



Master of Philosophy: Biokinetics

Minor Dissertation



**“SWEET HEARTS”: A PILOT BIOKINETICS  
PRIMARY PREVENTION PROGRAM IN THE SOUTH  
AFRICAN PUBLIC HEALTH SECTOR.**

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## Abstract:

This minor dissertation is comprised of 3 chapters. The first chapter is a meta-analysis that provides a quantitative summary of data from 10 community-based physical activity interventions across 5 countries. The analysis provides evidence for the efficacy of physical activity interventions (standardized mean difference (SMD) = 1.275; percentage increase in physical activity = 29.5%) in increasing levels of physical activity. These findings support the notion that multi-strategic community-wide interventions are able to reach a large proportion of the population regardless of social class and socioeconomic level. Broad-based instead of individual interventions are more cost-effective and help to spread knowledge about the importance of physical activity, stress reduction and nutrition, thereby improving health.

The second chapter details the effect of a 3-month pilot Biokinetics primary prevention program (“Sweet Hearts”) on health outcome measures. A total of twenty-seven exercise sessions, combined with nutritional advice and stress reduction techniques, were conducted. Despite a small sample size ( $n = 10$ ), the intervention showed significant improvements in health outcome measures amongst participants ( $p \leq 0.05$ ). These improvements include: a decrease in waist circumference and resting respiratory rate, as well as an increase in 1-minute time perception, Global Physical Activity Questionnaire (GPAQ) score, 12-minute walk distance and sit-to-stand test repetitions. Improvements were also noted in cognitive restraint with regards to eating behavior as well as heart rate variability (HRV), specifically in the low frequency spectrum. The combination of lowered resting breathing rates and improved HRV measures suggests that participant’s autonomic nervous system (ANS) regulation improved during the course of the intervention. Correlational analysis revealed that higher income levels were associated with poorer HRV measures. The favourable results of the community intervention show promise for the future expansion of the program into the public health sector and provide proof of concept to dedicate resources to conduct more robust research within a community setting.

The final chapter uses a mixed methods approach to explore factors promoting participation and predicting adherence to a community health intervention. The qualitative interviews conducted during this study offers rich and valuable information on how to improve the “Sweet Hearts” intervention. Five main themes were identified from the interviews conducted: 1) Enjoyment of the intervention 2) Benefits of the intervention 3) Obstacles affecting adherence 4) Future improvements to the intervention 5) State of non-communicable diseases in South Africa. Quantitative analysis showed that superior ANS regulation in participants at baseline was indicative of higher attendance rates. This improved regulation is evident through lowered systolic blood pressure and the ability to better regulate (attenuate an increase in) both breathing rate and HRV (low frequency power) from Rest to the Stroop Tasks. The detail collected within this analysis will be incorporated into an updated conceptual model that will then form the basis of improving adherence and ensuring the intervention grows from strength to strength in coming years.

South Africa is without a focused approach to reduce physical inactivity. The primary function of a Biokineticist is to improve physical functioning and health through exercise as a modality. An alarming number of non-communicable diseases (NCDs), such as cardiovascular disease and type-2 diabetes mellitus, were attributable to physical inactivity among South Africans based on the 1998 South African Demographic and Health survey data. The findings of this dissertation advocate for the support and funding of community-based physical activity interventions in combatting NCDs. The time has come for South African policy makers to act upon the Strategic Plan for Prevention and Control of NCDs (2013-2017). Such action should be A) the inclusion of Biokinetics into the public health sector and B) funding of multi-disciplinary community health programs supporting education, healthy eating and physical activity levels.

# Chapter 1:

## **Are community-based interventions effective in changing physical activity behaviours? A meta-analysis**

### **Introduction:**

#### *Non-communicable diseases & physical inactivity:*

Non-communicable diseases (NCD's) are a category of chronic disease that are not infectious and hence cannot be passed from one person to another. They typically progress at a slow rate and include conditions such as cardiovascular disease, cancer, chronic respiratory diseases and diabetes mellitus (ACSM, 2013). The South African summit on the prevention and control of non-communicable diseases (12-13 September 2011) reached a consensus regarding NCD's. This consensus identified the need for an intensified national action addressing prevention, early detection, behavioral change and universal treatment of NCD's in South Africa. The consensus materialized in the form of the Strategic Plan for Prevention and Control of Non-Communicable Diseases 2013-2017. The strategy, developed by the department of health, identified three public health strategies (South African Department of Health, 2013):

1. Prevent NCD's and promote health and wellness at population, community and individual levels.
2. Improve control of NCD's through health systems strengthening and reform.
3. Monitor NCD's and their main risk factors as well as conduct innovative research.

South Africa is a country currently experiencing rapid epidemiological, demographic and nutritional change. Parallel to this change are poverty-related infectious diseases such as HIV/AIDS and TB, violence & injuries, and NCD's such as cardiovascular diseases, diabetes and obesity (South African Department of Health, 2013).

Physical inactivity has been recognized internationally as a major independent modifiable risk factor contributing to the increased prevalence of cardiovascular disease, type 2 diabetes, metabolic dysfunction, obesity, hypertension, cancer and premature mortality (Steyn et al., 2006). Currently more than 50% of adult South Africans are physical inactive, a statistic which urgently needs to be addressed and managed to curb the rampant increase in NCD's throughout the country (South African Department of Health, 2013).

The South African Department of Health has a target to reduce the country's inactivity levels by 10% before 2020. However, South Africa is without a healthcare professional within the primary healthcare setting adequately equipped to develop and implement physical activity programs. Lee et al. (2012) showed that if the NCD's are treated and the level of physical inactivity is reduced; the South African population could gain an average of 1.26 years in their life expectancy. Taking into account that exercise interventions within the public health sector still need development, it is unlikely that there will be a 100% elimination of inactivity – however a decrease in physical inactivity by 10% will result in excess of 533 000 lives saved due to NCD's around the world every year (Lee et al., 2012).

Joubert et al. (2007) identified that an alarming number of NCD's were attributable to physical inactivity among South Africans based on the 1998 South African Demographic and Health survey data. Physical inactivity was identified as attributable to 47% of ischemic diseases and 20% of patients with diabetes mellitus. Eighty-seven percent of cases of type 2 diabetes were attributable to excess body weight along with sixty-eight percent of hypertensive disease. Although physical activity provides a multitude of health benefits, it is important to note it is not as effective in aiding weight loss as dietary interventions (Thomas et al., 2012). A meta-analysis by Johns et al. (2014) demonstrated that, in the long term, behavioral weight management programs that combine exercise with diet could lead to greater weight loss over a year than diet alone. However, over shorter interventions, adding exercise to dietary interventions did not significantly alter weight loss ( $p \leq 0.05$ ). These results highlight the importance of combining dietary interventions along with physical activity to significantly improve the body composition of participants.

### ***Biokinetics in the South African Public Health Sector:***

With no national plan to combat physical inactivity, or a focused approach in the primary healthcare setting, South Africa is in need of qualified healthcare professional dedicated to reducing physical inactivity levels. The primary function of a Biokineticist is to improve physical functioning and health through exercise as modality. It would thus appear that a Biokineticist is ideally suited to developing and implementing programs to reduce physical inactivity in the public sector. Unfortunately, the role of the Biokineticist is not incorporated into the national primary healthcare system. It is evident that based on the Biokineticist's scope of practice; there is an overwhelming demand for their skills in combatting the current burden of disease facing the country.

Biokineticists, in conjunction with physicians and other practitioners such as physiotherapists, psychologists and dieticians are in the best position to contribute towards reducing physical inactivity in the primary healthcare system. The demand for Biokineticists is evident within the private healthcare sector as demonstrated by Moss & Lubbe (2010). However the vast majority of people (40 million people) cannot afford the expense of private health care, therefore they are reliant on a public health care system already crippled by a quadruple burden of disease.

### ***Cost-effective approaches to combating non-communicable disease:***

The associated morbidity of health disorders related to inactivity, including health related quality of life as well as direct and indirect economic costs, exerts a substantial burden on societies and health systems. In South Africa, use of physicians to address physical inactivity has been estimated to cost R11.80 per head, a relatively large expense (South African Department of Health, 2013). The introduction of Biokineticists into the public healthcare system shows potential for a more cost effective method of managing the growth of NCD's through physical activity.

The Global Advocacy for Physical Activity (GAPA, 2015) 7 best investments for physical activity advocate for the integration of physical activity into the primary healthcare system to reduce the development of NCD's. The recommended approach to implementing a physical activity program in primary healthcare is a combination of brief counseling and links to community-based supports. These recommendations do not exclude the physician or other health care providers from the management of physical activity; rather it emphasizes that a multi-disciplinary approach is needed within the primary health care system to reduce physical inactivity.

Once physical activity interventions are implemented within the South African public health sector, the next hurdle to overcome is that of adherence. Approximately 50 percent of individuals who start an exercise program withdraw within 6 months, before significant health benefits can be realised (White et al., 2005). Evidence suggests that people from low-income groups, such as those reliant on the public health sector, are more difficult to identify and successfully recruit (Marcus et al., 2006). It is futile to establish community programs that are unable to retain participants and hence make a meaningful difference on their long-term health. Examples of difficulties with adherence are illustrated by Brown et al. (2014) who experienced an attrition rate of 66% and Scarinci et al. (2014) who had an attrition rate of 45% in their respective interventions. Thus, strategies to promote adherence must be incorporated into the initial design of physical activity interventions if they are to have a meaningful impact upon the people they serve.

The aim of this meta-analysis is to create a better understanding of the effectiveness of community-based physical activity interventions. The analysis builds upon a previous systematic review investigating the effectiveness of community-based physical activity interventions, covering studies from 2001-2012 (Bock et al., 2014). This paper firstly provides an updated review of studies published between 2010-2015 and secondly applies meta-analysis to estimate intervention/treatment effect sizes.

### **Methods:**

This meta-analysis followed the PRISMA checklist (Moher et al. 2009) and included studies that met the following inclusion criteria:

#### **Participants:**

Adults aged 18 years and over from the general population. General population was defined as not belonging to a specific clinical group, such as those with chronic or neurological disease.

#### **Interventions:**

Community-based interventions that target changes in physical activity. Community-based was defined as being conducted in a public area, thus excluding home and corporate based interventions. Studies could target a single behaviour or multiple behaviours in any combination as long as physical activity was an outcome variable.

#### **Comparisons:**

Single group analysis (no control group) was conducted by comparing the percentage change in physical activity measures over the course of the intervention. Two-group analysis (control group included) was conducted by comparing the mean changes between control and intervention groups over the course of the intervention.

#### **Outcomes:**

Behavioural outcomes relevant to physical activity were extracted for analysis. Self-reported individual physical activity behavior, predominately questionnaire based, was included. Objective measures of physical activity (pedometer readings) were extracted from one study (Robertson et al, 2012).

**Study design:**

No restriction was placed on study design due to the small number of studies published. Controlled and non-controlled studies were evaluated separately.

**Date:**

2010-2015. Studies published between 1<sup>st</sup> January 2010 and 29<sup>th</sup> March 2015. This date range was chosen as it developed upon Bock et al.'s (2014) systematic review of 2001-2012, whilst providing enough literature to perform a meaningful meta-analysis.

**Language:**

Only studies published in English were included for analysis.

**Search strategy:**

3 databases were searched: Pubmed, Scopus and Web of Science. Search strategies were based on Bock et al. (2014) and included three components: A) Terms relating to physical activity B) Terms relating to a community setting C) Terms relating to a behavioural intervention. The search strategy used across databases is as follows: In article's title and human research: ("physical activity" OR exercise OR walking) AND (communities OR community OR community-based OR "primary prevention" OR group) AND ("randomized control trial" OR intervention OR program).

***Study selection and data collection:***

The inclusion criteria listed above was used to screen the titles and abstracts of 460 articles published between 2010 and 2015. Twenty-five articles initially met the inclusion criteria and their full texts were screened. Fifteen articles were excluded as they either: A) Reported no physical activity data B) had an inadequate sample size C) reported no baseline physical activity measures. Final meta-analysis was conducted on 10 articles. These articles were further split with 6 studies containing a control group and 4 studies evaluating changes in a single group. The study selection process is summarized in *Figure 1* below.

