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Masterclass

The dangers of inactivity; exercise and inactivity physiology for the manual therapist

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ABSTRACT

Physiotherapists should take a primary role in relation to the prevention and management of all diseases that are associated with low levels of physical activity. The benefits of regular physical activity on health, longevity, and well being easily surpass the effectiveness of any drugs or other medical treatment. Physical activity has many beneficial effects on the body, helps prevent the development of many chronic diseases and is a useful complement to drug treatment in many diseases. As the importance of physical activity for health might well be underrated and undervalued even by manual therapists we describe the physiological consequences and health dangers of being inactive in this paper.

1. Introduction

Physical inactivity has become the biggest public health problem of the 21st century (Blair, 2009), with at least 60% of the global population failing to achieve the minimum recommendation of 30 min moderate-intensity physical activity daily (World Health Organisation, 2010).

Numerous well-conducted prospective observational studies have demonstrated that the least active and unfit people are at the greatest risk of developing a variety of chronic diseases, such as heart disease, diabetes and obesity, and all-cause mortality. This increased risk occurs independent of ethnicity, income, education, or body size and shape, and there is a dose–response across a wide range of activity and fitness levels (US Department of Health and Human Services, 2008; Haskell et al., 2009).

At the same time we see an increase in the strong evidence for the health benefits of physical activity and physical fitness. Physical activity protects against many chronic health conditions by improving glucose uptake and insulin sensitivity, improving blood lipid profiles, lowering blood pressure, improving the health of blood vessels, and protecting against obesity (Chakravarthy et al., 2002; Pedersen and Saltin, 2006). The evidence suggests the benefits of regular physical activity on health, longevity, and well being easily surpass the effectiveness of any drugs or other medical treatment (Chief Medical Officer, 2010; Pedersen and Saltin, 2006). Then, how come the silence on these health benefits in the physiotherapy community?

The paucity of research on the impact that physiotherapists can make in promoting physical activity for prevention of chronic diseases, suggests that the importance of physical activity for health might well be underrated and undervalued even by physiotherapists. Although studies on health promotion by physiotherapists are scarce, an American study reported that only 54% of physiotherapists assisted patients with increasing physical activity (Rea et al., 2004). Only one controlled trial assessed a behavioural intervention by physiotherapists to promote exercise among outpatients (Sheedy et al., 2000). The effect of the intervention was not clear, as both control and intervention subjects improved their physical activity participation from baseline to follow-up. This may not be surprising, considering the use of exercise therapy as treatment for many conditions to increase performance.

Physiotherapists should take a primary role in relation to the prevention and management of all conditions that are associated with low levels of physical activity. As experts in functional ability, in which movement and exercise are cornerstones, and with a thorough knowledge of pathophysiology of inactivity and its

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effects on all systems, physiotherapists may be the ideal professionals to promote, guide, prescribe and manage exercise activities that enable people living with chronic musculoskeletal, neurological or cardiopulmonary conditions or inactivity related disease (e.g. obesity and Diabetes type II (DM II)) to maintain or improve their level of physical activity.

Insight into the physiological impact of inactivity on physical fitness may eventually help us to design therapeutic strategies to minimize the loss of health-related fitness in people who are in situations associated with inactivity, due to prolonged hospitalization, ageing, and/or chronic disorders.

2. Physical activity and physical fitness

Physical activity is defined as “any bodily movement produced by contraction of skeletal muscles and resulting in energy expenditure above the basal level”. Exercise (therapy) is defined as a subcategory of physical activity in which planned, structured, and repetitive bodily movements are performed to maintain or improve one or more attributes of physical fitness. Physical fitness refers to the ability to carry out daily tasks with vigor and alertness without undue fatigue and with ample energy to enjoy leisure time pursuits and to meet unforeseen emergencies (Caspersen et al., 1985). Physical fitness includes body composition, muscle strength and endurance, flexibility, motor control and aerobic capacity. Physical activity and physical fitness are thus interrelated.

