

## INAUGURAL LECTURE – SJ MOSS

### Be Active – B-Healthy

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#### Introduction

From the beginning of existence, man was dependent on movement for survival. Due to the demand imposed on the human body for survival, man's physiology developed in harmony. Power, endurance, speed, strength, coordination, balance, perseverance and skills were part of everyday life. According to research by Svahn (1977) movements such as javelin, fencing, dance, running, and archery are some of the first movements identified associated with survival. Activities captured in the Bushman drawings from South Africa support the notion that activity was mainly related to survival in the form of hunting and gathering food (Marshall, 1976).

Ancient philosophers such as Plato (424 – 348 BC) recognised the importance of physical activity by stating that:

*"Lack of activity destroys the good condition of every human being, while movement and methodical physical exercise save it and preserve it."*

This view supported the view held by the Greek physician, Hippocrates (460 – 370 BC), and was reiterated by the Greek physician, Galen (130 – 217 AD), who advised that: *"... a lack of exercise was detrimental to health, while an over-exertion was also unwise."*

The aim of this article is to indicate the importance of regular, appropriate physical activity on health outcomes across various study populations across the human lifespan, highlight the professionals dedicated to the management of physical activity, the effects of various exercise interventions on health outcomes, the challenges associated with obtaining the research data, and introduce sustainability of physical activity in order to ensure active persons become healthy persons. In order to understand the association between physical activity and health outcomes, it is important to understand the effect of regular physical activity on the physiological systems in the human body.

#### Physiological effects of physical activity and exercise

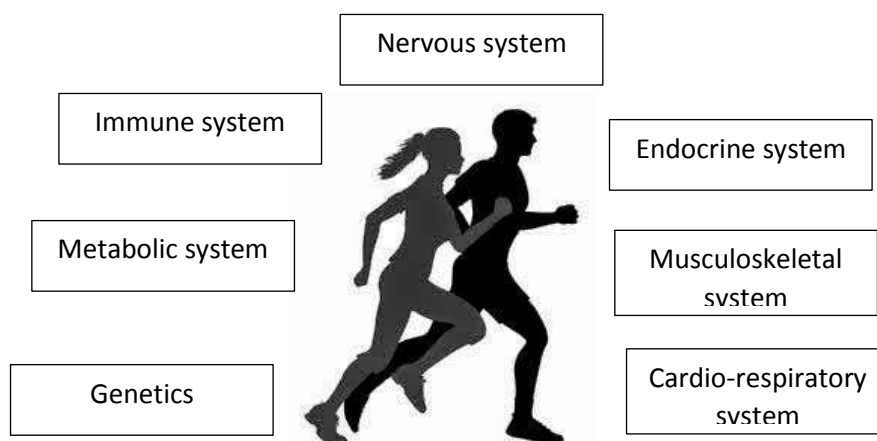
Physical activity is defined as any bodily movement that involves muscle activity and requires more energy than resting. This includes activities such as walking, running, dancing, swimming, yoga, gardening, vocational and housework to name a few examples (WHO, 2017). According to the Department of Health and Human Services' in the *"Physical Activity Guidelines for Americans"* 2008, physical activity generally refers to movement that enhances health (U.S. Department of Health and Human Services 2008).

Exercise is considered a type of physical activity that is planned and structured. Examples of exercise are lifting weights, taking an aerobics class, playing on a sports team, or participating in an individual sport such as tennis or gymnastics.

When humans move from a resting state to an active state, a multitude of physiological processes are activated. Upon the initiation of movement, the muscle cells immediately require an increase in energy, consequently driving the need for more oxygen to the cells in order to produce the required energy. In order to meet the increased oxygen demand of the cells, the arterial walls relax to increase the blood flow toward the muscles. This relaxation, called vasodilation of the blood vessels, is activated by means of nitrous oxide (NO) produced in the body. Nitrous oxygen is also implicated in the higher prevalence of hypertension in black compared to white persons.

As the blood vessels enlarge, the heart rate increases and the blood pressure becomes elevated. This cascade of activities results in the metabolic rate increasing by 15 – 20 times to ensure sufficient energy for cell activity, muscle contraction, and the supply of oxygen and nutrients to the cells (McArdle *et al.*, 2015).

In addition to the response of the cardio-respiratory system, the musculo-skeletal system, the neuro-endocrine system, immune system and the metabolic systems are all an integral part of the response elicited by physical activity and exercise. Once physical activity is repeated regularly over an extended period of time, called conditioning, the health benefits of physical activity become evident (Figure 1). Effects of exercise on the brain are evident through the cognition and planning that is improved in persons that exercise regularly. Regular exercise is known to improve the immune function in a J-curve. Moderate exercise presents optimal immune function compared to no exercise and vigorous exercise. Adaptations in the metabolic system are a reduction of fat deposits, increased insulin sensitivity, and up-regulation of the mitochondrial enzymes. The increase in insulin sensitivity reduces the risk of developing Type II diabetes. Muscle strength and endurance are improved through regular exercise and result in improved functional capacity and a reduction in the risk of falling in older persons. Recent research indicates that modifications in the genes that are turned on have been observed in persons who exercise regularly.



