Chapter

The Profession of Biokinetics in South Africa: The Need for Access to the Public Healthcare System

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Abstract

This chapter reviews the efficacy of the only South African exercise therapy profession (Biokinetics) in the rehabilitation of non-communicable diseases (NCDs). Biokinetics is a South African exercise therapy profession established in 1983 and which operates in both the pathogenic and fortogenic healthcare paradigms. Unfortunately, the profession of Biokinetics is restricted to the South African private healthcare sector. This chapter describes the scope of the profession of Biokinetics, empirical studies illustrating the efficacy of the profession in addressing society's non-communicable disease epidemic, and the challenges inhibiting the profession from gaining access to the South African public healthcare sector. It is hoped that the presentation and critical appraisal of the empirical evidence which illustrates the contribution of the profession of Biokinetics to the rehabilitation of NCDs justifies the authors' claims for the inclusion of the aforementioned profession in the South African public healthcare sector.

Keywords: Biokinetics, exercise therapy, non-communicable diseases, healthcare

1. Introduction

The profession of Biokinetics is a specialised application of clinical exercise therapy which developed from the South African Universities Physical Education Programme in 1983 [1]. The fundamental roots of the profession of Biokinetics date back to 1934 and form part of the history of the South African Defence Force [2]. In 1934, a resurgence in the study of Physical Education occurred in the South African Defence Force when senior military personnel found that South African recruits were in poor physical conditioning, with poor medical, dental, and psychological health [3–5]. As a result, the South African Defence Force established the *Physical Training Brigade*, a specialised unit aimed at rehabilitating military recruits experiencing medical, educational, dental, physical, social and/or psychological challenges [5, 6]. The multidisciplinary team responsible for the rehabilitation included medical doctors, educators, dentists, physical education instructors, physiotherapists, psychologists, and sociologists [5, 6]. Dr. Danie Craven was the inaugural director of the *Physical Training Brigade* [5]. This historical synopsis places the resurgence of the South African Physical Education programme in the context of military involvement in pioneering South African health and wellness efforts,

commemorating the inaugural establishment of the first of the South African multidisciplinary medical rehabilitation team, and the intuitive preliminary South African exercise therapeutic and research based approach to restoring an individual's health and well-being. Biokinetics was born out of the philosophy that *exercise is medicine*. The ground-breaking empirical research of Dr. Danie Craven, Dr. Ernst Jokl and Prof. Gert Lukas Strydom has led to the development of the profession of Biokinetics [1, 7]. Professor Gert Strydom is affectionately known as the *"Father of Biokinetics,"* due to his immense contribution to the establishment and continued advancement of the profession [8].

During the late 1960's a drastic change in the research philosophy of South African exercise rehabilitative medicine occurred, prompted by the inventive research of Gert Lukas Strydom [9]. In his doctoral thesis Mr. Gert Strydom investigated the impact of a habitual structured exercise regime as a therapeutic modality to rehabilitate the functional exercise physiological capacity of coronary heart disease patients [9]. The empirical evidence obtained from the study illustrated that habitual, structured exercise regimes could successful augment cardiac rehabilitation and improve patients' quality of life. The success of these findings encouraged other proponents of the Biokinetics profession, such as FJ Buys and JJ Cilliers, to pursue postgraduate exercise-based rehabilitation credentials in the newly emerging field of Biokinetics [4, 10]. FJ Buys investigated the effects of a structured exercise regime on pre-diabetic and diabetic patients [10], while JJ Cilliers reviewed the effects of structured exercise training on the post-medical rehabilitation of injured soldiers [4]. FJ Buys later became a professor at the Potchefstroom University for Christian Higher Education (now known as North-West University), with JJ Cilliers becoming a prominent professor at Tshwane University of Technology.

2. Scope of profession of Biokinetics

The scope of the profession of biokinetics focuses on enhancing the physical health status and quality of life of a person through a clinical exercise evaluation and subsequent prescription of personalised exercise rehabilitation in the dual context of pathology (pathogenic healthcare paradigm) and physical performance enhancement (fortogenic healthcare paradigm) [11, 12]. The profession of Biokinetics also aggressively campaigns for health and wellness promotion as well as for the prevention of neuro-musculoskeletal injury and NCDs (fortogenic healthcare paradigm), thereby inspiring a positive change in the health and wellness continuum towards optimal well-being [1, 13]. Biokineticists are clinically trained professionals who address *inter-alia* the chronic concerns of NCDs in South Africa and Namibia through structured exercise rehabilitative intervention [14]. In the fortogenic health paradigm a person who is otherwise considered healthy, having no predisposing risk of neuro-musculoskeletal injury and/or NCDs, but who seeks to adopt a physically active lifestyle in order to avoid the onset and/or risk of illness, while simultaneously increasing their quality of life, consults a biokineticist [1, 14].