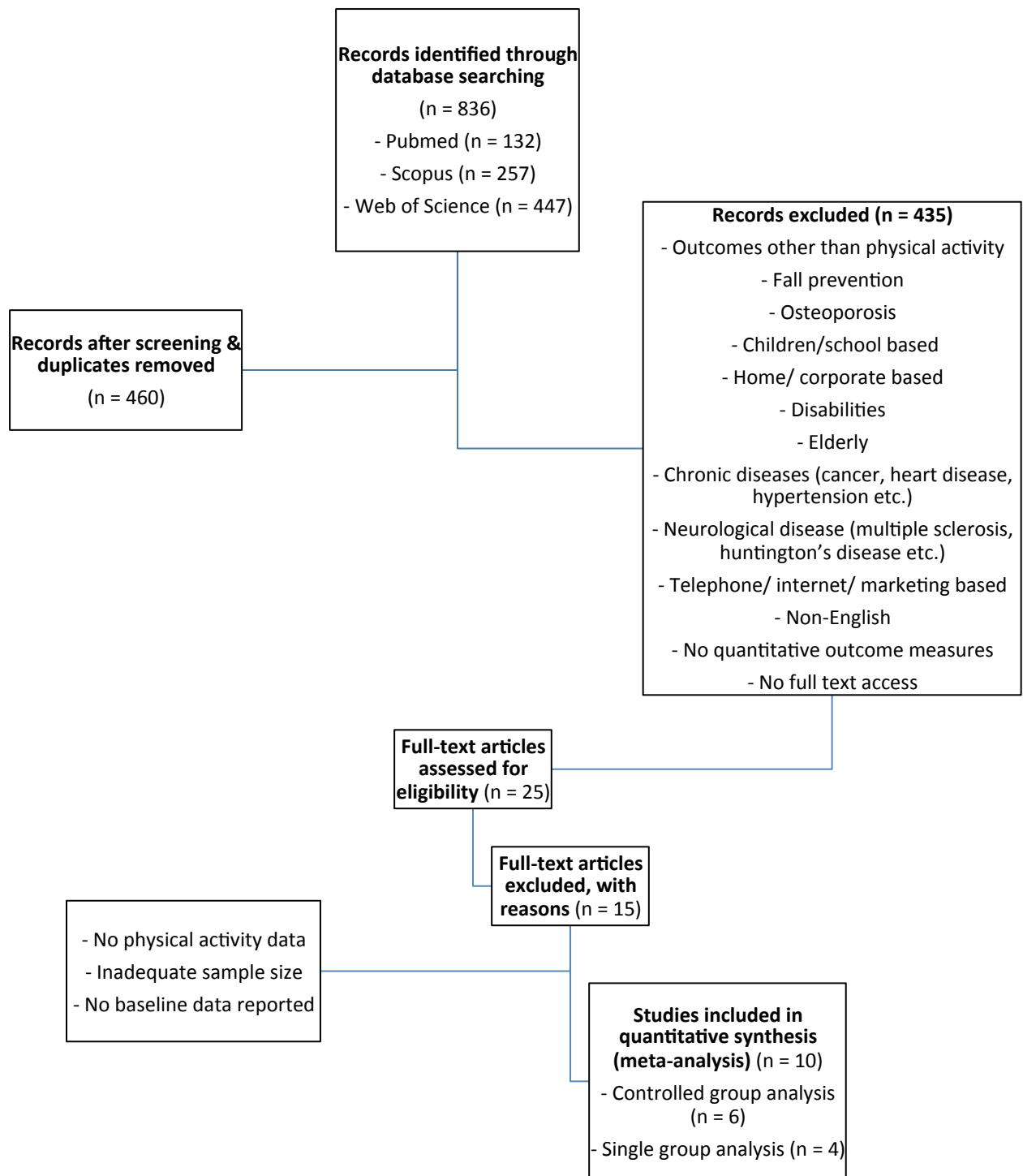


Figure 1: Flow chart of articles included within the meta-analysis (2010-2015)

Data was extracted into an evidence table (*Table 3: Pg. 13*) with each study being assigned a quality score out of 7. Grading of the quality of research was based on recommendations from Bock et al. (2014). Articles were graded according to the following seven attributes: 1) Randomization 2) Control group without contamination 3) Representative sample 4) Comparability of intervention and control group 5) Attrition rate < 30% or sample size > 100 6) Sufficient period for physical activity data collection 7) Valid instrument for physical activity.

Data was extracted for all time points measured. The time point at or nearest to the cessation of the intervention was considered for analysis. The mean and standard deviation of physical activity measures were extracted (e.g. increase in minutes of moderate-vigorous physical activity).

### ***Synthesis of results:***

Data from included studies were meta-analyzed in Open Meta-Analyst (V0.1503 - 2012) using random and fixed effect models. Studies with two groups (including control group) were analyzed using standardized mean difference. Studies with a single intervention group were analyzed using a mean percentage change in physical activity. Variation in effect size was assessed between studies using the  $I^2$  statistic, with an  $I^2 > 50\%$  interpreted as indicating the presence of heterogeneity.

### **Results:**

The characteristics of the 10 studies included in the analysis are summarized in *Table 1, 2 & 3 (Pg. 13)*. The majority of the studies ( $n = 4$ ) were conducted in the United States, the remaining studies were in Canada ( $n = 2$ ), China ( $n = 2$ ), Scotland ( $n = 1$ ) and England ( $n = 1$ ). A total of 14 485 participants are included in the analysis of the 10 articles.

The content of interventions varied from educational materials and publicity; to higher intensity walking programs and supervised group exercise. Control groups in the intervention received standard care, a less intense version of the intervention or an inactive version. Intervention duration varied from 5 weeks to 2 years.

### **Risk of bias within studies:**

The majority of studies did not describe their randomization process; allocation into the intervention group was a voluntary choice in certain studies (Adams et al. 2015; Brown et al. 2014; Foulds et al. 2011). Numbers for dropouts were provided but reasons were often omitted. It was also unclear if intention to treat analysis was used in the majority of studies. There is therefore some risk of bias particularly regarding randomization and attrition.

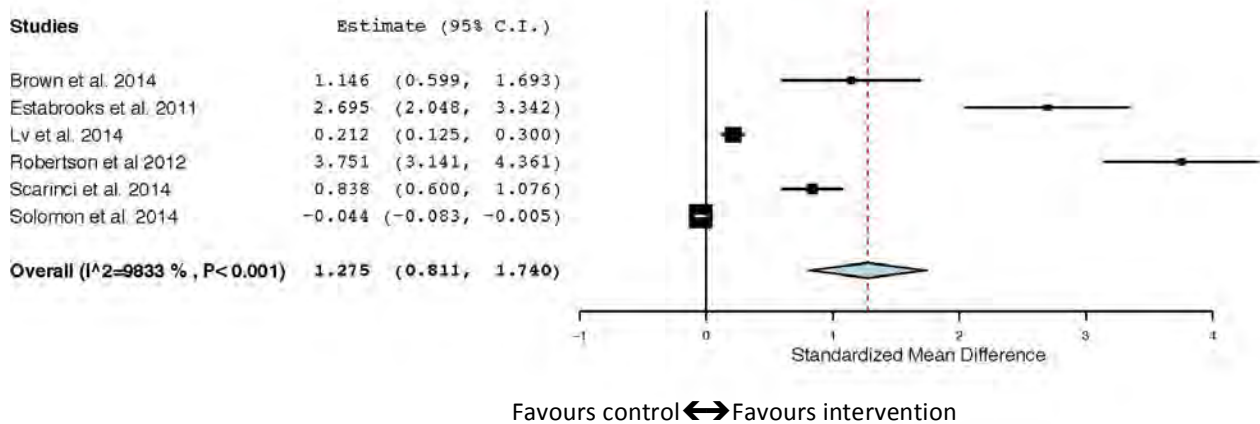
### **Quantitative data synthesis: effectiveness of intervention:**

#### *Physical activity:*

Six physical activity interventions yielded a standardized mean difference (SMD) of 1.275 (95% CI 0.881 to 1.740) – *Figure II*. The standardized mean difference was used as a summary statistic as the studies included all assess physical activity but measure it in a variety of ways. The standardized mean difference expresses the overall mean size of the intervention effect from each study, irrespective of the measurement tool, relative to the variability observed in that study.

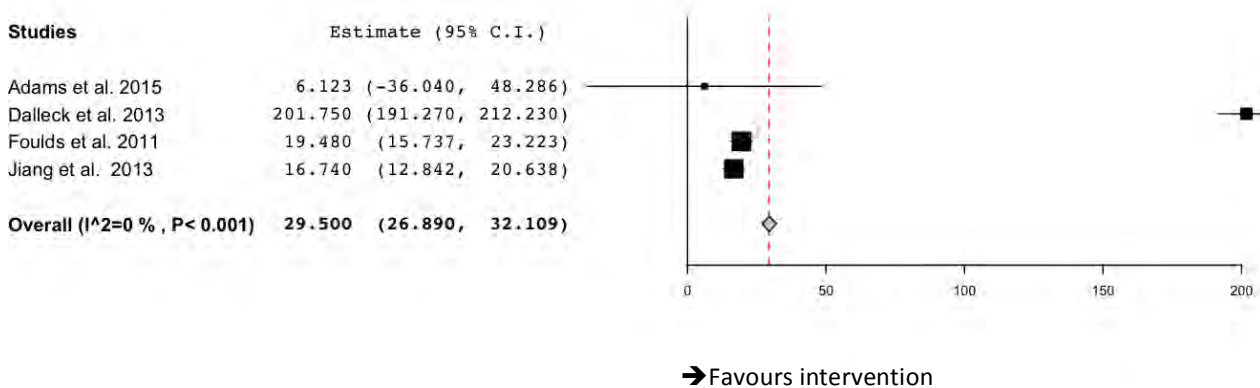
Four physical activity interventions with no control group yielded a mean percentage increase in physical activity of 29.5% (95% CI 26.9% to 32.1%) – *Figure III*. Only 1 of the 10 studies (Robertson et al., 2012) included an objective measure of physical activity (pedometer), the remaining 9 studies used self-report measures (e.g. minutes of moderate-vigorous physical activity). Examples of questionnaire-based measures of PA included the International Physical Activity Questionnaire (IPAQ), Global Physical Activity Questionnaire (GPAQ) and Healthy Physical Activity Participation Questionnaire. Heterogeneity was present in the two-group analysis, which justifies the use of a random-effects model. Although heterogeneity was also present in the single group analysis, a fixed effects model was used to avoid an overestimation bias in the effectiveness of interventions included. Thus the likelihood of committing a type-1 error was minimized.

**Two group analysis (Controlled studies):**



*Figure II: Forest plot showing standardized mean difference of physical activity interventions with a control group*

**Single group analysis (Intervention group):**



*Figure III: Forest plot showing mean percentage increase in physical activity in interventions without a control group*

Author	Year	Quality Score	Intensity	Study design	Sample Size	Demographics	Country	Intervention content	Intervention length	Attrition rate
Adams et al.	2015	2	Low	Single group (pre-post)	25 females	African American (38-68yrs, volunteers)	United States	Walking	5 weeks (1 x week)	55.16%
Brown et al.	2014	5	Low	Control group, pre-post	28 intervention, 32 controls (19 males, 41 females)	1st year university students (Mean age: 17.97yrs, moderate-strong desire to participate)	Canada	Education, behaviour change, sporadic physical activity events	20 weeks	66%
Dalleck et al.	2013	4	High	Single group, pre-post	332 (142 males, 190 females)	Wisconsin residents, range: 28-88yrs	United States	Walking, cycling, water aerobics, cross-training	14 weeks (3 days/week)	0%
Estabrooks et al.	2011	6	Moderate	Control group, pre-post	35 intervention, 35 controls	>18yrs, referred from clinic as not meeting PA guidelines	United States	Education, walking	12 weeks (2 group sessions, 1 telephone call)	39%
Foulds et al.	2011	3	Moderate	3 groups (walk, walk/run & run) pre-post	273 (58 males, 215 females)	18-75yrs aboriginal individuals	Canada	Walking/running	13 weeks (3 days/week)	64%
Jiang et al.	2013	5	Low	Two separate interventions, pre-post	1221 (490 males, 731 females)	Gongshu district communities, average age 55.8yrs	China	Multi-department cooperation, media publicity and building of a supportive environment	2 years	4%
Lv et al.	2014	4	Low	Two intervention groups, one control, pre-post	1016 intervention, 1000 control	Hangzhou community, range: 18-64yrs	China	Multi-department cooperation, media publicity and building of a supportive environment	2 years	0%
Robertson et al.	2012	6	Moderate	Wait listed control, pre-post	57	Range: 18-65yrs, low socioeconomic status	Scotland	Step count goals, behavioural & cognitive support	12 weeks	25%
Scarinci et al.	2014	7	Moderate	Two different interventions (healthy lifestyle & screening), pre-post	188 intervention, 121 controls	African American Women 45-65yrs	United States	4 group sessions, 1 individual session (behaviour change)	12 months	45%
Solomon et al.	2014	7	Low	Stepped wedged cluster RCT	4584 intervention, 5638 controls	128 Rural villages	England	Physical activity opportunities (3 different opportunities)	12 weeks	96%

*Table 1: Evidence table of studies included in the meta-analysis. Main outcome measure: change in physical activity*

Author	Physical Activity (PA) Measure	Control		Intervention	
		Sample Size	Change: Pre to Post (SD)	Sample Size	Change: Pre to Post (SD)
Brown et al. (2014)	Moderate-Vigorous PA (min/week)	32	-92.72 (140.58)	28	191.23 (325.31)
Estabrooks et al. (2011)	Moderate PA (min/week)	35	31.1 (26.9)	35	104.4 (26.9)
Lv et al. (2014)	Metabolic equivalent of PA (MET-minutes/week)	1000	6 (771)	1016	182 (882)
Robertson et al. (2012)	Pedometer step count	57	154 (800)	57	3175 (800)
Scarinci et al. (2014)	PA 5 or more days/week (%)	121	3 (25)	188	24 (25)
Solomon et al. (2014)	MET-Minutes per week	5638	2450 (3014)	4584	2317 (2964)

Table 2: Numeric evidence table of studies included in two-group analysis (controlled studies).

