Self-reported Fitness Levels, Actual Fitness Levels and Recorded Energy Expenditure on Graded Hiking Trails

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Declaration

I, Brenda Audrey Coetzee, declare that this thesis submitted for the Philosophiae Doctor Degree at the University of the Free State is my own independent work, except to the extent indicated in the reference citations. I also declare that neither the whole work nor any part of it has been, is being, or is to be submitted at another university or faculty for degree purposes. I furthermore cede copyright of the thesis in favour of the University of the Free State.

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Abstract

Introduction: Lack of information regarding the ability to complete a hiking trail creates perceived and real danger, and uncertainty for inexperienced hikers. The use of a standardised grading system linked to fitness tests will assist hikers in making informed decisions regarding hiking trails that are suitable for them in terms of the required time and fitness level needed to complete the trail without undue physical exertion.

Objectives: (i) To establish a profile of hikers; (ii) to determine if a correlation exists between the International Physical Activity Questionnaire (IPAQ) self-reporting physical activity (PA) questionnaire, the fitness grading classification of the Step-up Test proposed by De Villiers and Thiart (1988), the Cooper Test on the one hand, and on the other the heart rate (HR) of a hiker during the hike, and the rate of perceived exertion (Borg scale (RPE)) during two differently graded hiking trails; (iii) to determine if the calculated energy expenditure (EE) of a hiker is consistent with the Hugo calculations; (iv) to conduct an analysis of the use of the IPAQ as well as the actual fitness tests to predict the perceived exertion; (v) to determine whether the exertion levels on the two hiking trails can be predicted through the information gained from the physical fitness/PA tests.

Methods: A Prospective Descriptive design was used in this study. Fifty (n=50) participants (37 female and 13 male participants) completed the pre-hike tests, (IPAQ and Demographic Information, Medical history and Hiking Questionnaire, Step-up Test and Cooper Test), as well as the hiking of two graded hiking trails. Correlations between relevant sets of variables were calculated, together with the associated p-value. ANCOVAs were used to investigate if the exertion levels on the two trails, as characterised by the minimum HR, average HR, maximum HR and Borg Scale (RPE) at the end of the trail, could be predicted by the pre-hike fitness tests/PA (IPAQ, Step-up Test and Cooper Test). F-statistics and associated p-values for all model effects are reported. Stepwise backward model selection was performed, and based on the final selected model, the predicted values of the dependent variables were calculated for the different levels of the fitness test/PA variables selected for the final model.

Results: Trail 1 (grading 3 (“easy”) according to Hugo’s grading system) covered a grassland distance of 6.91 km, with average altitude of 1393m, and an average completion time of 97.5 minutes. Trail 2 (grading 5.4 (“moderate”)) was a mountain hike of 10.88km, with average altitude of 1978m and average completion time 297.6 minutes. No significant positive correlations were found between pre-hike IPAQ, Step-up Test, Cooper Test and Borg scale (RPE). The exertion levels on the two hiking trails (Trail 1 and Trail 2) can be predicted by information based on the pre-hike fitness tests. The analyses of data for both trails separately, and then jointly, yield essentially similar results: For Trail 1, the Step-up Test was selected as the only predictor of both average HR ($p=0.0026$) and maximum HR ($p=0.0015$). No predictor was selected for Borg scale (RPE) for the end of the hike. Similarly, for Trail 2, the selected predictors of average HR were the Step-up ($p=0.0607$) and Cooper Tests ($p=0.0005$), while the Step-up Test was the only selected predictor for maximum HR ($p=0.0070$), and the Cooper Test the only selected predictor for Borg RPE at the end of the trail ($p=0.0043$).

For example, for Trail 2, the selected model predicts a maximum HR of 154.5 bpm for a participant who attained a “Very Good” grading in the Step-up Test. However, the maximum HR increased to 176.5 bpm for a participant with a “Poor” grading in the Step-up Test. It is clear that the predicted maximum HR indicates that an unfit hikers’ maximum HR could become dangerously elevated on low classification fitness levels. The indicated increase in maximum and average HR in the Step-Up Test is due to lower fitness levels as indicated by lower ratings in the categories of the tests. Therefore, significant predictors of exertion during hiking could be identified, using simple pre-hike fitness tests. These observations were robust to different methods of analysis.

Conclusion: Simple, pre-hike fitness tests can be used to predict exertion on hiking trails with known ratings. The results of such predictions can be used to recommend hiking trails to hikers with varying fitness levels for safe use. Currently the Step-up Test of De Villiers and Thiart (1988) is the best predictor available.

Keywords: Hiking, Graded hiking trails, Self-reported fitness levels, Perceived exertion, Energy expenditure.

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Concept Clarification and List of Abbreviations

In order to ensure an unambiguous interpretation of terms, concepts and abbreviations used throughout the study clarification is provided in the list below:

bpm	Beats per minute (heart rate)
EE	Energy Expenditure
GPS	Global Positioning System
HR	Heart Rate
HOSA	Hiking Organisation of Southern Africa
MET	Metabolic Equivalent
NCD('s)	Noncommunicable disease(s)
PA	Physical Activity
RPE	Rate of Perceived Exertion. Referring to Borg's Rate of Perceived Exertion Scale.
Step-up Test	A step-up test developed by De Villiers and Thiart's (1988) for determining hikers fitness levels.
Trail 1	Trail within the city limits. Received an "Easy" difficulty grading from Prof Hugo. Total distance approximately 6.91 km.
Trail 2	Mountain trail in rural area. Received a "Moderate" difficulty grading from Prof Hugo. Total distance approximately 10.881 km
$\dot{V}O_{2\,max}$	Maximal Aerobic Power/ Maximal Oxygen Consumption
WHO	World Health Organization

Chapter 1

Overview

1. BACKGROUND

"Imagine a therapy that had no known side effects, was readily available, and could improve your cognitive functioning at zero cost. Such a therapy has been known to philosophers, writers, and laypeople alike: interacting with nature" (Walsh, 2011: 583). Inactivity and resultant obesity have been identified as a concern in many countries (WHO, 2009; Institute of Medicine, 2012), including South Africa (Van Zyl, van der Merwe, Walsh, van Rooyen, van Wyk and Groenewald, 2012). What then could be more beneficial than a combination of nature and physical activity (PA)? This is affirmed when it was observed that PA in nature as opposed to PA indoors had greater positive effect on participants in a study by Sturm, Plöderl, Fatracek, Kralovec, Neunhäuserer, Niederseer, Hitzl, Niebauer, Shiepek and Fartacek (2012). Greater decrease in depression was found along with greater enjoyment and satisfaction. Furthermore, participants were more likely to repeat the activity than when exercising indoors.

Hiking trails are an outdoor resource that can be utilised for recreational and PA purposes. The physical requirements can vary from little effort to extreme exertion. It has been contended that there is a need to comprehend physiological responses that accompany hiking (Manning, Montes, Stone, Rietjens, Young, DeBeliso & Navalta, 2015). Hiking can positively contribute to the PA levels of participants. This is affirmed by Collingwood, Adcock and Librett (2007) who remark that the guidelines of PA can even be met by taking some of the easier hikes that are available. It is not just the PA engaged in during the single activity of the hike itself, but the need or necessity to increase current fitness levels in preparation for the completion of a more demanding hike. The motivation and preparation for participation in the outdoor experience and the completion of the hike itself can therefore serve as additional aspects to encourage PA. The benefits of PA are numerous and well documented (American College of Sports Medicine (ACSM), 2014a) from delaying premature mortality to reducing the risks of many chronic disease and health conditions. Evidence is weighted strongly in favour of increased PA levels leading to longer and healthier lives with the drive behind exercise being considered as medicine (Sallis, 2009) to be used in primary and secondary prevention of chronic diseases (Durstine, Gordon, Wang & Luo, 2013).

Although PA benefits are numerous (Nordbø & Prebensen, 2015), the benefits of hiking are not only limited to physical benefits. A number of other benefits can be gained through hiking (Goldenberg, Hill & Freidt, 2008). These can be broadly categorised into social (Heggie & Heggie, 2012; Kil *et al*., 2014), aesthetic (Babic, 2009; Wolf & Wohlfart, 2014) and psychological benefits (Svarstad, 2010; Sturm *et al.,* 2012). Hiking is most often undertaken as a group activity (Hugo, 1999). Although social interaction and development of relationships are not the primary reason for the hike (Goldenberg *et al*., 2008), they often occur during the activity.

Psychological benefits abound in hiking. Benefits such as the physical nature of the activity that create psychological benefits, are linked to additional benefits of being outdoors in natural or wilderness environments (Barton, Hine & Pretty, 2009). Mental wellbeing from participation in PA in natural environments has been compared with indoor PA and has demonstrated a greater reduction in depression, increased fulfilment and enjoyment as well as an increased intent to repeat the activity (Coon, Boddy, Stein, Whear, Barton & Depledge, 2011; Sturm *et al.,* 2012). In addition to this, other benefits include revitalisation, attention restoration and a decrease in tension, confusion, anger and stress (Kil *et al.,* 2014; Lee & Lee, 2014). There is also the development of self-esteem and self-fulfilment (Goldenberg *et al*., 2008) and the opportunity to experience a flow experience. It can therefore be seen why hiking is a positive form of PA that can be used to change people's behaviour and may be viewed as a valuable contributor to the international "Exercise is Medicine" campaign.

There may however be some drawbacks to hiking. The ecological impact of hiking on the natural environment is not a new phenomenon (Lynn & Brown, 2003), with concerns being raised regarding site alteration and disturbance, harvesting of plants and animals, pollution, removal and redistribution of materials and the disturbance of native animals (Cole & Landres, 1996; Marion, 2006). There is also a concern regarding physical risk that is associated with hiking. Due to the physical nature of the activity there will always be risks similar to other physical activities which place demands on the cardiovascular system (Burtscher & Ponchia, 2010; Green, 2015). In hiking there is also the concern about falls that could lead to musculoskeletal or soft-tissue injury (Montalvo, Wingard, Bracker, Davidson, 1998; Hamonko, McIntosh, Schimelpfenig & Leemon, 2011). It is, however, felt that the injury rate in competitive sport is far greater than in hiking (Oscar, Tun-Hing & Kai-Ming, 2011).

A number of possible variables can influence the way hiking is experienced. Weather conditions can affect the way a trail is experienced, both positively and negatively (Li & Lin, 2012). Hot sweltering sun, or wind and rain can make a simple trail far more challenging than initially anticipated. The terrain will impact on the difficulty rating or energy expenditure (EE) required to complete the hike (Fattorini, Pittiglio, Federico, Pallicca, Bernardi & Rodio, 2012). This includes underfoot conditions like loose soil, wet soil and uneven terrain. The footwear that is selected for the trail can also increase or decrease the energy costs of the trail (Fattorini *et al*., 2012).

Another variable is the load carried in the backpack, which is often dependant on the type of hike being undertaken. A day hike requires some emergency items, a few snacks and water (Mason, Suner & Williams, 2013), whereas a self-sustaining multi-day hike's requirements necessitate a far greater load (for instance sleeping and cooking equipment). The heavier the load carriage on the hiker the greater the strain (Gebhardt, Groß-Bölting, Heß, Langhof & Ulmer, 2012) and therefore the greater the level of strength and endurance required for the hike (Schurman & Schurman, 2009).

The emotions of the individual, positive or negative, can influence the physical performance (Rathschlag & Memmert, 2013) and thus the experience of the hiker. Psychological factors of motivation, tenseness, happiness and anger can alter the physical performance, improving or reducing the opportunity for a positive experience. The psychological aspect could also be influenced by the duration of the hike as motivation could fall and negative feelings could develop if it is felt that the hike is “getting too long”. Other effects of the duration of the hike also include an increased pack-load and possibility of fatigue due to the physical nature of the activity, and the possibility of a reduced quality in sleep. Many of these elements could, however, be avoided by an experienced hiker. Someone who has hiked on previous occasions builds up knowledge and skills regarding the activity and can use this experience to their advantage when preparing for as well as participating in the hike. It has, however, been found that even experienced hikers desire information regarding the difficulty of the trail beforehand (Slabbert, 2015).

The accommodation one utilises during a hike can have a ripple effect on other variables. Firstly, the load carriage will be affected by the accommodation or lack thereof. Should the hiker, for instance, use accommodation where everything is provided for, or when supplies are transported to each stopover (such as slackpacking), then one could simply pack requirements for each day. On the other hand, should the hiker be participating in a self-sustaining hike then, amongst other requirements, the hiker would need to provide their own tent, food and cooking utensils, change of clothes etc. The type of accommodation can also influence the quality of rest that is achieved. Loss of sleep can lead to reduced performance both cognitively and physically (Abedelmalek, Boussetta, Chtourou, Souissi & Tabka, 2014; Jarraya, Jarraya, Chtourou & Souissi, 2014; Fowler, Duffield & Vaile, 2015; Fullagar, Skorski, Duffield, Hammes, Coutts & Meyer, 2015).

It is thus evident that many variables can influence a hiking experience as well as the preparation or preparedness for a hike. The positive impact of physical outdoor recreation and, more specifically, hiking, can evidence an increase in PA levels. However, the variables impacting on the nature, and resulting energy levels required for hiking, necessitates pre-information for the potential hiker regarding the diverse requirements of the different trails. Grading of trails will assist potential hikers in selection of suitable trails beforehand and increase the probability of a pleasant physical outdoor recreation experience. Hiking trails cannot be graded in a manner similar to the grading of hotels and other tourist facilities (Hugo, 1999). Some hikers will prefer a hike in an open area with little change in terrain, while others will favour a mountain or even a forest or perhaps a beach. Some will prefer not to encounter other hikers, or even farming activities on the trail, while for others this may be arousing. People's needs, abilities and preferences are different when it comes to hiking. It is thus difficult to label one type or kind of hike as better than another because it has a certain facility or setting. These issues are all subjective and although used in the grading of some hiking trails are not considered to be very scientific (Hugo, 1999). Many hiking trails are given a descriptive rating based on the difficulty of the hike considered. The description is subjective and certainly not standardised amongst various trails. A system that can indicate the appropriateness of a trail in an objective scientific manner, based on reliable, comparable and usable information, will be advantageous to potential hikers.

The necessity of being at a satisfactory physical fitness level to participate in a hike has been highlighted in previous research (Hugo, 1999; Fattorini *et al*., 2012; Green, 2015). It is believed that knowledge of fitness levels will assist in the safety of the participant (Fattorini *et al.,* 2012). There is sparse literature on how to determine the hikers' fitness level or the levels required to participate in various hikes. Of the physical risks identified in the literature many, if not most, can be managed with proper information regarding the degree of difficulty of a hike. The proper knowledge of determining what this difficulty degree means for an individual could be an important piece of information separating positive experiences from negative ones. The physical abilities of individuals differ and although the physical demands of a trail are constant, a grading system will not mean the same for different hikers. Determining what the difficulty level means to the individual hiker will amplify meaning in a grading system. Providing answers on how to apply the grading system to the potential hiker's own physical abilities and needs will assist in solving the problem.

2. PURPOSE OF THE STUDY

Lack of information regarding the ability to complete a hike, creates perceived and real danger and uncertainty for inexperienced hikers. It also leads to "apprehension" and consequently "many potential hikers never take to the countryside because of the uncertainty about the character of the trail and whether they would be able to cope with the challenge" (Hugo, Kruger, Van Vuuren & Hugo, 1998/9: 48). Arias (2007) notes that there is a large number of ad hoc trail grading systems currently in use internationally. This creates ambiguity and results in difficulty in determining the ability to complete the hike. The use of a standardised grading system will assist hikers in making more informed decisions regarding trails that are suitable for them in terms of the required time and fitness/activity level needed to complete the trail without undue physical exertion. People's perceptions of these requirements will differ for many reasons.

Hugo (2007) is of the opinion that hikers who are not sure of their capabilities, can be tested at a sport science centre to determine whether they are fit enough for a specific trail they have in mind. Although ideal, it is unlikely that many would do so due to time, accessibility and monetary constraints. However, the need for information regarding their capability of completing the hike within their own comfort zones exists and can be a determining factor for participation or avoidance. The potential hiker can be (negatively) influenced through uncertainty regarding the hike, which could influence the decision of whether to hike or not. Furthermore, discomfort during the hike may adversely affect the hiker's enjoyment thereof. Therefore, if it is possible to ascertain beforehand if a hiker's physical fitness or PA levels are suitable for a hike, physical discomfort may be reduced whilst both enjoyment and participation levels are increased. The use of standard classification fitness criteria linked to a trail grading system will add value to the hiking fraternity.

The purpose of this study is thus to determine if a simple pre-hike test that determines PA or fitness levels can be used to predict exertion on hiking trails with known ratings. The results of such predictions can be used to recommend hiking trails to hikers with varying fitness levels for safe use.

3. RESEARCH OBJECTIVES

The objectives of this study are therefore:

1. To profile the hikers in terms of morphological factors, *viz*: gender, age; height, weight, body fat percentage, medical history, eating habits, grading classification of the Step-up Test proposed by De Villiers and Thiart (1988), classification of fitness as determined by the Cooper Test, the GPS measurement (HR) of a hiker, and the rate of perceived exertion (Borg scale (RPE)) during two differently graded hiking trails.

2. To determine the relationship between the IPAQ self-reporting physical activity questionnaire, the fitness grading classification of the Step-up Test proposed by De Villiers and Thiart (1988) and the Cooper Test, the GPS measurement (HR) of a hiker during the hike, and the rate of perceived exertion (Borg scale (RPE)) during two differently graded hiking trails.

3. To determine if the calculated EE of a hiker is consistent with the theoretical grading of the trails by Hugo *et al*. (1998/9).

4. To conduct an analysis of the use of the IPAQ (user friendly self-reporting physical activity questionnaire) as an instrument of self-reported physical activity levels and actual fitness levels (fitness tests) to best predict the perceived exertion (Borg scale (RPE)) by the hikers.

5. To determine if the exertion levels on the two hiking trails could be predicted by information based on the fitness tests/physical activity.

4. STRUCTURE OF THE THESIS

Chapter two comprises the literature study that focuses on PA and hiking. The prevalence of low PA is explored as well as briefly examining the impact of physical inactivity, and reviewing the recommended amount of PA. The well-known benefits of PA are highlighted along with the various measures that can be used to measure PA. Hiking is then investigated, under aspects such as the prevalence, nature and tourism.

As with PA, the benefits of hiking are explored. Variables that could possibly influence hiking are reviewed with an emphasis on grading of hiking trails.

The reader is introduced to the EE experienced in hiking along with the techniques to determine EE. Measures on how to determine a hiker's perceived exertion levels are considered. The chapter ends with a summary of how physical fitness and hiking interlink, and draws attention to the question of how to determine the required fitness levels linked to the difficulty level of a hike.

Chapter three describes the research methodology undertaken in this study. The research design is highlighted. The study participants, the recruitment and inclusion and exclusion criteria are clarified. The chapter offers a detailed explanation of the pre-hike testing and hike testing undertaken in the study. The statistical analysis is expounded upon. Mention is made of the pilot study that was undertaken to ensure that all pre-hike testing and hike testing procedures proceed smoothly. Ethical considerations are then elucidated along with methodological measurement errors that were considered. Finally, the limitations of the study are referred to.

Chapter four reports the research results. Hikers' real and perceived exertion rates are given. Self-evaluated PA scores and actual fitness results are reported. The results are then discussed in chapter five. The discussion concludes with recommendations and conclusions. A reflection on the research process from a personal perspective is given in the final section. The reference list incorporates all resources for all chapters in one comprehensive list. Referencing was done according to the regulations of the Department of Exercise and Sports Sciences at the University of the Free State, making use of the Harvard referencing system.

Chapter 2

Literature Review

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1. INTRODUCTION

This chapter will begin with a brief overview of physical activity (PA) in order to set the background for the discussion on hiking which is considered to be a form of PA. Physical demands, barriers and benefits of hiking are then explored, whereafter the variables that may impact on hiking are briefly investigated. Grading systems used throughout the world are highlighted. Physical activity and the contribution that hiking can make to PA is then considered. The chapter concludes with a discussion on the link between hiking grading systems and fitness levels.