3. Health dimensions and health paradigms

Strydom *et al.* described the pathogenic healthcare paradigm as being inclusive of both the illness-care dimension and illness prevention dimension (**Figure 1**) [15]. The illness-care dimension involves the presence of disease and/or injury, while the illness prevention dimension involves the predisposing intrinsic risk of prospective disease and/or injury [15]. The illness-care and illness prevention health

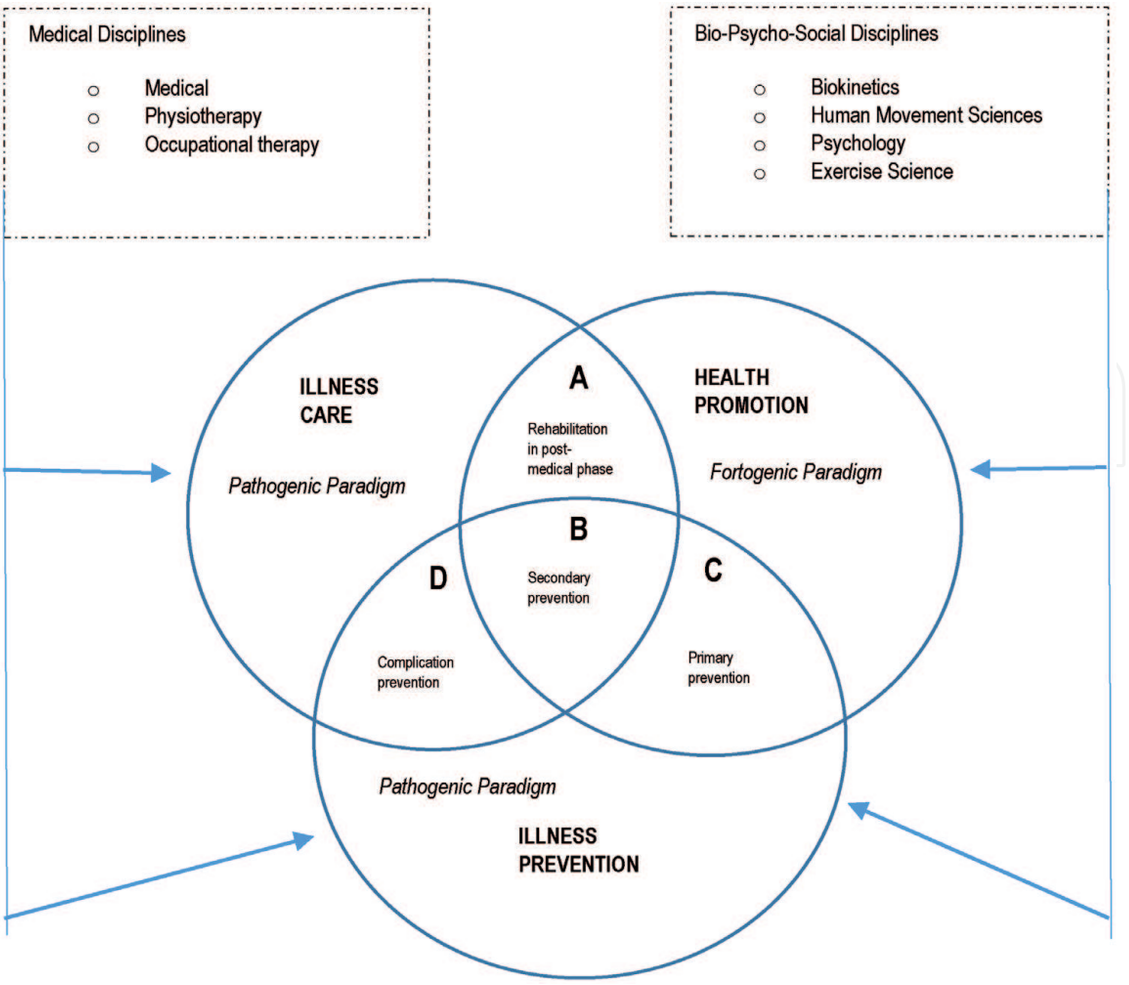

Figure 1.
Articulation of the health dimensions in the health paradigms [15].

dimensions necessitate clinical management by the medical discipline that involves the expertise of the following medical specialists: oncologists, cardiologists, cardio-thoracic surgeons, endocrinologists, neurologists, neuro-surgeons and orthopaedic surgeons, general medical practitioners, physiotherapists and nurses [16]. The fortogenic healthcare paradigm is the active attempt to prevent the onset of pre-disposing risk of neuro-musculoskeletal injury and/or NCDs. The aforementioned three healthcare dimensions actively intersect each other, thereby necessitating the expertise of the aforementioned medical and psycho-social disciplines (biokineticists, dieticians, and psychologists). This dynamic interweaving of the health paradigms encourages interprofessional collaboration [14, 17]. **Figure 1** provides a graphic representation of the dynamic overlap of the different health dimensions and of the interventions of the respective healthcare practitioners [12, 15]. **Table 1** describes the interaction of medical specialists in the rehabilitation of NCDs. The focus of this chapter is to illustrate the value of the profession of Biokinetics to the South African public healthcare sector. As such the chapter will exclusively describe the rehabilitation of NCDs. It must be stressed that Biokinetic rehabilitation also has a strong emphasis on neuro-musculoskeletal rehabilitation.