Author	Sample Size	Physical Activity Measure	Baseline (SD)	Post-intervention (SD)
Adams et al. (2015)	25	Moderate PA min/week	9.5 (125)	99.23 (76.13)
Dalleck et al. (2013)	332	Relative Energy Expenditure (Kcal/Kg/week)	Men: 5.4 (5.8)	16.8 (5.3)
			Women: 6 (6.3)	17.3 (6)
Foulds et al. (2011)	273	Physical Activity Score <sup>a</sup>	Men: 8.09 (2.47)	8.95 (2.09)
			Women: 6.90 (2.93)	8.96 (1.97)
Jiang et al. (2013)	1221	Vigorous PA min/week	163.5 (273.5)	189.1 (284.4)

Table 3: Numeric evidence table of studies included in single-group analysis.

<sup>a</sup>: Overall score from Healthy Physical Activity Participation Questionnaire (Gledhil & Jamnik, 2003)

## **Discussion:**

Significantly large intervention effects were found in both meta-analyses (SMD = 1.275; Percentage increase = 29.5%). These results suggest that community-based PA interventions are effective in increasing levels of PA. As previously mentioned, a decrease in physical inactivity by 10% would result in excess of 533 000 lives saved due to NCD's around the world every year (Lee et al., 2012). The efficacy of the interventions included in this analysis thus provides further evidence to support the funding of Biokineticist-lead community-based interventions in the South African public health sector.

The findings however differ from a recent Cochrane review evaluating the effectiveness of community wide interventions for increasing PA (Baker et al., 2011). The body of evidence within the Cochrane review does not support the hypothesis that multi-component community wide interventions effectively increase population levels of PA. The most likely reason for this discrepancy is that the Cochrane review used a different time period (up to November 2009) and included only higher quality studies. Insignificant intervention effects were attributed to a lack of methodological rigor in the studies analyzed; however the authors note that a lack of evidence does not necessarily indicate a lack of effectiveness.

Attrition and adherence are a common issue within community-based settings. Without sufficient adherence to an intervention, no meaningful effect can be enacted upon its participants. Independence should be fostered amongst participants to sustain healthy behaviours once an intervention comes to an

end. Estabrooks et al. (2011) found that by reducing the frequency of group-based intervention contacts from two times per week, to once per week, and finally to occasional booster sessions successfully led to increased PA, beyond the life of the group. The use of pedometers has also been shown to be effective in increasing levels of PA through setting step goals (Bravata et al., 2007). Robertson et al. (2012) demonstrated the efficacy of pedometers by producing the largest intervention effect within the 2-group analysis (SMD = 3.75).

Heterogeneity amongst studies was predominantly caused by variation in intensity of interventions. It is misleading to compare low intensity interventions targeting entire communities with high intensity interventions working personally with a hand-full of participants. For example, the study by Dalleck et al. (2013) illustrates an example of a high intensity intervention whereby a kinesiology senior student served as each participant's exercise trainer with further supervision from a qualified PhD-trained exercise physiologist. This high intensity intervention can be contrasted against the low intensity intervention of Solomon et al. (2014), who provided PA opportunities to large communities and performed recruitment and data collection through postal surveys.

Intensity of all interventions was subjectively rated (*Table 1*), the heterogeneity present justifies the use of a random-effects model within the two group analysis (controlled studies), ensuring that studies with large sample sizes were not overly weighted during the meta-analysis. Heterogeneity was also present within the single group analysis, which once again suggests the use of a random-effects model. However, as stated by Borenstein et al. (2007), when the sample size of a meta-analysis is small, such as the 4 studies included in the single group analysis, the tau-squared statistic of heterogeneity may be unreliable. Therefore a fixed effects model, rather than random effects, was used during the single group analysis. The results obtained from the fixed effects model were more conservative and had less variance, thus decreasing the likelihood of committing a type-1 error.

Multi-strategic community-wide interventions are able to reach a large proportion of the population regardless of social class and socioeconomic level. Broad-based instead of individual interventions are more cost-effective and help to spread knowledge about the importance of physical activity and nutrition, thereby improving health. The small number of studies included in the meta-analysis and previous inconclusive findings from Baker et al. (2014) call for more robust research including randomized controlled trials. The lack of research emerging from developing countries is also a concern as it is these regions that are undergoing extremely rapid lifestyle changes that should be guided by community-health programs (GAPA, 2015).

### **Limitations:**

This meta-analysis was not completely exhaustive, informally published reports or 'grey literature' were not included in the analysis. No restriction was placed upon the study design of articles included in the analysis, resulting in non-controlled studies contributing to the results of the analysis. However, it is argued that less well-controlled studies should be included, as they often have enhanced external validity (Glasgow et al., 2006). Measurement of PA was largely subjective and methods of measurements varied between studies. Sources of articles included were exclusively from developed countries, resulting in poor generalizability to developing countries. The small number of articles (n = 10) further reduces the generalizability of the findings. Our analysis was also restricted to English articles, causing a selection bias in the papers included for analysis. Articles by Robertson et al. (2012) and Lv et al. (2013) did not

report standard deviations (SD's). SD's for these articles were estimated from box and whisker plots as well as minimum and maximum values (maximum value-minimum value/6).

**Conclusion:**

This meta-analysis provides a quantitative summary of data from 10 community-based PA interventions across 5 countries. The analysis found beneficial effects of PA interventions (SMD = 1.275) when compared to controls and supplementary significant benefits (percentage increase in PA = 29.5%) in non-controlled studies.

Highlighted within the analysis is the lack of physical activity research in developing nations. This concern is coupled with the omission of control groups and objective measurements in multiple studies. More robust studies are required in order to enact change and influence government policy in this challenging area of research

The positive findings of this meta-analysis advocate for the support and funding of community-based PA interventions. South African policy makers need to act upon the Strategic Plan for Prevention and Control of Non-Communicable Diseases (2013-2017). Such action should be A) the inclusion of Biokinetics into the public health sector and B) funding of multi-disciplinary community health programs supporting education, healthy eating and PA levels.

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## CHAPTER 2:

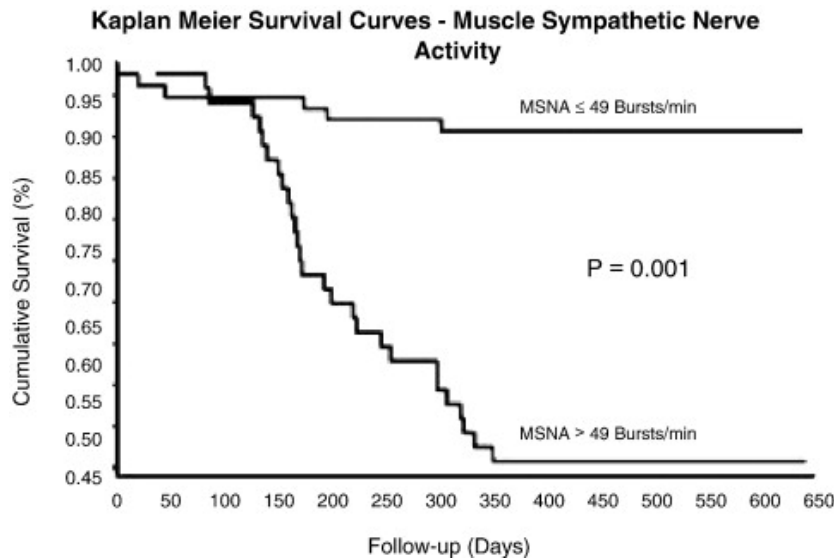
### **“Sweet Hearts”: A twelve-week pilot Biokinetics primary prevention program and its effect on health outcomes.**

#### **Introduction:**

Traditional approaches to tackle non-communicable diseases (NCD's) have been based on the big three of diet, smoking and physical inactivity. This approach has proved largely unsuccessful, resulting in the prediction that NCD's will cause 70% of all deaths in developing countries by 2020 (Boutayeb, 2006). Within the South African setting this failure to adequately control NCD's may be partly attributed to the lack of a dedicated health care provider in the public health sector as well as a tendency to treat rather than prevent NCD's (South African Department of Health, 2013). Recent research into NCD's aims to gain a better understanding of the underlying factors, and more effectively prevent the spread of NCD's. Researchers are doing this by moving towards exploring the impact of the brain & behaviour and more specifically the autonomic nervous system (ANS) on NCD's (Camm et al., 1996).

The ANS is a component of the peripheral nervous system, which controls the functions of the internal organs and blood vessels within the body. The functions of the ANS are involuntary and hence we are often unaware of its actions (Gabella, 2001). The ANS is further divided into the parasympathetic (PNS) and sympathetic nervous systems (SNS). Excessive sympathetic nervous activity (SNA), the extreme of which is known as the 'fight or flight' response, is associated with practically all NCD's; including heart disease, hypertension, obesity and the metabolic syndrome (Grassi et al., 2003; Lambert et al., 2013).

Evidence for these links was provided by Grassi et al. (2003) who found that obese individuals with one co-morbidity presented with greater SNA than obese individuals without co-morbidities; and obese individuals with two co-morbidities presented with greater SNA than those with only one. Barretto et al. (2009) provided additional evidence by demonstrating that increased muscle SNA is a significant independent predictor of one-year cardiac mortality. As depicted in *Figure 1* below, rates of survival are significantly poorer in patients with resting muscle SNA values above the median value of 49 bursts.min<sup>-1</sup>.



*Figure 1: Kaplan-Meier analysis of the cumulative rates of survival in patients with heart failure, stratified in two groups on the basis of resting muscle SNA (MSNA, bursts.min<sup>-1</sup>) (reproduced from Barretto et al., 2009)*

During endurance exercise the SNS is up regulated as the intensity and duration of exercise increases (Arai et al., 1989). Victor et al. (1987) used microelectrode recordings from the peroneal nerve, a rather invasive yet effective technique, to directly measure the effect of exercise intensity on SNA. Since the leg with the microelectrode had to be kept immobile for the recording of SNA, Victor and co-workers used arm cycling at varying intensities. Results indicated that very mild arm cycling produced graded increases in heart rate and blood pressure but did not significantly increase SNA ( $p \leq 0.05$ ), but moderate arm cycling dramatically increased SNA. Hence mild dynamic exercise, such as Tai Chi, therefore should not produce mass, uniform sympathetic discharge in humans (Motivala et al., 2006). However, as exercise intensity progresses from mild to moderate, a concomitant increase in SNA would occur. This increase in SNA is not considered harmful, as it is physiologically required in order for the cardiorespiratory and musculoskeletal systems to maintain the desired workload (Arai et al., 1989).

However, chronically elevated SNA, in the absence of physical activity, creates a vicious cycle within the human body. Raab & Gige (1955) compared epinephrine content, a marker of SNA activity, in normal and diseased human hearts. Significantly higher levels of epinephrine were present in cases of fresh myocardial infarction, congestive heart failure and renal uremia ( $p \leq 0.05$ ). A review by Moreira et al. (2015) evaluated the link between elevated SNA and the metabolic syndrome. The conclusions of the review are in line with the findings of Raab & Gige (1955), whereby excessive SNA activation exerts unfavorable effects on the body. These effects include a contribution towards the development of cardiac hypertrophy, arterial remodeling and endothelial dysfunction. Acutely, stress, cortisol and SNA may also lead to fat accumulation (Bjorntorp, 2001) and insulin resistance (Deibert & DeFronzo, 1980). Chronic secretion of cortisol and SNA results in an auto-immune response in obese individuals that may cause inflammation within adipose tissue, thereby further worsening insulin resistance and fat accumulation (Balasubramanyam, 2013).

### ***The self-regulatory function of the central stress network:***

It is well known that excessive stress increases SNA (Fisher et al., 2009), however a sedentary lifestyle can also lead to dysfunction of reflex-mediated sympathetic output. A study by Mischel & Mueller (2011) suggests that a sedentary lifestyle increases the risk of cardiovascular disease by increasing resting SNA, particularly to the splanchnic circulation and also by increasing vascular sensitivity to adrenergic stimulation. Schlaich et al. (2011) demonstrated the beneficial effects of reducing SNA by performing bilateral sympathetic renal denervation in obese women. The procedure resulted in a decrease in overall SNA and blood pressure as well as improved insulin sensitivity; factors that are also closely associated with heart failure (Ramchandra & Barrett, 2015).

The ventromedial prefrontal cortex (vmPFC) has some modulatory control over SNA (Gianaros & Sheu, 2009). This is a top down pathway meaning that afferent feedback does not directly regulate its function; but signalling from other brain areas like the hippocampus and amygdala (Godsil et al., 2013) can disrupt this top down regulation. Evidence for this disruption is provided by Simpson et al. (2001) where blood flow to the vmPFC decreased during anticipatory anxiety as compared to an eyes-closed resting condition. This finding demonstrates the dynamic balance between anxiety and vmPFC modulation. Therefore strengthening of the vmPFC regulatory top-down pathway, through improved anxiety management, may have therapeutic potential.