2. PHYSICAL ACTIVITY

2.1 Definition

Physical Activity (PA) is defined as “any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure” (ACSM, 2014a: 2). Exercise is a type of PA consisting of planned, structured, and repetitive bodily movement done to improve and/or maintain one or more components of physical fitness. Physical fitness is defined as a set of attributes or characteristics individuals have or achieve that relates to their ability to perform PA (ACSM, 2014a). Health-related physical fitness components include cardiorespiratory endurance, body composition, muscular strength, muscular endurance and flexibility (ACSM, 2014a). Physical Activity (PA) should be distinguished from exercise. Exercise is a subcategory of PA and is “planned, structured, repetitive, and aims to improve or maintain one or more components of physical fitness” (WHO, 2016a, n.p.).

2.2 Prevalence of Low Physical Activity in Contemporary Society

Physical inactivity levels are rising with major implications for increases in the prevalence of noncommunicable diseases (NCD’s) and the general health of the population worldwide (WHO, 2010; Bauman, Reis, Sallis, Wells, Loos & Martin, 2012; Lee, Shiroma, Lobelo, Puska, Blair & Katzmarzyk, 2012). Physical inactivity has been identified as the fourth leading risk factor for global mortality (WHO, 2010). Dumith, Hallal, Reis and Kohl (2011) provide estimates of a world-wide prevalence of physical inactivity. The results of this study prove perturbing in that one out of five adults around the world is physically inactive. Even more worrying is that South Africa was listed as having the fifth highest prevalence of inactivity out of 76 countries. Evidence indicates that the prevalence of low PA increased worldwide since the above-mentioned report by Dumith *et al.* (2011). Updated statistics on the World Health Organization (WHO) website (WHO, 2016a) indicate that one in four adults is not active enough and that 80% of the world’s adolescent population is insufficiently physically active. The Global status report by WHO on NCD's reports that NCD's are rising rapidly in Africa and by 2030 are expected to surpass communicable, maternal, perinatal, and nutritional diseases as the most common causes of death (WHO, 2011). The 2015 WHO Fact Sheet on PA for Europe indicates that 1 million people die each year from causes related to physical inactivity and that 8.3 million disability-adjusted life years are lost (WHO, 2016b). Van Zyl, van der Merwe, Walsh, van Rooyen, van Wyk and Groenewald (2010) state that the burden for NCD risk factors in South Africa is high. This statement is supported by statistics available from the WHO for South Africa (WHO, 2015) which indicate that adult risk factors generally surpass those of the WHO African region. Raised blood glucose for males and females were 3.6% and 2.5% respectively higher than the WHO regions measures of 8.3 for males and 9.2 for females 9 aged 25 and older. Obesity for persons aged 20 and older was 42.8% of the female population compared to the WHO African region that reported only 11.1%. Males indicated 23.2% obesity rate in comparison to the African regions whose statistics indicated 5.3%. More recent results suggest an increase in the obesity figures, with 68% of South African women and 31% of South African men being overweight or obese (Stats SA, 2017). The study highlights that one in five South African women are considered severely obese.

Burden of disease is regarded as the effect of a health problem that is measured in various terms such as financial cost, mortality and morbidity. It is often measured in terms of quality-adjusted life years (QALYs) or disability-adjusted life years (DALYs), both of which quantify the number of years lost due to disease (YLDs) (Prüss-Üstün, Mathers, Corvalán & Woodward, 2003; WHO: 2008). South African burden of disease statistics from the WHO indicate that cardiovascular diseases and diabetes were second on the list of DALYs. These were second only to HIV and TB and malaria (grouped together). Deaths by broad cause group showed a noteworthy increase from 2000 to 2012 for cardiovascular diseases and diabetes, cancers as well as other NCDs (WHO, 2015).

The Commission on Ending Childhood Obesity (ECHO) (WHO, 2016c) released a report indicating that at least 41 million children under the age of five are obese or overweight with 25% of these overweight children residing in Africa. The report states that the number of overweight children in Africa in this age group has doubled since

1990 from 5.4 million to 10.3 million. This is a concern as the co-chair of the report, Dr Sania Nishtar, explains:

> “Overweight and obesity impact on a child’s quality of life, as they face a wide range of barriers, including physical, psychological and health consequences. We know that obesity can impact on educational attainment too and this, combined with the likelihood that they will remain obese into adulthood, poses major health and economic consequences for them, their families and society as a whole" (WHO, 2016c, n.p).

As a result of the industrial revolution and the development of various new technologies, daily physical labour has been greatly reduced. The motivation often behind the technology is to reduce physical adversity and to increase productivity (Kohl, Craig, Lambert, Inoue, Alkandari, Leetongin & Kahlmeier, 2012). Even with the advances in technology, time pressures in modern society are often the cause of reduced PA (Brown & Roberts, 2011). Consequently the low levels of PA have an impact on the individual and society as a whole.

2.3 The Impact of Low Physical Activity

Diseases that have been identified through studies that are related to lack of regular PA include “cardiovascular disease, thromboembolic stroke, hypertension, type 2 diabetes mellitus, osteoporosis, obesity, colon cancer, breast cancer, anxiety and depression” (Haskell, Lee, Pate, Powell, Blair, Franklin, Macera, Heath, Thompson & Bauman, 2007: 1082). In addition to the list above Lee *et al*. (2012:29) add that physical inactivity “increases the risk of many adverse health conditions” and shortens life expectancy. They found that in the case of inactivity not being eliminated, but only reduced by just 10%, more than 533 000 deaths could be averted every year. If inactivity could be decreased 25% then more than 1.3 million deaths could be averted every year (Lee *et al*., 2012). Kohl *et al.* (2012) commented that in 2007 alone, between 5.3 and 5.7 million deaths could have theoretically been prevented globally if people who were inactive had changed their level of activity to being sufficiently active.

It is reported that globally physical inactivity causes:

- 6% of the worldwide burden of coronary heart disease,
- 7% of the worldwide burden of type 2 diabetes,

- 10% of the worldwide burden of breast cancer and
- 10% of the worldwide burden of colon cancer (Lee *et al.,* 2012)

The impact of low PA can also be seen as the inverse of the benefits described later in this chapter. Bouchard, Blair and Haskell (2007) comment that not only does sedentary behaviour have a relationship with chronic disease, it also influences premature mortality, poor quality of and loss of function and independence with aging.

Kohl *et al.* (2012) summarises the situation well when stating that PA has not yet received the appropriate recognition and investment that it requires. They further state that the situation is unacceptable and should be attended to with urgency in order for the world goals for the control of NCD's to be achieved.

2.4 Recommended Amount of Physical Activity

For adults in the age group of 18 to 64 years old PA may include leisure or recreational-time PA, modes of transportation, occupational, household chores, play, games, sports and planned exercise (WHO, 2010). The World Health Organisation (WHO, 2010) published global recommendations on PA for health. These recommendations suggest that adults aged 18 to 64 years should do at least 150 minutes of moderate-intensity aerobic PA throughout the week. In order to obtain additional health benefits, adults should increase their moderate-intensity aerobic PA to 300 minutes per week. Recommendations have also been made for children and youth (Janssen, 2007; Strong, Malina, Blimkie, Daniels, Dishman, Gutin, Hergenroeder, Must, Nixon, Pivarnik, Rowland, Trost & Trudeau, 2005), adolescents (Sallis & Patrick, 1994) and older adults (Chodzko-Zajko, Proctor, Singh, Minson, Nigg, Salem & Skinner, 2009, Vallance, Eurich, Lavallee & Johnson, 2012; Sparling, Howard, Dunstan & Owen, 2015).

The recommendations by the WHO are based on the 2007 Updated Recommendation for Adults from the American College of Sports Medicine and the American Heart Association (Haskell *et al*., 2007). These recommendations attempt to provide more detail than the initial 1995 recommendations in order to avoid confusion and misinterpretation. "In order to promote and maintain health, all healthy adults aged 18–65 year need moderate-intensity aerobic physical activity for a minimum of 30 minutes on five days of the week or vigorous-intensity aerobic activity for a minimum of 20 minutes on three days each week" (Haskell *et al*., 2007: 1083). Moderate and vigorous activities can be combined in order to meet the suggested guidelines. It is also advocated that every adult should participate in activities that maintain or increase muscular strength on two or more non-consecutive days each week using the major muscles of the body. By exceeding the minimum recommended amounts of PA people can further improve their personal fitness, reduce their risk for chronic diseases and disabilities or prevent unhealthy weight gain (Haskell *et al*., 2007).

2.5 The Benefits of Physical Activity

Because of the many associated health benefits, Durstine *et al*. (2013) maintain that exercise and PA should be viewed as a medication. They contend that the health benefits of PA and exercise surpass those of conventional medications for many chronic diseases. They add that a noteworthy benefit is the absence of side-effects. They clarify this by stating that the underlying mechanisms of physiological functioning change with PA. This change is not limited to the cardiovascular system, however all bodily systems are functionally altered and improved by PA and exercise (Durstine *et al*., 2013). This is in agreement with Haskell *et al.* (2007) who state that the present preventive recommendation of the WHO specifies how adults, by engaging in regular PA, can promote and maintain health, and reduce risk of chronic disease and premature mortality.

Physical Activity (PA) continues to take on an increasingly important role in the prevention and treatment of multiple chronic diseases, health conditions, and their risk factors (ACSM, 2014a). Important health benefits can be obtained by performing a moderate amount of PA on most, if not all, days of the week (ACSM, 2014a). Additional health benefits result from greater amounts of PA that is longer in duration and/or of more vigorous intensity.

The benefits of PA have been grouped into the following categories: Physical, Cognitive, Psychological and Social.

2.5.1 Physical Benefits

As discussed a large body of scientific evidence supports the role of PA in delaying premature mortality and reducing the risks of many chronic disease and health conditions (Bouchard *et al*., 2007; Kunstler & Daly, 2010; O'Neil, 2010; Sharkey & Gaskill, 2013; ACSM, 2014a). There is also clear evidence for a dose-response relationship between PA and health. Thus, any amount of PA should be encouraged (ACSM, 2014a).

When reviewing the works of Bouchard *et al*. (2007), Marcus and Forsyth (2009), Kunstler and Daly (2010), O'Neil (2010), Sharkey and Gaskill (2013) and the ACSM (2014a) the following brief summary of physical benefits can be identified (supported by additional research):

Cardiovascular benefits:

- Improvement in cardiovascular and respiratory function (Seals, Hagberg, Spina, Rogers, Schechtman & Ehsani, 1994; Baggish, Yared, Wang, Weiner, Hutter, Picard & Wood, 2008; Andersen, Hansen, Søgaard, Madsen, Bech & Krustrup, 2010)
- Reduction in cardiovascular disease risk factors factors (Lavie, Arena, Swift, Johannsen, Sui, Lee, Earnest, Church, O'Keefe, Milani & Blair, 2015)
- Reduce the risk of stroke and other vascular problems (Howard & McDonnell, 2005)

Skeletal benefits:

- Enhanced building and maintaining of healthy bones, muscles and joints (Mitchell, Chesi, Elci, McCormack, Roy, Kalkwarf, Lappe, Gilsanz, Oberfield, Shepherd, Kelly, Grant & Zemel, 2016)
- Protective effect on the risk of bone loss, hip fracture, and factors associated with falls as well as on the rate of function decline that is common with aging (Krustrup, Hansen, Andersen, Jakobsen, Sundstrup, Randers, Christiansen, Helge, Pedersen, Søgaard, Junge, Dvorak, Aagaard & Bangsbo, 2010)
- Healthy and strong bones (Krustrup, *et al*. 2010)
- Reduce the likelihood of osteoporosis, osteoarthritis and lower back pain (Vuori, 2001)

Decrease in the incidence of various illnesses including:

- Type 2 diabetes (Laaksonen, Lindström, Lakka, Eriksson, Niskanen, Wikström, Aunola, Keinänen-Kiukaanniemi, Laakso, Valle, Ilanne-Parikka, Louheranta, Hämäläinen, Rastas, Salminen, Cepaitis, Hakumäki, Kaikkonen, Härkönen, Sundvall, Tuomilehto & Uusitupa, 2005; Sigal, Kenny, Wasserman, Castaneda-Sceppa & White, 2006)
- Hypertension (Huai, Xun, Reilly, Wang, Ma & Xi, 2013)
- Cancer (Paffenbarger, Lee, Wing, 1992; Thune & Furberg, 2001; Lee, 2003)
- Colds and Flu (Nieman, 1994; Chubak, McTiernan, Sorensen, Wener, Yasui, Velasquez, Wood, Rajan, Wetmore, Potter & Ulrich, 2006)
- Obesity (Tremblay, Despres, Leblanc, Craig, Ferris, Stephens & Bouchard, 1990; Slattery, McDonald, Bild, Caan, Hilner, Jacobs & Liu, 1992)
- Back Pain (Hagen, Hilde, Jamtvedt & Winnem, 2002)
- Gallstones (Leitzmann, Giovannucci, Rimm, Stampfer, Spiegelman, Wing & Willett, 1998)
- Diverticulitis (Strate, Lui, Aldoori & Giovannucci, 2009)
- Peripheral vascular disease (McDermott, Liu, Ferrucci, Criqui, Greenland, Guralnik, Tian, Schneider, Pearce, Tan & Martin, 2006)

Improved weight management and regulation:

- Burn calories and lower risk of overweight, obesity and metabolic syndrome (USPSTF, 2003; Tremblay, Despres, Leblanc, Craig, Ferris, Stephens & Bouchard, 1990; Slattery, McDonald, Bild, Caan, Hilner, Jacobs & Liu, 1992; Pitsavos, Panagiotakos, Chrysohoou, Kavouras & Stefanadis, 2005)
- Improved weight management and weight loss (Klentrou, Hay & Plyley, 2003)

Protective factors:

- Improve function of the immune system (Nieman, 1994; Carlsson, Ludvigsson, Huus & Faresjö, 2015)
- Reduce frailty and infirmity, and extend the prime of life (de Vries, Staal, van der Wees, Adang, Akkermans, Rikkert & Nijhuis-van der Sanden, 2015; Tarazona-Santabalbina, Gómez-Cabrera, Pérez-Ros, Martínez-Arnau, Cabo, Tsapara, Salvador-Pascual, Rodriguez-Mañas & Viña, 2016)

- Decreased morbidity and mortality (Hu, Willett, Li, Stampfer, Colditz & Manson, 2004; Myers, Kaykha, George, Abella, Zaheer, Lear, Yamazaki & Froelicher, 2004)

General conditioning:

- Improved strength and agility in older adults (Ferreira, Teixeira, Alves Dos Santos, Dantas Maya Americano do Brasil, Souza, Córdova, Ferreira, Lima. & Nóbrega, 2018)
- Reduced fatigue and pain (Kennedy & Newton, 1997; Bojner-Horowitz, Theorell & Anderberger, 2003; Adamsen, Midtgaard Andersen, Quist, Moeller & Roerth, 2004; Weinstein, Chin, Keyser, Kennedy, Nathan, Woolstenhulme, Connors & Chan, 2013; Segura-Jiménez, Borges-Cosic, Soriano-Maldonado, Estévez-López, Álvarez-Gallardo, Herrador-Colmenero, Delgado-Fernández & Ruiz, 2017)
- Increased flexibility and mobility (Pahor, Guralnik, Ambrosius, Blair, Bonds, Church, Espeland, Fielding, Gill, Groessl, King, Kritchevsky, Manini, McDermott, Miller, Newman, Rejeski, Sink & Williamson, 2014)
- Increased energy levels (Bojner-Horowitz *et al*., 2003)
- Increase oxygen consumption and blood flow (Ogawa, Spina, Martin, Kohrt, Schechtman, Holloszy & Ehsani, 1992; Proctor, Shen, Dietz, Eickhoff, Lawler, Ebersold, Loeffler & Joyner, 1998; Jubrias, Esselman, Price, Cress & Conley, 2001)
- Improved sleep (Sherrill, Kotchou & Quan, 1998; Alessi, Yoon, Schnelle, Al-Samarrai & Cruise, 1999)
- Improvement of: gross motor skills, fine motor skills, balance (Patla, Frank & Winter, 1992), flexibility (Rider & Daly, 1991) range of motion (Sandel, Judge, Landry, Faria, Ouellette & Majczak, 2005), coordination, muscle mass (Sugawara, Miyachi, Moreau, Dinenno, DeSouza & Tanaka, 2002) cardiovascular endurance, respiratory capacity, posture (Meusel, 1991; Pan, Chu, Tsai, Sung, Huang & Ma, 2017)

2.5.2 Cognitive Benefits:

- Improved cognition and problem solving (Sibley & Etnier, 2003)

- Improved cognitive function (Sherrill, Kotchou & Quan, 1998; Davenport, Hogan, Eskes, Longman & Poulin, 2012; Douw, Nieboer, van Dijk, Stam & Twisk, 2014)
- Improved memory and learning (Breitenstein, Mooren, Voelker, Fobker, Lechtermann, Krueger, Fromme, Korsukewits, Floel & Knecht, 2007; Erickson, Voss, Prakash, Basak, Szabo, Chaddock, Kim, Heo, Alves, White, Wojcicki, Mailey, Vieira, Martin, Pence, Woods, McAuley & Kramer, 2011)
- Improved attention span (Colcombe & Kramer, 2003) and reduced attention-deficit/hyperactivity disorder (Smith, Hoza, Linnea, McQuade, Tomb, Vaughn, Shoulberg & Hook, 2013)
- Reduced risk of dementia and Alzheimer's disease (Laurin, Verreault, Lindsay, MacPherson & Rockwood, 2001)
- Reduced disk of Parkinson's disease (Yang, Trolle Lagerros, Bellocco, Adami, Fang, Pedersen & Wirdefeldt, 2015)
- Activity improves cognitive health (Vance, Wadley, Ball, Roenker & Rizzo, 2005)
- Improvement of: concentration, decision-making, following rules and instructions, sense of direction, judgement (Colcombe & Kramer, 2003)
- Enhanced cognitive performance in work/academic, recreational, and sport activities (Strong, *et al.*, 2005; Singh, Uijtdewilligen, Twisk, van Mechelen & Chinapaw, 2012)

2.5.3 Psychological Benefits:

- Reduces anxiety and depression (Dunn, Trivedi & O'Neal, 2001; Gujral, Manuck, Ferrell, Flory & Erickson, 2014; Knapen, Vancampfort, Moriën & Marchal, 2015; Taylora, Beckerley, Hennigera, Hernández, Larson & Granger, 2017)
- Improve stress management (Föhr, Tolvanen, Myllymäki, Järvelä-Reijonen, Peuhkuri, Rantala, Kolehmainen, Korpela, Lappalainen, Ermes, Puttonen, Rusko & Kujala, 2016)
- Reduction of symptoms of schizophrenia (Firth, Cotter, French & Yung, 2015)
- Enhanced sense of self
  - Self-esteem, self-concept (Fox, 1999; Folkin & Sime, 1981; Strong, *et al.*, 2005) and body image (Hausenblas & Fallon, 2006)

- Positive self-image (Dibbel-Hope, 2000)
- Increased self confidence
- Increased life and vigour (Barton *et al*., 2009)

- Positive psychological factors:
  - Enhanced interest in intimate behaviour
  - Improved mood (Brown, Wang, Ward, Ebbeling, Fortlage, Puleo, Benson & Rippe, 1995; Kennedy & Newton, 1997; Dibbel-Hope, 2000)
  - Increase quality of life (Vancampfort, Probst, Adriaens, Pieters, De Hert, Stubbs, Soundy & Vanderlinden, 2014)
  - Enhanced feelings of well-being (Bojner-Horowitz *et al*., 2003; Korge & Nunan, 2018)
  - Improvement of: feelings of joy, accomplishment and pride; releasing stress and frustration; coping with winning and losing; experiencing healthy competition and relaxation

2.5.4 Social Benefits:

- Improvement of teamwork and cooperation
- Direct working toward a mutual goal
- Enhanced social interaction
- Generating peer relationships
- Promotes giving and receiving praise and feedback

It is therefore evident that there are numerous benefits associated with PA, and it is apparent why "Physical activity and exercise are now considered principal interventions for use in primary and secondary prevention of chronic diseases" (Durstine *et al*., 2013: 3) and quality of life in general. The benefits of habitual PA substantially outweigh the risks involved (ACSM, 2014a).