The aforementioned examples of NCD management provided by a biokineticist illustrate the value of their expertise that can serve both the private and public healthcare sectors. Many patients in the public healthcare sector who experience NCDs receive standardised treatment and do not receive individualised management. The medical and paramedical staff in the public healthcare sector are over-worked and therefore prescribe general healthcare management strategies whose

Areas	Non-communicable diseases
Area A displays the overlap between the pathogenic and fortogenic health paradigms, which is known as *final-phase rehabilitation,* or *post medical phase* (Figure 2). During this phase rehabilitation consists exclusively of physical activity and conditioning as the primary therapeutic modality.	An example would be an asthmatic patient who takes prescribed medication, has undergone physiotherapy and, lastly, is referred to a biokineticist [15]. While medication management falls within the purview of a pulmonologist and a pharmacist, the physiotherapist provides acute and sub-acute phases of physical activity rehabilitation and the expertise of the biokineticist improves the asthmatic patient's respiratory (and subsequently cardiorespiratory) function and quality of life, encouraging independent living through structured exercise and physical activity. Ensuring the patient's capacity for, and their improvement in, independent living is also the function of an occupational therapist.
Area B is known as *secondary prevention*, in which a given patient has an injury and/or disease, and has undergone surgical intervention, pharmaceutical management, and is subsequently engaged in final-phase functional rehabilitation in order to prevent deterioration of the predisposing injury (and/or disease) and avoid the development of co-morbidities.	A typical example would be a cardiac artery disease (CAD) patient who has successfully undergone surgery, has been prescribed chronic cardiac medication (to reduce the viscosity of his blood, as well as to control his blood pressure and heart rate). The patient would have completed acute and sub-acute phases of physiotherapy before finally being referred to a biokineticist. The primary goal of the biokineticist is ensure that the patient maintains a controlled and structured physically active lifestyle (within safe clinical exercise physiology guidelines) in order to prevent the recurrence of, and/or development of, co-morbidities. Many cardiac patients have experienced the value of controlled structured clinical exercise regimes but are reluctant to habitually comply with further clinical exercise programmes [15]. As such, many CAD patients continue to be physically active through participation in structured controlled games and sport (*recreational therapy)*.[15] Biokineticists should refer these patients to recreational therapists to prescribe games, sport and physical activity regimes [14]. It is, however, imperative that these patients comply with regular biokinetic clinical cardiorespiratory evaluations so as to determine their cardiorespiratory status and the efficacy of exercise therapy. This interaction implies interprofessional collaboration between cardiologists, pharmacists, physiotherapists, biokineticists and recreational therapists.
Area C refers to the scenario in which a healthy, illness free, person is who is not predisposed to any risk of pathology seeks to use physical activity as a proactive protective mechanism against illness and risk of illness (*primary prevention*). Such individuals seek the expertise of biokineticists in order to prescribe a physical activity programme so as to increase their physical conditioning and quality of life. A common example of this would be an apparently healthy person exercising at a health and fitness centre and/or gymnasium (Virgin Active).	
Area D is known as *complication prevention*, which occurs when a patient has no disease and/or injury but is categorised as being at an elevated risk of developing NCDs due to an unhealthy lifestyle (**Figure 1**).	Coronary artery disease, diabetics and obese patients are common examples of individuals who need to adopt lifestyle modifications that include dietary improvements, a reduction in alcohol ingestion, and termination of smoking and regular compliance with structured controlled exercise. Individuals are influenced by both modifiable (nutritional choice, alcohol ingestion abuse, tobacco abuse, physical inactivity, and stress) and non-modifiable (genetic predisposition, age, and gender) risk factors which adversely impact their cardiometabolic profiles. In order to prevent the development of, or advancement of existing NCDs, these patients require the interprofessional collaborative expertise of both the medical and bio-psych-social disciplines [17, 18].

Table 1.
The collaborative interface among the various healthcare professionals while managing non-communicable and neuro-musculoskeletal injuries.

efficacy may not be applicable to all patients suffering from NCDs. The inclusion of skilled practitioners (such as biokineticists) in the public healthcare sector will provide the necessary medical assistance to patients and alleviate the stress placed upon already overworked public healthcare sector staff. The incidence of NCDs and the upsurge in their mortality is of international concern, therefore countries that have skilled professions that are able to assist the present medical workforce in order to better combat NCDs should embrace the aid offered by these healthcare practitioners and include them in the public healthcare management team. The paper encourages the South African Department of Health to include the profession of Biokinetics in the public healthcare registry.

4. Non-communicable diseases

Non-communicable diseases (NCDs) are a group of non-infectious diseases which include chronic diseases of slow progression over a prolonged period of time. These diseases can, however, progress rapidly should they remain untreated and have the potential to lead to premature death. Epidemiological statistics attribute approximately 41 million premature deaths per year globally to NCDs [19], with 85% of the aforementioned mortalities occurring in low to middle income countries such as South Africa [19]. The World Health Organisation has identified four primary non-communicable diseases, which include cardiovascular diseases, respiratory diseases, cancer, and diabetes mellitus as being of particular concern. Collectively, these primary NCDs account for 80% of all deaths attributable to NCDs per year [19]. The individual morality rates of the primary NCDs are: 17.9 million deaths (43.6%) due to cardiovascular diseases, followed by cancer (nine million deaths, 21.9%), respiratory diseases (approximately four million deaths, 9.7%), and diabetes mellitus (approximately one and a half million deaths, 3.6%) [19].