### ***Combating stress through locomotion:***

Locomotion is a basic human movement. The reticulospinal (RS) extra-pyramidal tract mediates both spinal locomotor activity (Grillner et al., 2005) as well as autonomic activities such as vasomotor drive (Morrison & Reis, 1989) and spontaneous breathing rate (Urfy & Suarez, 2013). The therapeutic effect of patterned movement, such as Tai Chi (Väänänen et al., 2002), is affected by engaging the RS tract in focused locomotion; thereby modulating its influence upon the ANS and more specifically attenuating excess sympathetic drive (Rauch et al., 2013). Controlled breathing influences the autonomic nervous system, deep and rhythmic inspiration gives rise to increased vagal flow to the sinus node in the heart. An increase in vagal flow to the sinus node results in a reduction of SNA, evident through a lowered heart rate and increased heart rate variability (HRV) (Prinsloo et al., 2013). The clinical relevance of HRV was first demonstrated when Horn & Lee (1965) noted that fetal distress was preceded by alterations in inter-beat intervals before any significant change occurred in the heart rate itself. A recent meta-analysis directly linked vmPFC activations to HRV (Thayer et al., 2012). This finding supports the use of HRV as an easy to measure peripheral index of vmPFC activation. This has practical implications for a health professional that is now able to measure a marker of “top-down” vmPFC regulation before, during or after therapeutic exercises.

### ***South African Context:***

During the South African summit on the prevention and control of non-communicable diseases on 12-13 September 2011, a consensus was reached that identified the need for intensified national action addressing prevention, early detection, behavioral change and universal treatment of NCD's in South Africa. This consensus materialized in the form of the Strategic Plan for Prevention and Control of Non-

Communicable Diseases 2013-2017. The plan, developed by the department of health, identified three public health strategies (South African Department of Health, 2013):

1. Prevent NCD's and promote health and wellness at population, community and individual levels.
2. Improve control of NCD's through health systems strengthening and reform.
3. Monitor NCD's and their main risk factors as well as conduct innovative research.

The intervention discussed below sought to implement these three strategies at a community level. Thus the aims of this study were to:

- 1) Establish an effective, sustainable and holistic community health program.
- 2) Explore the effect of a community health program on health related outcomes.
- 3) Explore the effect of a community health intervention on autonomic nervous system regulation.
- 4) Explore factors that promote participation and predict adherence to a community health intervention.
- 5) Advocate for the inclusion of Biokinetics in the South African Public Health Sector.

### **Methods:**

The study was conducted with approval from the Faculty of Health Science's Human Research Ethics Committee (HREC REF 214:2012), University of Cape Town, Cape Town, South Africa.

Tramway Football Club in Southfield, Cape Town, served as the venue for the study. Southfield forms a part of Cape Town's Southern Suburbs area. NCD's account for a total of 30.7% of years-of-life-lost in the Southern Suburb's population (Sampson, 2014). The large prevalence of NCD's in this population made it an appropriate setting for a community lifestyle intervention.

#### *Inclusion criteria*

- Age greater than 18 years.
- Possess  $\leq 1$  risk factor according to American College of Sports Medicine risk stratification categories for atherosclerotic cardiovascular disease (ACSM, 2013).

#### *Exclusion criteria*

- Orthopaedic injury
- Possess existing disease or  $\geq 1$  risk factor, currently physically inactive or have insufficient physical ability to participate<sup>1</sup>

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<sup>1</sup> The traditional ACSM exclusion criteria of an existing chronic disease or 2 or more risk factors for coronary heart disease were utilized as a guide (ACSM, 2013). The on-site medical doctor assessed those who still wished to participate but would ordinarily be excluded according to these criteria. Participants were included if it was deemed the benefits they stood to gain from the study outweigh the risks of participation. This practice is commonplace in cardiac rehabilitation programs globally (Corra et al., 2010). No adverse events occurred during the course of the intervention.

A review of risk assessment and physical activity clearance by Thomas et al. (2011) provides evidence that ordinarily ‘high-risk’ individuals who are medically stable, are involved with physical activity, and who have adequate physical ability; should participate in medically supervised physical activity interventions of lower to moderate risk. The physical activity component of the intervention was considered a moderate risk with the main modality of activity being walking. Hence prospective participants with existing disease or 2 or more risk factors but were medically stable, currently physically active and had sufficient physical ability to participate were included into the medically supervised intervention. It is suggested that this principle of recruiting participants into a community lifestyle intervention, with adequate medical supervision, be adopted in the future. It is fundamentally incorrect to only allow ‘apparently healthy’ individuals to participate as those most in need of change are discriminated against.

Twenty-five participants (twenty-two female, three male) were recruited into the 3-month intervention through radio announcements, flyers and email. Data analysis could only be conducted on participants attending both baseline and post-intervention testing sessions; thus ten participants (all female) were included for final analysis (*Table 1*). Participants included for analysis had an overall attendance rate of 72%; a minimum attendance rate of 60% was required to be included in the final analysis. All participants completing both pre and post testing met this requirement.

*Table 1. General characteristics of participants*

Variable	Value (n = 10)
Age (years)	29.4 ± 8.5
Height (cm)	162.3 ± 5.5
Income Group <sup>#</sup>	5.3 ± 2.2
Smokers (%)	40%
Medical aid members (%)	60%

*Values reported as mean ± sd.*

<sup>#</sup> *Income groups: 1 = No income; 2 = R1-R2499;  
3 = R2500-R4999; 4 = R5000-R7499; 5 = R7500-R9999;  
6 = R10 000-R15000; 7 = R15000 or more*

### ***Testing Procedures:***

Testing was conducted by Intern Biokineticists and qualified Biokineticists with the assistance of the Biokinetic Humanitarian Project (Noorbhai, 2013). On the first day of testing participants completed an informed consent and ACSM pre-participation questionnaire designed to identify any factors that indicate a risk of participation in exercise (ACSM, 2013). If the participant satisfied the requirements of this questionnaire and fulfilled the inclusion criteria for participation, they were recruited into the study.

Participants then completed questionnaires designed to predict their physical activity level (GPAQ), demographics, eating habits (three factor eating questionnaire), tobacco use and resilience (CD-RISC). Intern Biokineticists performed a method of brief behavioural counseling (Whitlock & Williams, 2003) with participants to establish achievable goals whilst participating in the intervention. Participant's stature, body mass, waist circumference, blood pressure, glucose, heart rate and the thickness of 7 skinfolds were then measured.

Participants then performed a simple cognitive task on a computer (*Windows 7*). The test in its entirety lasted approximately 15 minutes whilst heart and breathing rates were measured (*Biopac MP150, Goleta, CA*). Five minutes of resting data was initially recorded followed by five minutes of familiarization to the cognitive task and lastly the recorded cognitive task was performed. The task completed was a modified Stroop task consisting of 80 colour word prompts; interspersed with 20 calorie dense food cues designed to illicit a stress response from participants (Prinsloo et al., 2011). Many HRV measures are dependent upon the length of recording, thus statistical analysis using AcqKnowledge (Wester, 1993) & Kubios (Tarvainen et al., 2014) software was conducted on constant 2-minute segments of data. Frequency-domain methods of HRV analysis were preferred to the time-domain methods as the frequency-domain has greater validity when investigating short-term recordings (Camm et al., 1996).

Participants also performed a novel 1-minute time perception test, a 1-minute lower body muscle endurance test and a 12-minute walking test where they were encouraged to walk as far as possible in 12 minutes. The lower body muscle endurance test involved doing as many repetitions of 'sit-to-stands' as possible in 60 seconds. The time perception test was conducted by seating the participant in a quiet isolated area and timing 60 seconds on a stopwatch. Participants were asked to say 'stop' when they believed 60 seconds had passed; participants were explicitly requested not to consciously count as seconds passed. This testing protocol was repeated after the 3-month intervention.

### ***Intervention:***

A total of 27 exercise sessions, one hour in duration, were conducted over the 3-month intervention. Sessions were 60 minutes long and held bi-weekly every Monday and Wednesday evening, with two extra sessions held on public holidays. All sessions were planned and conducted by Intern Biokineticists, completing their final year of practical training. Each session progressed from low to moderate intensity (approximately 40-70%  $\text{VO}_2^{\text{max}}$ ) and contained a combination of strength, cardiovascular and flexibility training. An open field and basic equipment such as cones, skipping ropes and medicine balls were used. Examples of exercises prescribed include push ups, squats, elastic rows, pelvic bridges, repeat sprints, agility drills, medicine ball throws, hamstring stretches etc.

Brief behavioural counseling (Whitlock & Williams, 2003) was conducted during warm up/cool down periods. The counseling addressed pertinent lifestyle issues such as physical inactivity, smoking and eating behaviours. Intern-Biokineticists were trained in basic life support and a medical doctor was on site or on emergency call.

### ***Standardisation of conditions:***

To maximize the reliability of measurements, a single researcher administered each test. Participants were asked to abstain from caffeine, strenuous exercise and medication potentially influencing performance 24 hours before testing. Participants were also encouraged to get sufficient sleep (minimum of 7 hours) the night preceding testing. To avoid any influence of circadian variance, testing sessions were performed at the same time of day.

### ***Data analysis:***

Statistica 12 software package was used for all the analyses. Descriptive statistics were performed. Levene's test was used to confirm that data was parametric. Analyses of variance (ANOVA) and student t-tests were utilized to detect differences between participants at baseline and post-intervention. Pearson product-moment correlations were used to explore baseline variable correlations with adherence. Level of significance for all analyses was set at  $p < 0.05$ .

### **Results:**

Significant changes occurred in the following basic physiological variables ( $p \leq 0.05$ ): a decrease in waist circumference from  $85.9 \pm 15.4$  to  $80.8 \pm 11.4$ cm, an increase in 1-minute time perception from  $47 \pm 10.2$  to  $75.3 \pm 32$  seconds, an increase in global physical activity questionnaire (GPAQ) score from  $689 \pm 791$  to  $2760 \pm 2523$  MET-minutes/week, an increase in 12-minute walk distance from  $1360 \pm 353$  to  $1565 \pm 220$  meters and an increase in sit-to-stands from  $35.8 \pm 6.3$  to  $42.5 \pm 3.4$  repetitions. A summary of changes in basic physiological variables is contained in *Table 2* below.

*Table 2. Basic physiological changes over 3-month intervention period*

Variable	Baseline (n = 10)	Post- Intervention (n = 10)	p
Body mass index (kg/m <sup>2</sup> )	29.4 ± 8.5	29 ± 8.6	0.26
Body fat (%)	34.3 ± 3.6	34.7 ± 4.3	0.53
Waist circumference (cm)	85.9 ± 15.4	80.8 ± 11.4	0.01*
Systolic blood pressure (mmhg)	116.6 ± 8	104.9 ± 36.9	0.31
Diastolic blood pressure (mmhg)	76 ± 7.5	78.2 ± 10	0.49
Resting heart rate (beats·min <sup>-1</sup> )	79.7 ± 16.3	76.8 ± 10.9	0.30
Blood glucose (m·mol/l)	5.4 ± 0.9	5.3 ± 0.38	0.69
1-Minute time perception (s)	47 ± 10.2	75.3 ± 32	0.02*
GPAQ Score (MET-minutes/week)	689 ± 791	2760 ± 2523	0.03*
12-Minute walk test (m)	1360 ± 353	1565 ± 220	0.01*
Sit-to-stand test (repetitions)	35.8 ± 6.3	42.5 ± 3.4	0.001*
CD-RISC score	73.8 ± 10.6	75 ± 8.2	0.66

*Values reported as mean ± sd. \* Denotes significant differences between baseline and post-intervention (p < 0.05)*

Scores on the Three Factor Eating Questionnaire (Stunkhard & Messick, 1985) showed favorable changes across restraint, dis-inhibition and hunger scores (Table 3). However, only the increase in restraint reached a level of significance.

Table 3. Variable changes over 3-month intervention period

Variable	Baseline (n = 10)	Post- Intervention (n = 10)	p
Restraint (score)	7.2 ± 5.2	9.9 ± 5.9	0.03*
Disinhibition (score)	7.6 ± 4	5.7 ± 3.1	0.15
Hunger (score)	5.7 ± 4	4.5 ± 3.4	0.31

Values reported as mean ± sd. \* Denotes significant differences between baseline and post-intervention ( $p < 0.05$ )

At rest, log LF HRV was significantly ( $p \leq 0.05$ ) higher post-intervention (Pre:  $5.58 \pm 0.9$  vs. Post  $6.4 \pm 0.96 \text{ logmsec}^2$  – Table 4). At baseline log LF HRV showed an overall upward trend from Rest to the Stroop task, increasing by  $0.41 \pm 0.39 \text{ logmsec}^2$ . This trend reversed post-intervention with an overall downward trend from Rest to Stroop task, decreasing by  $0.78 \pm 1.33 \text{ logmsec}^2$  (Table 5).