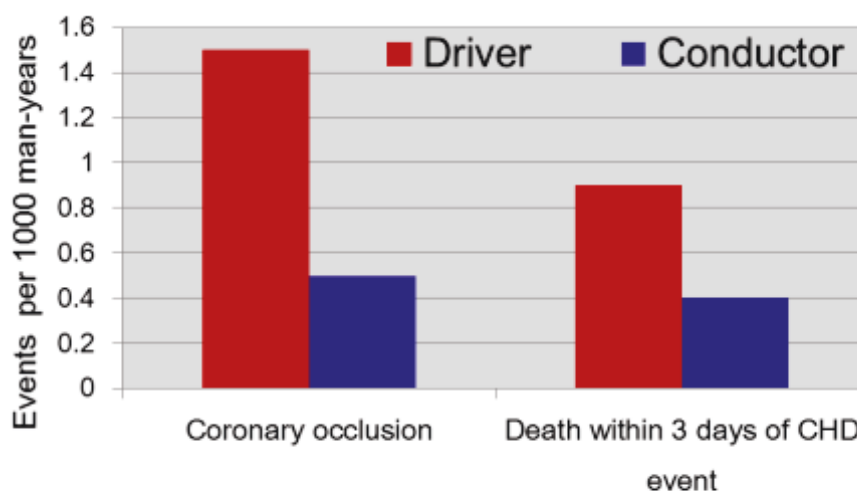
**FIGURE 1: The multi-system benefits of regular physical activity in the human body**

## International history of physical activity research

Although our understanding of the human physiology is based on information collected over many centuries, claims about the benefits of regular movement, physical activity and exercise made as early as 1500 BC have only been validated in the last 40 – 50 years. Initial research in the field reported on the relationship between occupation and health, and the findings were received with scepticism.

The arrival of the Industrial Revolution introduced the opportunity to measure the benefits of physical activity more objectively., Research focussing on exercise physiology and the cardio-respiratory system started in America in the 1920s. The establishment of the Harvard Fatigue laboratory resulted in the recognition of exercise physiology as an evidence-based science. Subsequent laboratories were also established in Norway, Finland and across Europe. During this period the mortality rate due to heart disease was high in countries with a high income, particularly amongst white-collar workers.

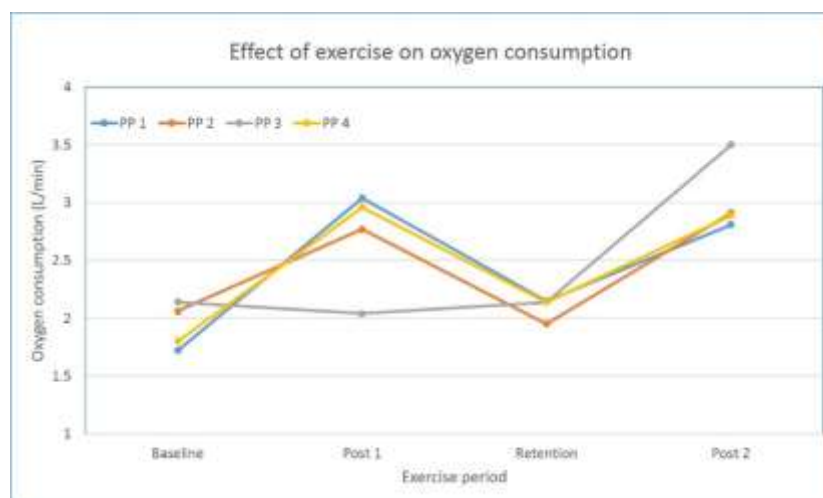
The first work that linked the lack of physical activity to health and heart disease in particular, was the observation by Dr Jerry Morris in 1949, published in 1953 (Morris *et al.*, 1953). He reported that transport workers from a similar background who were bus drivers and sat most of the day, had substantially higher heart disease rates than the conductors who walked through the bus and had to climb the stairs (Figure 2). This sparked a series of epidemiological studies on both sides of the Atlantic with Ralph Paffenbarger's work that tracked coronary heart disease (CHD) in San Francisco longshoremen for 22 years, from 1951 until the age of 75 years or death. In Finland, Mati Karvonen studied lumberjacks. The results of both these studies indicated that repeated bursts of high energy output activity offered protection against CHD (Paffenbarger *et al.*, 1970). Persons in more active jobs demonstrated a lower heart disease rate than those in sedentary jobs. However, these were findings in first-world countries at the time.