Unhealthy nutritional choices, physical inactivity, alcohol, and tobacco use have been identified as modifiable predisposing risks for mortality related to NCDs. These aforementioned risk factors have been classified as modifiable risk factors, suggesting that if a patient changes their behaviour, this would favourably improve their health status. Regular physical activity of moderate intensity (150 minutes/week) and/or high intensity (75 minutes/week) as recommended by the American College of Sports Medicine has proven successful in improving the risk factors associated with NCDs, thereby improving not only the longevity of patients, but also their quality of life [16, 18, 20].

5. How exercise combats non-communicable diseases

This section will describe the manner in which habitual exercise, through exercise-induced physiological mechanisms, favourably influences the primary mortality agents of NCDs: cardiovascular diseases, chronic respiratory diseases, diabetes mellitus, and cancer.

5.1 Exercise-induced mechanisms for combatting cardiovascular diseases

Empirical exercise physiology literature has shown that habitual physical activity and exercise reduces heart rate and blood pressure, favourable alters high density lipoprotein (HDL) levels, low density lipoprotein (LDL) ratios, total serum cholesterol, excess body mass and body fat [20, 21]. The following exercise-induced physiological mechanisms assist compromised cardiovascular function:

i. Regular exercise improves arterio-venous extraction of oxygen from haemoglobin, which improves cardiorespiratory function. At rest 75–85% of the oxygen bound haemoglobin (oxyhaemoglobin) returns to the heart without having been extracted, while during exercise a larger portion of oxygen (approximately 75%) is extracted from oxyhaemoglobin in order to be used to produce energy. Increased exercise intensity lowers arterial partial pressure extracting more oxygen from oxyhaemoglobin, which becomes a chronic exercise-induced adaptation and prevents an increase in heart rate and blood pressure. This exercise induced mechanism lowers the incidence of cardiac arrest.

ii. Regular exercise and physical activity increase vagal tone, reducing heart rate. This reduction in heart rate affords greater ventricular filling time, thereby increasing end diastolic volume. The increased end diastolic volume in turn contributes to larger stroke volume, where a greater volume of blood being pumped means that a greater volume of oxygen and nutrients is available to the physically active musculature [20].

iii. Regular exercise also decreases arterial blood pressure as measured by the heart rate pressure product (RPP). The rate pressure product (RPP) is the product of the heart rate (HR) multiplied by systolic blood pressure (SBP) [RPP = SBP x HR] [21]. It is the index of myocardial oxygen consumption. As the RPP decreases, greater exercise intensity is required in order to elicit chest pain and/or discomfort (angina pectoris), which allows the patient to perform a greater volume of physical activity, thereby improving their quality of life. Clinically, decreased RPP lowers the myocardial oxygen index, reducing elevated heart rate and blood pressure [21].

iv. Exercise primarily increases venous return through the following hemodynamic mechanisms:

- Habitual physical activity and exercise produces laminar shear stress on the coronary endothelium, which changes the shape of the endothelial cells in the direction of blood flow which in turn stimulates the release of nitric oxide. Nitric oxide diffuses into the endothelium and surrounding smooth muscles producing vasodilation [20].

- Habitual exercise produces better calcium handling in coronary muscles, which decreases coronary vasoconstriction and conversely increases coronary vasodilation. Coronary vasodilation reduces resistance to blood flow thus lowering blood pressure [20].

5.2 Exercise-induced mechanisms for combatting chronic respiratory diseases

Chronic respiratory diseases include both chronic obstructive pulmonary disease, characterised by airway obstruction due to emphysema, and chronic bronchitis (inflammation of the bronchioles). Chronic restrictive pulmonary disease consists of chronic lung disorders that produce fibrosis (scarring) and inflammation, which limits inhalation. The most crucial impediment of patients suffering from chronic obstructive respiratory disease pertains to the hyperinflation exercise response that stems from their constrained exhalation. Hyperinflation could be due to increased airway resistance and reduced lung elasticity recoil. Durstine and

Moore have reported that structured and controlled physical activity can offer the following exercise-induced benefits:

i. Cardiorespiratory reconditioning

ii. Reduced hyperinflation

iii. Enhanced ventilatory efficiency and ventilation-perfusion matching

iv. Increased respiratory muscle strength and endurance

v. Desensitisation to dyspnoea (shortness of breath) and anxiety of physical activity regarding exertion

vi. Improves lung diffusing capacity for carbon monoxide

5.3 Exercise-induced mechanisms for combatting diabetes mellitus

Habitual physical activity and structured exercise reduces the hyperglycaemic state of diabetic patients during and after an exercise session by increasing glucose absorption, which reduces glucose blood concentration.

- Regular exercise increases insulin sensitivity, which necessitates a reduction in exogenous insulin intake [22]. Insulin changes glucose to glycogen, decreasing the diabetic patient's hyperglycaemic state. The enhanced insulin sensitivity allows reduced amounts of insulin to more readily facilitate this function, inhibiting excessive insulin release from the pancreas. This exercise-induced endocrine mechanism limits pancreatic hyperactivity. When a diabetic patient exercises, there is a reduction in insulin secretion, which upregulates the sensitivity of the insulin receptors, enabling them to better recognise the presence of blood glucose, which increases glucose absorption into the exercising muscle [21]. Habitual muscle strength training increases the resting metabolic rate of the patient, increasing blood glucose uptake without augmenting insulin secretion [21].