Table 4. Resting heart rate variability & respiration changes over 3-month intervention period

Variable	Baseline (n = 8)	Post- Intervention (n = 8)	p
STD RR (ms)	38.8 ± 29.1	37.2 ± 10.98	0.83
Mean Heart Rate (beats/min)	79.7 ± 16.3	76.8 ± 10.9	0.44
RMSSD (ms)	39.8 ± 33.8	29.4 ± 11.1	0.28
Low Frequency (LF) Peak (Hz)	0.12 ± 0.03	0.11 ± 0.04	0.59
High Frequency (HF) Peak (Hz)	0.22 ± 0.08	0.18 ± 0.03	0.25
Log LF ( $\text{logmsec}^2$ )	5.58 ± 0.90	6.4 ± 0.96	0.03*
Log HF ( $\text{logmsec}^2$ )	6.34 ± 2.06	5.82 ± 1.18	0.38
Log LF + Log HF ( $\text{logmsec}^2$ )	11.9 ± 2.85	12.3 ± 1.31	0.66
Respiratory rate ( $\text{breaths} \cdot \text{min}^{-1}$ )	12.8 ± 1.6	10.3 ± 3.3	0.02*

Values reported as mean ± sd. \* Denotes significant differences between baseline and post-intervention ( $p < 0.05$ ). STD RR : Standard deviation of R-R interval; RMSSD: Root Mean Square of Successive Differences.

Table 5. Difference between Resting and Stroop heart rate variability & respiration measures.

Variable	Baseline (n = 8)	Post- Intervention (n = 8)	p
STD RR (ms)	2.99 ± 15.8	8.20 ± 9.6	0.46
Mean Heart Rate (beats/min)	-4.4 ± 4.3	-5.9 ± 7.3	0.54
RMSSD (ms)	5.60 ± 18.1	1.83 ± 7.9	0.58
Log LF (logmsec <sup>2</sup> )	-0.41 ± 0.39	0.78 ± 1.33	0.02*
Log HF (logmsec <sup>2</sup> )	0.53 ± 1.07	0.42 ± 0.68	0.80
Log LF + Log HF (logmsec <sup>2</sup> )	0.12 ± 1.38	1.20 ± 1.33	0.11
Respiratory rate (breaths min <sup>-1</sup> )	-2.93 ± 3.11	-7 ± 5.03	0.13

Values reported as mean ± sd. Differences calculated by subtracting Stroop value from Resting value (i.e. Rest – Stroop). \* Denotes significant differences between baseline and post-intervention ( $p < 0.05$ ). STD RR: Standard deviation of R-R interval; RMSSD : Root Mean Square of Successive Differences.

Multiple HRV measures were negatively correlated with income level (i.e. the higher the level of income, the poorer the HRV outcomes – Table 6 & Figure V)

Table 6. Baseline measures correlated with income level

Variable	r value (n = 8)	P
Resting STD RR (ms)	-0.75	0.03*
Resting Log Low Frequency Peak (Hz)	-0.74	0.04*
Stroop STD RR (ms)	-0.87	0.01*
Stroop RMSSD (ms)	-0.76	0.03*
Stroop Log Low Frequency Peak (Hz)	-0.76	0.03*

STD RR : Standard deviation of R-R interval; RMSSD : Root Mean Square of Successive Differences. \* Denotes significant association with income level ( $p < 0.05$ ).

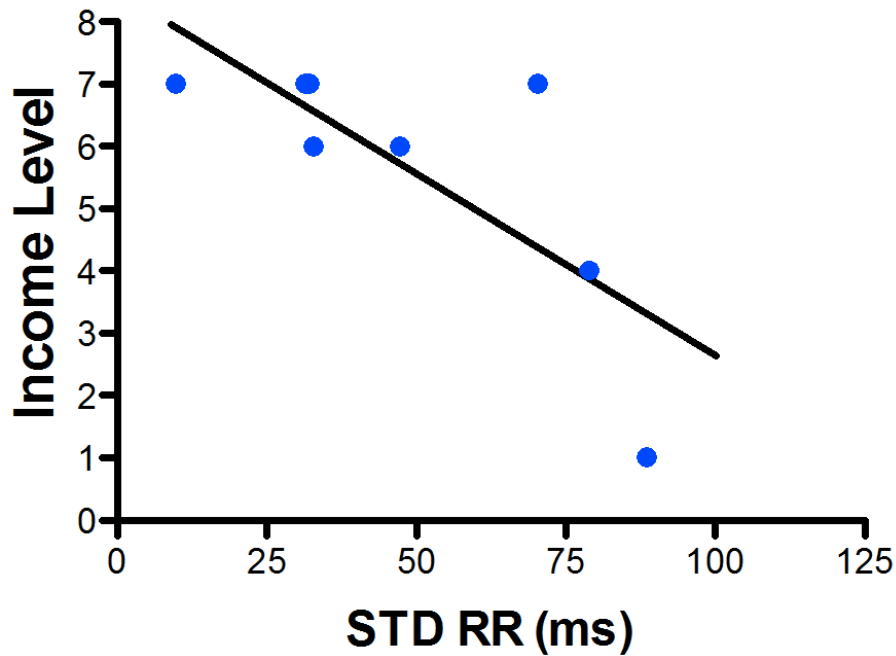


Figure II: Association between income level and Resting STD RR ( $R = -0.75$ )

STD RR : Standard deviation of R-R interval<sup>#</sup> Income groups: 1 = No income; 2 = R1-R2499; 3 = R2500-R4999; 4 = R5000-R7499; 5 = R7500-R9999; 6 = R10 000-R15000; 7 = R15000 or more

### **Discussion:**

Over the duration of the 3-month intervention, significant changes occurred in the following basic physiological variables ( $p \leq 0.05$ ): a decrease in waist circumference and resting respiratory rate, as well as an increase in 1-minute time perception, GPAQ score, 12-minute walk and sit-to-stand tests.

With the addition of two regular physical activity sessions per week, participants who were largely sedentary at baseline increased their physical activity levels (GPAQ score) during the intervention. Aerobic capacity and lower body muscular endurance, measured through the 12-minute walk and sit-to-stand tests respectively, significantly increased during the intervention ( $p \leq 0.05$ ).

Koster et al. (2008) examined the association between waist circumference and mortality among 154,776 men and 90,757 women in the NIH-AARP Diet and Health Study. In comparison to participants with a normal BMI ( $18.5\text{--}25\text{kg/m}^2$ ) and waist circumference, those in the normal-BMI group with a large waist circumference (men  $> 102$  cm; women  $> 88$  cm) had an approximately 20% higher mortality risk. This finding supports the fact that an elevated waist circumference is an independent risk factor for all-cause mortality. A significant decrease ( $p \leq 0.05$ ) of 5cm in participant's waist circumference will thus likely confer health benefits and lower risk of all-cause mortality.

Multiple models of time perception have been proposed, the energy readout model theorizes that perceived elapsed time corresponds to the amount of neural activity (Ivry & Schlerf, 2008). Sympathetic nervous stimulation invokes the flight or fight response where decisions made over short time periods are crucial. It is thus hypothesized that the presumably lowered sympathetic activation, as evidenced by the decreased spontaneous breathing rates (Narkiewicz et al., 2006), allowed the participants to feel more

relaxed; hence leading to a significant increase in the duration of the 1-minute time perception task ( $p \leq 0.05$ ).

Scores on the Three Factor Eating Questionnaire (Stunkhard & Messick, 1985) showed favorable tendencies across restraint, disinhibition and hunger scores. However, only the increase in restraint reached a level of significance. In a cross-sectional study of 529 middle-aged adults and 358 teenagers and young adults, cognitive restraint was positively associated in adults eating healthy food groups such as green vegetables and negatively associated with french fries and sugar (de Lauzon et al., 2004). Hence the increase in cognitive restraint observed over the course of the intervention may have resulted in improved dietary choices amongst participants.

Changes in HRV were predominately insignificant, except for changes in the low frequency spectrum ( $p \leq 0.05$ ). Variance is mathematically equal to total power of spectral analysis, thus higher powers are equivalent to larger variance. During sympathetic activation of the heart, the resulting tachycardia reduces cardiac spectral power, whereas the reverse occurs during vagal activation (Camm et al., 1996). The logarithmic of the frequency spectrums was used to normalize the data and allow for parametric analysis. The low frequency spectrum (LF) is associated with an individual's baroreflex function (Rahman et al., 2011), while the high frequency spectrum (HF) is generally associated with respiration (Camm et al., 1996).

At rest, LF HRV was significantly higher post-intervention ( $p \leq 0.05$ ), indicating greater vagal drive to the heart and/or less sympathetic arousal of the heart. This change in HRV is presumably linked to the significantly slowed resting respiratory rates from pre to post testing ( $p \leq 0.05$ ), resulting in deeper and more rhythmic inspiration. A direct correlation exists between SNA and spontaneous breathing rate (Narkiewicz et al., 2006). Slow breathing at 6 breaths/min increases baroreflex sensitivity, reducing sympathetic activity and chemoreflex activation (Joseph et al., 2005). The slowed respiration rate of approximately 10 breaths per minute ( $0.17 \pm 0.06$  Hz) in our participants post-intervention would have impacted the LF band of the cardiac spectrogram and may have increased baroreflex sensitivity. This likely contributed to the changes in HRV observed and is associated with lowered risk for cardiac and arrhythmic mortality (La Rovere et al., 2001). It is thus hypothesized that through the stress reduction techniques adopted during the intervention, such as regular exercise and controlled breathing, participants were enabled to better regulate their autonomic responses. This regulation includes a more efficient SNA response to the Stroop task post-intervention. As depicted in *Figure 4*, at baseline log LF HRV showed an overall upward trend from Rest to the Stroop task, increasing by  $0.41 \pm 0.39$  logmsec<sup>2</sup>. This trend reversed post-intervention with an overall downward trend from Rest to Stroop task, decreasing by  $0.78 \pm 1.33$  logmsec<sup>2</sup>. The downward trend observed post-intervention is indicative of a more efficient stress response (increase) to deal with the demands of the cognitive task. This hypothesis is further supported by the manner in which regular exercise training is able to modify autonomic balance (Furlan et al., 1993; Arai et al., 1989).

As previously mentioned, a close link exists between breathing rate and SNA (Narkiewicz et al., 2006). The increase in breathing rate from Rest to Stroop ( $10.3 \pm 3.3$  to  $17.5 \pm 4.3$  breaths per minute) was greater post-intervention than pre-intervention ( $12.8 \pm 1.6$  to  $16 \pm 3.2$  breaths per minute). Due to the small sample size this difference did however not reach significance ( $p = 0.13$ ). This finding of a trend towards a larger increase in breathing rate from Rest to Stroop post-intervention is indicative of improved

ANS regulation (Joseph et al., 2005). It is theorized that participants were more relaxed at Rest post-intervention. While completing the Stroop task participants had more efficient withdrawal of vagal input during the induced cognitive stress. This was evident through increased breathing rates, needed in order to increase body arousal and concentration to successfully deal with the Stroop task (Collet et al., 2005).

Correlational analysis highlighted an interesting overall negative relationship between HRV and income levels. It is important to note that with a sample size of  $n = 8$ , solid conclusions cannot be drawn from these relationships, however future research can evaluate potential links with a larger sample. Increases in income level were associated with poorer HRV outcomes. Both Resting (*Figure 5:  $r = -0.75$* ) and Stroop ( $r = -0.87$ ) variation in the R-R interval showed a downward trend as income level rose. Variation in the R-R interval is an accurate measure of vagal input to the heart, with lowered variation being associated with poorer health outcomes (Camm et al., 1996). The root mean square of successive differences (RMSSD), an additional measure of variation in the beat-to-beat interval, also showed a downward trend during the Stroop task as income levels rose ( $r = -0.76$ ). Lastly, both Rest and Stroop low frequency powers decreased as income level increased, indicating higher sympathetic arousal with higher incomes. Fisher et al. (2009) & Lucini et al. (2002) link excessive stress to increases in sympathetic nerve activity. The findings on our small sample size are in contrast to those of Cohen et al. (2006) whereby lower socioeconomic status was associated with higher stress levels. Further investigation should thus explore this contradiction to the literature.

### **Conclusion:**

This chapter examines the effect of a 3-month pilot Biokinetics primary prevention program on health outcome measures. A total of twenty-seven exercise sessions, combined with nutritional advice and stress reduction techniques, were conducted. Despite a small sample size ( $n = 10$ ), the intervention showed significant improvements in health outcome measures amongst participants ( $p \leq 0.05$ ). These improvements include: a decrease in waist circumference and resting respiratory rate, as well as an increase in 1-minute time perception, Global Physical Activity Questionnaire (GPAQ) score, 12-minute walk distance and sit-to-stand test repetitions. Improvements were also noted in cognitive restraint with regards to eating behavior as well as heart rate variability (HRV), specifically in the low frequency spectrum. The combination of lowered resting breathing rates and improved HRV measures suggests that participant's autonomic nervous system (ANS) regulation improved during the course of the intervention. Correlational analysis revealed that higher income levels were associated with poorer HRV measures. The favourable results of the community intervention show promise for the future expansion of the program into the public health sector and provide proof of concept to dedicate resources to conduct more robust research within a community setting

South Africa is without a focused approach to reduce physical inactivity. The primary function of a Biokineticist is to improve physical functioning and health through exercise as a modality. An alarming number of NCD's, such as heart disease and type 2 diabetes mellitus, were attributable to physical inactivity among South Africans based on the 1998 South African Demographic and Health survey data (Joubert et al., 2007). Community based interventions, such as the one described here, have been shown to be effective in reducing the risk of developing NCD's (Li & Siegest, 2012). The positive effects that this intervention had on its participants demonstrates the feasibility of combating NCD's through primary prevention. Drastic change is needed in order to combat the crippling prevalence of NCD's affecting our

nation; it is suggested that this change should be set in motion by taking the following action: A) the inclusion of Biokinetics into the public health sector and B) funding of multi-disciplinary community health programs supporting education, healthy eating and physical activity levels.