**Figure 2: Comparison between coronary heart disease and mortality in bus drivers and conductors**

### Biokineticists as exercise physiology professionals

During the same time period in South Africa, a young researcher that understood the relationship between exercise and the physiological adaptations elucidated by exercise and health outcomes, decided to conduct a study to determine the effect of an exercise intervention in post-cardiac event patients. This was deemed a no-go area in the early 1960s. Bed rest was the choice of treatment prescribed by physicians. Results from this study indicated that individualised, specific cardiovascular training restored functional work capacity in persons that suffered a myocardial infarction (Strydom, 1968). In ensuing years, the focus on exercise as cardiac rehabilitation was established at the then Potchefstroom University for Christian Higher Education. The foundation for the profession of Biokinetics was laid for eventual registration with the South African Medical and Dental Council on 9 September 1983. Until this period, South African research in the field of physical activity mostly focused on the teaching of sport and games within the physical education context (Strydom, 2006).



**Figure 3: First exercise intervention on post-myocardial infarction patients**

The initial registration of Biokineticists as medical scientists with the then South African Medical and Dental Council and later the Health Professions Council of South Africa, with a pertinent scope of profession, instigated research in the field of physical activity and health within the South African context.

### Physical (in)activity in the South African context

Physical inactivity is currently the 4<sup>th</sup> leading cause of death in the world (Ding *et al.*, 2016). The Lancet published a series on the effect of physical inactivity on major non-communicable diseases. The authors concluded that the prevalence, global reach and health effect of physical inactivity is of such an extent that it should be described as a pandemic with health, economic, environmental and social consequences (Lee *et al.* 2012b). In 2016, a follow-up series was published determining the progress and challenges with particular reference to low and middle income countries. Findings indicate that physical activity is not improving; although action is possible from various intervention studies, failure to upscale effective interventions at a population level is still evident (Das and Horton, 2016).

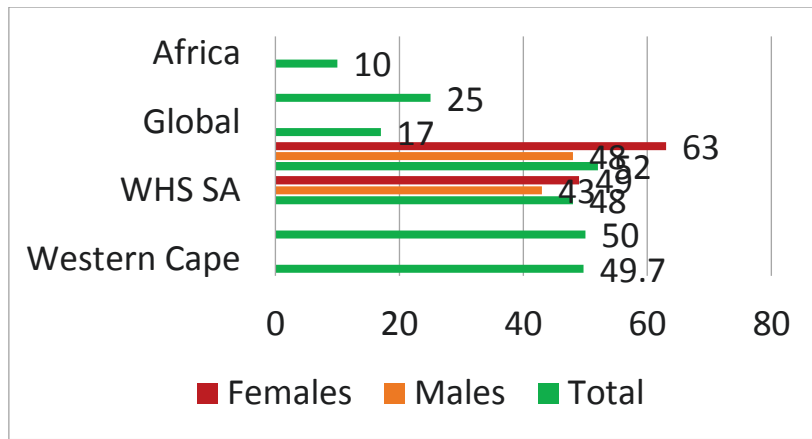
A summary of the global physical activity levels indicate that, in 2013, the global burden of physical inactivity was US\$ 53.8 billion (Ding *et al.*, 2016). Low-middle income countries are bearing the largest brunt of the burden. The burden is mostly due to related diseases of lifestyle associated with physical inactivity, such as type II diabetes mellitus, hypertension, dyslipidaemia, overweight and obesity. In order to understand the potential of physical activity on health outcomes, it is necessary to grasp the extent of physical inactivity of South Africans within the international context.

The latest updated country survey indicates that more than 80% of the world's adolescent population is not physically active, while one in four adults are not active enough (Figure 4). In South Africa, > 50% of South Africans are not physically active enough (WHO 2010). This places South Africa in the 3<sup>rd</sup> place globally for physical inactivity.