2.6 Leisure-time Physical Activity

The WHO definition of health has not changed since its declaration in 1948 stating that "Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (WHO, 2003: n.p.). It is acknowledged that PA is not the only contributor to health. Diverse factors like social health, mental health, emotional health and spiritual health (Greenberg, Dintiman & Oakes, 2004) environmental wellness (Kunstler & Daly, 2010) and occupational wellness (O'Neil, 2010), contribute to well-being. Leisure experiences can be used to address these various components of health and can contribute significantly to overall health and well-being as contended by Kunstler and Daly (2010). They continue by adding that "being able to engage in specific leisure-related behaviors is an indicator of health, can promote health, and contributes to the well-being and quality of life of the individual" (Kunstler & Daly, 2010: 99).

Leisure time PA can be defined as an activity that is participated in during an individual's discretionary time that will increase the total daily EE (Bouchard *et al.*, 2007). The activity one selects is done according to the individual's personal needs, interests and motivation. Such activities include "sports, gardening, walking, active games, and any other physical activity done for recreation" (Kunstler & Daly, 2010: 177). Outdoor recreation promotes physical health through active participation with the natural world (Kunstler & Daly, 2010). One such PA is hiking. "Hiking trails provide an opportunity to discover the country-side by a direct association with the natural environment" (Hornby, 1977: 9).

Hiking constitutes walking and walking plays a large role in the total PA of adult populations (Monteiro, Conde, Matsudo, Matsudo, Bonseñor & Lotufo, 2003). Walking is a familiar, accessible and inexpensive form of PA (Kelly, Murphy, Oja, Murtagh & Foster, 2011; Hallal, Andersen, Bull, Guthold, Haskell & Ekelund, 2012) and known to have great potential to increase PA levels in sedentary individuals (Ogilvie, Foster, Rothnie, Cavill, Hamilton, Fitzsimons & Mutrie, 2007; Kelly *et al*., 2011). Walking can be easily included into everyday schedules and it can be continued into old age (Hörder, Skoog & Frändin, 2013). Walking at a brisk pace (6.4km/h) demonstrates the achievement of major gains of activity and health-related fitness without adverse effects (Morris & Hardman, 1997).

2.7 Measuring Physical Activity

There are a number of methods that can be used in the assessment of PA. These include self-report, interviews and activity records, systematic observation, activity and heart-rate monitors, cardiorespiratory fitness and calorimetry as well as doubly labelled water (Sallis, 2010; Kowalski, Rhodes, Naylor, Tuokko & MacDonald, 2012). Each method has its own strengths and limitations. Direct measures are generally considered more accurate, but are more expensive, intrusive and time consuming (Kowalski *et al.*, 2012).

The Alberta Centre for Active Living (n.d.) suggests that, in order to determine the most suitable methods of assessing PA the following factors should be considered:

1. reason for the assessment,
2. the population you are working with,
3. the aspects of PA and sedentary behaviour being measured,
4. practicality of the measurement tool,
5. participant burden, and
6. reliability and validity of the tool being used.

A number of self-report questionnaires are available that cater for different age categories. For example the LASA Physical Activity Questionnaire (LAPAQ) (Stel, Smit, Pluijm, Visser, Deeg & Lips, 2004), the Physical Activity Scale for the Elderly (PHASE) and Community Healthy Activities Model Program for Seniors (CHAMPS) (Cyarto, Marshall, Dickinson & Brown, 2006; Kowalski *et al.*, 2012), are used for older adults. Patient Assessment and Council for Exercise (PACE) (Van Hoye, Nicaise & Sarrazin, 2014), The Previous Day Physical Activity Recall (PDPAR) (Trost, Ward, McGraw & Pate, 1999) and the Questionnaires for Youth Seasonal vs Annual Format (Rifas-Shiman, Gillman, Field, Frazier, Berkey, Tomeo & Colditz, 2001) are examples of questionnaires used for children and adolescents. Questionnaires used for the adult population include the Godin Leisure Time Questionnaire (GLTEQ) (Godin & Shephard, 1997), the International Physical Activity Questionnaire (IPAQ) (Craig, Marshall, Sjöström, Bauman, Booth, Ainsworth, Pratt, Ekelund, Yngve, Sallis & Oja, 2003), Global Physical Activity Questionnaire (GPAQ) (Bull, Maslin & Armstrong, 2009) and others (Wendel-Vos, Schuit, Saris & Kromhout, 2003; Vol, Bedouet, Gusto, Leglu, Beslin, Decou, Nègre, Planage, Chazelle, Mercier, Lantieri & Tichet, 2011; Webster, Khan & Nitz, 2011). Sternfeld and Goldman-Rosas (2012) highlight the fact that there is no self-report measure that is perfect. They add that no given measure is the best measure in all circumstances. A PA questionnaire can usually be administered inexpensively and is not time consuming. It does not provide an absolute measure of the EE but allows for estimation and grouping or ranking of the individual being tested (ACSM, 2014b).

The Godin Leisure Time Questionnaire (GLTEQ) is a self-report measure of the frequency of light-intensity, moderate-intensity, and vigorous-intensity leisure-time PA. Weekly Metabolic Equivalent (MET) values can be estimated by following the calculations provided (Godin & Shephard, 1997). The GPAQ looks at three behavioural domains (work, transport and discretionary) and has 19 questions on these various domains. Frequency and duration of activities is captured as well as a measure of time spent in sedentary activities (Bull *et al.*, 2009).

The International Physical Activity Questionnaire (IPAQ) (Craig *et al*., 2003) has been verified to be an appropriate self-report instrument for characterising patterns of PA across several fields (leisure, work, home and transport) in the general population (Sternfeld & Goldman-Rosas, 2012). There are two versions of the IPAQ. The long version consists of 31 items and was designed to collect detailed information within the domains of household and yard-work activities, occupational activity, self-powered transport, and leisure-time PA as well as sedentary activity. The short version consists of 9 items and collects information on the time spent walking, in vigorous- and moderate-intensity activity and in sedentary activity.

Another form of measuring PA is the use of pedometers. Pedometers are small devices used to measure steps or footfalls (Tudor-Locke, 2002; Laurson, Welk & Eisenmann, 2015; Sayah, Johnson & Vallance, 2016). Steps can be measured intermittently or continuously over the day. According to Tudor-Locke, Craig, Beets, Belton, Cardon, Duncan, Hatano and Blair (2011) pedometers are increasingly garnishing credibility for research in order to obtain acceptable calculations of daily walking PA levels. Another device that has been increasingly used is an accelerometer. An accelerometer is a small device that can objectively measure “real time” minute-by-minute steps and activity counts by measuring acceleration over one or two axes (Igelström, Emtner, Lindberg & Âsenlof, 2013). The information supplied by the accelerometer can be configured to identify time spent in sedentary behaviour (Igelström *et al*., 2013; Klaren, Hubbard, Zhu & Motl, 2016) and PA (Igelström *et al.,* 2013; Lawinger, Uhl, Abel & Kamineni, 2015). A key attribute of the accelerometer is the capability to distinguish between different intensities of movement such as walking and running; furthermore, multi-axis accelerometers measure acceleration over multiple planes to assess movements such as stair climbing (Alberta Centre for Active Living, n.d.).

Both pedometers and accelerometers are small, light unobtrusive devices that can be worn comfortably (at the waist, back or upper arm) and count movement (Tudor-Locke, 2002). Pedometers are often selected above accelerometers for assessing PA as they are less expensive (Tudor-Locke, 2002; Laurson *et al.*, 2015). Pedometers do not record velocity of movements and this limits their use to total accumulated steps per day or timeframe of measurement (Tudor-Locke, 2002). It has also been noted that there is a difference in accuracy between various devices (Barreira, Bennett & Kang, 2015) and that the algorithms for data analysis differ between devices (Igelström *et al.*, 2013) making comparisons between studies difficult. Kowalski *et al.* (2012) remark that accelerometry and pedometry results are limited in the ability to capture the type of activity. Hikihara, Tanaka, Ohkawara, Ishikawa-Takata and Tabata (2012) concur with this when stating that some activities, such as housework, do not involve sufficient steps, therefore limiting the accuracy of the PA-intensity assessment. In addition, nonlocomotor activities can lead to prediction errors as the equations used to predict the MET values are based on locomotor movements. Moreover, the accelerometer device tended to underestimate the EE when the wearer was performing higher intensity activities, like road and track running (Igelström *et al.*, 2013). Smartphone pedometer applications have been shown to be inaccurate with an unacceptable error when compared to a pedometer (Orr, Howe, Omran, Smith, Palmateer, Ma & Faulkner, 2015). Caution should therefore be exercised when using smartphone applications.

Several methods have been used to measure EE due to PA. Some of the methods are constrained to the laboratory, and other are more suitable for the field. Such tests include step-up tests also that measure aerobic fitness. Step-up tests are simple and require minimal equipment and space. A number of different step-up tests are readily available and well known, for example the Harvard Step Test (Hillman, 2012), YMCA 3-minute step test, McArdle Step test (Bryant & Green, 2003). Step-up test results are then compared to established norms and an estimation of maximal oxygen consumption can be made (Bryant & Green, 2003).

Doubly-labelled water is another method to determine EE. In this method urine samples and saliva are required and oral administration of doubly-labelled water ($^{2}H_2{}^{18}O$). Samples are then analysed in a laboratory. Although this is a validated measure of determining EE it remains a prohibitively expensive method (DeLany, 1997).

Due to the close relationship between HR and EE during exercise it is possible to use HR measures to determine an estimate of EE using portable armband devices (St-Onge, Mignault, Allison & Rabasa-Lhoret, 2007). Many studies have made use of a heart-rate monitor to determine intensity of PA (Haskell & Kiernan, 2000; Collingwood *et al.,* 2007; Bourrilhon, Philippe, Chennaoui, Van Beers, Lepers, Dussault, Guezennec & Gomez-Merino, 2009; Sperlich, Haegele, de Marées, Mester & Linville, 2010; Sun, Liu, Li, Li & Chen, 2013; Wolf & Wohlfart, 2014). The HR is used to estimate the EE based on the assumed linear relationship between HR and EE. Potential disadvantages of HR monitoring include the need to calibrate the heart-rate monitor for each individual, as well as the problem of losing the linear relationship (Haskell & Kiernan, 2000).

Maximal aerobic power, also referred to as Maximal Oxygen Consumption ($\dot{V}O_{2\,max}$), is a commonplace measurement undertaken in exercise physiology laboratories (Howley, Bassett & Welch, 1995). Day, Rossiter, Coats, Skasick and Whipp (2003) summarise maximum oxygen uptake ($\dot{V}O_{2\,max}$) as reflecting the upper limit of the body's aerobic functioning, and comment that it is the most widely used parameter characterizing the effective integration of the central nervous, cardiopulmonary, and metabolic systems. Typically a cycle ergometer or treadmill is used and required oxygen uptake ($\dot{V}O_2$) is measured until it reaches a value such that further increases in work rate result in no further (or trivially small) increases in $\dot{V}O_2$. This indicates that a plateau has been reached (Howley *et al*., 1995; Day *et al*., 2003).

Although the $\dot{V}O_{2\,max}$ is viewed as the most accurate measure of maximal oxygen uptake, there are a few drawbacks to this method. The potential risks associated with maximal exercise, the required technical expertise to conduct tests and utilise equipment and the desired participant motivation, have led to indirect methods/submaximal tests being developed. These are considered to be safer and more convenient (Marsh, 2012). A number of submaximal tests that have been developed to meet varying needs and limitations of various age groups are available (Noonan & Dean, 2000). Submaximal tests to determine $\dot{V}O_{2\,max}$ include both cycle ergometry and running tests. Noonan and Dean (2000) expounded on the two major categories of submaximal tests being identified as predictive and performance. Examples of predictive submaximal tests as supplied by Noonan and Dean (2000) include, but are not limited to the Modified Bruce Treadmill Test, Single-Stage Submaximal Treadmill Walking Test, Astrand and Ryhming Cycle Ergometer Test, Canadian Aerobic Fitness Test, 12-Minute Run Test (also known as the Cooper Test). Some of the Performance Submaximal Tests include the Self-Paced Walking Test, Modified Shuttle Walking Test, Bag and Carry Test, Timed Up & Go Test (Noonan & Dean, 2000).

The ACSM/American Heart Association (AHA) recommendations (Haskell *et al.,* 2007) also include metabolic equivalents (MET) as a method for estimating EE. MET is considered a convenient method of stating oxygen uptake. It indicates the "ratio of the rate of energy expended during an activity to the rate of energy at rest (1MET = the rate of EE while sitting at rest, which is equal to oxygen uptake of 3.5 $mL \cdot kg^{-1} \cdot min^{-1}$)" (O'Connor, Casa, Davis, St. Pierre, Sallis & Wilder, 2013: 19). When moderate and vigorous intensity activity are combined to meet the current weekly recommendations, the minimum goal should be in the range of 450 to 750 $MET \cdot minwk^{-1}$. Examples of classifications of activities by Haskell *et al.* (2007) include jogging at 8.04kmh = 8.0 METS, jogging at 9.35kmh = 10.0 METS and running at 11.27kmh = 11.5 METS. The IPAQ referred to previously (pg 21) uses scoring that is described in MET-min/week. Those achieving a minimum of 600 MET-min/week fall into the moderate category. Participants who score a minimum of 3000 MET-min/week fall in the high category (IPAQ, 2005).

Global Positioning System (GPS) systems have been increasingly used to track athlete performance (Coutts & Duffield, 2008; Harley, Barnes, Portas, Lovell, Barrett, Paul & Weston, 2010; Jennings, Cormack, Coutts, Boyd & Aughey, 2010; Cummins, Orr, O'Connor & West, 2013; Cormack, Smith, Mooney, Young & O'Brien, 2013). Several studies have been undertaken in order to establish reliability and validity of the use of GPS in the sports setting (Coutts & Duffield, 2008; Petersen, Pyne, Portus & Dawson, 2009; Jennings *et.al.* 2010; Castellano, Casamichana, Calleja-González, Román & Ostojic, 2011; Venter, Opperman & Opperman, 2011; Johnston, Watsford, Kelly, Pine & Spurrs, 2014). The findings generally indicate that the use of a GPS for sport measurement is useful.

Johnston *et al.* (2014) found the 10 Hz GPS unit to be valid and a reliable measure of total distance. This was found to be a more reliable measure of movement demands than the 1 Hz, 5 Hz and 15 Hz GPS units (Johnston *et al.,* 2014). Varley, Fairweather and Aughey (2012) found that the 10 Hz GPS units were up to six times more reliable for instantaneous velocity measurements than the 5 Hz units, with a coefficient of variation of 1.9 to 6.0%. By contrast, the results of some studies highlighted the fact that 10 Hz GPS units were not as valid a measure of peak speed or great acceleration (Petersen *et al*., 2009; Jennings *et al.*, 2010; Akenhead, French, Thompson & Hayes, 2013; Johnston *et al.,* 2014) and over short distances (Petersen *et al.,* 2009; Jennings *et al., 2*010).

Although useful for measuring distance and movement in the sport arena, a GPS system alone cannot measure physical activity. It must be used in conjunction with a heart-rate monitor and/or accelerometer to provide a measurement of physical activity. The use of GPS within the measurement of PA provides additional information to contextualise information, such as location. It therefore serves as a valuable additional means to gain further understanding of PA behaviour (Maddison & Ni Mhurchu, 2009).

As is evident in the literature, there are numerous ways in which to measure PA. The nature of the measurements required, practical implications, nature of the research being undertaken, monetary constraints as well as the type of participant being tested all play a role in selecting the method of measurement. The relevant measurements for use in the hiking arena will be discussed later, and in greater detail under the heading 3.12.2, Measurement of Fitness of Hikers, on page 93.

3. HIKING

3.1 The Nature of Hiking

Hiking is an activity that combines both the use of wilderness or natural areas and PA. Hiking has been described as trips taken for leisure purposes conducted on foot during the summer, based on the use of the human body (Svarstad, 2010). Additionally, Svarstad (2010) states that hikers typically go through forests, or into mountain areas, or pass through landscapes that in various degrees bear signs of human influences from present or earlier activities. The statement that the activity takes place in summer is not consistent with the South African context. In Europe many of the locations used for hiking are not accessible for hiking in winter months due to snowfall. They are either not hiked or used for skiing. This is not the case in Southern Africa. For example, the Fish River Canyon Hike in Namibia is open only from May to August or mid-September (winter season) each year (Footprint Hiking Club, n.d.; Namibia Cardboard Box Travel Shop, 2016.). It is stated that due to extreme temperatures and possibilities of flash floods the route is not open in the summer months. The well-known Otter Trail on the Garden Route in the Eastern Cape is open all-year round (SANParks, n.d.a). Examining various hikes available on the South African National Parks (SANParks) Website it appears that most hikes within the parks are available all year round (SANParks, n.d.b).

Schurman and Schurman (2009) define a hike as a 1-day outing lasting at least an hour and potentially involving elevation gain on uneven terrain. They use the term trekking for multiday hikes that are linked together with overnight stays and have porters or pack animals to carry gear and food, which may be supplied at each stop. Backpacking is used to describe the activity when hikers carry everything they need for the length of the trip, and can range in duration from one night to several weeks.

The term trail has been adopted in Australia (Wearing, Scheinsberg, Grabowski & Tumes, 2008) to describe the path taken by a hiker. The American National Park Service (NPS, 2016a: n.p.) does not provide a definition of hiking or hikers but only a definition of a recreational trail…

> "... a travel way established either through construction or use which is passable by at least one or more of the following, including but not limited

to: foot traffic, stock, watercraft, bicycles, in-line skates, wheelchairs, cross-country skis, off-road recreation vehicles such as motorcycles, snowmobiles, ATVs, and 4-wheel drive vehicles."

There is no official definition for Hiking from a South African perspective (Slabbert, 2015). When visiting various websites concerning hiking in South Africa (South Africa.info, n.d.; SANParks, n.d.c; Hiking S.A. n.d.; Mountain Club of South Africa - Free State, n.d.; Green Flag Trails, n.d.a) no definitions were supplied. The various websites covered long and shorter trails, single and multi-day trails and refer to the persons walking such trails as hikers. This differs from Schurman and Schurman (2009) who label recreationists that carry everything needed for the length of their trip as backpackers. In South Africa, diverse terms like trails, hikes, hiking trails, trekking, backpacking, and slackpacking are used. This conforms to Nordbø, Engilbertsson, and Vale (2014: 383) who state that "The word hiking is common in the English language, but can be referred to in different ways such as 'walking', 'trekking', 'rambling', 'strolling' and 'bushwalking'". The most common term that is used in South Africa is, however, hiking. This is in line with Nordbø and Prebensen's (2015) understanding of the term hiking which includes shorter or longer walks ranging from less than an hour to multiple days. They highlight the purpose of the walk as one of pleasure, exercise, introspection or other experiences that are similar to these.

It can thus be deduced that from the South African perspective and for the purpose of this thesis that the term "hiking" will be used to describe an outdoor recreational activity that involves shorter or longer walks for one day (or part thereof) or multiple days with or without a load.

3.2 The Prevalence of Hiking

There has been a large increase in the recreational use of natural areas over the past few decades (D'Antonio, Monz, Newman, Lawson & Taff, 2012; Mason *et al.*, 2013). According to Cole and Landres (1996) the total wilderness recreation in the United States had increased 10-fold in the 40 years prior to their study. According to the 2014 Outdoor Recreation Participation Topline Report, the most popular activities among young people (aged 6+) in 2013 were running, biking, fishing, camping and hiking. The study also highlighted that 11.4% of adults, representing 23.8 million participants, participated in hiking in the United States of America. The 2014 study indicates that hiking was in the top five activities with youth and young adult participants (Outdoor Foundation, 2015). Hiking was listed as the fourth most popular adult outdoor activity with 25.9 million participants indicating a 1.7% growth in the activity. The 2015 report (Outdoor Foundation, 2016) indicates that hiking was still in the fifth position for youth and young adult participation with 10.8 million participants. Aspirational participation examined the type of activities that appealed to non-participants. Hiking was indicated by all age groups in the youth and young-adult categories as an activity in which they would like to participate. In 2015 hiking moved up to the third most popular activity for the adult participants with 26.4 million participants. The aspirational participation for adults aged 25 years and older also reflected a keen interest in hiking with all three age groups (25-34, 35-44 and 45+) rating hiking in the top five activities (Outdoor Foundation, 2016). Ólafsdóttir and Runnström (2013) state that hiking has been one of the most popular tourist activities in Iceland for a long time. In Thompson's 2014 Worldwide survey of fitness trends for 2015 (Thompson, 2014), outdoor activities (which include hiking, canoeing, kayaking, and games or sports) was ranked number 12. It has progressively improved since 2010 when it was ranked number 25, dropped in 2012 to number 27 then it moved to number 14 in 2012. In 2013 it was ranked 13. Currently no such statistics are available for hiking in South Africa (Bossert, 2015) and the literature does not provide an account of historical growth or future prospects of the hiking sector (Slabbert, 2015).