5.4 Exercise-induced mechanisms for combatting cancer

Habitual exercise rehabilitation of cancer patients is beneficial. For cancer patients who are undergoing treatment, the primary objective of the exercise therapy is to maintain muscle strength, endurance, and functionality. For patients who are in remission, the objective of the exercise therapy is restore prior optimal aerobic fitness, muscle strength, endurance, and functionality. Concurrent aerobic and resistance training have the potential to enhance bone remodelling and inhibit the muscle atrophy that is a side effects of glucocorticoids which are common cancer medications. Durstine and Moore have reported that regular structured exercise therapy has the following exercise-induced benefits for cancer patients:

i. Increases muscle flexibility and joint range of motion

ii. Decreases muscle atrophy

iii. Increases muscle strength and endurance

iv. Increases aerobic fitness

v. Maintains body mass

vi. Facilitates various psychological benefits (alleviates depression, increases self-confidence and body image and improves quality of life) [20].

6. Empirical evidence of Biokinetics research into non-communicable diseases in South Africa

In order to determine whether the profession of Biokinetics has made a scientific rehabilitative contribution to the plight of patients suffering from NCDs in South Africa, the authors reviewed the Biokinetic research related to NCDs. In so

Year	Authors	Title	Journal
2002	Du Plessis, Loots, Brits [23]	Abdominal fat distribution and cardiovascular risk factors in hypertensive females.	South African Journal for Research in Sport, Physical Education and Recreation, 24(1):53-76
2004	Schutte, Huisman, Malan, Van Rooyen, Schutte, Malan, De Ridder [24]	Differences in cardiovascular function of rural and urban African males: the THUSA study.	Cardiovascular Journal of South Africa, 15(4):161-165
2005	Schutte, Kruger, Wissing, Underhav, Vorster [25]	The emergence of the metabolic syndrome in urban obese African women: the POWIRS study.	South African Journal of Science, 101(1):61-67
2006	Shaw & Shaw [26]	Consequence of resistance training on body composition and coronary artery disease risk.	Cardiovascular Journal of South Africa, 17(3):111-116
2006	Schutte, Huisman, Schutte, Malan, Underhav [27]	Cardiovascular function of African women with different BMIs and blood pressures: the POWIRS study.	Cardiovascular Journal of South Africa, 17(1):12-18
2007	Shaw & Shaw [28]	Physical activity and high-density lipoprotein cholesterol in sedentary male smokers: physical activity.	African Journal for Physical Health Education, Recreation and Dance 13(4,): 441-452
2008	Shaw & Shaw [29]	Exercise therapy and its role in glucose maintenance s medicine.	African Journal for Physical Health Education, Recreation and Dance, 14(4): 418-427
2008	Shaw & Shaw [30]	Relationship between resistance training and lipoprotein profiles in sedentary male smokers: cardiovascular topics.	Cardiovascular Journal of Africa, 19(4): 194-197
2008	Shaw, Loots, Lategan, Shaw [31]	Effectiveness of aerobic exercise training in improving pulmonary function in asthmatics.	African Journal for Physical Health Education, Recreation and Dance, 15(1): 150-159
2008	Heilbrunn [32]	Exercise and weight loss in diabetes and coronary artery disease.	South African Journal of Diabetes, 1(1):10-12

Year	Authors	Title	Journal
2009	Moss [33]	Changes in coronary heart disease risk profile of adults with intellectual disabilities following a physical activity intervention.	Journal of Intellect Disability Research, 53(8):735–44.
2009	Shaw, Shaw, Brown [34]	Resistance training and predicted risk of coronary heart disease in sedentary males.	African Journal for Physical Health Education, Recreation and Dance, 15(4) https://doi.org/10.4314/ajpherd.v15i4.47294
2009	Shaw, Shaw, Krasilshchikov [35]	Comparison of aerobic and combined aerobic and resistance training on low-density lipoprotein cholesterol concentrations in men.	Cardiovascular Journal of Africa, 20(5):290-295
2010	Hoebel, De Ridder, Malan [36]	The association between anthropometric parameters, the metabolic syndrome and microalbuminuria in black Africans: the SABPA study.	Cardiovascular Journal of Africa, 21(3):148-152
2010	Shaw, Shaw, Brown, Cilliers [37]	Concurrent resistance and aerobic training as protection against heart disease.	Cardiovascular Journal of Africa, 21(4):196-199
2010	Zeelie, Moss, Kruger [38]	The influence of physical activity on components of metabolic syndrome and vascular function in adolescents: A Narrative Review and Physical Activity.	African Journal for Physical Health Education, Recreation and Dance, 16(2):285-296
2010	Zeelie, Moss, Kruger, Van Rooyen [39]	The impact of a 10-week physical activity intervention programme on selective metabolic syndrome markers in black adolescents.	South African Journal for Research in Sport, Physical Education and Recreation, 32(1): 147-162
2011	Goon, Toriola, Uever, Wuam, Toriola [40]	Prevalence of body weight disorders among adolescent school girls in Tarka, Nigeria.	Minerva Paediatric 63(6):467–71.
2011	Prinsloo, Malan, de Ridder, Potgieter, Steyn [41]	Determining the waist circumference cut off which best predicts the metabolic syndrome components in urban Africans: the SABPA study.	Experimental and Clinical Endocrinology of Diabetes, 119(10):599–603
2012	Botha, Malan, Potgieter, Steyn, De Ridder [42]	Association of waist circumference with perception of own health in urban African males and females: the Sympathetic Activity and Ambulatory Blood Pressure in Africans (SABPA) study: Diabetes Education.	Journal of Endocrinology, Metabolism and Diabetes in South Africa, 17(2):106-112
2012	Du Toit, Kruger, Govender, Henning, Kleynhans, Wood, De Villers, Fletcher, Grant, Van Rooyen [43]	Cardiovascular health screening among South African students.	African Journal for Physical Health Education, Recreation and Dance, 18(1): 159-168