**Figure 4: Percentage of insufficient physical activity across the globe**

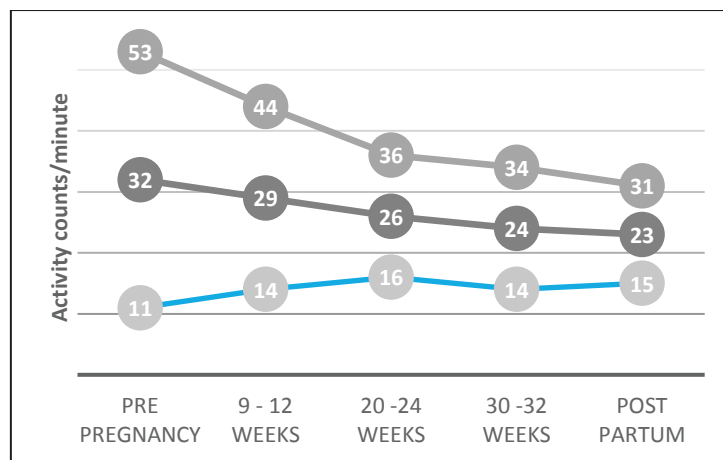
Data from various South African studies support the findings from the WHO with regard to the levels of physical activity (Joubert *et al.* 2007; Steyn *et al.* 2004; Kruger *et al.*, 2003). The majority of previously published data are on subjective questionnaire-based surveys (Figure 5). In general, Africa has very low levels of physical inactivity (10%), compared to the global prevalence of 17% and the insufficient physical activity of 25% for Eastern Europe (WHO, 2010). South Africans are, therefore, the leaders in physical inactivity on the continent, with women reporting the highest percentage of inactivity. Unfortunately, the most recent national survey that included any form of physical activity measurement was the first South African National Health and Nutrition Examination Survey conducted in 2012 (Shisana *et al.*, 2013). The results indicated that one third of the men were physically unfit while 50% of the women were unfit.



**Figure 5: Physical activity levels within the South African context (18+ years)**

The health outcomes observed in later life is often due to lifestyle habits during early life. If we therefore observe the physical activity levels across the lifespan in South Africans, the current burden of disease due to non-communicable diseases will continue to rise.

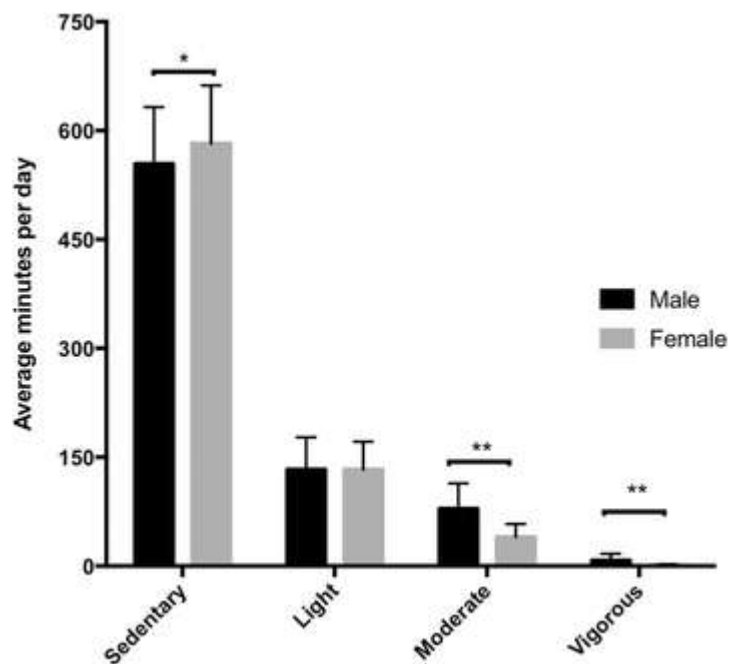
In a first longitudinal study determining physical activity objectively during the 40 weeks of gestation, we found that women were not sufficiently physically active during pregnancy. Physical activity levels decreased by 50 % during the postpartum period compared to pre-pregnancy (Figure 6) (Moss *et al.*, 2016).



**FIGURE 6: Longitudinal changes in activity counts per minute during pregnancy: The HAPPY-study (Moss *et al.*, 2016)**

In adolescents from the age 13 – 18 years, objective physical activity measurements indicated that an average of 50 minutes per day were spent on moderate to vigorous physical activity (Wushe, *et al.*, 2014). This is 10 minutes per day less than the recommended 60 minutes per day, according to the guidelines for physical activity for children. On average, only 36% of the adolescents achieved the recommendation for daily physical activity. Although South Africa lacks data on a national sample, regional data was collated in order to determine the current state of health in SA children.

In the recently launched Healthy Active Kids of South Africa report card, between 40 – 49% of South African children reported achieving the proposed guidelines for physical activity (Uys *et al.*, 2016). These levels tend to decrease in girls, especially as they approach adulthood. In young adults aged 19 – 20 years (Figure 7), males reported 83 min of moderate to vigorous physical activity while the females reported 48 min per day by means of objective measurements of physical activity (Prioreshi *et al.*, 2017)