Physical fitness provides the capacity to perform physical activities. With increasing fitness, people tend to become more active, and the fittest persons tend to be the most active. The association between fitness and health is also reciprocal. Fitness influences health, but health status also influences both physical activity and fitness (Bouchard and Shephard, 1994). One aspect of physical fitness is aerobic capacity or VO_{2max}. VO_{2max} is a measure of the ability and efficiency of the body to take up oxygen and use it to convert fat and carbohydrates into energy (adenosine triphosphate or ATP). Factors influencing the VO_{2max} are described by the Fick equation:

$$VO_2 = Q \times \Delta a - \nu O_2,$$

where Q is cardiac output (cardiac stroke volume × heart rate) and Δ a-v O_2 is the mixed arterio-venous O_2 content difference. VO_{2max} describes the maximal amount of energy available by aerobic metabolism per unit of time (Mezzani et al., 2009). Normal values of VO_{2max} depend on age and gender and are influenced by body size, level of physical activity and genetic endowment. VO_{2max} declines with age and accelerates from 3% to 6% per decade during the 20 s and 30 s to >20% per 10 years in the 70 s and beyond, regardless of physical activity habits (Fleg et al., 2005), because of decreasing maximal heart rate, stroke volume, blood flow to skeletal muscle and skeletal muscle aerobic potential with age (Betik and Hepple, 2008). VO_{2max} is 10–20% greater in males than in females of comparable age, because of the higher hemoglobin concentration, greater muscle mass and cardiac stroke volume in males (Mezzani et al., 2009).

Part of aerobic capacity is used for basal metabolic rate; the other part is available for physical activities (metabolic scope). Physical activities are coded in Metabolic Equivalent of Task (MET) intensity levels. One MET equals the resting metabolic rate obtained during quiet sitting and equals an approximate oxygen uptake of 3.5 ml/kg/min. The oxygen usage for physical activities ranges, for example, from 0.9 MET for sleeping to 16 METS running a 6 min mile (Ainsworth et al., 2000) (see Table 1).

Table 1
Examples of metabolic equivalent of task (MET) cost (Ainsworth et al., 2000).

Activities	METS
Watching TV	1
Desk work	1.5
Standing	2
Walking the dog	3
Gardening -general	3–4
Cleaning windows	3–4
Cleaning floors	3–4
Mowing lawn	5–6
Carry 10–20 kg	4–5
Bicycling (slow)	6
Running (6 min/mile)	16

A person’s aerobic capacity thus directly affects the amount and intensity of physical activity an individual is able to perform and determines exercise capacity. Higher aerobic capacity not only enables individuals to “do more”, but has also been shown to predict a lower risk of death in normal males and males with cardiovascular disease (Myers et al., 2002) and asymptomatic women (Gulati et al., 2003).

3. Deconditioning

Inactivity or disuse leads to deconditioning. Deconditioning is defined as the integrated physiological response of the body to a reduction in metabolic rate; that is, how the body reacts to a reduction in energy use or exercise levels (Greenleaf, 2004), such as in bed rest. Deconditioning is associated with a host of physiological changes. Muscle mass decreases, with loss of muscle strength. Muscle capillary density declines along with mitochondrial enzymatic activity and ATP production. This leads to loss of muscle oxidative potential (Δ a-v O_2) and increased fatigability of muscle. This, in combination with loss of cardiac output (Q) leads to a decrease of VO_{2max}. In response to unloading, bone strength decreases through a rapid and sustained increase in bone resorption and a more subtle decrease in bone formation (Zerwekh et al., 1998). The greatest bone loss occurs at weight-bearing skeletal sites. Disuse decreases the collagen turn-over in tendons and muscles (Kjaer, 2004), weakens the attachment of ligaments to bone and causes a disorganization of collagenous fibers. Proprioceptive mechanisms within the muscle and muscle-tendon junction degenerate and become less responsive (Simonson, 2004) potentially increasing risk of injury. Metabolic changes can lead to an increased risk of cardiovascular disease (CVD) and Diabetes type II (DM II) (see Fig. 1).

A result of deconditioning is a shift towards increased reliance on carbohydrate as an energy substrate at submaximal and maximal exercise intensities in exercising muscle and a corresponding decrease in the contribution from lipid metabolism. In addition, a decline in sensitivity to insulin-mediated glucose uptake occurs, which partly results in a reduction of whole-body glucose uptake. Due to the increased reliance on carbohydrate as an energy substrate with deconditioning, the blood lactate concentration during exercise increases at submaximal intensities and the lactate threshold is apparent at a lower percentage of VO_{2max} (Mujika and Padilla, 2001). Consequently, exercise performed at the same absolute intensity after disuse results in a higher heart rate, higher blood lactate accumulation, an increase in muscle glycogen utilization and carbohydrate oxidation, a reduction in exercise time to fatigue and increased dyspnoea. Activities demand a higher relative percentage of VO_{2max} and may cause shortness of breath and fatigue. As a result, activities may be reduced or avoided, causing physical functioning to decline. A vicious cycle develops where activity is reduced, walking speed is lowered, fitness levels decline