Year	Authors	Title	Journal
2012	Grace, Wilders, Strydom, Ellis [44]	A comparison of the effect of two intervention regimes on coronary prone executives in the South African colliery industry.	Occupational Health Southern Africa, 18(1):15-21
2012	Grace & Semple [45]	The prevalence of cardiovascular disease risk factors in normotensive, pre-hypertensive and hypertensive South African colliery executives.	International Journal of Occupational Medical and Environmental Health. 2012, 25(4):375–82.
2012	Heilbrunn [46]	The CDE biokinetic approach to recreational activities in type 1 diabetes.	South African Journal of Diabetes, 5(4): 25-28
2012	Heilbrunn [47]	Does exercise improve or impair blood glucose control in type 1 diabetes? Report.	South African Journal of Diabetes and Vascular Disease, 9(2):66-69
2012	Reger, Kolwicz, Libonati [48]	Acute exercise exacerbates ischemia-induced diastolic rigour in hypertensive myocardium.	Springer Plus, 2;1:46
2012	Rossouw, Du Plessis, Reynecke [49]	Exercise compliance and health outcome in a chronic disease management programme.	African Journal for Physical Health Education, Recreation and Dance, 18(1):77-89
2012	Semple & Johnson [50]	Allied health professionals and cardiometabolic disease risk screening in the workplace: a study of two companies in Darwin, Australia and physical activity.	African Journal for Physical Health Education, Recreation and Dance, 18(1):65-74
2012	Toriola, Moselakgomo, Shaw, Goon [51]	Overweight, obesity and underweight in rural black South African children: original research.	South African Journal of Clinical Nutrition, 25(2):57–61
2013	Gradidge, Constantinou, Goldberg [52]	Sudden cardiac arrest risk in young athletes.	South African Journal of Sports Medicine. 25(2): 53-54
2013	Goon, Toriola, Shaw, Amusa, Khosa, Shaw [53]	Body fat percent of urban South African children: implications for health and fitness.	West Indian Medical Journal, 62(7): 582–8.
2013	Heilbrunn [54]	The CDE Biokinetic approach to safe exercise prescription in people with complications of diabetes.	South African Journal of Diabetes, 6(1): 19-24
2013	Mathunjwa, Semple, du Preez [55]	A 10-week aerobic exercise program reduces cardiometabolic disease risk in overweight/obese female African university students.	Ethnicity Disability, 23(2):143–8.
2013	Toriola, Moselakgomo, Shaw, Goon, Anyanwu [56]	Are rural South African children abdominally obese?	Pakistani Journal of Medical Science, 29(3): 740–3

Year	Authors	Title	Journal
2014	Ellapen, Essack, Thwala, Van Heerden [57]	Coronary risk profiles among University of Kwa Zulu Natal students.	African Journal of Physiotherapy and Rehabilitative Sciences, 6(1): 21
2014	Mamabolo, Sparks, Moss, Monyeki [58]	The association between dyslipidemia and anthropometric indicators in black and white adolescents residing in Tlokwe Municipality, North-West Province, South Africa: the PAHL study.	African Health Science, 14(4):929–38.
2014	Heilbrunn, Strybos, Mufamadi, Flynn [59]	The Centre for Diabetes 'Why Weight?' weight loss and lifestyle change programme.	South African Journal of Diabetes, 7(2): 19-23
2014	McKersie & Baard [60]	Obesity in 7 - 10-year-old children in urban primary schools in Port Elizabeth.	South African Journal of Sports Medicine, 26(2):55-58
2014	Muluvhu, Mukoma, Amusa, Goon [61]	Screening for components of metabolic syndrome among corporate executives in Gauteng Province, South Africa.	African Journal for Physical Health Education, Recreation and Dance, 20(1):388-399
2016	Heilbrunn & Haddow [62]	Why is activity essential as you get older? : living with diabetes.	Diabetes Lifestyle, 1: 44-47
2017	Van Rooyen & Coopoo [63]	Change in patient nutritional knowledge following coronary artery bypass graft surgery.	Health SA Gesondheid, 22(1): 123-129
2017	Van Rooyen & Coopoo [64]	Physical activity and lifestyle modification in the reduction of cardiovascular disease risk in coronary artery bypass graft patients.	African Journal for Physical Activity and Health Sciences, 23(2): 336-353
2017	Van Rooyen & Coopoo [65]	Comprehensive cardiac rehabilitation and quality of life in coronary artery bypass graft patients.	SA Heart, 14(3): 154-160
2018	Pillay & Rugbeer [66]	Occupational cardiovascular disease risk profile and physical activity categories of university cleaners.	Occupational Health Southern Africa, 24(4):101-104
2018	Van Biljon, McKune, DuBose, Kolanisi, Semple [67]	Do Short-Term Exercise Interventions Improve Cardiometabolic Risk Factors in Children?	Journal of Paediatric, 203:325–329.
2019	Ellapen, Broodryk, Paul, Buys [67]	The effects of exercise on diabetes management.	South African Journal of Diabetes and Vascular Diseases, 16(1): 40–43.
2019	Paul, Ellapen, Barnard, Swanepoel, Hammill, Strydom [68]	Are there sufficient number of exercise therapists in South Africa in order to equitably manage the non-communicable disease epidemic?	International Quarterly in Community Health Education, 39(2): 127–132.