**FIGURE 7: Physical activity patterns in young adults from Soweto (Prioreshi *et al.*, 2017)**

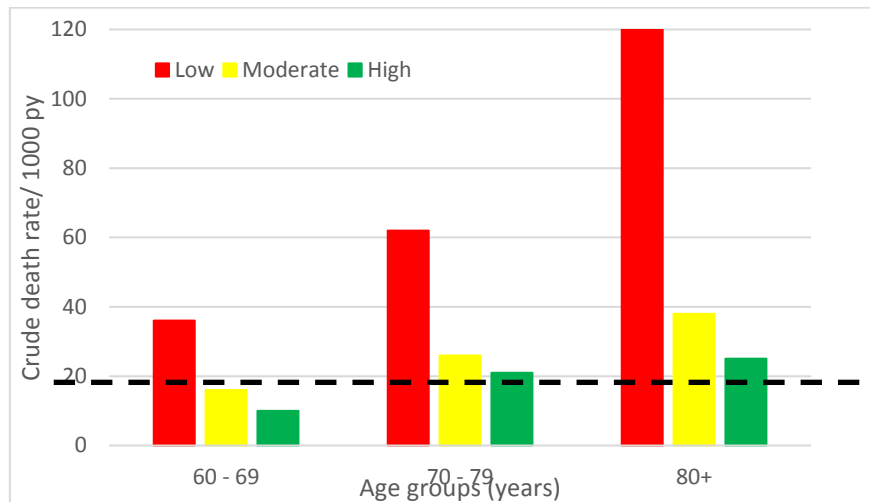
Data on adults were not collected during the recent South African Health and Demographic Survey, but data collected in the North-West Province during the Prospective Urban to Rural Epidemiological Study (PURE) indicated that physical activity levels are on the decrease in adults across the last 10 years (Phumudzo *et al.*, 2017). These trends are consistent as a sharp decrease in physical activity is observed after the age of 40 years (Manini, 2010). In special populations, such as persons with intellectual disabilities, levels of inactivity of up to 80% were reported (Moss, 2009). If we consider that persons with intellectual disabilities age earlier and are mostly dependent on caregivers, this often neglected population would benefit from regular physical activity.

Against this backdrop of a pandemic of physical inactivity in South Africa across the lifespan, knowledge about the positive relationships associated between regular physical activity and risk factors of non-communicable diseases are important as a strategy to change behaviour. Unfortunately, the South African numbers are dismal: 13% of children are overweight and obese – double the international number – 68% of adult women, and 31% of men. Hypertension, on the other hand, is reported to be prevalent in 46% of women and 44% of men (Statistics South Africa, 2016).

The WHO aims to reduce the prevalence of physical inactivity by 10% by 2025 (WHO, 2017) due to the strong evidence of the association between physical activity and risk factors for NCDs.

### Effect of physical activity on health outcomes

A few classic studies over the years have supplied the unequivocal evidence for the role of physical activity and the implied fitness. The lowest death rate per 1000 person years was reported by Blair and Wei (2000) across all age groups between 60 – 80 years for persons with high levels of fitness. Moderately fit persons aged 80 years plus reported similar death rates to persons with low fitness at 60 years old (Figure 8).



**Figure 8: Death rates and fitness (Blair & Wei, 2000)**

Findings from various local studies supported the findings from international studies with regard to the association between physical activity, fitness and risk factors for NCDs.

In the PLAY study undertaken with adolescent participants, an inverse relationship was found between leptin and fitness (Swanepoel *et al.* 2007) and an inverse association between physical activity and body fatness in adolescents from the Physical activity and health longitudinal study (Monyeki *et al.* 2012).

Data from intervention studies indicated that regular physical exercise as preventative strategy can be implemented to reduce the prevalence of risk factors for NCDs. Findings from a walking intervention in persons with intellectual disabilities reported that body fat percentage was significantly reduced with an exercise intervention while fitness was significantly improved. A reduction in blood pressure was also reported (Moss, 2009). When high intensity interval training was introduced as an exercise intervention for persons with intellectual disabilities – with and without Down syndrome – body composition improved significantly, together with fitness and functional ability. At the same time, the exercise time was reduced (Boer and Moss, 2016).

Besides studies preventing the development of risk factors for NCDs, research from across the globe also indicates that physical activity serves as a strategy to manage diseases of lifestyle. Data on the effect of physical activity on hip fractures of more than 61 000 women indicated that persons that exercised at least three times per week at a vigorous intensity of 24 MET-hours/week, reduced the risk of hip fractures by 55% (Feskanich *et al.* 2002; Larson *et al.* 2006 & Lee *et al.* 2012a) reported a

40% reduction in the risk of dementia for persons exercising more than three times per week than those exercising less than three times per week. People suffering from mental health issues reported a 40% remission rate after taking part in 180 min of brisk walking per week compared to a control group (Dunn et al. 2005).

Data from online survey (Cure Together, <http://curetogether.com>) indicate that exercise is indicated as the most popular and effective means of treatment for depression when compared with medical interventions and relaxation strategies. Exercise combined with dietary changes for the treatment of obesity and type II diabetes also presented as the most popular and effective means of managing these health conditions.