According to South African Tourism (SAT, 2016a) there are over 1000 registered hiking routes that can be found across South Africa. The website also adds a "did you know" point stating that "South Africa is rated as one of the top hiking destinations in the world". Descriptions are given of the various opportunities in very diverse settings, thus showcasing the prevalence and potential of hiking within South Africa.

3.3 Demographic Profile

Previous research on hiking does not explore the demographic profile of the hikers in depth. Questionnaire-based surveys were often done at the site, limiting collection of physical data such as weight and fat percentage. General sociodemographic data were sometimes collected such as age, gender, education, homeownership income (Nordbø & Prebensen, 2015; Kil, Stein & Holland, 2014; Mason *et al.,* 2013). It is also evident that experimental studies on hiking have had small populations varying from ten to seventeen participants (Manning *et al.,* 2015; Sturm *et al.,* 2012; Perrey & Fabre, 2008).

Differing demographic profile results were found, for instance Mason *et al.* (2013) indicated male participants aged between twenty and twenty-nine to be the most common hikers in their study. With a total of 199 participants, 59.8% were male and 29.2% fell in the 20-29 age category. Hill, Goldenberg and Freidt (2009) interviewed 43 participants of which 65% were females, 98% Caucasian, and one African-American participant. Ages in this study ranged from 21 to 75 years with the largest single group being that of retired individuals. Rodrigues, Kastenholz and Rodrigues (2010) only provide an age range for their participants (between 25 and 54 years) and do not provide further demographic detail. A recent study regarded their results as being unique when having a close male-female ratio of 57% male to 43% female (Collins-Kreiner & Kliot, 2017). A South African questionnaire-based survey completed by Slabbert (2015) found the majority of hikers to be in the 30-59 age category, thus comparable to Rodrigues *et al*. (2010). The gender results for the Slabbert study concur with the Collins-Kreiner and Kliot (2017) study with 56% male participants and 44% female participants. Only 2% of the respondents in Slabbert (2015) study were from the Free State Region of South Africa, with the largest response rate coming from the Western Cape (40%) followed by Gauteng (34%). According to Slabbert (2015) Caucasian (87%) is the dominant group followed by Coloured/Indian/Asian (5%), Black (3%) and 3% “other” participants.

3.4 The Physical Demands of Hiking

Some researchers consider walking and hiking in mountain scenery as sport activities with a low to moderate exercise intensity (Neumayr, Fries, Mittermayer, Humpeler, Klingler, Schobersberger, Spiesberger, Pokan, Schmid & Berent, 2014). This is echoed by Heggie and Heggie (2012) who consider it to be a continuous low-intensity form of exercise. This is in contrast to Haskell *et al.* (2007) who classified hiking as a common PA with a vigorous intensity with >6.0 METs. Due to the variations in hiking intensities, there are different MET values allocated. Hiking at a moderate pace and grade with no or light pack 4.536 kg = 7.0 METS, hiking at steep grades and pack 4.536-19.05 kg = 7.5-9.0 METS. These MET classifications can be compared to jogging at 8.04kmh = 8.0 METS, jogging at 9.35kmh = 10.0 METS and running at 11.27kmh = 11.5 METS (Haskell *et al.*, 2007). In addition, Greenberg *et al.* (2004) rated backpacking as an activity suitable for all ages. They label the type of activity as 50% aerobic with medium to high cardiovascular requirements and high caloric expenditure and leg requirement. Requirements of the abdomen are judged to be medium and arm and shoulder requirement deemed as low.

Fitness requirements for hiking rated by Schurman and Schurman (2009), are indicated in Table 1. The criteria used for the stated rating for each fitness category is not explained by the researchers. When setting up a training programme they suggest that the components that have a rating of three deserve the most emphasis while the rating of one indicates a low priority.

Table 1: Fitness Requirements for Hiking (adapted from Schurman & Schurman, 2009: 88-9)

Fitness Category	Rating
Aerobic conditioning	3
Anaerobic conditioning	1
Upper-body strength	1
Lower-body strength	3
Flexibility	2
Activity skill	1
Cross-training	2

These conflicting fitness requirement perceptions reflect on the diverse trail physical exertion requirements and requisite fitness levels of hikers. However, what adds to the appeal of hiking is that it can be simple and feasible for nearly everybody, depending on the physical exertion levels required. The discrepancies that exist regarding the perception of physical exertion required is obvious and could impact negatively on participation levels. Currently there is a lack of information regarding the physiological demands of hiking trails. If there is a difference in perceptions on the physical demands of hiking amongst researchers, the possibility of the general public having misconceptions about the physical requirements of hiking is highlighted as quite probable. The need to have an uncomplicated method to determine requirements to enjoy a hiking trip becomes more apparent. The description of physical requirements provided in previous research is helpful, but the practical implication thereof is very challenging for hikers. This research aims at addressing this issue in order to highlight the physical demands required to enable potential hikers to physically prepare themselves adequately for a hike or to at least be aware of the possible physical constraints and demands posed by various hiking trails. The selection of an appropriate hiking trail in line with the physical fitness level of the hiker should lead to a more fulfilling experience.

3.5 Hiking and Tourism

As stated in the Review of South African Tourism (2015:3) “Tourism makes a massive contribution to World Domestic Product, jobs and foreign exchange earnings”. It is also well known that “tourism can be a powerful force for local economic development, and the development of tourism clusters can unlock major economic multipliers in an area that might otherwise have little ‘industrial’ potential.”

The United Nations World Tourism Organisation (UNWTO) states that international tourism is on the increase with a record 1133 million tourist arrivals worldwide in 2014, which constitute an increase of 4.3% (UNWTO, 2016a). This report also states that over half of the visits are for purposes of leisure. In South Africa a steady flow of tourists has been experienced and South Africa is considered the most popular destination in Sub-Saharan Africa. According to the report, Africa is expected to double the number of arrivals by 2030 and this offers many opportunities for tourism development in South Africa.

The 2013 Annual Tourism Performance Report (South Africa, 2014) indicates that there were 9 616 964 total tourist arrivals in South Africa in 2013, showing a growth in the sector. The 2015 statistics show no significant increase, however, for 2016, UNWTO projections for Africa estimate a 2% to 5% growth (UNWTO, 2016b). According to the Review of South African Tourism (2015) Tourism direct GDP was R103,6 billion in 2013. Domestic visitors contributed 57% (R124,7 billion) of total tourism spend, while international visitors contributed 43% (R94,2 billion). Total tourism spend in 2013 was R218,9 billion, a rise of 9,7% from R199,4 billion in 2012. The number of persons employed in the tourism industry was 655 609 persons in

2013. The tourism industry employs about 4,4% of all employed persons in South Africa. In 2015 (Stats S.A., 2016) the main purpose of visit for foreign arrivals was holidays, with 93.8% of the arrivals falling into this category. Most of those who came for holidays came mainly in December (1 484 191) and January (1 293 107).

It is said that “authenticity and perceptions thereof in an increasingly commoditized world favour destinations that offer outstanding and unique natural and cultural characteristics” (Review of South African Tourism, 2015: 3). South Africa has a great deal to offer when it comes to unique characteristics, especially for nature-based tourism activities such as hiking. Hugo (1999) indicates that in South Africa, hiking is considered as part of the tourism industry. He explains that in South Africa, unlike other countries (for example Britain) the concept of free access to the countryside is unknown. A person wanting to hike over a few days often has to pre-book a hut for overnight accommodation and is issued with an official permit in order to make use of the trail (at a financial cost).

It has previously been established that nature-based tourism and community-based tourism can benefit local communities, can contribute to regional economies, develop rural areas, and provide employment and protection of the natural resource (McNamara & Prideaux, 2011; Mearns, 2012; Job & Paesler, 2013). In order to hike in South Africa one generally needs to move away from your place of residence, either for a day trip, an overnight stay or a longer period of time for longer hikes. Thus hiking contributes to the tourism industry and as a form of tourism can make diverse contributions to local communities.

3.6 Perceived Negative Aspects to Hiking

3.6.1 Ecological Impact

The effect hiking can have on the natural environment is one of the few negative aspects relating to hiking discussed in the literature (Cole & Landres, 1996; Lynn & Brown, 2003; D’Antonio *et al*., 2012; Guo, Smith, Leung, Seekamp & Moore, 2015). The ecological impacts of recreation are one of the seven “specific human activities” that impact wilderness ecosystems (Cole & Landres, 1996). Five primary ecological impacts of recreation were identified by Cole and Landres (1996:170). These are:

1. “Physical site alteration and disturbance of biota by trampling of humans and packstock.
2. The removal of and redistribution of materials by packstock grazing and the collection and burning of wood for campfires.
3. Disturbance of native animals by human presence and the importation of foreign substances, particularly food.
4. Harvesting of animals and plants.
5. Pollution of waters by human waste and foreign substances.”

The construction of trails and campsites as well as administrative facilities can also alter the site. Due to many wilderness areas being located at high elevations it is stated that they are “naturally stressed ecosystems that are not highly resilient” (Cole & Landres, 1996: 170).

Marion (2006:1) adds to Cole and Landres point by commenting that:

> “…concentrated traffic on trails and primitive roads can remove protective vegetative and organic litter cover and increase water runoff and erosion rates. Impacts to trail treads include excessive tread widening, muddiness, and proliferation of visitor-created paths. While some of these environmental impacts are unavoidable, excessive impacts threaten natural resource values, visitor safety, and the quality of recreational experiences.”

3.6.2 Physical Risk

Most participation barriers relate to the physical safety of, and risk to participants. Concerns raised regarding the body include cardiovascular events (Burtscher & Ponchia, 2010; Green, 2015), musculoskeletal or soft-tissue injury, ankle and knee injuries that are secondary to falls (Montalvo, Wingard, Bracker, Davidson, 1998; Hamonko, McIntosh, Schimelpfenig & Leemon, 2011) and fatalities (Heggie & Heggie, 2012). Ankle injury was identified as a common problem for hikers (Oscar *et al*., 2011). The study, however, stressed that the prevalence was lower than in other sports attributing this to the lower speed of hiking and stating that it was less demanding than other competitive sports.

There is a perception that hiking is also “less dangerous” than other outdoor pursuits. “Compared to other activities such as mountain climbing and rock climbing, the risks associated with hiking are perceived as minimal” (Heggie & Heggie, 2012: 118). Green (2015) is in agreement stating that although risks exist, injury rates are low and risks can be anticipated and mitigated.

Research recently carried out by Mason *et al.* (2013) found that injuries leading to rescues were often caused by hikers being underprepared. They suggest that groups are most often underprepared, tended to be younger, less fit, and inexperienced. They also found that often day hikers were the most underprepared due to the perception that shorter hikes are less dangerous (Mason *et al*., 2013). Green (2015) is also of the opinion that proper training should take place before embarking on a hike. These findings emphasise the necessity of being able to determine the diverse trail physical expenditure requirements and fitness levels required by hikers.

Hikers can be affected by "acute bad judgment syndrome" (Heggie & Heggie 2012: 120). This involves the overestimation of their abilities. The hikers consider themselves as proficient to hike a substantial distance over a short duration when in reality they cannot. This can then lead to risks of physical injuries or even death.

3.7 Benefits of Hiking

Numerous articles on the World Wide Web can be found that enumerate the diverse benefits of hiking. Examples include an article by Robinson (2013) that lists benefits as simple as the scenery, fresh air and the “sounds and smells of nature”, to listing benefits due to the activity being a “cardio workout”. Items listed include reduced risk of cardio-vascular disease, boosting bone density, building strength of muscles, improving balance, improving blood pressure and sugar levels, strengthening core and boosting mood. A literature investigation indicates four general benefits of hiking namely social, physical, aesthetic and psychological. Each of these benefits will now be expounded.

3.7.1 Social Benefits

Hiking primarily occurs in groups resulting in social interaction and numerous sociological benefits (Heggie & Heggie, 2012; Kil *et al*., 2014). According to Loughman

(2014) hiking provides camaraderie along with cardiovascular training. Along with the endorphins from exercising one has the opportunity to socialise with others and possibly have a life-style change, instead of seeing PA as a chore.

Furthermore, in Goldenberg *et al*.'s (2008) study on why individuals hike the Appalachian Trail, and echoed in a subsequent publication by the same authors (Hill *et al*., 2009), numerous benefits or "positive consequences" of completing a wilderness-based hiking experience were identified. These included "companionship and camaraderie, acquisition of skills needed to function in outdoor settings, and increased environmental awareness" (Goldenberg *et al*., 2008: 278). The study also points out that hiking helps to develop and foster warm relationships (Goldenberg *et al*., 2008). This is especially applicable to social bonding and family togetherness (Kil *et al.*, 2014). Hugo (1999: 141) indicates that the South African hiking fraternity is in agreement that hiking in South Africa is a "family affair or embarked on by small groups of friends or organised hiking clubs".

3.7.2 Physical Benefits

Nordbø and Prebensen (2015) indicate that hiking is a way to improve the physical wellness dimension. This is echoed throughout various research (Hill *et al.*, 2009; Svarstad, 2010; Bowler, Buyung-Ali, Knight & Pullin, 2010; Heggie & Heggie, 2012; Kil *et al.*, 2014; Neumayr *et al.*, 2014). Schurman and Schurman (2009) and Loughman (2014) maintain that hiking tones everything. Hiking utilises the whole body, especially the lower body, and if carrying a pack, the strength and endurance of the upper body will be challenged as well. Furthermore, hiking affords the opportunity to control the workout. The author suggests that hiking allows the hiker to determine the difficulty, time and distance of the hike. This is applicable to the astute hiker who does not overestimate his/her ability and underestimate the difficulty of the hike (Priest & Gass, 2005). The hiker does have the control to select the route that he/she feels is within his/her capabilities. This does not however necessarily mean that the hikers will exercise the correct judgement. The hiker who, according to Priest and Gass (2005), is classified as astute will judge his/her abilities and the level of risk appropriately and so will most likely be able to select the correct physical challenge him/herself. An arrogant and fearless hiker will underestimate the risk and overestimate his/her abilities and so possibly select a hike that is not actually within the physical capabilities of the individual. This links with Heggie and Heggie's (2012) acute bad judgment syndrome mentioned previously. The third type of individual, according to Priest and Gass (2005), is the timid and fearful. This individual misperceives adventure by underestimating his/her abilities and overestimating the risk. This hiker will often not challenge him/herself sufficiently, although he/she can exercise the control (Loughman, 2014).

The Good Hiker.com (2011) provides a top-ten list of health benefits of hiking. The benefits listed are all exercise related and are covered by the discussion on physical benefits of PA (2.5.1 beginning on page number 16). The benefits of hiking are summarised by Heggie and Heggie (2012) as having a positive effect on cardiovascular, cardiopulmonary and locomotor systems. Neumayr *et al.* (2014) similarly found that hiking is safe for patients with metabolic syndrome and that the hiking activities provided several improvements to the cardiovascular parameters of the participants in their study. Furthermore, arterial stiffness improved in elderly women after participating in hiking activities (Lee & Lee, 2014). In addition, a decrease in blood pressure was also found in several studies (Mair, Hammerer-Lercher, Mittermayr, Klingler, Humpeler, Pachinger & Schobersberger, 2008; Neumayr *et al.,* 2014). The physical nature of hiking and the benefits thereof cannot be disputed.

3.7.3 Aesthetic Benefits

Participants in Roberson and Babic's (2009) study expressed an appreciation for their surroundings. Physical activity was an incidental benefit to most participants in a study conducted by Wolf and Wohlfart (2014). Often hikers' primary reason for participation was for "other activities such as sightseeing, socialising, and experiencing nature" (Wolf & Wohlfart, 2014: 89). This implies that hiking can contribute to people being more physically active without focussing on the physical exertion itself. The primary motivation can be aesthetic in nature. Seeing, experiencing and appreciating something of beauty can lead to a sense of aesthetic appreciation. Aesthetics focuses on beauty in nature and human existence. Hiking experiences can offer opportunities to focus on or to create activities that are pleasing from an aesthetic standpoint (Edginton, Hanson & Edginton, 1992; Mills & Butler, 2005).

3.7.4 Psychological Benefits

Environmental Psychology is a field of study that examines the interrelationship between environments and human affect, cognition and behaviour (De Young, 2013). Literature within the field of Environmental Psychology attest to the benefits that participants experience while being in nature (Berto, 2005; Maas, Verheij, de Vries, Spreeuwenberg, Schellevis & Groenewegen, 2009; Roberson & Babic, 2009; Bowler *et al.,* 2010). Different people participating in the same activity have differing experiences and within an individual a recreation experience is not static, it changes over the course of the activity(ies); dispositions of participants shift, the scenic beauty changes. The degree of engagement in the activity fluctuates over time. A recreation experience is dynamic and so too the recreation outcomes and psychological benefits (Hull, Stewart & Yi, 1992). Several possible definitions for leisure and recreation exist (Edginton, Hudson, Dieser & Edginton, 2004; Rossman & Schlatter, 2008) signifying that recreation is a dynamic and subjective experience. Although variations may occur in definitions there is a growing literature that attests to the beneficial effects of nature-based outdoor recreation on well-being. One such example notes that being more connected with nature leads to greater subjective vitality, levels of flourishing and positive emotions, in addition to reduced negative emotions (Wolsko & Lindberg, 2013). As hiking can be seen as a recreation experience that is undertaken in the outdoors (in nature), the benefits of recreation in general, as well as direct contact with nature can be attributed to hiking.

Hiking has been described as a "classic leisure activity" (Ween & Abram, 2012: 167). Not only is it a way to be close to nature but also to leave everyday cares behind, and become "re-created". Maas *et al.* (2009: 967) comment that "exposure to nature has been found to have a positive effect on mood, concentration, self-discipline and physiological stress". Similar results were found by Wolf and Wohlfart (2014: 98) in that hikers experienced "strong to very strong immediate improvements in their well-being, mood, relaxation, and energy".

Walsh (2011: 585) comments that involvement in enjoyable activities is central to healthy lifestyles. The author is of the opinion that the word *recreation* summarises some of the many benefits.

> "In behavioral terms, many people in psychological distress suffer from low reinforcement rates, and recreation increases reinforcement. Recreation may overlap with, and therefore confer the benefits of, other TLCs such as exercise, time in nature, and social interaction. Recreation can involve play and playfulness, which appear to reduce defensiveness, enhance well-being, and foster social skills and maturation in children".

Walsh also states that humour can also form part of recreation "which appears to mitigate stress, enhance mood, support immune function and healing, and serve as a mature defense mechanism" (Walsh, 2011: 585).

Fifty-nine (59) publications were examined in a review on nature and human health (Hartig, Mitchell, de Vries & Frumkin, 2014). The researchers came to the conclusion that: nature can promote intermediate outcomes such as increased subjective well-being; it has restorative qualities; and the motivation behind the appreciation of nature comprises beautiful scenery, symbolic qualities and other valued attributes.

Mental benefits from hiking include greater feelings of revitalisation and positive engagement, decreases in tension, confusion, anger, and depression, and increased energy having a "tremendous benefit on your psyche" (Coon, 2011; Loughman, 2014: n.p.). In both Svarstad's (2010) and Nordbø and Prebensen's (2015) it was found that hikers themselves rated mental benefits as one of the most important attributes to the hiking experience. Loughman (2014) concurs and comments that hiking enhances your disposition. Benefits of participation in an outdoor adventure experience also include developing self-esteem, self-fulfilment, and fun and enjoyment of life (Goldenberg *et al*., 2008). It was also found that wild-land users also seek the benefit of achievement, skill dependence and risk taking (Kil *et al.,* 2014).

It is emphasised that attention restoration processes encourage recuperation from stress and fatigue through natural settings and that "soft fascination (intriguing environmental stimuli) promotes involuntary attention, enabling cognitive recovery from fatigue, and is typically present in natural settings." (Aspinall, Mavros, Coyne & Roe, 2015: 272). This differs from urban settings that are considered hard fascination (demanding stimulation). Urban settings seize attention dramatically, thus increasing cognitive load.