Year	Authors	Title	Journal
2019	Thaane, Motala, McKune [69]	Lifestyle modification in the management of insulin resistance states in overweight/ obesity: the role of exercise training.	Journal of Endocrinology, Metabolism and Diabetes in South Africa, 24(2) 65-69
2020	Ellapen, Barnard, Strydom, Masime, Paul [70]	Comparison between the non-communicable diseases mortality rates between 2010 and 2016 of selected South African countries.	International Quarterly in Community Health Education. http://www. doi:10.1177/0272684X2091658
2021	Hene, Wood, Schwellnus, Jordaan, Laubscher [71]	High Prevalence of Non-Communicable Diseases Risk Factors in 36,074 South African Financial Sector Employees: A Cross-Sectional Study.	Occupational Environmental Medicine, 63(2):159–165

Table 2.
Chronological listing of biokinetics research publications relating to investigations concerning non-communicable diseases.

far as Biokinetics is a uniquely South African profession, the empirical literature published will be focused on the South African population, and in all likelihood be published in South African academic journals, the authors reviewed the Sabinet database. In addition, the PubMed and Medline databases were used to identify international journal publications relating to biokinetics research which was focused on NCDs. This was in order to take both national and international research databases into consideration. The authors identified 599 records from Sabinet and 2241 records from PubMed and Medline using the keyword "biokinetics." All records underwent a three-phase evaluation process, namely: title, abstract, and full text analysis. Inclusion criteria was all biokinetic research concerning NCDs. Records therefore included randomised control trial experiments, observational experiments with and without concurrent controls, review papers, and narrative papers. Exclusion criteria were records unrelated to the profession of Biokinetics (exercise therapy) and to NCDs, biokinetic research related to neuromusculoskeletal injuries and rehabilitation, biokinetic research related to sport performance enhancement, and non-English papers. No time frame was instituted, all appropriates records were interrogated for inclusion. Based on the premise that this was a preliminary literature search in order to determine the involvement of the profession of Biokinetics in NCD research, the quality of the records was not accessed. 51 records complied with the inclusion criteria. Of the 51 records, 3 records were common to both the Sabinet database and to the PubMed and Medline databases. The extraction of the common records left 48 records. These records were classified into 16 experimental observations, two review articles, and 30 NCD profiling studies. Further stratification of the records revealed that there were four common categories: respiratory research (n = 1), cardiovascular research (n = 18), metabolic research (n = 22), and cardiometabolic research (n = 7). These categorises included three of the primary NCD mortality agents: cardiovascular and respiratory diseases, as well as diabetes mellitus (which fell into the category of metabolic diseases). No records concerning research relating to cancer were uncovered. **Table 2** details the Biokinetics research publications relating to NCDs. The efficacy of the empirical findings of the randomised control trials measuring the impact of Biokinetics (exercise therapy) on NCDs were reviewed against Mill's Epidemiological Canons.

7. Experimental research evidence supporting the valuable effects of Biokinetics (exercise therapy) in improving the NCD patient profile

The authors employed Mill's Epidemiological Canons in order to determine the value of experimental research evidence supporting the causal extrapolation of the effect of Biokinetics exercise therapeutic interventions on NCDs [72]. Mill's epidemiological canons have five criteria:

- *Temporal sequence* refers to the sequence of the exposure of the intervention, which must precede the change of the diseased condition within a sufficient time frame in order to make a plausible conclusion. Fourteen (87.5%) of the 16 experimental investigations reported that exercise therapy (Biokinetics interventions) improves the NCD profile of participants. Eight (50%) of these 16 investigations reported that Biokinetic cardiovascular rehabilitation improved the cardiac profile of participants [26, 32, 33, 35, 37, 44, 64, 65]. Five (43.7%) investigations illustrated that Biokinetic exercise therapy interventions improve metabolic risk profiles of NCDs patient [29, 39, 47, 55, 67]. One (6.25%) study showed that exercise improved pulmonary function of NCD patients [31].

- *Strength of association* refers to the clinical meaningful difference between the disease and the intervention. Fourteen (87.5%) of the 16 investigations indicated a strong association between Biokinetic exercise therapy and improved NCD profiles (**Table 2**).