### **Limitations:**

The 'Sweet Hearts' program was organized and run by a single post-graduate student who also concurrently worked as an intern-Biokineticist. No funding was received to support the program; which mirrors somewhat the lack of financial support and human capital available in combating the rise of NCD's through physical activity in South Africa. Due to limited resources the intervention had a relatively small sample size and no control group. Thus the ability to make inferences from the results is limited. However, limited inferences should be expected from a pilot study whose main purpose is to facilitate future research. The favourable results discussed herein show promise for the future expansion of the program and provide proof of concept to dedicate resources to conduct more robust research within a community setting.

### **Practical Application:**

To date, the profession of Biokinetics has been confined to the private health sector, only available to those who are able to afford the service. A major component of a Biokineticist's training involves the prevention and treatment of NCD's such as obesity, diabetes and heart disease. These skills are desperately needed within the public health sector to slow the devastating impact of NCD's on our communities and economy.

A large number of Biokinetics students are denied internship positions due to a lack of capacity within the private health sector. The utilization of both intern and qualified Biokineticists in the public health sector provides a cost effect approach to combating an increasingly sedentary South African lifestyle. The model of lifestyle intervention used during the study serves as a valuable starting point for future interventions. This pilot study demonstrated a wide array of positive effects on its participants and future research should expand upon this pilot. The model used is easily reproducible and through external funding can be implemented across the country.

### **Acknowledgements:**

Biokinetic Humanitarian Project (BHP) (Noorbhai, 2013) which aims to provide exercise testing, exercise prescription and health education in underprivileged communities, sport and university settings, primary health care and other settings in need.

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## Chapter 3:

# Factors promoting participation and predicting adherence to a community health intervention: a mixed methods approach.

### Introduction:

Once physical activity interventions are implemented within the South African public health sector, the next hurdle to overcome is a lack of adherence. Evidence suggests that people from low-income groups, such as those reliant on the public health sector, are more difficult to identify and successfully recruit (Marcus et al., 2006). It is a waste of resources to establish community programs that are unable to retain participants and hence impact their long-term health. Examples of difficulties with adherence are illustrated by Brown et al. (2014) who experienced an attrition rate of 66% during a 20 week intervention with 1<sup>st</sup> year university students and Scarinci et al. (2014) who had an attrition rate of 45% during a 12 month intervention with African American women.

The social ecological model (Fleury & Lee, 2006) contains the multitude of factors that may affect an individual's adherence to a community health intervention (*Figure I*). Research, especially of the mechanistic kind, is focused upon the individual and attempts to eliminate all contextual factors. By adopting the framework of the social ecological model, the external influences acting upon participants can be better understood.

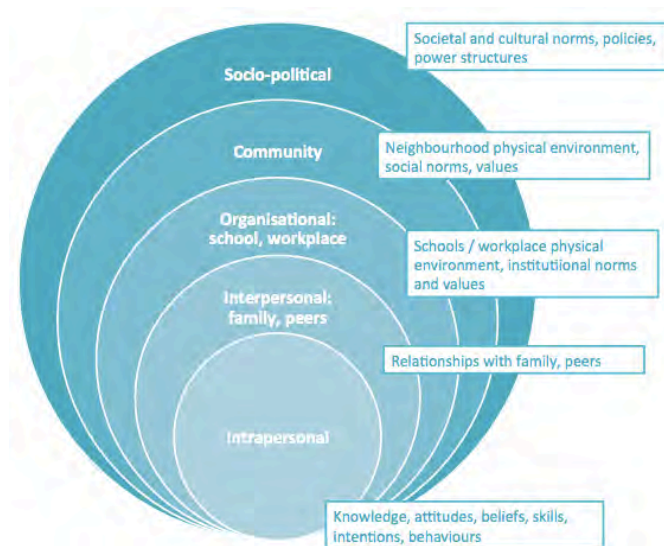


Figure I: Social Ecological Model (reproduced from Fleury & Lee, 2006)

Most individuals have a desire to be physically active and lead a healthy lifestyle, however environmental and personal circumstances rarely promote these behaviors (Bauman et al., 2012). Community health interventions assist in promoting healthy behaviours; however they are only effective if adhered to. *Figure II* below taken from Cox (2000) explores the determinants of adherence rates to physical activity interventions. As depicted in the model, adherence is a product of both personal and environmental characteristics.

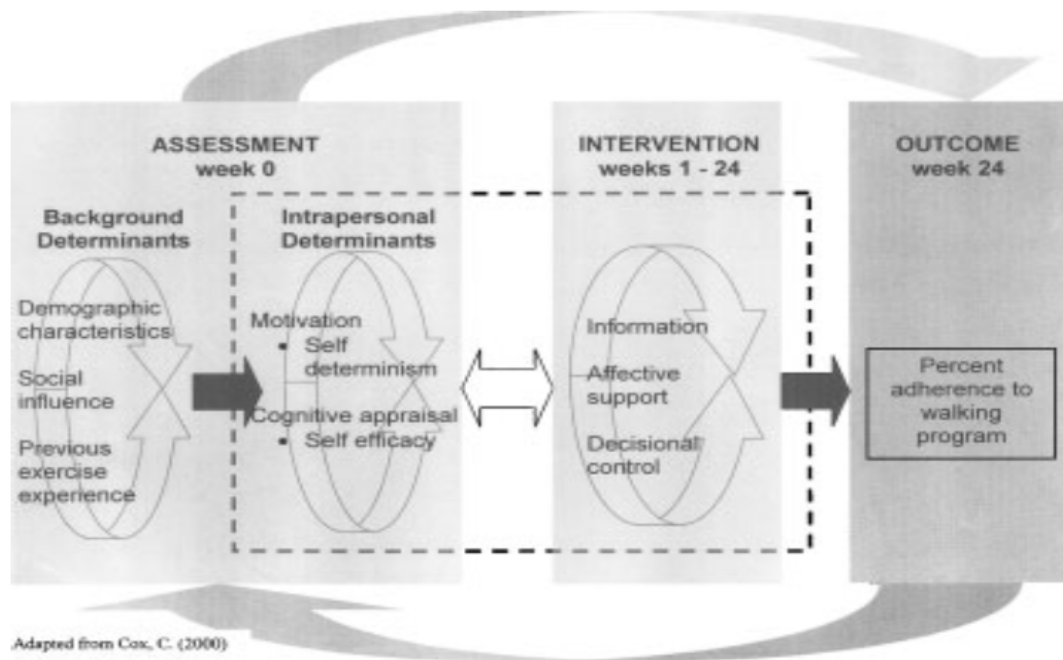


Figure II: Determinants of adherence to a physical activity program (reproduced from Cox (2000))

The aim of the following chapter is to inductively explore the issue of adherence to a community group physical activity intervention. Quantitative analysis of factors influencing adherence is unlikely to paint a complete picture and hence a qualitative analysis, guided by Kuper et al. (2008), was conducted to shed light on the unique issues participants face during interventions.

## **Methods:**

### ***Study context & setting:***

The study was conducted with approval from the Faculty of Health Science's Human Research Ethics Committee (HREC REF 467:2015), University of Cape Town, Cape Town, South Africa.

Tramway Football Club in Southfield, Cape Town served as the venue for the community intervention, "Sweet Hearts". Southfield forms a part of Cape Town's Southern Suburbs area. NCD's account for a total of 30.7% of years-of-life-lost in the Southern Suburb's population (Sampson, 2014). The large prevalence of NCD's in this population made it an appropriate setting for a community lifestyle intervention.

A total of 27 exercise sessions, one hour in duration, were conducted over the 3-month intervention. Sessions were 60 minutes long and held bi-weekly every Monday and Wednesday evening, with two

extra sessions held on public holidays. All sessions were planned and conducted by Intern Biokineticists, completing their final year of practical training. Each session progressed from low to moderate intensity (approximately 40-70%  $\text{VO}_2^{\text{max}}$ ) and contained a combination of strength, cardiovascular and flexibility training. An open field and basic equipment such as cones, skipping ropes and medicine balls were used. Examples of exercises prescribed include push ups, squats, elastic rows, pelvic bridges, repeat sprints, agility drills, medicine ball throws, hamstring stretches etc. Brief behavioural counseling (Whitlock, 2003) was conducted during warm up/cool down periods; counseling addressed pertinent lifestyle issues such as physical inactivity, smoking and eating behaviours. Intern-Biokineticists were trained in basic life support and a medical doctor was on site or on emergency call.

### ***Sample selection & recruitment:***

#### *Inclusion criteria:*

- Completed “Sweet Hearts” intervention
  - Age greater than 18 years.
  - Possess < 1 risk factor according to American College of Sports Medicine risk stratification categories for atherosclerotic cardiovascular disease (ACSM, 2013) \*Or deemed fit to participate by a medical doctor
- Willing to partake in telephonic interview

Twenty-five participants (twenty-two female, three male) were recruited into the 3-month intervention through radio announcements, flyers and email. A purposive sampling technique was used to select participants for interviews. This technique was deemed the most feasible within the context of the study. Interviews with participants were conducted telephonically to reduce the burden placed upon participants. Of the 10 total participants completing the community health intervention, 5 agreed to partake in an interview.

The process of asking participants to engage in an interview was as follows: A phone call was made during working hours (9am-5pm) whereby the details of informed consent, including brief reasoning and motive for interviews was given. An example of the wording used to describe the interview is as follows: “The interview will consist of an approximately 15 minute discussion about your views and experiences of the intervention. Your identity will not be revealed outside of the interview and the interview will be used to ensure the intervention can be improved upon when it is repeated.” Participants were then asked if they would like to volunteer to participate in the interview. If consent was given then the interview was conducted telephonically during the same call or alternatively set up for a more convenient time. If participants declined then they were thanked for their time and the call was ended.

### **Interview schedule:**

A semi-structured interview schedule was used to ensure pertinent topics were covered whilst allowing the researcher and participant the freedom to discuss a wide range of issues. The semi-structured schedule was as follows:

1. Demographics
  - a. Were you born and raised in Cape Town?
  - b. Which area do you live in?
  - c. Do you work, which profession?
  - d. What are your family commitments?
2. How did you first hear about the Sweet Hearts initiative?
3. What made you decide to get involved in the initiative?
4. What did you enjoy most about the program?
  - a. How did you benefit from the program?
5. What did you dislike about the program?
  - a. How would you improve upon the program?
6. What factors made it easier and motivated you to attend exercise & testing sessions?
7. Were there any difficulties that you experienced in attending exercise/testing sessions?
8. What do you think the profession of Biokinetics entails?
  - a. (Explain the scope of Biokinetics practice here)
9. How could you benefit from having access to a Biokineticist?
10. Do you think diseases of lifestyle such as obesity, diabetes and heart disease are a problem in South Africa?
11. Do you believe we as South Africans are doing enough to slow the progression of these diseases?
12. Participant will be thanked for their time and told that written feedback will be given.

### **Data collection & analysis:**

With verbal informed consent, telephonic interviews were audio-recorded (Samsung Galaxy S3-mini) and later transcribed. Transcripts were printed and manually analyzed with initial colour coding and later collated into overarching themes.

### **Qualitative results:**

Five main themes were structured into the interview schedule: 1) Enjoyment of the intervention 2) Benefits of the intervention 3) Obstacles affecting adherence 4) Future improvements to the intervention 5) State of NCD's in South Africa. Quotations to support the analysis are identified by a code, indicating their source - interviewee (IN).

### ***Theme 1: Enjoyment of the intervention***

Interviewees identified fun and pleasure whilst being physically active as major motivators for continued adherence to the intervention. Exercise sessions were lighthearted with camaraderie between participants. Variation in exercise drills ensured participants never became bored.

*“I love exercising, so this was my main motivation. (IN1)”*

*“I enjoyed the varied nature of workouts; I was never bored. (IN2)”*

Group dynamics played an important role in the success of the intervention. Participants started out as strangers but formed friendships throughout the intervention. The group setting allowed participants to work at their own pace whilst still being encouraged to challenge themselves. A family (mother and two daughters) was able to spend more time together as a result of participating in the intervention.