3.7.4.1 Attention Restoration

Kaplan's foundational research on Attention Restoration Theory (ART) offers an exploration of the various experiences that lead to recovery from fatigue (Kaplan, 1995). Kaplan refers to directed attention and the significant role it plays in human effectiveness. Directed attention is susceptible to fatigue and when one experiences fatigue in directed attention it becomes difficult to deal with situations with appropriate action (Kaplan, 1995). Kaplan (1995) suggests that natural settings are filled with soft fascination-characteristics and these aid in recovery from directed attention fatigue. There are four requirements for an environment to be restorative, these are: being away, fascination, the environment must have extent and compatibility. *Being away* refers to a break from the usual routine and can refer to geographical or psychological distance from routines that impose demands on directed attention (Kaplan, 1995; Roe & Aspinall, 2011). *Extent* refers to a setting "rich enough and coherent enough so that it constitutes a whole other world" (Kaplan, 1995: 173). *Compatibility* refers to "a good fit between an individual's purposes or inclinations and the kinds of activities, supported, encouraged or demanded by the setting" (Roe & Aspinall, 2011: 103). *Fascination* stimuli abound in natural settings offering sufficient interest to hold someone's attention but not to the extent that it excludes room for reflection.

Most hiking trails would meet these requirements and therefore should contribute to recovery from directed attention fatigue. The sheer fact that hiking takes place in nature would lean it to meeting the requirements of being away. Different trails could meet the extent criteria differently, but extent exists on all hiking trails. Compatibility could be affected by one's choice of hiking trail in that the setting "must fit what one is trying to do and what one would like to do" (Roe & Aspinall, 2011: 103). Selecting an incorrect trail that does not fit with the hiker's intended outcome can therefore negatively affect attention restoration. The natural setting of hiking trails offers many opportunities for fascination to occur.

3.7.4.2 Stress Reduction

Unlike Kaplan (1995), Ulrich, Simons, Losito, Fiorito, Miles and Zelson (1991) focus on stress reduction and not attention restoration. Their study hypothesised that following a stressor that participants "exposed to unthreatening natural environments would foster greater recuperation from stress than contacts with various urban settings" (Ulrich *et al*., 1991:209). The results of this study indicated that subjects recovered from stress faster and more completely when they were exposed to natural settings than those exposed to urban environments (Ulrich *et al*., 1991).

Building on Ulrich *et al*. (1991) and Kaplan's (1995) foundational studies, many other studies (Hartig, Evans, Jamner, Davis & Garling, 2003; Laumann, Gärling & Stormark, 2003; Berto, 2005; Hansmann, Hug & Seeland, 2007; Maas *et al*., 2009; Thompson, Roe, Aspinall, Mitchell, Clow & Miller, 2012) have also concluded that people living in greener environments or participating in activities in a natural environment report better physical and mental health.

Tension and stress relief, enhancing relaxation (Kil *et al.,* 2014; Lee & Lee, 2014), to disengage or detach the mind, recharging batteries, mental purification, source of pleasure, reflection and contemplation (Svarstad, 2010) and restorative outcomes (Ulrich *et al.*, 1991; Kaplan, 1995) can all be viewed as emotional and psychological benefits of hiking. Other research findings have indicated that hiking has a number of positive mental or psychological effects such as improvement of hopelessness, depression and suicide ideation in patients suffering from high-level suicide risk (Berman, Kross, Krpan, Askren, Burson, Deldin, Kaplan, Sherdell, Gotlib & Jonides, 2012; Sturm *et al.,* 2012).

"Modern life style" and stress seem to be terms that fit together (Walsh, 2011; Bosma-den Boer, van Wetten & Pruimboom, 2012; Aseervatham, Sivasudha, Jeyadevi & Ananth, 2013; APA, 2015). The American Psychological Association reported that the overall stress levels have increased with a greater percentage of adults reporting extreme levels of stress (APA, 2015). This report on stress highlights the negative consequences of stress such as mental health-related symptoms, irritability or anger, overeating or eating unhealthily, skipping a meal, changes in sleeping habits and or sleeping quality and a change in behaviour towards others (APA, 2015). This is not a novel finding as Hartig *et al*. (2003: 122) commented in 2003 "An inability to periodically renew one's capacity to focus may impair work performance and interpersonal relations" leading to a need for cognitive and emotional restoration due to fatigue. Studies are not limited to the adult population as Schraml, Perski, Grossi and Simonsson-Sarnecki (2011) discovered high levels of stress symptoms amongst adolescents leading to stress-related health disturbances. However, other research demonstrated that participants' stress levels decreased and life satisfaction and mindfulness increased after a hiking experience (Mutz & Müller, 2016).

It is stated that mental disorders make a substantial independent contribution to the worldwide burden of disease (Prince, Patel, Saxena, Maj, Maselko, Phillips & Rahman, 2007). Bhosale and Shejwa (2013) add that there are a number of studies supporting the possible link between life stress and illness behaviour and chronic disorders. A 2009 South African study indicated that the prevalence of mental disorders in South Africa (especially anxiety and mood disorders) was relatively high when compared to other countries that participated in the World Mental Health Survey (Herman, Stein, Seedat, Heeringa, Momal & Williams, 2009).

Physical activity has been shown to improve mental health (Richardson, Faulkner, McDevitt, Skrinar, Hutchinson & Piette, 2005), especially depressive symptoms (Sarris, O'Neil, Coulson, Schweitzer & Berk, 2014). Bhosale and Shejwa (2013) suggest that interventions aiming at anxiety reduction and stress management may help patients diagnosed with coronary heart disease. They add that such interventions may also have a protective effect. For individuals with high trait anxiety, PA has been shown to be positively associated with self-perceived dispositional resilience (Hegberg & Tone, 2015). Furthermore, Hegberg and Tone (2015) indicate that PA may facilitate resilience and reduce the possibility of developing stress-related symptoms and disorders in those that are at risk for mental health problems. Exercise offers both preventive and therapeutic psychological benefits (Walsh, 2011). Considerable research and clinical evidence support therapeutic lifestyle changes. Walsh (2011) identified eight therapeutic lifestyle changes, *viz*: exercise; nutrition and diet; time in nature; relationships; recreation; relaxation and stress management; religious and spiritual involvement; and contribution and service to others. Five of the eight lifestyle changes that are suggested (exercise, time in nature, relationships, recreation, relaxation and stress management) are all elements found in hiking activities. This emphasizes the power of hiking as a stress-reduction agent.

This is echoed in studies such as those performed by Roberson and Babic (2009), Rodrigues *et al.* (2010) and Mutz and Müller (2016). It has been observed that exercise training significantly reduced cortisol stress reactivity (Klaperski, von Dawans, Heinrichs & Fuchs, 2014). Furthermore, it was found that men reported that PA helped them to manage negative emotions that accompanied stress such as feeling upset, frustrated or angry (Ellis, Griffith, Allen, Thorpe & Bruce, 2015). Additionally, it was found that "Healthy lifestyle habits, for example, eating regular meals and proper physical exercise, can help prevent physical stress reactions, while negative lifestyle habits can be associated with greater susceptibility to stress" (Schraml *et al*., 2011: 989). Natural settings can enhance both physical and mental health (Walsh, 2011). An added "gift" that is offered by nature is that of silence. Walsh further states that immersion in nature does appear to reduce symptoms of stress and depression.

3.7.4.3 Experiencing Flow

Flow describes the condition of experience that is captivating and intrinsically rewarding and outside the limitations of worry and boredom (Csikszentmihalyi, 1975). The term flow was first coined in 1975 after studying various activities and the reasons for people participating in selected activities. The model of flow (Figure 1) that was proposed states that when a person believes that challenges that are faced are too demanding for their capabilities, the resulting stress is experienced as anxiety. If the participant's skills are greater than the opportunity to use them, a state of boredom ensues. When the opportunities for action are in balance with the participant's skill a state of flow is felt (Csikszentmihalyi, 1975).

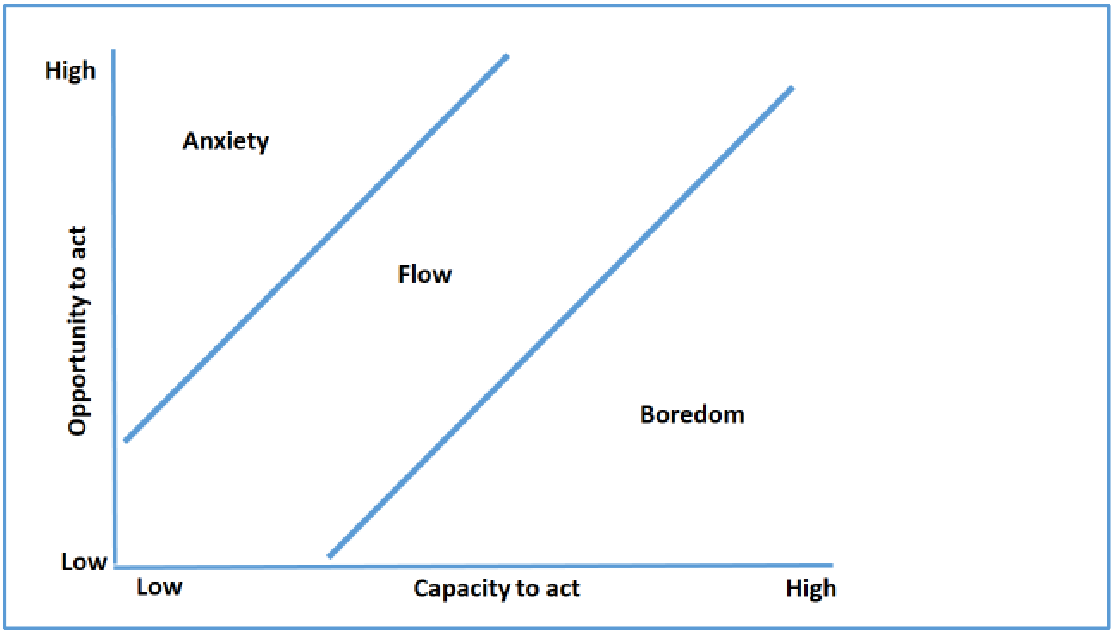

Figure 1: The Flow Theory (Csikszentmihalyi, 1975)

Flow seems to occur only when tasks are within one's ability to perform (Csikszentmihalyi, 1975). In hiking therefore it can be assumed that the hiker would have an increased chance of experiencing flow when there is a balance between physical fitness levels and required exertion levels. Participating in a hike that is beyond one's physical fitness levels could lead to a state of anxiety and hence an experience that is not a pleasurable one. Participating in a hiking trail that is far easier than the physical capabilities can also lead to boredom. High physical opportunity to act requirements and low physical capacity to act, will result in the hiker experiencing anxiety (Figure 2).

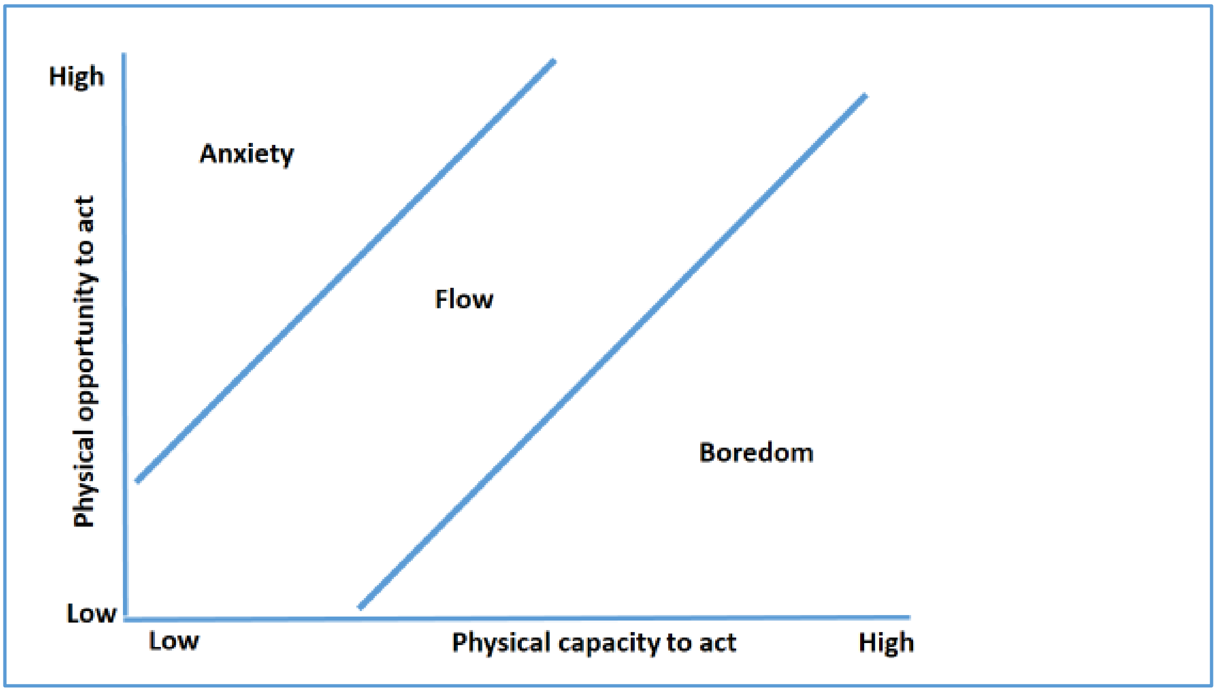

Figure 2: The Flow Theory for Hiking (adapted from Csikszentmihalyi, 1975)

Mitchell (1983 in Priest & Gass, 2005: 48) was of the opinion that there was a lack of antecedents in Csikszentmihalyi's flow theory. Mitchell included freedom of choice, state of mind, intrinsic motivation, outcome uncertainty and competence engagement. Firstly, for a flow experience to occur an activity must be completely voluntary, the participant therefore chooses the level of involvement. Secondly, adventures are experienced differently by different people. Each person brings unique aspects to the experience and each setting is different and has its own risks. Adventure is engaged in for a number of reasons, but those who are motivated intrinsically tend to continue participation. This is supported by Priest and Gass (2005: 47) who contend that "Studies on flow suggest that people are motivated to participate in adventure experiences because of the intrinsic feelings of enjoyment, well-being, and personal competence they achieve". Mitchell continued by adding that there is uncertainty of outcome. Too much or too little uncertainty results in no flow occurring, but rather boredom and complicity on the one hand or anxiety on the other. It is stressed that "participants should feel challenged, yet in control of the situation" (Priest & Gass, 2005: 48). The last antecedent is that of active engagement, where the participant has the opportunity to influence the outcome and resolve uncertainty. This is done through applying personal competence within the situation.

Priest and Gass (2005) report that Martin and Priest (1986) combined Csikszentmihalyi's model of flow with Mitchell's antecedents of adventure to develop their own model: the adventure experience paradigm. Risk and competence feature in the adventure-experience paradigm and the interaction between the two creates the challenge. Five conditions of challenge exist, influenced by the mix of risk and competence (Figure 3). Exploration and experimentation (minimal risk and maximal competence), adventure (more competence than risk), peak adventure (equal or matching levels), misadventure (more risk than competence), devastation and disaster (maximal risk and minimal competence) (Priest, 1993).

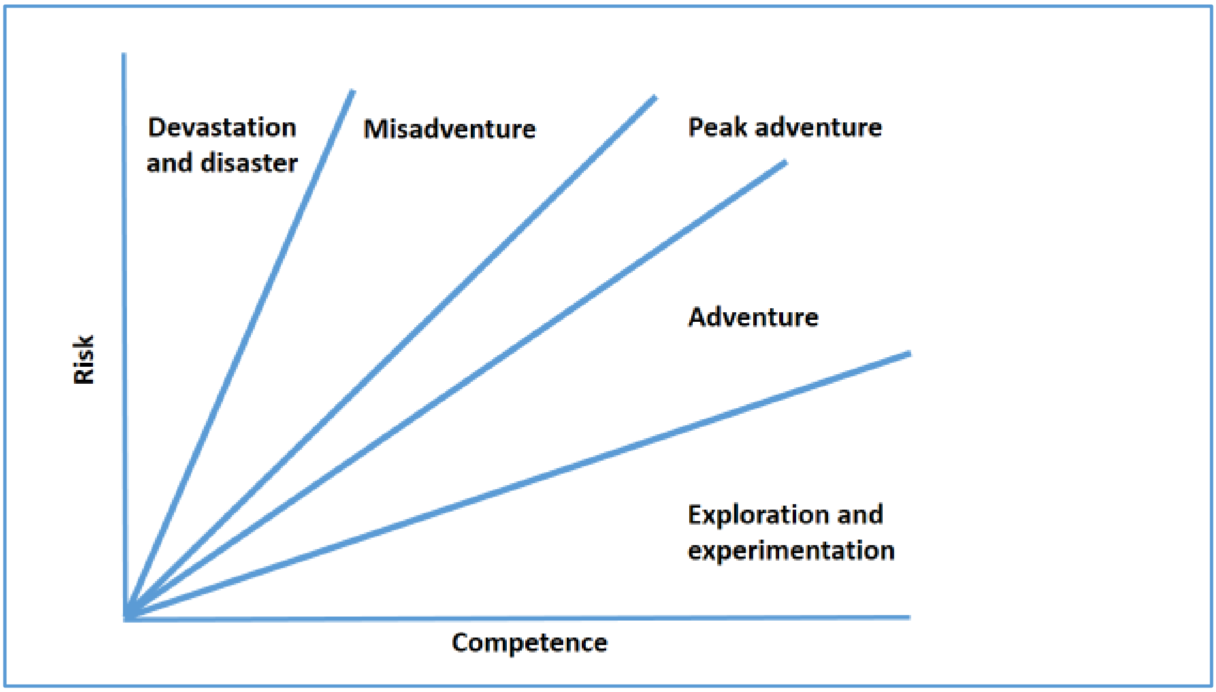

Figure 3: The Adventure-experience Paradigm (Priest & Gass, 2005: 50)

Figure 3 illustrates that when a competent individual performs a low-risk activity it results in exploration and experimentation. When competence decreases or risk increases, or a combination of decrease in competence with an increase in risk, the participant will move to adventure. When balance occurs and the two components are matched the participant should experience peak adventure. Should the participant attempt an activity where the competence is low and risk increases greatly devastation and disaster may occur.

The question arises about what constitutes competence in hiking? The answer may lie in answering the question "What can we control?" Competence in hiking could possibly include knowledge of the area, walking technique and experience, carrying the correct equipment and using equipment and maps correctly. The fitness level of a hiker will additionally contribute to this competence. One would need to be in "good enough" physical condition to complete the desired trail competently and with physical comfort. During a hike, the likelihood of an unfit participant incurring an injury increases as risk increases (Boulware, Forgey & Martin, 2003; Hamonko *et al*., 2011). It can be assumed that no specialised technical (i.e. mountaineering skills) will be required in a graded hiking trail. Competence will primarily be focused on physical fitness levels/the physical competence to complete the trail. It would be ideal for the participant to experience "Peak Adventure" as this is "the realm that provides flow and the positive benefits of adventure experiences" (Priest & Gass, 2005: 50). This is supported by findings of Wöran & Arnberger (2012), who found that flow experiences were more likely to occur with increasing specialization. Therefore if a participant could accurately gauge his/her physical fitness levels (competence) and compare these to estimated requirements (risk) the chances for misadventure or an unfulfilling experience can be reduced (Figure 4) and flow be experienced.