The strong evidence presented here from mostly USA-based studies resulted in the establishment of the Exercise is Medicine movement in the USA. There is now an international drive to promote “Exercise is Medicine”. The concept proposes that it is expected of medical practitioners to address physical activity as a lifestyle modifier during each consultation.

### **Demand for Biokinetics in public and private health care**

The identification of an unhealthy lifestyle with a lack of physical activity will have to be addressed by an expert in the field of exercise physiology. Biokineticists are currently the primary health professionals trained in the field of exercise and exercise as treatment modality for risk factors of diseases of lifestyle, management of diseases of lifestyle with exercise as modality, and optimal performance in activities of daily living to prevention and optimisation of sport performance (Government Gazette, 1984).

The scope of profession for Biokineticists is also aligned with the National Development Plan (National Planning Commission, 2011). The National Development Plan diagnosed that poverty and inequality is linked to the high disease burden. The proposed solution is to improve the quality of health care as a means to improve prosperity and equity. Quality health care is to be attained by increasing the number of healthcare workers and by promoting healthy active lifestyles and healthy eating. These proposals are in conjunction with various other domains and proposed interventions.

Biokineticists are the health professionals best trained to introduce physical activity, but they are currently not part of the public healthcare system. Therefore, the benefits associated with regular physical activity remains beyond the reach of more than 50 million South Africans dependent on the public health system. In 2007, the number of biokineticists in the private healthcare sector in South Africa would only have been able to potentially reduce the burden of NCDs in less than 7% of the population (Moss & Lubbe, 2011). This lack of implementation of physical activity as part of the public healthcare treatment plan is detrimental to attempts to reduce the burden of non-communicable diseases in South Africa (Figure 9).

**TABLE IV. The relationship between the current number of practising biokineticists and the potential market need for the different provinces**

Province	Current number of practices (N)	Market need for biokineticists* (N)
Eastern Cape	19	465
Free State	11	331
Gauteng	130	3 006
KwaZulu-Natal	33	1 129
Limpopo	5	472
Mpumalanga	9	422
North-West Province	11	498
Northern Cape	3	112
Western Cape	63	1 003
Total	284	7 438 <sup>§</sup>

\* Based on 100 patients/biokineticist.  
<sup>§</sup> Numbers differ due to some claims not being linked to original place of prescribing of medication.

**Figure 9:** *Potential market need for Biokineticists with in the different provinces (Moss & Lubbe, 2011)*

The B-Healthy study (Figure 10) was therefore designed to be a pragmatic, controlled-exercise intervention study over a period of six months to determine the effect of regular exercise on physical activity, fitness, risk factors for NCDs, functional performance, and quality of life.



**Figure 10:** *The B-healthy study: An exercise intervention in a low-resourced community to prevent and manage risk factors of NCDs in adults and improve quality of life*

Preliminary findings from the B-Healthy intervention study revealed valuable information with regard to the implementation of interventions in communities with limited resources in addition to the intervention effect.

At baseline, the average BMI of the participants was 31 kg/m<sup>2</sup> with a body fat percentage of 27%. Resting blood pressure indicated that all participants were on average hypertensive. With regard to the physical activity levels, fitness was determined as 19 ml/kg/min in the females and 26 ml/kg/min in the males. This is considered poor fitness compared to international norms for this age group (Heyward, 2006). Results from the functional fitness tests indicated low muscle strength as represented by the average grip strength of 25 kg for women and 35 kg for the men. Values below 44 kg in women and 75 kg in men require improvement. The average physical activity levels (PAL) were classified as inactive. Guidelines indicate that a level of above 1.6 is required to prevent persons from becoming overweight. The results of the health-related quality-of-life questionnaire (SF-8) indicated that the participants were experiencing a below average quality of life both mentally and physically (Ware *et al.*, 2001)

Results from the first 12 weeks of interventions indicated that, compared to the control group, a significant increase in fitness (17 ml/kg/min to 23 ml/kg/min), grip strength (25 kg to 26 kg), waist circumference (90 cm to 88 cm), systolic and diastolic blood pressure (141/86 mmHg to 133/82 mmHg), and the physical component of HR-QoL (45 to 50) were found. Although habitual physical activity increased, the change was not considered statistically significant.

These preliminary results within a limited-resource community is an indication of how being active contributes to being healthy. Results of the exercise intervention on the prescription and usage of medication is currently being analysed. These findings will give an indication of a potential reduction in the economic burden by implementing an exercise intervention as prevention and management strategy.