*“I felt encouraged, supported and motivated by other participants and so worked harder than I might otherwise have in a solo endeavor; like gym (IN2)”*

*“I love exercising! My mom and my sister don’t. Glad we found something that they would enjoy as well. (IN3)”*

*“I felt the ..... group dynamic, which I knew I would be more accountable for and to, were draw cards. (IN2)”*

Participants also discussed the satisfaction they gained from challenging themselves. Muscle aches in the days after training were not seen as negative but rather a sign that they had sufficiently worked the body and overcame perceptions of fatigue.

*“Most people don’t enjoy the muscle pains after a good workout. I do. Just like the saying goes, “no pain, no gain! (IN3)”*

The intervention was considered convenient for participants. The times of training were well suited and coincided with some of the participants’ children soccer practices.

*“I couldn’t drop my son off [at soccer practice] and not attend a session! (IN4)”*

### ***Theme 2: Benefits of the intervention***

Interviewees mentioned many of the physiological changes brought about by an increase in physical activity. These changes included an increase in fitness, muscle tone, decreased weight, increased awareness of dietary intake and assistance with injuries.

*“I not only lost weight, but I gained muscle and became more fit. And eating unhealthy didn’t feel right anymore, so we just didn’t (IN4)”*

The structured, scientific focus of the intervention assisted participants in establishing safe exercise routines. The intervention also taught participants the value of becoming more responsible for their own health.

*“Establishing the routine also helped me to become more accountable to myself by requiring me to proactively set up boundaries: my family and employer knew that on the days and during the time of training I was not available, which freed me to up to concentrate on my fitness goals. (IN2)”*

*“I learnt the correct way to do actual exercises to prevent injuries. (IN4)”*

The difficulty of exercise sessions appeared to be well suited to each individual. Instructors were flexible in their exercise prescription whilst providing encouragement or empathy when appropriate.

*“The positive feedback from trainers was also a plus - there was always encouragement to work beyond perceived limitations but empathy when any of us were genuinely taking strain. (IN2)”*

### ***Theme 3: Obstacles affecting adherence***

The intervention ran throughout the Cape Town cold and rainy months and hence poor weather was an obstacle to participation. Only one exercise session was officially cancelled due to heavy rain, however cold and wet weather did affect adherence.

*“It was difficult to motivate myself to train when it was wet and rainy. (IN5)”*

Family and work commitments reduced the time available to interviewees to participate in the intervention. Four of the five participants interviewed had children and four of the five were employed.

*“Only difficulty with attending sessions was when they clashed with scheduled meetings at work. (IN5)”*

*“I have a spouse and 4 kids. (IN4)”*

### ***Theme 4: Future improvements to the intervention***

Interviewees suggested an expansion of the intervention. An increase from 2 to 3 exercise sessions per week and the inclusion of mid-way assessments was suggested. It was also suggested that more members of differing ages, especially younger, would enhance the diversity of the intervention.

*“I wouldn’t change anything in the program besides adding an extra exercise session each week. (IN5)”*

*“I would have enjoyed it more if there were more members of a similar [young] age to me. (IN3)”*

Individual tailoring and more comprehensive feedback, including eating plans, were mentioned as possible improvements to the intervention.

*“The program could be improved by incorporating a formal eating plan and another assessment session halfway through for motivation. (IN4)”*

#### ***Theme 5: State of non-communicable diseases (NCD’s) in South Africa.***

Participants were generally aware of the negative impact that NCD’s such as obesity, diabetes and heart disease have on our country. A career-focused instead of health-focused society that promotes the consumption of fast food was acknowledged. These societal influences combined with modern technology that diminishes our habitual physical activity levels were seen to be one of the factors fuelling the rapid rise in NCD’s.

*“In my extended family we're constantly griping about how although we're relatively intelligent and enjoy successful careers, we can't shake off the weight and all of the lifestyle related diseases that are attendant to it. (IN2)”*

Access to equipment was no longer seen as a barrier to physical activity by interviewees. The intervention was able to conduct a wide variety of exercise drills with minimal equipment such as cones, exercise balls and skipping ropes. Participants also identified that changing one’s lifestyle is not a solitary effort but that support from peers is crucial in modifying dietary and activity behaviors.

*“I was struck by how few resources we needed for the program. We are socialised to believe that in the absence of contraptions and equipment we are unable to exercise. So the greatest benefit of having access to a Biokineticist would be learning how to effectively and naturally get one's heart rate up and muscles working. (IN2)”*

*“The fact that someone was actually waiting for me is what got me there (IN3)”*

Poor education and low socio-economic class were mentioned as factors associated with the rise in NCD’s. Many individuals in South Africa have little knowledge about the importance of exercise or nutrition and their effect on health. With poor awareness of the problem at hand, and insufficient income to make healthy lifestyle choices, the burden of NCD’s continues to rise.

*“More focus needs to be placed on areas where knowledge and information about health, exercise and diet are not freely available. (IN3)”*

### **Quantitative results:**

Quantitative analysis involved calculating Pearson product moment correlations to investigate which baseline measures showed significant associations with adherence ( $p \leq 0.05$ ), and could thus potentially be used to predict adherence rates. This quantitative analysis is depicted in *Table 1*.

*Table 1. Baseline measures correlated with attendance rates during intervention*

	r value	Sample size	p
Systolic blood pressure (mmHg)	-0.51	n = 17	0.04*
Resting breathing rate (breaths/min)	0.64	n = 14	0.01*
Change in breathing rate - Rest to Stroop (breaths/min)	-0.62	n = 13	0.03*
Change log low frequency (LF) – Rest to Stroop (Hz)	-0.94	n = 11	0.00*

*Changes in variables calculated by subtracting stroop value from Resting value (i.e. Rest – Stroop). \* Denotes significant association with attendance rates ( $p < 0.05$ ).*

Attendance rates were calculated as a percentage of exercise sessions attended out of total exercise sessions conducted. Systolic blood pressure at baseline was moderately negatively correlated with attendance rates during the intervention ( $r = -0.51$ ). Therefore participants with higher initial systolic blood pressures showed a trend towards poorer adherence. Resting breathing rate at baseline showed a moderate positive correlation with attendance rates ( $r = 0.64$ ). Change in breathing rate ( $r = -0.62$ ) and log LF ( $r = -0.94$ ) from Rest to Stroop demonstrated negative correlations with attendance rates. Therefore the greater the increase in breathing rate and log LF from Rest to Stroop, the lower the attendance rate.

### **Discussion:**

The determinants of adherence rates to physical activity interventions are complex. These determinants, as described by Cox (2000), are a product of both personal and environmental characteristics.

#### ***Personal characteristics:***

Personal characteristics include factors such as motivation, current health, desired appearance, enjoyment, social interaction, stress relief, challenge, skill development, achievement and personal satisfaction (Sherwood and Jeffery 2000). Interviewees saw personal benefits from attending exercise sessions. These benefits included aspects such as increased fitness, better eating habits and improved body composition.

Personal characteristics were rarely attributed as barriers to participation as the participants interviewed had positive attitudes towards physical activity. This finding is supported by McCreedy & Long (1985) who found that participants with a more positive attitude toward exercising in order to reduce stress and tension, tended to have a higher percentage attendance. This finding may however be partly due to the common social phenomena whereby individuals are more likely to use external factors beyond their control (e.g. time) as a scapegoat to rationalize their own personal inability to perform an action (e.g. adhere to an exercise program) (Cobb-Clark et al., 2014).

Throughout the duration of the intervention it was evident that participants became more confident in their ability to perform exercise drills, thus increasing their self-efficacy with regard to physical activity. Previous research has demonstrated that with continued exercise participation, self-efficacy increases and adherence increases concurrently (White et al., 2005; Wilbur et al., 2003). A prior history of physical activity is also beneficial as it positively influences physical activity behaviour during an intervention by promoting and shaping self-efficacy for exercise (White et al., 2005).

### ***Environmental characteristics:***

Environmental characteristics include factors such as demographics, work and family commitments, education and exercise group dynamics. Behavior change can only occur when both the individual and their social environment support that change (Cox, 2000). Social support within a group exercise setting increases adherence to physical activity due to the “bonding” experience of setting and reaching goals together (White et al., 2005). For many of the participants being part of a group was integral to their involvement and the camaraderie with fellow participants helped them maintain their physical activity levels.

Although time availability is a personal resource, lack of time is typically attributed to external factors (Cobb-Clark, 2014). Family and work commitments are often prioritised over one’s health, leading to reductions in physical activity. This is supported by White et al. (2005) who demonstrated that becoming a parent is associated with reductions in physical activity for mothers.

Participants gained the most enjoyment from the environmental characteristics of the intervention. These characteristics included the positive group dynamics, convenient location and time as well as the structured scientific approach. Poor weather was the only environmental constraint mentioned during interviews, this barrier is being addressed by acquiring the use of an indoor facility in future interventions.

The researchers were glad to document that participants were aware of the socio-political environment in which the intervention was conducted. As previously mentioned, NCD’s account for a total of 30.7% of years-of-life-lost in the Southern Suburb’s population (Sampson, 2014). Interviewees were aware of the cultural influences that perpetuate this statistic, such as the proliferation of fast food and a sedentary lifestyle. It is at the socio-political level that change is required; the inclusion of Biokinetics into the public health sector would allow a movement away from medicinal treatment of NCD’s and a movement towards advocating for lifestyle modification.

### **Quantitative analysis:**

In reference to *Table I*, baseline systolic blood pressure ( $r = -0.51$ ) and increase in breathing rate (Rest to Stroop:  $r = -0.62$ ) at baseline were moderately negatively correlated with attendance rates whilst baseline resting breathing rate was moderately positively correlated ( $r = 0.64$ ). Increase in low frequency power (Rest to Stroop) at baseline was strongly negatively correlated with attendance rates ( $r = -0.94$ ).

These findings are based upon a relatively small sample but do however suggest that superior autonomic nervous system (ANS) regulation in participants at baseline is indicative of higher attendance rates. This improved regulation is evident through lowered systolic blood pressure and the ability to better regulate

(attenuate an increase in) both breathing rate and HRV (low frequency power) from Rest to the Stroop task. The ventromedial prefrontal cortex (vmPFC) is in part responsible for autonomic system regulation. The vmPFC is a top down pathway meaning that afferent feedback is not required to regulate its function and it may in fact become dysfunctional with conflicting feedback such as in the form of anxiety (Simpson et al., 2001). It is therefore hypothesized that participants with improved vmPFC regulation, most evident through efficient low frequency HRV regulation, may potentially have improved adherence to a community lifestyle intervention.

The moderate positive correlation of resting breathing rate ( $r = 0.64$ ) with attendance is the sole finding that does not support the theory of efficient ANS regulation predicting improved adherence. This finding suggests that participants with a faster breathing rate at baseline will have improved adherence, faster breathing rates are associated with higher sympathetic nerve activity and less favourable ANS regulation (Narkiewicz et al., 2006).

### **Reflexivity:**

Reflexivity refers to recognition of the influence a researcher brings to the research process (Kuper et al., 2008). As a researcher within the physical activity and public health fields, my involvement in this study is unlikely to be bias free. I actively conducted the 12-week intervention and developed friendships with participants. Because I wanted the intervention to succeed, questions may have been framed in a more positive light. Interviewees offered little criticism about the intervention, likely to maintain social desirability. If a researcher other than I conducted the interviews then the results may have differed.

Participants saw researchers as a source of knowledge to guide them on their journey of behavior change. This dynamic made certain aspects of the interview process challenging as interviewees felt they were 'not qualified' enough to answer and provide critique. The dynamic between researcher and participant was however advantageous to the success of the intervention. The researcher was not considered as superior and actively engaged with participants on a personal basis. This individual attention is key to the success of a lifestyle intervention (GAPA, 2015).

### **Strengths and limitations:**

This study provides a rich resource of perceptions of a physical activity based community health intervention. The aim of the study was to understand the social dynamics of the intervention, not generalisability. Quantitative data is provided to supplement qualitative results, aiding in more detailed interpretation. We used a purposive sampling technique to recruit interviewees, thus bias was introduced as not all participants could be contacted and interviewed. We recognise that our findings did not represent the views of participants who were not interviewed. Social desirability may have also resulted in interviewees favouring positive feedback whilst avoiding being critical of the intervention.

We did not have ethical permission to gather data on participants who did not complete the intervention. 'Drop-outs' would have added value by providing valuable and rich information regarding the community intervention. These individuals would be able to offer criticism and shed light on factors that contribute to poor adherence rates. After 5 interviews there were still new themes emerging, which suggests the

qualitative process did not reach saturation. The addition of more interviews would thus enhance the detail and richness of the study.

### **Conclusion:**

This study highlighted the positive effects that a community health intervention had on its participants. Despite its wide range of physiological benefits, adherence to the program can be improved upon. Determinants of adherence rates, such as socioeconomic class, sex, ethnicity and age can quantitatively explain adherence rates. These associations are effective in describing relationships, but offer little valuable information on ways in which to improve.

The qualitative interviews conducted during this study offer rich and valuable information on how to improve the “Sweet Hearts” intervention. Five main themes were discussed during the interviews conducted: 1) Enjoyment of the intervention 2) Benefits of the intervention 3) Obstacles affecting adherence 4) Future improvements to the intervention 5) State of non-communicable diseases in South Africa.