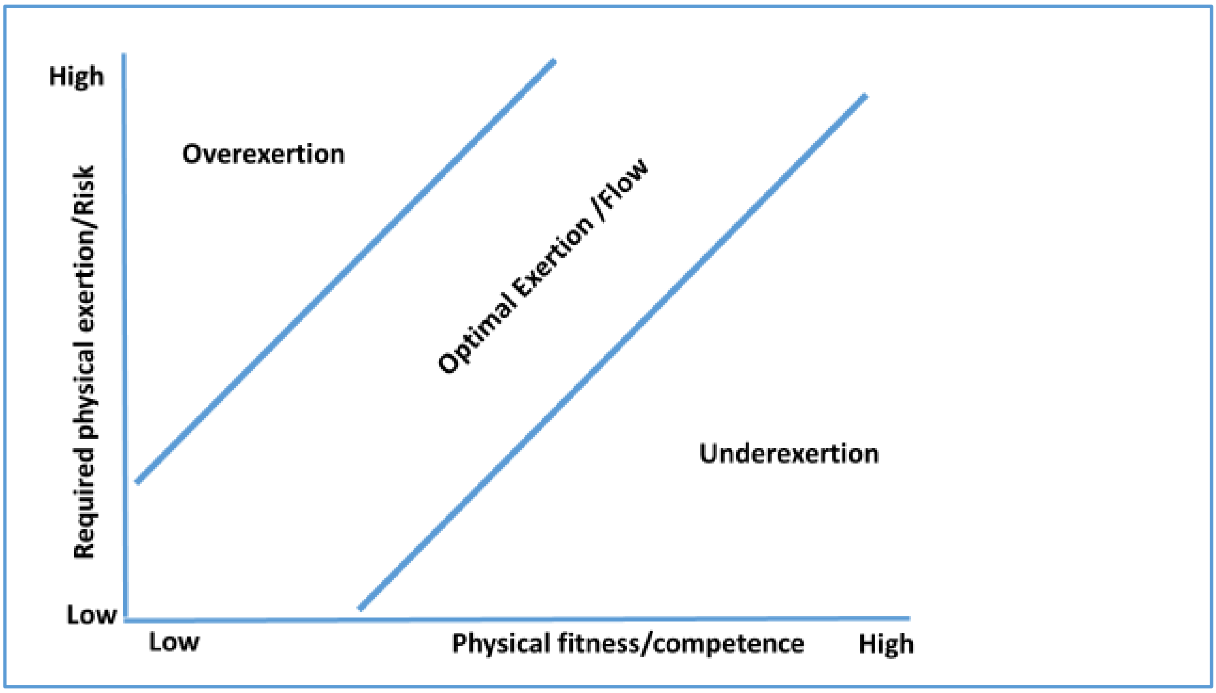

Figure 4: The Optimal Hiking Exertion and Flow (adapted from Priest & Gass 2005: 50)

Flow was experienced by thru-hikers on the Appalachian Trail (Mills & Butler, 2005), approximately three out of every five thru-hikers in this study experienced flow. Cheng, Hung and Chen (2016) confirmed that leisure involvement positively and significantly relates to flow experiences. Through recognising the importance of the activity a greater investment and engagement with hiking will occur. Consequently, by engaging in the activity, hikers express themselves and obtain a flow experience (Cheng *et al.,* 2016).

"People commonly engage in physical activity not only or even primarily because it will serve their health in the long run, but also because it helps them to feel good in the short run, sometimes by reducing tension and stress. Conversely, people who want to enter a natural environment for restoration ordinarily must engage in some form of physical activity to do so" (Hartig *et al.,* 2014: 218). As hiking is generally considered a PA it encompasses all the benefits of PA together with the psychological benefits of being outdoors. As stated earlier, numerous health and well-being benefits have been linked to participating in hiking. These include physical, social, aesthetic and psychological benefits. Many are related to the activity being a physical one, therefore producing the many benefits that can be gained from being physically active.

3.8 Variables that Influence Hiking

3.8.1 Introduction

The environments in which hiking takes place are very volatile and are exposed to the subjective individual perception of participants. The variables that impact on the excursion are diverse and may impact severely on the outcomes of the hike. Literature addressing the possible variables that impact on hiking is sparse. In most instances the various elements that could affect a hiker are only listed rather than discussed in detail.

3.8.2 Weather

Fluctuating weather conditions can influence how the hike is experienced. Weather can be viewed as a dominant variable in hiking as it can be volatile and can effect risk or enjoyment. Li and Lin (2012) carried out a Stepwise multiple-regression analysis to determine the major weather factors affecting hiking participation. These variables are pressure, temperature, wind, precipitation, sunlight, cloud and humidity. The research highlighted the differences in hiker's preferences according to the season. A light comfortable breeze was preferred in summer and in autumn the temperature (average temperature of 25°C and lowest temperature of 20°C) played the most important role Cloud coverage acted as a deterrent to hike. In winter, temperatures below 10°C as well as the wind speed discouraged hiking. The effect of weather discussed in Li and Lin's 2012 study refers to the decision to take a hike and how the weather element will influence the decision-making process. It does not, however, discuss how the conditions will affect the hiker in terms of difficulty in completing the hike. Hot conditions can lead to heat illness that could include a number of problems such as heat cramps, heat exhaustion and heat stroke (Hillman, 2012). The opposite weather effect, that of cold, can also impact a hiker and influence performance. Cold conditions can lengthen reaction time and reduce tactile sensitivity and manual dexterity. Extreme cases could lead to hypothermia (Hillman, 2012). The examples of heat and cold could happen on the same trail at different times of the year (or even on the same hike). This clarifies why Hugo (1999) describes weather as an intangible aspect that is neither quantifiable nor constant.

3.8.3 Terrain

Fattorini *et al.* (2012: 2883) state that "it is shown how walking on rough terrain requires a greater metabolic effort per meter than walking on smooth terrain". A recent study by Manning *et al.* (2015) reported that the perceived rate of exertion is significantly greater on a strenuous uphill hike when compared to an easy hike. Not only was the perceived rate of exertion greater, but the strenuous uphill trail elicited significantly increased HR compared with the easy rated trail ($p = 0.006$). In this study the "HR response was equivalent to 53% ± 9% of the age-estimated maximal during the strenuous uphill hike and 39% ± 5% during the easy rated hike" (Manning *et al*., 2015: 85). The uphill portion of the trail also generated significantly elevated HR measures compared with the downhill portion. The perceived exertion was also significantly higher for the strenuous uphill portion than for the downhill portion of the trail (Manning *et al*., 2015).

The route that is undertaken by the hiker will increase in difficulty if the elevation changes. Subtle changes will not be as noticeable as steep or sudden changes in elevation/altitude. Many descriptive gradings of hikes (to be discussed later in this chapter) include a description of the elevation or changes in terrain. These descriptions give additional information to hikers about steep slopes or climbs needed. Hugo (1999) considers the topographical height differences as an important variable. He states the obvious - the more difficult a trail is, the more energy a hiker will need to complete a trail and the more tired the hiker will be.

Altitude (meters above sea level) is not considered to be of great importance in trail grading below 3000m according to De Villiers and Thiart (1998). On the other hand, Fox, Bowers and Foss (1993) state that at altitudes of over 1500 m, the ability to perform work is affected. They have established that there is a reduction in endurance capacity, as measured by maximal oxygen consumption of 3-3,5% for every 300 m ascended above 1500 m. Acclimatisation will have an impact on ability. A person who lives at high altitude will be better suited to hike a high mountain trail.

3.8.4 Footwear

It is stated that when walking on the treadmill at near optimal speed (~1.03 $m \cdot s^{-1}$), oxygen intake is 6% greater when one wears boots compared to wearing sneakers (Fattorini *et al*., 2012). The Fattorini *et al*. (2012) study demonstrated that the energy cost of walking on level natural pathways while wearing trekking boots as required by rough terrain was greater, regardless of speed, than wearing running shoes. Thus the footwear that the hiker chooses to wear can increase the EE during the hike.

3.8.5 Load Carriage

Several studies regarding load carriage have been undertaken primarily on backpacks for school and university students (e.g. Heuscher, Gilkey, Peel & Kennedy, 2010; Pau, Mandaresu, Leban & Nussbaum, 2015; Dahl, Wang, Popp & Dickin, 2016; Vieira, Lehnen, Noll, Rodrigues, de Avelar & da Costa, 2016) and for military purposes (e.g. Liu, 2007; Heller, Challis & Sharkey, 2009). Effects of backpacks and pack load have also been examined for recreational and hiking use (e.g. Boulware, 2003; Simpson. Munro & Steele, 2011; Vieira, de Avelar, Silva, Soares & da Costa, 2015; Mao, Macias & Hargens, 2015). It has been demonstrated that load carriage can affect the trunk motor control, create neck and back pain (Chow, Hin, Ou & Lai, 2011), produce changes in posture (Heller *et al*., 2009; Vieira *et al.*, 2015; Dahl *et al*., 2016), decrease muscle oxygenation and skin-blood flow in the shoulder (Mao *et al*., 2015) and affect lower-limb muscle activity (Simpson *et al*., 2011). The metabolic rate of walking increases linearly with additional loads that are carried (Gebhardt *et al*., 2012). One could therefore conclude that the greater the load carriage, the greater the strength and endurance requirement for the hike (Schurman & Schurman, 2009).

3.8.6 Psychological Factors

It has been established that emotions can have an effect on physical performance (Rathschlag & Memmert, 2013). In soccer it was found that a team that scored the first goal were inclined to improve their psychological aspect, maintaining or improving their performance. By contrast, the team that conceded the first goal tended to experience a decrease in their psychological aspect leading to a reduction in performance (Leite, 2015). It has also been found that greater levels of tension and anxiety can increase the risk of traumatic injuries (Gregg, Banderet, Reynolds, Creedon & Rice, 2002). In addition, happiness and anger have been shown to increase physical performance in comparison to anxiety, and sad emotions (Rathschlag & Memmert, 2013). This adds credit to the statement by Hugo (1999) that the emotional state of the hiker can have an influence on their feelings of tiredness (Hugo, 1999).

Hikers could possibly lose motivation to continue, become negative, feel tension with other members in the groups, and possibly frustration at a slow or fast pace, or become lost. Positive emotions however can also be associated with improvement of the physical state. Hiker speed may be influenced by the length of hike, motivation and fatigue (Zanker, Gamper & Andritsos, 2012). Furthermore, longer hikes may require more equipment to be carried resulting in a slower pace. However, at the end of a long hike, hikers may speed up due to increased enthusiasm as they approach their goal (Zanker *et al*., 2012), usually referred to as “smelling the barn”. It is therefore important to note that the psychological state of the hiker can impact on the experience both emotionally and physically.

3.8.7 Duration

The duration of a hike can possibly affect various aspects regarding the hike. The physical requirements of a day hike compared to an overnight hike or a multi-day hike are quite different. The need to carry one’s own equipment, food and water for an overnight stay increases the load carriage with the consequences as discussed above. Walking for multiple days with no rest in-between can have severe physiological effects. This could include fatigue, acute-onset muscle soreness, delayed onset of muscle soreness (DOMS) (Prentice, 2011), and reduced recovery time. Should one not be fit enough for the multi-day hike there could also be negative psychological consequences to the individual, such as a lack of motivation and experiencing the negative feelings mentioned previously.

3.8.8 Experience

To be experienced in an activity indicates the acquisition of skill or knowledge developed by doing something; it can also include the length of time that an individual has been doing something (Cambridge Dictionary, n.d.; Merriam Webster Dictionary, n.d.). This differs from the emotional experience which refers to the emotional state as influenced by a variety of factors for example psychological factors. The hiker's level of experience could influence the hiking activity and how it is enjoyed by the participants. Hikers with experience will have more knowledge of how to deal with various circumstances that may arise while hiking, including weather conditions, appropriate clothing, adequate nutritional supply and load carriage (Schurman & Schurman, 2009). In addition, Schurman and Schurman (2009) remark that skilled participants are meticulous when moving and doing so, use a reduced amount of energy when performing an activity in comparison to those with less skill.

It has been reported that expert hikers view the scene in front of them differently from novice hikers (Kawamura, Suzuki & Morikawa, 2007). This study found that "expert hikers recognised more functional scenes that implied action possibilities than did novice hikers" (Kawamura *et al*., 2007: 774). Although more experienced hikers will have increased knowledge regarding the safety and difficulty levels of the trail, Slabbert (2015) found that there was no difference between frequent and infrequent hikers' importance rating of the information regarding safety and difficulty level of the trail. A difference does, however, exist with regard to how infrequent hikers use their past experiences to decide whether a hike should be undertaken. It was found that infrequent hikers consider information at hand more frequently than they do their past experiences when considering a new trip.

The variable of experience therefore refers to the person who has undertaken a hiking adventure before, and has developed knowledge and skill in the activity that can influence the outcome of the activity. This experience links with the psychological aspects discussed previously. A negative emotional experience can occur due to high anxiety levels when one's capabilities are low and the challenge is overwhelming (the flow theory). Prior experience in hiking can also lead to boredom if the level of challenge is not high enough for the person to experience flow.

3.8.9 Accommodation

The type of accommodation a hiker uses during a hike may have an impact on the hiker. As has been noted, the duration of the hike impacts the type of accommodation and the load carriage. If a hiker is overnighting in a log-cabin, the number of accessories and other items that need to be carried is reduced. If no infrastructure exists and the hiker is sleeping in a tent, then not only are there additional items to carry like cooking equipment, but items such as the tent itself. Many South African trails do not require sleeping in an own tent and provide some sort of shelter. This can range from a cave to a wooden cabin or even a farmhouse. The accommodation facilities have proven to be an important factor in determining which trails to hike (Slabbert, 2015).

The quality of the accommodation and the related quality of the sleep can have an effect on the recovery and energy levels for the following days' hike. Numerous studies have been undertaken regarding the effects of sleep loss on performance. It has been shown that waking earlier than usual can cause a reduction of anaerobic performance, especially in the afternoon directly following the sleep loss (Abedelmalek *et al.,* 2014; Fowler *et al.*, 2015) reducing capacity to maintain effort. Sleep deprivation has also been found to negatively affect the cognitive performance of athletes (Jarraya *et al.,* 2014; Fullagar *et al.,* 2015), reduces high-power output (Souissi, Souissi, Souissi, Chamari, Tabka, Dogui & Davenne, 2008), reduces recovery after performance (Skein, Duffield, Minett, Snape & Murphy, 2013) as well as increasing perceived exertion (Fowler *et al.,* 2015).

3.8.10 Nutrition

Many variables that can affect the hiker are interlinked. The food and fluid intake is an example of such a linkage. The weather, terrain and duration of the hike all contribute to the need levels of the hiker to consume fuel to maintain energy levels, and water or other fluids for hydration. These factors influence the amount of food and hydration needed that can in turn affect the load carriage required. Should the hiker not consume enough food or fluids this could have a negative impact on the hiking experience and may result in life-threatening medical conditions such as dehydration. Although nutrition can be seen as a variable that can influence the hiker, no supporting research could be found that had been performed on the hiking population or on hiking trails.

3.8.10.1 Hydration

In order to avoid compromised performance, the hikers' water intake should be balanced with the sweat rate in order to avoid dehydration (Popkin, D'Anci & Rosenberg, 2010; Je´quier & Constant, 2010; ACSM, 2014b). Cognitive functions can be impaired by mild dehydration of 1 or 2% of body water. This can also affect alertness and capacity for exercise (Casa, Stearns, Lopez, Ganio, McDermott, Yeargin, Yamamoto, Mazerolle, Roti, Armstrong & Maresh, 2010; Popkin *et al*., 2010; Je´quier & Constant, 2010). Heart rate, physiological strain and core temperatures all increase with dehydration (Casa *et al*., 2010) and result in a decrease in aerobic exercise performance (ACSM, 2014b). This would not be a desirable state for a hiker as it will increase the actual and perceived physical exertion during the hike. Although it is recommended that sufficient fluid should be consumed to prevent a water loss of >2% of body mass, it should also be noted that overhydrating is also a risk factor (Montain, 2008).

Although it is noted that hydration can play role in the reduced performance of an athlete (Carter, Cheuvront, Wray, Kolka, Stephenson & Sawka 2005; Casa *et al*., 2010; Popkin *et al*., 2010; Je´quier & Constant, 2010; Goulet, 2012; Bardis, Kavouras, Arnaoutis, Panagiotakos & Sidossis, 2013; Carlton & Orr, 2015) most of the previous research was simulated in a laboratory. One study was performed under extreme heat conditions, such as the 40°C (Carter *et al*., 2005), and used either a cycling or treadmill protocol. The studies mentioned also used endurance or exercise to exhaustion protocols. In the review performed by Carton and Orr (2015) they comment that the research to date could not be considered to represent the general population as the studies lacked sport specificity. Carton and Orr (2015) also add that the true impacts of hydration are not fully known as the majority of research is from the laboratory and so do not take environmental conditions into account. Field studies have results that contradict laboratory findings (Casa *et al*., 2010), such as the body temperature did not increase with dehydration and other performance outcomes were not related to hydration status.

Cheuvront, Kenefick and Montain (2007) also emphasise that in well controlled studies, such as those done in the laboratory regarding hydration previously mentioned, other variables are well controlled. This would not be possible on a hike. Cheuvron *et al.* (2007) state that ambient temperature, length of exercise, humidity, terrain, and other variables could compromise consistency amongst trials; the influence of hydration status can only be isolated when these variables are controlled. Furthermore, hydration studies in the laboratory had invasive procedures such as a rectal thermometer (Carter *et al*., 2005), taking of urine samples (Bardis *et al*., 2013) or weighing of individuals to determine water loss (Carton and Orr, 2015). It would not be feasible to weigh participants before and after the hike due to the terrain and reliability of a scale that could be transported to the hiking areas. In addition, there was no difference in HR between euhydrated or dehydrated participants in Bardis *et al*., 2013 study or in the laboratory study of Carter *et al*. (2005). The Carter study did notice an increase in HR but only during the recovery stage. As the present study was making use of HR measurements, and participants were not due to exert themselves excessively in temperatures that were expected to induce heat stress, the hydration status was not measured for this study. In addition, the complexity of measuring hydration was taken into consideration. The issues of hydration and the possible impact thereof on the hiker, including HR should be addressed in future research as a study on its own.

The recommended daily intake of water for a sedentary adult has been suggested to be 1.5l (Je´quier & Constant, 2010). This does not take food consumed into account and implies the water needed in addition to the water consumed with food. It does also not take the initial hydration status of the individual into account. It is recommended that water intake be increased during exercise and most notably in hot conditions (Popkin *et al*., 2010; Je´quier & Constant, 2010).

Guidelines regarding water intake for active people and athletes generally indicate individual differences amongst participants (amount of sweat and the sodium concentration of the sweat for example). Climate and rate of exertion complicate the establishing of rigid guidelines (Je´quier & Constant, 2010). In general, guidelines for athletes suggest individualised hydration regimens (Coyle, 2004).

The ACSM (2014b) suggests drinking 5-7 $mL \cdot kg^{-1}$ at least 4 hours before exercise. Depending on the colour of urine, additional quantities could be consumed. During activity ACSM suggest that the fluid should include sodium, potassium and a small amount of carbohydrate. This should be noted for hikes of longer than 2 hours and in hot, humid conditions as these recommendations can reduce the possibility of both dehydration and overhydration. Generally, the consumption of conventional beverages and meals should restore one to a normal level of hydration post activity, but if rapid recovery is needed then 1.5 $L \cdot kg^{-1}$ of body weight lost is suggested. This would prove difficult on a multi-day hike as one would not have the facilities to weigh oneself before and after a hike. These recommendations are most suited to the athlete. Consulting the World Wide Web, as hikers may do, the general recommendation for hikers was between a half and one litre of water every hour depending on the weather conditions, altitude and pace of the hike (Honan, 2017; Werner, 2017). Websites such as Camelbak have hydration calculators where a suggested amount of hydration per hour is calculated according to data input such as age, gender, current urine colour, type of activity and weather conditions (Camelbak, 2017).

3.8.10.2 Food Intake

Food requirements on a hike will differ according to the duration and EE of the hike. The requirements and type of food for a multi-day hike will differ from that of a day hike. If one is carrying all one’s own food for a multi-day hike the type of food and weight will be significant as the nutritional value as well as the carrying weight of the food must be taken into consideration. In the sports arena it has been advocated that adequate carbohydrate intake is important for performance (Close, Hamilton, Phil, Burke & Morton, 2016). Consumption of carbohydrates for exercise over two hours has been advised (Jeukendrup, 2004; Jeukendrup, 2014), although it has also been stated that the needs will differ according to different intensities. Most research on nutrition during activity has been done in order to improve sport performance. It was, however, noted that there was no difference in carbohydrate uptake between trained individuals and untrained individuals (Jeukendrup, 2014), indicating that a nutritional intake similar to that of an athlete could be considered for a hiker.