It is against this backdrop of the large burden of disease and the lack of resources to treat the burden, that strategies to prevent the development of lifestyle diseases should become the focus of the healthcare system. Exercise is considered a low-cost intervention strategy that can be implemented in any environment. Exercise is also a “whole system” approach, since exercise activates all physiological systems and produces positive changes in mental and physical health, which improves quality of life.

### **Low income communities**

South Africa is also considered a low-middle income country with unique challenges to introducing behaviour changes with regard to healthy lifestyles. To implement active lifestyles, various challenges must be considered and managed. These challenges include an understanding of the environment based on political instability, cultural beliefs and perceptions, as well as the influence of low levels of literacy and lack of exposure to technological advances. These challenges result in persons not being able to continue participating in interventions, the disposal of expensive research equipment due to ignorance, and the implementation of interpreters/translators to overcome language barriers and understand perceptions about physical activity. With great effort, challenges can be overcome and regular exercise introduced to communities. If we give a voice to participants in the B-Healthy study, the comments made by the participants in regular physical activity support the findings of the intervention study.

## **B-Healthy – The voice of the participants**

“04: Ever since I started exercising, from the clinic and then here at the hall, my blood pressure does not go up and down any more, it is always on the right level. I am always feeling well/healthy. Even when I get home I can work in my garden. I am well.”

On general muscle strength and endurance:

“05: When I came to the hall to exercise I had a problem with my spine, I had a back injury. Ever since I started exercising I can do house chores which I could not do before, I can even walk on my own without assistance. I used to walk with a stick but now I do not need the stick, I can walk without assistance “

And their NCD risk factors:

“07: I started with the project at the clinic before we came to the hall, I am diabetic and my sugar level was constantly high, every time I went to collect my medication they would put me on a drip. Ever since I started exercising they have never put me on the drip again. Even my blood pressure is now under control. I always feel so energetic. If I go weeks without coming to gym, I don't feel well, I missed gym for two weeks and my whole body was aching and I did not know what was wrong with me. But now that I came today I feel a lot better. At the clinic they are very happy with my sugar levels and have now started giving me medication that can last for up to three months.”

### **Sustainability of being active**

However, interventions should be sustainable. In order to ensure sustainability, various factors have to be considered. These factors include the inclusion of professionals in the public health sector as part of the treatment plan, perceptions and knowledge of physical activity and risk factors of NCDs, the influence of the built environment, and the application of new technologies in promoting physical activity within communities.

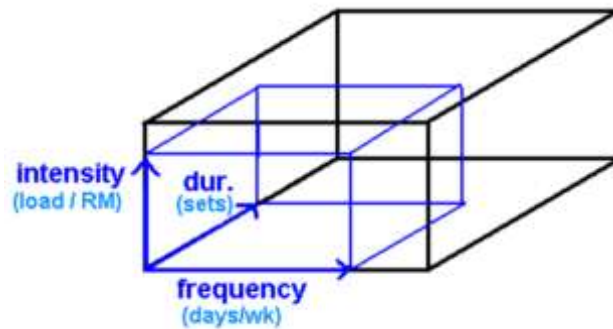
Introducing PA in the public health sector is difficult due to a lack of funding, but Biokineticists can screen for risk factors, educate on the management of risk factors and run group sessions or home-based exercises. In B-Healthy, waiting time for NCD support groups was reduced by 2-3 hours which also included an exercise session.

Data on knowledge and perception that was collected through qualitative research indicated that persons from the North West had the knowledge about physical activity, but when compared to their physical activity levels, the implementation of their knowledge was lacking. Perceptions about physical activity indicated that the influence of the men in their lives was an important barrier to physical activity (Makamu, 2016).

In addition to perceptions and knowledge influencing physical activity participation, the built environment also has an impact. Research in the Potchefstroom area found that areas where walkways were separated from the main roads saw increased physical activity in comparison to walkways directly next to a road. The upscaling of physical activity within low resource communities is a multi-professional challenge, with urban planners and developers having to join forces to create environments that are more conducive to physical activity.

## Be active

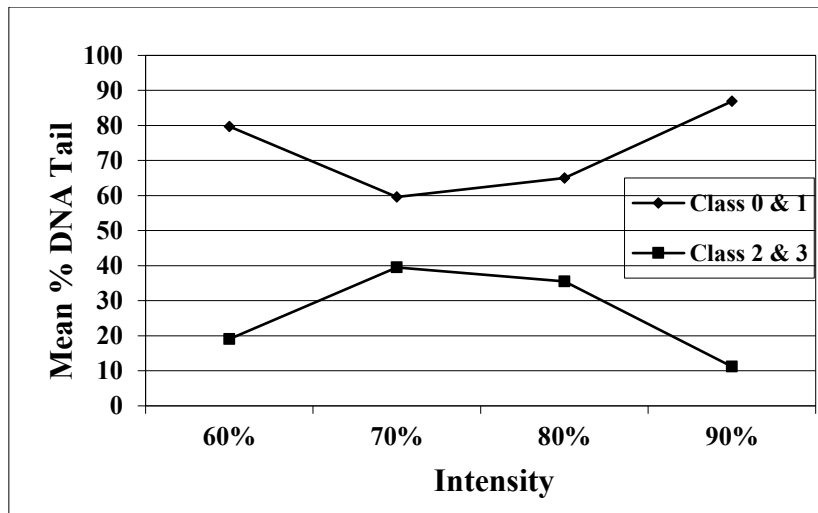
In order to be more active, it is important to understand the components that constitute health outcomes through physical activity. International research indicates that there is a dose response for the volume of physical activity necessary for health benefits. This volume is determined by the intensity, duration and frequency of exercise (Haskell *et al.* 1994) (Figure 11).



