inactivity is responsible for 6.6% of the total burden of disease and injury in Australia – some 173,763 DALYs (Begg et al. 2007). This is comparable to the burden caused by tobacco (7.8%), high blood pressure (7.6%), high body mass (7.5%) or high cholesterol (6.2%) and around double that of alcohol (3.2%), low fruit and vegetable consumption (2.2%) and illicit drug use (2.0%). Currently the estimated contribution of occupational exposures and hazards to total burden of disease and injury is 2.0% (through cancer, back pain, occupational overuse syndrome, chronic obstructive pulmonary disease, road traffic accidents and ‘other’), however this does not include the occupational inactivity contribution.

The role of work

Despite the fact that workers spend a large proportion of their waking time at work, the vast majority of research on ways to enhance moderate to vigorous physical activity and reduce sedentary behaviour has focussed on non-occupational time. Even those studies which have been conducted in workplaces have focussed on the breaks between productive tasks, transport to and from work and leisure time (Dugdill et al. 2008).

Physical ergonomics has tended to view work as a negative – and that changes to work need to be made to reduce the risk of injury. However work is generally a very positive contributor to health (Waddell 2006). Other areas of ergonomics have long recognised the opportunities for work design to not just be reducing negative impact but actually have a positive impact on health (Herzberg 1966). Recently, physical ergonomics has been encouraged to change its paradigm and see work as an opportunity to enhance the physical status of workers, not just avoidance of injuring workers (Straker et al. 2009).

Designing work for 21st century bodies and lifestyles

Given contemporary bodies and lifestyles, better designed work could play a key role in enhancing health. At a bare minimum, work should be designed to minimise sustained sedentary exposure and total sedentary exposure and increase light or moderate to vigorous physical activity.

For example, the approach of ergonomics to office chairs needs to be reconsidered. Until recently, the goal with office chair research was to make chairs comfortable with minimal muscle activity required. Indeed fidgeting has been used as a proxy of poor seating design as has increased trunk muscle activity. However, given the musculoskeletal evidence mounting over the last 3 decades and cardiometabolic evidence mounting over the last decade, it is clear that comfortable office chairs could be seen as a health hazard as they encourage sustained sedentariness.

Workplace interventions are now being trialled to reduce overall sedentary time and break up periods of sustained sedentary time. For example, Gilson et al. (2009) found a program encouraging incidental walking during work tasks – such as walking to talk with a colleague rather than email – was able to increase the number of steps taken in a day. However finding productive tasks away from a computer has become more difficult as computers have become more capable. Two approaches to reducing sedentariness during computer work have emerged, both were first developed by ergonomics and are now being promoted by physical activity researchers.

Sit-stand desks were popularised in the 1990s as a way of reducing sustained sedentary time and thus reduce musculoskeletal discomfort and disorders. Such desks were implemented in many workplaces in Scandinavia

including call centres (Toomings et al. 2012). Several studies demonstrated that whilst prolonged standing was associated with discomfort, alternating sitting and standing at work reduced discomfort (Roelofs et al. 2002). More recently a laboratory study has shown no decrement in computer task productivity when standing compared to sitting (Straker et al. 2009b). Sit-stand desks have received renewed interest as a way of improving cardiometabolic health (Alkhajah et al. 2012).

The even more radical approach to reducing the sedentariness of computer work has been the creation of active workstations – where computer work is performed whilst gently walking or cycling (Edelson et al. 1989). Levine et al. (2007) developed a workstation with treadmill and showed that slow walking whilst operating a computer for several periods of the day resulted in a substantial energy expenditure increase of sufficient magnitude to reverse the population weight gain trend. Laboratories studies have shown a small decrement in typing and a moderate decrement in fine mousing work whilst walking, which may reduce with practice and may not make a noticeable difference to general office task performance (Straker et al. 2009b). Interestingly, there was no performance decrement when cycling suggesting this may be an even more acceptable intervention.

Conclusion

21st century bodies are more commonly fat, unfit and inactive compared with 20th century bodies. 21st century lifestyles are more commonly inactive compared to 20th century lifestyles and this is particularly the case with occupational exposure. Physical ergonomics therefore needs to change its focus from reducing occupational health risk by reducing physical load to a focus on designing work to enhance health through appropriate activity.

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