Hiking is done as a leisure activity and is not a performance sport, therefore not often performed at high intensity rates that would require specific foods or exact quantities to be consumed before or even during the hike. Due to the potentially leisurely nature of the activity participants will often stop and eat a meal while resting. This provides a greater variety of eating options for a hiker in comparison to an athlete who is practising or competing. It is however advisable to consume some food in order to maintain energy levels. It is plausible therefore that a hiker could apply the recommendations of Thomas, Erdman & Burke (2016) of carbohydrate intake of 30-60 g/h when hiking for longer than two hours. This would need to be adapted according to the difficulty of the hiking trail, distance hiked and the time taken to complete the trail.

Websites on World Wide Web provide some suggestions to hikers. On these sites hikers are encouraged to eat before hiking and to take food along for a hike. Carbohydrates are advocated most often. Before a hike, food such as oats, yoghurt or non-sugary cereals is recommended (Hara, 2011; Kraklio, 2017). Nutrient dense snacks for a day hike include items such as nuts and seeds, trail mix, energy bars, chews or gels, granola or granola bars, ready-made tuna pouches (Kraklio, 2017; Newgent, 2017). Saltier items such as crackers and beef jerky (the South African option would be biltong) are also suggested by Ireland (2015).

It has been contended that well-chosen nutritional strategies enhance both performance and recovery (Thomas *et al*., 2016). It is therefore advised that hikers not withhold nutritional intake in order to spare weight in their backpack, and to consume both fluids and snacks on a regular basis.

3.9 Grading Systems

Hiking literature has focused primarily on the benefits of green space near to communities (e.g. Librett, Yore & Schmid, 2006; Thompson *et al.,* 2012), the hikers' experiences (e.g. Wearing *et al.,* 2008), the importance of easy access to parks to motivate the community to exercise in natural landscapes (e.g. Wolf & Wohlfart, 2014) and impacts of hiking on the environment (Cole & Landres, 1996; Lynn & Brown, 2003; D'Antonio *et al*., 2012; Guo *et al.*, 2015). There is, however, limited research on the grading of hiking trails (Hugo, 1999; Yamaki & Shoji, 2004; Arias, 2007; Hugo, 2007).

Two issues arise when considering hiking as a form of PA: one being the person's current level of fitness and how this will affect the hiker's ability to complete the hike, and secondly, how the hike is graded as an indication to the hiker of the fitness requirements required to complete the hike and have an enjoyable experience in doing so.

3.9.1 Current Grading Systems

Various grading or classification systems are used world-wide for various trail routes (Arias, 2007). Most are descriptive and do not make use of a standardised system. When visiting various routes, a prospective hiker may receive different information due to the use of different grading criteria (See table 2). This makes it difficult to determine the suitability level of the hike for a specific hiker.

Prospective hikers may make use of the internet to search for information before participating in a hike. However, when viewing various hiking options across continents, there is no standard description of difficulty levels. The following table reflects the information available in various countries regarding grading systems.

Table 2: Current Grading Systems

Categories	**Description (when given)**
Country: USA	
State: Utah (Utah Outside, 2010)	
Class 1	Well established trail the entire time.
Class 2	Some route-finding skills and may take you over boulder fields or loose rock slopes.
Class 3	The trail will be steep and almost certainly require route-finding skills.
Class 4	Use of your hands for scrambling.
Class 5	Mountaineering/rock climbing.
State: Maine (NPS, n.d.a)	
Very easy	No description given (left blank on website).
Easy	Uneven ground but fairly level.
Moderate	Some steep grades, some level stretches.
Strenuous	Steep grades, many steady climbs.
	Short single-sentence description and distances given.

State: Denver (Colorado Mountain Club, 2016)	
Class A	Up to 8 miles round trip and 1200 ft. elevation gain. (Prior hiking experience is usually not necessary.)
Class B	Up to 12 miles round trip and 2500 ft. elevation gain. (Moderate to strenuous PA. Some prior experience is beneficial.)
Class C	Up to 15 miles round trip and 3500 ft. elevation gain. (Strenuous to very strenuous PA. Prior experience and training is beneficial.)
Class D	Over 15 miles round trip or 3500 ft. elevation gain. (Very strenuous PA often including exposure or requiring use of technical skills. Knowledge based on prior experience and training is highly beneficial.)
Class E	If you also see the letter "E" after the classification (such as C-E or D-E), the trip involves exposure (i.e., risk of falling) and may require advanced climbing skills. In addition to the classes, descriptions of easy, moderate, and difficult given. Some mountaineering aspects included (on trail, off trail and scrambling).
State: California (United States Department of Agriculture, Forest Service, n.d.a; United States Department of Agriculture, Forest Service, n.d.b)	
	Difficulty Level: More to Most Difficult (with no description)
State: Southeast Wisconsin and Northeast Illinois (Trailville.Com, 2008)	
Descriptive	Descriptive paragraph, for example McHenery County Glacial Park: Terrain / Scenery: Mix of prairie, woodlands, river, and plenty of rolling hills. Trail Conditions: Moderately wide (6 to 8 feet) mowed grass, wood chip, and natural trails with frequent rolling hills.

State: Pacific Northwest (Northwest Hiker, 2014)	
Difficulty calculator	Difficulty calculator that only takes length of trip and elevation into account. A description of the difficulty level is then given.
Easy	Young and elderly, someone in fair hiking condition, trails are generally in good condition, very little elevation gain.
Moderate	Someone in good hiking condition, trails are generally in good condition, increased mileage, moderate elevation gain.
Challenging	Someone in good hiking condition, trails are generally in good condition, increased mileage, significant elevation gain.
Difficult	Someone in excellent hiking condition, trails are generally in good condition, significant increase in mileage, significant increase in elevation gain.
Very difficult	Someone in excellent hiking condition, trails are not always in good condition, significant increase in mileage, significant increase in elevation gain.
Extreme	Someone in exceptional hiking/climbing condition, trails are not always available, significant increase in mileage, extreme elevation gain, technical aspects of hike.
State: Arizona (NPS, n.d.b)	
Steep Very steep	Categories based on Distance, Trailhead elevation Trail surface and slope (at accessible spots).

State: Southern Arizona (Southern Arizona Hiking Club, n.d.)		
A	No limit to miles or climb	
B	Max 16 miles 3000 foot climb	
C	Max 8 miles 1500 foot climb	
D	Max 3 miles 500 foot climb	
Canyon hikes:		
Class 1	Easy	Hands used for balance only
Class 2	Difficult	Hands used for climbing
Class 3	Moderate	Exposure, rock scrambling
Class 4	Strenuous	Exposure, large boulders to negotiate
State: Colorado (Loveland Mountain Club, 2016)		
A	Max 8 miles & elevation 1200 feet	
B	8-12 miles & elevation 1200-2500 feet	
C	12-15 miles & elevation 2500+ feet	
D	15miles + elevation 3500+ feet	
E	Dangerous, mountaineering skills required	

State: Northern California (Sierra Club. n.d.; Sierra Club Yokuts Group, 2016)	
Grade 1	less than 6 miles
Grade 2	6 to less-than-10 miles
Grade 3	10 to less-than-15 miles
Grade 4	15 to less-than-20 miles
Grade 5	20 or more miles
A	less than 1,000 feet
B	1,000 to less-than-2,000 feet
C	2,000 to less-than-3,000 feet
D	3,000 to less-than-4,000 feet
E	4,000 or more feet
State: New York State (Adirondack Mountain Club, n.d.a; Adirondack Mountain Club, n.d.b)	
A	Easy, maximum 8 miles and altitude gain of up to 1200 feet.
B	Maximum 12 miles and/or an altitude gain of 1200 to 2200 feet.
C	Maximum 15 miles R/T and/or an altitude gain of 2200 to 3500 feet.
D	Exceeding 15 miles R/T and/or an altitude gain of over 3500 feet.

Easy	Trail travel, 5 miles maximum per day, 1000 foot maximum elevation gain per day.
Moderate	Mostly trail, 8 miles maximum per day, 2000 foot maximum elevation gain per day.
Advanced	Trail, but part of trip may be without a trail. 12 miles maximum per day, up to 3500 feet max elevation gain per day.
Difficult	Any of the following: No trail with bushwhacking, over 12 miles per day, over 3500 feet elevation gain per day.
State: Virginia (NPS, 2016b)	
	Elevation Gain x 2 x distance (in miles). The product's square root is the numerical rating. The hike's numerical rating is then tied to one of five descriptors: Easiest, Moderate, Moderately Strenuous, Strenuous, Very Strenuous.
Easiest	Numerical Rating: less than 50. Generally suitable for anyone who enjoys walking. Mostly level or with a slight incline. Generally less than 3 miles.
Moderate	Numerical Rating: 50-100. A moderate hike is generally suitable for novice hikers who want a bit of a challenge. Moderate incline and may have some steeper sections. Generally 3 to 5 miles.
Moderately Strenuous	Numerical Rating: 100-150. Generally challenging for an unconditioned person. The terrain will involve a steady and often steep incline. Generally 5 to 8 miles.
Strenuous	Numerical Rating: 150-200. Will challenge most hikers. The hike will generally be longer and steeper, but may be deemed "Strenuous" because of the elevation gain. Generally 7 to 10 miles.
Very Strenuous	Numerical Rating: greater than 200. Only well-conditioned and well-prepared hikers should attempt. The hike will generally be long and steep, and may include rock scrambling, stream crossings, and other challenging terrain. Generally 8 miles and over.

YDS	Indicated that the Yosemite Decimal System (YDS) is used (no descriptions available on websites visited.) See below for description.
Country: Canada	
(Trent University, 2011)	
Easy Moderate Difficult	Short trips or mostly level terrain or both. Longer trips, rougher terrain and some climbing. Prolonged steep climbing or are longer and more remote. Previous experience will be helpful.
Montreal (Randonnee Adventure Montreal, 2014)	
Level 1 Level 2 Level 3 Level 4 Level 5	Elevation gain between 500 feet and 1000 feet, distance of about 5 to 7 miles. A few short, steep sections, relatively even terrain. Elevation gain between 1000 feet and 1500 feet, distance of about 5.5 to 7.5 miles, some steep sections, uneven terrain. Elevation gain between 1500 feet and 2500 feet, distance of about 6 to 7.5 miles, several long, steep sections, rough terrain. Elevation gain between 2500 feet and 3000 feet, distance of about 7 to 9 miles, frequent long, steep sections, rough terrain, some scrambling. Elevation gain between 3000 feet and 5000 feet, distance of about 8 to 12 miles, many long, steep sections, often very rough terrain, more scrambling.
YDS	Stated that Yosemite Decimal System (YDS) is used (no descriptions available on websites visited.) See below for description.

Yosemite Decimal System (Colorado Mountaineering, n.d.; Climber.Org, n.d.; The Climb, n.d.)	
Class 1	Walking with a low chance of injury.
Class 2	Simple scrambling, with the possibility of occasional use of the hands. Little potential danger is encountered.
Class 3	Scrambling with increased exposure. Handholds are necessary. A rope should be available for learning climbers, or at your discretion for the day, but is usually not required. Falls could easily be fatal.
Class 4	Simple climbing, with exposure. A rope is often used. Natural protection can easily be found. Falls may well be fatal.
Class 5	Considered technical, rope free (without hanging on the rope, pulling on, or stepping on anchors) climbing; belaying, and other protection hardware is used for safety. Un-roped falls can result in severe injury or death.
Finland	
(Nationalparks (Finland), 2016)	
Easy	Little elevation change. Even surface, grounded or covered with duckboards if needed.
Intermediate	Some elevation change. Some rough terrain allowed.
Demanding	Parts of the trail are steep or difficult to explore. The trail may include a section that requires wading.
Germany	
(German Alpine Club, n.d.)	
Blue	Easy mountain paths.
Red	Moderate mountain paths.
Black	Difficult mountain paths.

Norway	
(Fjord Norway, n.d.; The Norwegian Trekking Association (ADT), n.d.)	
Easy (Green)	Easy day events for everyone. Adjustable to the participants. The tour is on relatively flat terrain. The planned route will mostly follow a waymarked route.
Medium (Blue)	Up to approximately 15 km. Tours are suitable for those who are used hiking / skiing while carrying a backpack and are in normally good shape. The tour is in lightly varied terrain with smaller climbs and descents. The planned route will mostly follow the waymarked tracks.
Intermediate (Red)	Day tour stages are up to approximately 25 km. Tours are suitable for those with some mountain hiking / skiing experience and in good physical shape. The tour is in highly varied terrain with many climbs and descends. The planned route can be both on and off the waymarked tracks.
Advanced (Black)	Day tour stages are more than approximately 25 km. Tours are suitable for especially experienced mountain hikers /skiers who are in very good physical shape. The tour will for some parts be in very steep and uneven terrain. The planned route can be both on and can often be off the waymarked tracks.
Slovakia	
(Slovakia. n.d.)	
Easy Moderate Hard Medium Heavy Medium- heavy Easy Easy to moderate Moderate Difficult	No description given of what rating implies.

Ireland	
(Footfalls Walking Holidays, n.d.; Irishtrails.ie, n.d.; Hillwalk Tours Ireland, 2016; Ireland.com n.d.a; Ireland.com n.d.b)	
	Most websites include a descriptive paragraph, distance, ascent and approximate walking time.
Multi-Access	Flat smooth trails, suitable for all users including people with reduced mobility, wheelchair users, people with a vision impairment, using crutches, with a buggy, with small children, older people and so on.
Easy	Generally flat trails with a smooth surface and some gentle slopes or shallow steps. These trails are generally suitable for family groups including children and the elderly.
Moderate	These trails may have some climbs and may have an uneven surface where the going is rough underfoot, with some obstacles such as protruding roots, rocks, etc. The routes are appropriate for people with a moderate level of fitness and some walking experience.
Strenuous	These are physically demanding trails, which will typically have some sections with steep climbs for long periods, while the going underfoot can be extremely rough including many obstacles. Suitable for users accustomed to walking on rough ground and with a high level of fitness.
Very Difficult	These routes are predominantly in remote upland areas. They will typically include steep slopes and very variable and rough underfoot conditions on sometimes indistinct trails. They may be unmarked so the use of a map and navigational skills will be required. Suitable only for very fit and competent mountain walkers with a high level of experience.
Class 1	Multi-access trails, minimal cross slopes and gradient. No steps, waterbars, stiles, barriers or trip hazards of any kind. Flat to 5% gradient.
Class 2	Reasonably flat and relatively smooth surface with minimal loose material. No waterbars or climb-over stiles should be used. Steps should be minimal and if used should be limited. Gradient: flat to 8%.
Class 3	Relatively narrow undulating trails. Variable surfaces. 5% average gradient.

Class 4	Typically challenging, single-file walking trails over mixed terrain. Very variable and uneven surfaces. Gradient flat to 30%.
Class 5	Challenging trails, surfaced or unsurfaced over variable ground, may be in exposed areas. Extremely variable and uneven surfaces with large rocks, roots and other obstacles offering a challenging hike. No gradient constraints.
United Kingdom	
(National Trails, n.d.a; National Trails, n.d.b; National Trails, n.d.c; The West Highland Way, n.d.; Allison Howell's Foot Trails, 2016)	
	Most websites provide descriptive notes on various walks. No grading given, only distances and route.
New Zealand	
(Hiking New Zealand, 2016a; Hiking New Zealand, 2016b; Department of Conservation, n.d.)	
Grade A	General good health necessary. No specific fitness requirements.
Grade B	Average of 4-5 hours PA per day. At times carrying small backpack of 4-5kgs (9-11 lbs). Tracks generally in good condition. Altitude gains of up to 600m (2000ft) on harder days. No hiking experience necessary. Reasonable standard of fitness required.
Grade C	Up to 6 hours of PA per day. At times carrying a backpack of 5-6kgs (11-13 lbs). Tracks generally in good condition. Altitude gains of up to 600m (2000ft) on harder days. No hiking experience necessary. Reasonable standard of fitness required.
Grade D	Average 4-5 hours PA per day, up to 8-9 hours on longer days. Pack weights of 10-12kgs (22-26 lbs). On some days altitude gains of up to 800m (2600ft). Some uneven track surfaces and river crossings. No multi-day hiking experience necessary. Agility and fitness required.
Grade E	Up to 8-9 hours PA each day. Pack weights of 12-15kgs (26-33 lbs). Altitude gains of 900 to 1000m (2950 to 3300ft). Some exposure to heights. Hiking experience necessary. High level of fitness required.
(New Zealand Trails, 2016a; New Zealand Trails, 2016b; New Zealand Trails, 2017a; New Zealand Trails, 2017b)	
Activity level 1-5	Distance, duration, elevation, altitude and an info graphic.

Peru	
(Adventure Travel Guide to South America, 2015a; Adventure Travel Guide to South America, 2015b; The Only Peru Guide, 2016a; The Only Peru Guide, 2016b; The Only Peru Guide, 2016c; The Only Peru Guide, 2016d)	
Moderate Moderate - challenging	Difficulty levels not discussed at all, no indication of what descriptions mean. Trek description. Description indicates the need to be in good physical condition. No indication of what moderate or challenging means.
Brazil	
(Brazil Trails, n.d.a; Brazil trails, n.d.b; Outdooractive, n.d.a; Outdooractive, n.d.b; Halfway Anywhere, 2013)	
Easy, Easy to Moderate, Moderate, Challenging	Short description of hike and then difficulty. No description of what the difficulty incudes. Includes a 1-5 scale of technique, stamina and experience. Minimum and Maximum altitude and distance also included.
Australia	
Victoria Victoria State Government Environment. Land, Water and Planning, 2015a; Victoria State Government. Environment, Land, Water and Planning, 2015b; Trail Hiking Australia, 2016)	
	Australian Walking Track Grading System
Grade 1	No bushwalking experience required. Flat even surface with no steps or steep sections. Suitable for wheelchair users who have someone to assist them. Walks no greater than 5 km.
Grade 2	No bushwalking experience required. The track is a hardened or compacted surface and may have a gentle hill section or sections and occasional steps. Walks no greater than 10km.
Grade 3	Suitable for most ages and fitness levels. Some bushwalking experience recommended. Tracks may have short steep hill sections a rough surface and many steps. Walks up to 20km.
Grade 4	Bushwalking experience recommended. Tracks may be long, rough and very steep. Directional signage may be limited.

Grade 5	Very experienced bushwalkers with specialised skills, including navigation and emergency first aid. Tracks are likely to be very rough, very steep and unmarked. Walks may be more than 20km.
South Africa	
“Hugo” system (HOSA, n.d; Footprint Hiking Club, 2009)	
	Accredited trails on particular website have a trail description including a difficulty rating. When clicking on the option it gives a description that includes: Energy usage is calculated in terms of kCal and transferred onto a scale of 1 – 10+: 1 being exceptionally easy and 10 extremely difficult. With info graphic of the various days of the hike.
Easy	Category 1 – 4 (<1000 kCal);
Moderate	Category 4 – 7 (1000 – 2200 kCal);
Difficult	Category 7 – 10 (2200 – 3300 kCal);
Extremely difficult	Only for very fit hikers cat 10+ (> 3300 kCal).
	Technical Difficulty refers to the character of the terrain, whether it is a walk, or if one has to scramble or climb. Key and info graphic is given.
Mountain Club of South Africa (MCSA)-Free State Division (Mountain Club of South Africa-Free State, 2016)	
A	Easier outings. Suitable for inexperienced or less fit people and children. Distance is not that far and terrain not so rough.
A-	Very easy
A	Easy
A+	Slightly more difficult

B	Average outings. Reasonable fitness required, but not demanding. Distances may sometimes be far and terrain rough or fairly difficult.
B-	Fairly easy
B	Average
B+	Pretty hard
C	Difficult and often long walks, only suitable for fit and experienced hikers. Distances are often far and the terrain is difficult and steep.
C-	Not too bad
C	Really hard
C +	Very demanding hike

Several variables are identified in Table 2 that are used in the various grading approaches. Elevation, distance and terrain are used most often to grade a hike. Often, short, single sentences are used to give a descriptive account of what could be expected “A demanding walk off road over rough terrain” is used to describe the Benbradagh walk in Ireland (Ireland.com. n.d.c. City Walks Benbradagh). In other instances, a longer, paragraph-style description is given. Tollymore Forest Park - River Trail in Ireland paints a more aesthetic and less physical exertion-based picture: “Having descended the Azalea Walk to the Shimna River, the trail turns upstream along the attractive tree lined river bank past the Hermitage to cross the river at Parnell's Bridge. The 10 metre cascade fall is most spectacular” (Ireland.com. n.d.d. City Walks Tollymore Forest Park – River Trail).