**Figure 11: The roleplayers in determining the volume of exercise**

Being optimally active entails appropriate physical activity at an effective level of intensity for a specific duration of time an optimal number of times per week with the necessary progression of difficulty to ensure an imposed demand on the physiological systems. The current physical activity guidelines for South Africans have been adopted from the American College of Sports Medicine (Pescatello *et al.*, 2014). The guidelines state that adults should aim to be active every day. Over a week, activity should add up to at least 150 minutes (2½ hours) of moderate intensity activity in bouts of 10 minutes or more. Alternatively, comparable benefits can be achieved through 75 minutes of vigorous intensity activity spread across the week or a combination of moderate and vigorous intensity activities. Adults should also undertake physical activity to improve muscle strength on at least two days a week. All adults should avoid spending extended periods of time sitting (ACSM, 2014).

In a study to understand the effect of exercise intensity on the level of DNA damage, we found a biphasic DNA damage-repair cycle with the Comet analysis in a group of well-trained middle-aged males. The highest amount of damaged cells was measured directly after acute exercise and the highest incidence of DNA damage over a 72-hour period was observed following exercise at 70%  $VO_2$ max, with the least amount of damage following exercise at 90%  $VO_2$ max. The conclusion was that less DNA damage occurred with exercise at 90%  $VO_2$ max than with exercise at 70%  $VO_2$ max in middle-aged men (Figure 12). The mechanisms involved are not clear, but it is hypothesised that the body releases heat shock proteins as protection at maximum exercise exertion (Aikman, 2007). Seventy percent of  $VO_2$  max is currently the prescribed intensity for training in order to moderate physiological adaptation.



**Figure 12:** Trends in % DNA damage for all classes over the various exercise intensities for trained middle-aged subjects

In order to increase your daily dose of physical activity, it is important to break the daily thirty minutes up into manageable 10-minute chunks. This can be done by: 1) walking early in the morning; 2) parking further away from your office or the entrance to the shops; 3) playing with your children for 10 minutes; 4) taking the stairs instead of the elevator when possible; 5) taking a brisk walk during your tea break; 6) walking to buy lunch; 7) introducing standing and/or walking meetings; 8) joining a sports club; 9) doing your gardening/housework; and 10) walking while talking on the phone. These are just a few ideas prior to starting you own walking group.

**Future perspective on physical activity research and implementation**

The evidence for the association of physical activity with risk factors of NCDs and exercise interventions to reduce non-communicable diseases is strong, yet levels of physical inactivity remains high. Future developments in the field of physical activity research should have a strong focus on modifying behaviour. The Health Belief Model, Theory of Meaning of Behaviour, Self-Determination Theory and Social Cognisance Theory should be implemented with exercise intervention studies. New technologies such as tracking devices and mobile applications will in future contribute to the motivation for physical activity. More recent studies have indicated that, although the evidence is strong for the positive effect of exercise on the majority of physiological systems, the Heritage study of Bouchard on twins revealed that under very well-controlled exercise intervention situations, some participants responded to the exercise intervention with an improvement in health risk markers as well as fitness measurements. A group of participants did not respond to the intervention and were identified as the non-responders. These findings drive the role of genetics and the environment on reported physical activity levels. This has developed into the field of epigenetics.

## Summary

Although Hippocrates made statements about being active for health, the true evidence for his statements only became evident during the middle 1900s. As populations developed to become mechanised, physical activity levels decreased and people became increasingly overweight and obese. This has introduced a new burden of disease, with persons in low income countries representing the greatest numbers. Findings from a variety of intervention studies have evidenced that the South African context warrants a serious effort in the war against inactivity and obesity. Findings from our B-Healthy project indicate that, besides a reduction in risk factors for NCDs, physical activity improved functionality as well as health-related quality of life. The total of the findings support the notion that being active results in being healthy.

There is a Chinese saying: “We cannot add more days to our lives, but we can add more life to our days.”

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