- *Consistency of results* refers to the consistent observation of the association between the outcome of the intervention and the disease. Fourteen (87.5%) of the 16 experimental studies indicated that Biokinetic exercise therapy had a positive outcome on the NCD profiles of participants (**Table 2**).

- *Biological plausibility* refers to the clinical explanation of the observed outcome of the intervention in regard to the disease. The 14 studies that reported favourable outcomes proposed credible reasons for these improvements (**Table 2**).

- *Dose response* refers to the volume of intervention required to produce a specific outcome on the disease. There is, however, no consensus pertaining to the amount or volume of Biokinetic exercise therapy needed to produce beneficial outcomes. It is recommended that prospective experimental research be conducted in order to determine the dose response regarding intensity, duration, and frequency of exercise therapy for NCD patients. This new research will help medical practitioners and exercise therapists determine the adequate dose response to exercise.

8. The need to include Biokinetics in the public health sector and challenges facing inclusion

Non-communicable diseases are increasingly prevalent within South Africa [73]. Physical inactivity is recognised internationally as a significant modifiable risk factor contributing to the increased prevalence of NCDs [74]. The integration of physical activity programmes into the primary health care system through multidisciplinary platforms is thus advocated for and envisioned to be more cost-effective than current practices. However, within the current primary health care setting of

South Africa, there is an absence of Biokinetics professionals. These professionals, whose scope of practice is to improve physical functioning and health through exercise, are ideally suited to developing and implementing physical activity programmes in the public sector. Despite the evident need for such interventions, the role of the Biokineticist has not yet been incorporated into the national public healthcare system.

8.1 Role of Biokinetics in the public sector

In South Africa, while research in this field is ongoing, preliminary results are however promising and provide an alternative strategy beyond pharmaceutical medication regarding the management of NCDs. Effectively, the profession of Biokinetics advocates structured exercise interventions as a cheaper alternative to current pharmacological and medical strategies employed in the treatment of NCDs [69, 73]. The inclusion of Biokinetics in the public sector will assist in accomplishing the following strategies, as defined by the Department of Health: [75].

- Prevent NCDs and promote health and wellness at population, community, and individual levels.
- Improve control of NCDs through the strengthening and reform of healthcare systems.
- Monitor NCDs and their main risk factors, as well as conducting innovative experimental research validating the efficacy of exercise therapy.

Other benefits that Biokinetics offers to the public sector include:

- Counselling/educating patients while they are waiting for chronic medication.
- Support in the assessment of risk factors for NCDs.
- Provision of services aimed at preventing (fortogenic healthcare paradigm) and managing (pathogenic healthcare paradigm) NCDs through lifestyle education and exercise–based activities.
- Prescription of home-based physical activity programmes that are cost-effective.
- Visiting communities using mobile health clinics in order to educate people and evaluate risk factors for NCDs.
- Organising community activities after having assessed physical working capacity and risk factors.
- Offering rehabilitation programmes for chronic diseases and injuries in a hospital environment in concert with the treatment offered by physiotherapists and doctors.
- Supporting non-clinical phase rehabilitation and physical strengthening of patients.

8.2 Challenges for the inclusion of the profession of Biokinetics into the South African public healthcare sector

These challenges include a lack of recognition for the invaluable role that the profession of Biokinetics can play in the South African public healthcare sector, coupled with the inaccessibility of national funding for Biokinetics positions by the South African Department of Health and a lack of policy regarding strategic planning relating to the inclusion of the profession of Biokinetics in regards to the prevention (fortogenic healthcare paradigm) and management of NCDs (pathogenic healthcare paradigm). The mobilisation of these solutions so as to overcome these challenges is fundamental for the inclusion of the profession of Biokinetics into the public healthcare sector and for the funding of multidisciplinary community health programmes supporting education regarding physical activity interventions and its role in improving health at all levels of society.

9. Conclusion

The profession of Biokinetics is an exercise therapy vocation that advocates habitual physical activity and exercises as an adjunct to other management strategies adopted within a multi-disciplinary healthcare support team. At present, the profession of Biokinetics is only operational in the private healthcare sector in South Africa. Biokinetics has shown to be a valuable adjunct therapeutic modality both in the pathogenic and fortogenic healthcare paradigms. Numerous experimental research studies have been undertaken illustrating the efficacy of Biokinetic exercise therapy programmes in managing NCDs and improving the quality of life of patients. The inclusion of Biokinetics holds significant promise in helping to better manage the NCD epidemic in the South African public healthcare sector. Exercise therapy is a substantially more cost-effective alternative to other healthcare management strategies as concerns the ongoing management of NCDs within the South African population. The profession of Biokinetics is comparable to the South African professions of Physiotherapy and Occupational Therapy who also prescribe exercise and human movement activity as a rehabilitative modality, however these professions are allowed to function within the South African healthcare public sector. Internationally, clinical exercise physiologists, clinical kinesiologists and exercise specialist (scientists) who have an analogous scope of profession to that of Biokinetics function within both the private and public healthcare sector. As such the authors strongly recommend the inclusion of the profession of Biokinetics into the South African public healthcare sector.

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