Interviewees were vocal about the enjoyment and benefits they received from the intervention, thus adding detail to our positive quantitative findings. Generally participants were aware of the negative effect that NCD’s are having on our country. Participants offered valuable suggestions for improvements to the intervention. Potential improvements include the use of an indoor venue, an increase from 2 to 3 sessions per week, inclusion of mid-way assessments, more detailed dietary guidance and greater diversity in the demographics of participants. These suggestions will be incorporated into an updated conceptual model that will then form the basis of the intervention growing from strength to strength in coming years.

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## Addendum:

Table 1. Stroop task heart rate variability & respiration changes over 3-month intervention period

Variable	Baseline (n = 8)	Post- Intervention (n = 8)	p
STD RR (ms)	35.8 ± 24.9	28.97 ± 13.1	0.38
Mean Heart Rate (beats/min)	84.1 ± 15.8	82.7 ± 9.7	0.67
RMSSD (ms)	34.2 ± 26.0	27.6 ± 15.9	0.25
Low Frequency (LF) Peak (Hz)	0.11 ± 0.03	0.11 ± 0.02	0.87
High Frequency (HF) Peak (Hz)	0.21 ± 0.08	0.24 ± 0.09	0.39
Log LF (logmsec <sup>2</sup> )	5.99 ± 0.93	5.66 ± 0.99	0.36
Log HF (logmsec <sup>2</sup> )	5.81 ± 1.99	5.40 ± 1.55	0.17
Log LF + Log HF (logmsec <sup>2</sup> )	11.8 ± 2.87	11.1 ± 2.27	0.25
Respiratory rate (breaths min <sup>-1</sup> )	16 ± 3.2	17.5 ± 4.3	0.45

Values quoted as mean ± s. \* Denotes significant differences between baseline and post-intervention ( $p < 0.05$ ). STD RR : Standard deviation of R-R interval; RMSSD : Root Mean Square of Successive Differences.

Table 2: Relative weightings of studies included in single group analysis & model results (fixed effects model used)

```

weights
study names      weights
Adams et al.   : 0.383%
Dalleck et al.: 6.199%
Foulds et al. : 48.610%
Jiang et al.  : 44.808%

Summary
Continuous Fixed-Effect Model
Metric:
Model Results
Estimate  Lower bound  Upper bound  Std. error  p-Value
29.500    26.890      32.109      1.331      < 0.001

Heterogeneity
Q(df=3)  Het. p-Value
1107.577 < 0.001

```

Table 3: Relative weightings of studies included in two-group analysis & model results  
(random effects model used – DerSimonian-Laird method)

```

weights
study names      weights
Brown et al.    : 15.145%
Estabrooks et al.: 13.971%
Lv et al.       : 19.053%
Robertson et al : 14.410%
Scarinci et al. : 18.263%
Solomon et al.  : 19.157%

Summary
Continuous Random-Effects Model
Metric: Standardized Mean Difference

Model Results
Estimate  Lower bound  Upper bound  Std. error  p-Value
1.275     0.811        1.740        0.237       < 0.001

Heterogeneity
tau^2  Q(df=5)  Het. p-Value  I^2
0.292  298.767  < 0.001      98.326

```

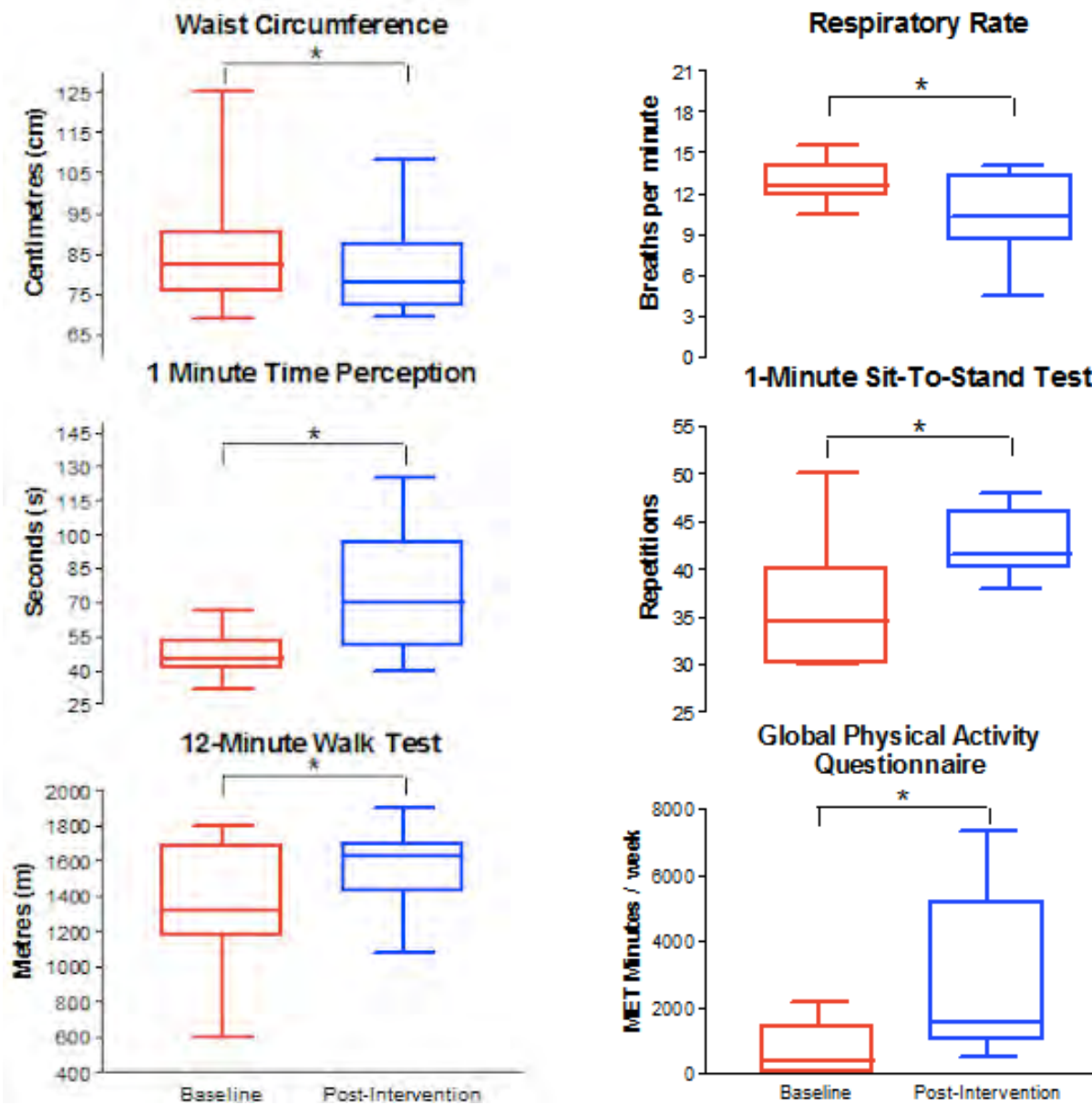


Figure I: Box plot illustration of significant changes in waist circumference, resting respiratory rate, 1-minute time perception, sit-to-stand test, 12-minute walk test and GPAQ score ( $p \leq 0.05$ ).

### 3 Factor Eating Questionnaire

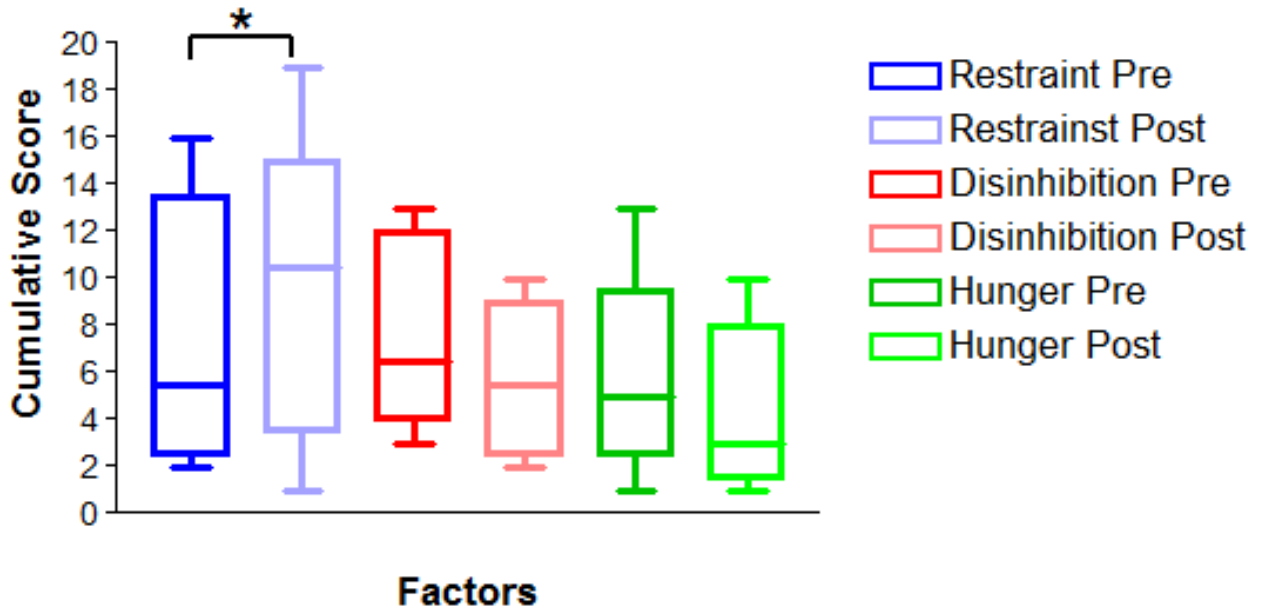


Figure II: Restraint, disinhibition and hunger changes on the 3 Factor Eating Questionnaire from Pre to Post intervention

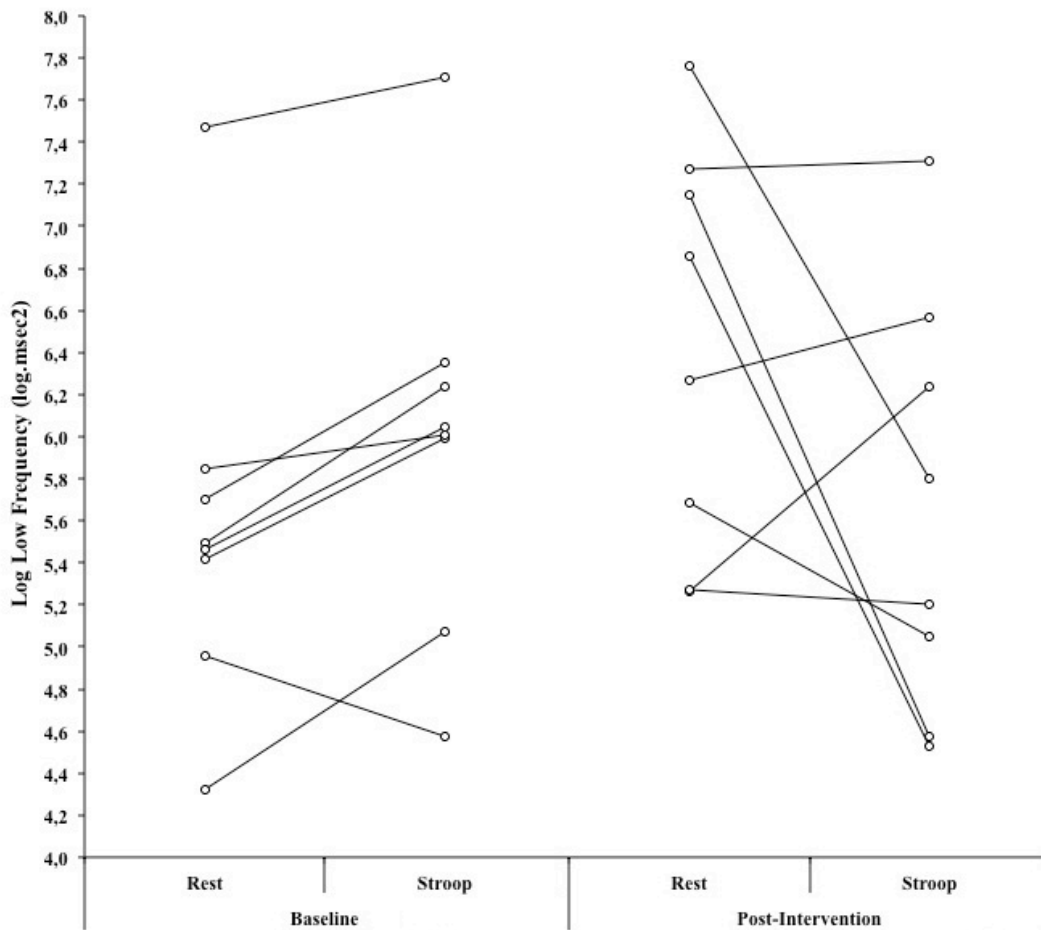


Figure III: Regulation of low frequency power (logarithmic) from rest to stroop task, Pre and Post intervention.