From the above information it is clear that there are numerous approaches used in the hiking world to describe (or grade) a hike. No single system is used across the board. Even in a single country some ratings are the exact opposite. In the United States of America in Southern Arizona, for example, a hike classified as an “A” hike is the most extreme where there is no limit to the miles or the climb. The D-rated hike is one that is a maximum of 3 miles and a 500-foot climb (Southern Arizona Hiking Club, n.d.). In Colorado an “A” hike has a maximum distance of 8 miles and elevation of 1200 feet and the D-rated hike is 15 miles or more with an elevation of 3500 feet (Loveland Mountain Club, 2016). This information could be very confusing to a hiker and lead to a very unpleasant hiking experience due to a misjudged trail.

Most accounts are of a descriptive nature and are thus fairly subjective. “A pleasant walk”, or an easy, moderate or hard hike can have different meanings for different participants. Some sites refer to fitness requirements. These requirements are again subjective as they do not give a definite measure of fitness. Phrases like “moderate level of fitness”, “reasonable standard of fitness required” “good physical shape” are all subjective and can be misleading.

The Mountain Club of South Africa – Free State division, makes use of an A, B, C grading system (Mountain Club of South Africa-Free State, 2016). Table 2 contains the descriptions of the grades used. The grading descriptions were only available on the club’s list of planned hikes (Mountain Club of South Africa-Free State, 2015). When visiting other affiliates of the Mountain Club of South Africa, no grading or description was given for hikes, only for some rock climbing excursions. Where symbols were given no explanation or description of the symbols could be found. This is problematic. The first description given is “not that far”. The question remains, how far is it then?

3.9.2 Research-Based Grading Systems

Grading systems based on scientific research published in accredited research journals are limited to a few attempts. They are the Recreation Opportunity Spectrum Approach (Yamaki & Shoji, 2004), the Australian Walking Track Grading System (Arias, 2007) and the South African based Hugo Energy Method developed by Hugo (Hugo, 1999 & 2007; Hugo et al., 1998/99). A discussion on the published research is presented below.

3.9.2.1 Recreation Opportunity Spectrum Approach

Yamaki and Shoji (2004) classified trail settings using the Recreation Opportunity Spectrum approach. This research was done in order to improve management in the specific hiking area (Daisetsuzan National Park, Japan) in order to overcome problems experienced in the park. The approach focuses on the quality of the experience for the visitor. Classification of trails were based on to the visitors’ preferences and were classified as primitive, semi-primitive, semi-urban and urban areas. The research does not investigate the ability of the walkers to complete the trail or classify the difficulty of the trail.

A return-mail questionnaire was used in this study. The results from the questionnaire were used to classify areas. The questionnaires were distributed at trailheads where visitors were asked to complete the questionnaire and return it later. Forty-five point six percent (45.6%) of questionnaires were returned. Data was first analysed with categorical principal component analysis (CATPCA) and then respondents were classified using object scores obtained from the CATPCA.

Trails were divided according to the physical, social and managerial conditions of the environment. Thereafter data sets were made for each segment. Data was then substituted into the formula in the CATPCA procedure producing object scores of the trail segments. Next, a discriminant analysis was performed to discriminate trail segments according to the visitor classification "distants (sic) between the trail segments and the gravities of the visitor groups were calculated using Maharanobis distant (sic). The distants (sic) to the gravities of the visitor groups were compared for each trail segment, and each trail segment was classified as the group that has the closest distant" (Yamaki & Shoji, 2004: 321).

The results can be seen as useful for managerial decisions in order to improve the utilisation of the space and future planning of the park. The classification of areas, however, provides no information on the suitability of the hike for an individual or the difficulty level of the area used by the visitor.

3.9.2.2 Australian Walking Track Grading System

In an attempt to limit confusion amongst interstate and international visitors, Standards Australia developed the Australian Standards for walking tracks in 2001 (Wearing *et al.*, 2008). Standards Australia published standards in 2001 for classification, signage and infrastructure of walking tracks (Standards Australia, 2001a; 2001b). "The objective of this Standard is to provide managing authorities with guidance for walking track classification and signage in order to provide consistency of information to users of walking tracks. This is intended to minimize risk, preserve natural features and enhance recreation opportunities associated with the use of walking tracks" (Standards Australia, 2001a: 4). Design limits, live loads, provision of barriers, number of steps (e.g. track class 2 has a maximum of 18 risers) are examples of the standards set out in part 2, Infrastructure and design (*sic*) (Standards Australia, 2001b). A six-category system was selected for track classifications during design. The variables included were the conditions, signage, infrastructure and terrain. Conditions referred to the surface and amount of space on the track, signage indicated the use of arrows at intersections (or not) and the frequency of interpretive signage. Infrastructure included items such as lookouts, seats, presence of barrier rails to nothing provided. Terrain was indicated by the gradient and skills required to complete the hike (Wearing *et al*., 2008).

An overview of existing trail classification systems performed by Arias (2007) identified that that there was a lack of consensus between standards. The research indicated that within Australia there were a large number of "ad hoc classification systems" in use (Arias, 2007: 35), although there were recommended standards in place. It was postulated that one classification system that could be used throughout different walking trails would make it easier for the users of a trail to decide what was suitable for them. Such a system would therefore “simplify the decision making process for the public when choosing a walking trail” (Arias, 2007: 35).

In the overview conducted by Arias (2007) with regard to Australian Territories and for the purpose of determining existing classification systems, telephone interviews, books, guides, reports, other publications and internet sites were consulted in order to summarise various classifications used. Selected countries, considered leaders in walking trails, were then studied (New Zealand, United States, United Kingdom, Canada, South Africa and Ireland) and a table summarising findings was formulated. A second report of research findings was published in September 2007 (Market Solutions, 2007). Using walking track grading systems identified by Arias (2007), focus groups involving walkers (hikers) with the aim of determining preferred signage was undertaken. Here it was noted that “All respondents wanted information about the degree of difficulty of the walk they were considering undertaking” (Market Solutions, 2007: 14). From the information gathered a Technical Reference Group was formed. This group, made up of representatives of all the State and Territory park agencies, designed a final research project in order to gather consumer input into a National Walking Track Classification System. This was conducted in two stages. Firstly, a qualitative stage where eight focus-group discussions across Australia were held. Secondly, a quantitative stage to measure the features of a grading system that are important to walkers was undertaken. A survey was conducted on all walkers who had recently been walking in Australia (including international tourists). It was against this background of standards established, and research done by Arias that an Australian Walking Track Grading System was developed in 2010 (included in Table 2).

The system has subsequently been endorsed by the body for park management organisations (Parks Forum) but is viewed as a voluntary industry standard and not as an obligatory requirement. The Australian Walking Track Grading System Discussion Paper (Victorian Government DSE 2010: 9) states that the grading system “answers one question – is this walk suitable for me?” The information provided to the walker is considered to be the key elements of a walk’s difficulty. These elements comprise distance, gradient, quality of path, quality of markings, experience required and the presence or absence of steps (i.e. stairs to climb during walk). A time descriptor is given, but it should be emphasised that this is for walker information only and is not factored into the technical descriptors for the difficulty level.

Summarising from the Victorian Government DSE (2010) document and, as indicated in Table 2, there are five grades to the Australian Walking Track Grading System. Grade 1 walks are under 5km and the gradient may not exceed 4.1 degrees or a 7.14% slope in order to be suitable for a person in a wheelchair. The surface should be hard with a minimum width of 1200mm, be well maintained and have minimal intrusions. Signage and route markers at intersections are mandatory. No previous experience is required. Steps will only be found on a Grade 1 route if there is alternate ramp access.

A grade 2 walk must not exceed 10 km and a gradient no steeper than 5.7 degrees or 10%. The surface is a hard surface or a modified surface with a width of 900mm or more. As with the grade 1 trail it should be well maintained with minimal intrusions, with signage and route markers at intersections; users also require no previous experience. Unlike a grade 1 walk, “Suitable for most ages and fitness levels” is added under the experience required descriptor. There is minimal use of steps.

A grade 3 walk may not be longer than 20km and have steep sections that may not exceed 10% or 5.7 degrees. There may be a few obstacles on the formed earthen track. Generally the trail is a modified surface with some sections that may be hardened. The width can vary and may be less than 1200mm and is kept mostly clear of intrusions and obstacles. Signage is expected at the track head and at route markers, intersections and at places where the track is indistinct. No bushwalking experience is needed and a minimum level of specialised skills. Natural hazards such as steep slopes, minor water crossings and unstable surfaces may be encountered. Steps may be common.

The distance of grade 4 walks can be greater than 20km and it is said that distance does not influence the grading. There may be long steep sections exceeding 10% or 5.7 degrees that may be arduous. The trail surface is generally distinct without major modification to the ground. Natural obstacles and fallen debris may occur on the path.

Signage and route markers exist, and a moderate level of specialised skills may be required. Maps may be required to successfully complete the walk and users should be self-reliant. Steps do not influence grading.

No modification of the natural environment for path occurs with a grade 5 track. The total distance may be greater than 20km, but distance does not influence grading. The gradient descriptor is the same as for a grade 4 trail, but unlike a grade 4 route there is no signage. It is said that previous experience in the outdoors is needed and a high level of specialised skills is required (such as navigation). As with a grade 4 trail, maps may be required to successfully complete the walk and users should be self-reliant. Steps do not influence grading.

Although the elements in the Australian Walking Track Grading System provide considerable information regarding the trail, it does not provide the level of fitness required to complete the trail within a desired level of comfort. Many hikers enjoy difficult trails, and the effort required for preparing for the trip, whereas others would regard an easy trail as far more enjoyable (Hugo, 2007). There are, however, differences in interpretation of what an “easy” or “hard” trail would be for a hiker. Human variables like age, gender and fitness levels will impact on the level of difficulty experienced. Arias (2007) also notes that one should consider the physical features as well as the environment. Aspects such as the “climate, seasonality and overall environment have an impact in the difficulty for the walker to complete the trail” (Arias, 2007: 37). He adds that other weather elements like heat, cold and rain can impact the classification given to a trail and these elements can affect the ability of the average person to complete the walk.

3.9.2.3 “Hugo Energy Method”

According to Hugo (1999 & 2007) the development of a standardised grading system in South Africa should enable hikers to make informed decisions regarding trails that are more suitable for them in terms of the required time and fitness level needed to complete the trail without undue physical exertion. The grading system is based on physical laws and laboratory experiments which Hugo utilised to determine the energy equivalent value of a trail from a topographical map. Hugo (2007) proposed that the required fitness level could be determined by undergoing a physical fitness test at a sports centre (a specific fitness test is not suggested). Although this would be the best predictor of fitness before a hike, it is quite improbable that most hikers would undertake a laboratory fitness test before attempting a hike. On the contrary, many decisions to undertake a day walk are made on the spot and therefore a need arises for the potential hiker to determine their ability to complete the hike quickly and easily beforehand.

As has been indicated in the previous section on the available grading information in different areas of the world, Hugo *et al.* (1998/99:48) are in agreement when they comment “Although existing methods are not without value, their inherent subjectivity rules them out”. A new system is proposed that is based on three premises. Firstly, it is argued that this logical approach should be scientifically sound. Secondly, it should be objective therefore not affected by different persons performing the evaluation and finally it must be possible to exclude field surveys and be able to compute results from existing topographical maps.

The premise of Hugo *et al.* (1998/99) is that the work rate of a person should be predicted and the trail then evaluated according to the average person’s energy usage on the trail. The suggested equation upon which the rate of energy usage can be determined is:

$$P = (Cv \cdot mgv \sin \theta) + (Ch \cdot \mu\, mgv \cos \theta) + C$$
$$= mg[(Cv \cdot v \sin \theta) + (Ch \cdot v \cos \theta) + Cm]$$

Where:

P	=	rate of work (watt)
Cv	=	vertical efficiency coefficient
θ	=	gradient (slope) (degrees)
v	=	walking speed (m/s)
m	=	mass of hiker with rucksack (kg)
g	=	gravitational acceleration (9.81 m/s^2)

Ch is the combined coefficient of horizontal efficiency and friction

$$Ch = CH \cdot \mu$$

Where: CH = horizontal efficiency coefficient

= friction coefficient

C is the rate of energy required while standing still

$$C = mg \cdot Cm$$

Where: Cm = equivalent speed in m/s

Where: CH = horizontal efficiency coefficient

In order to determine the constants for Cv, Ch and Cm Hugo *et al*. performed a laboratory test on a treadmill at a speed of 5km/hour with altering inclination the rate of energy use at different gradients was measured. A separate formula was calculated for walking downhill. This was also determined by laboratory tests as for the inclined tests. The resultant equation was $P = mgv\ [7.8(\tan^{\theta})^2 + 1.35(\tan^{\theta}) + 0.45] + 0.95m$ (Hugo *et al.,* 1998/99:51).

Due to the number of fluctuating and subjective variables that can be considered when grading a hiking trail (e.g. weight of rucksack, speed of hiking, height above sea level) Hugo (1999) contends that these elements cannot all be included in a scientific equation for trail grading. The information used by Hugo includes a detailed length profile of the trail. The trail is then subdivided manually to obtain uniform gradient segments. The altitude as well as the length of each segment is then recorded. A computer programme subsequently calculates the following:

- the gradient of each segment
- the expected rate of energy use (according to the specific gradient of the segment)
- the amount of energy needed to complete each segment
- the sum of the amount of energy needed for all the segments. This results in a kJ-value

Hugo's system has been adopted by the Hiking Organisation of Southern Africa (HOSA) and is known as Green Flag Trails in South Africa (Green Flag Trails, 2015; Green Flag Trails, n.d.a; SAT, 2016b). For a trail to be accredited by the Green Flag system, various components of the trail are investigated, and not just the difficulty of the trail. The trail is audited according to the administration and management of the trail, layout and planning and impact of the trail (Green Flag Trails, n.d.b). A description of the trail by means of symbols is supplied and includes aspects such as technical difficulty, energy rating, guiding, catering, trail format, trail type, path character, accommodation, environmental character, safety and environmental education (Green Flag Trails, 2016).

An example of the scale is given in Figure 5. The description of the energy rating (Green Flag Trails, n.d.c) falls under the category “difficulty rating”. This rating given on the Green Flag website for the various accredited hikes is based on Hugo’s energy requirements as explained above. The rating is given in a kCal range and then placed on a scale of 1-10. Level 1 to 4 is considered an easy category with a Kcal rating of under 1000. The moderate category is from 1000 kCal to 2200 kCal and has a level rating from 4-7. The Difficult category is rated from 7-10 with a range of 2200-3300 kCal. Extremely difficult is categorised as over 3300 kCal and is emphasised that it is only for very fit hikers (Green Flag Trails, n.d.c).

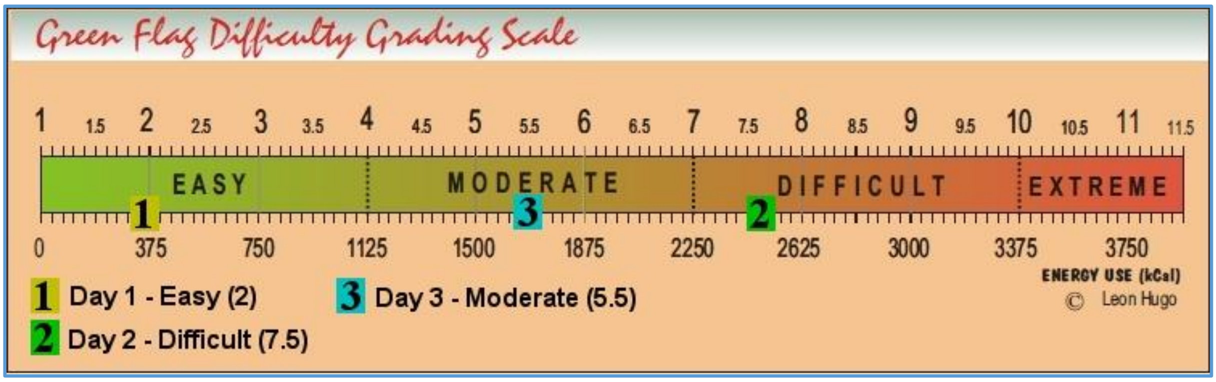

Figure 5: Theoretical Trail from Green Flag Trails n.d.c

True multi-day hikers who carry all their gear are also catered for in Hugo’s system in that an additional weight is added to the average hiker in order to compensate for the backpack (Hugo, 2016a). When considering the effect of multiple day hikes Hugo (Hugo, 2016b) comments that 10% is to be added to the Kcal for every day of uninterrupted hiking (from the second day), thus increasing the difficulty level of subsequent days of hiking. In order to accommodate for increases in altitude, Hugo (Hugo, 2016b) increases the difficulty level as height above sea level increases. A hike that is easy at an altitude of 1000m could be graded as moderate at 3500m or strenuous/hard at 4000m above sea level.

Slabbert (2015) is of the opinion that the use of the Green Flag accreditation system reduces the hikers’ task of planning for the trip, providing sufficient information to know what equipment should be included and how to prepare for the unique conditions of the trail. Furthermore, Slabbert (2015: 78) emphasises that:

> “No accreditation system can guarantee a positive outcome for the client, as the outcome of a hiking experience is dependent on various intangible factors such as weather conditions, the hikers’ affinity towards the specific environmental character (preference toward desert, forest, coastal or bushveld areas), mental state of the hiker, travel party the hiker is with and so forth”.

3.9.3 Advantages and Disadvantages of Current Grading Hiking Trails

When examining the various methods used to design grading systems, some advantages and disadvantages can be identified. As mentioned earlier, the subjective nature of most descriptions is a major stumbling block. Easy for one individual may be considered moderate for another, taking into consideration variables like age and fitness levels. Distance and elevation gain give an indication of the demands that may be required. When these elements are added to the description of the trail, a potential hiker already has a better idea of what to expect. Inconsistencies, even within a single country may exist. When a symbol or label is allocated in one area it represents a difficult hike, whereas the same symbol or label elsewhere may indicate the easiest hike. The comprehensiveness of descriptive elements often differs, even within a single web page. One hike will have elevation gain, surface, time, obstructions, distance, route and other descriptions, while another has minimal information. A system that is too complicated for a hiker may add to anxiety and stress before an activity thus reducing the quality of the leisure experience. A system that is too directive may also lead to a participant's’ perceived freedom being reduced and also have a negative effect on the experience. Arias (2007) finds that the system proposed by Hugo and used in South Africa is very complex, and that putting it into practice is unrealistic. Arias (2007: 5) comments that by developing a standard classification system, potential hikers will be in the position to make “informed decisions about trails that are suitable for them in terms of the required time and fitness level needed.”

> "A classification system is useful to make decisions prior to the visit and the channels used to communicate these systems are as important as the classification system itself. It can be assumed that for someone that wants to plan before visiting the trail, web-based information will be important. However, for someone that is already in the area the information should be provided at the start of the trail. The findings reflect how the description and definitions behind each level are not always available, resulting in ambiguity of the information. This makes it difficult for the user to determine whether the difficulty level assigned to walk will be suitable or not. Thus, information provided on the web or printed material should be available with descriptors." (Arias, 2007: 38.)

Arias illustrates the advantages of a grading system linked to fitness levels that will be of use to potential hikers. To those hikers planning a trip and to those already in the area wishing to make a spur-of-the-moment decision, a trail can be selected that is suitable for the individual at that time. Steyn, Van Niekerk and Jacobs (2014: 211) conveyed a similar need in mountain bike trails when commenting: "By classifying the trails on a more rational basis, the risk of injury and uncertainty can be limited for cyclists because they receive enough information on the difficulty of the trail".

3.10 Energy Expenditure (EE) in Hiking

It has been found that hikers (916.3kcal) and runners (790.2 kcal) experienced a similar net caloric expenditure; and that in comparison to walking, hikers' expenditure was more than 50% that of walkers (450.4 kcal) (Wolf & Wohlfart, 2014). It was notable in Wolf and Wohlfart (2014) that hikers expended greater amounts of energy than runners although the motivation for hiking was not to exercise, but to experience nature. The greater EE was mostly due to hikers hiking for a longer period of time and selecting more difficult tracks than the runners. Self-estimates of EE were significantly underestimated by hikers, suggesting that they were not focusing on the intensity of the PA due to the enjoyment of the hike thus distracting them from physical strain or discomfort. The perceived improvements and joy experienced was considerably higher than the perceived effort (Wolf & Wohlfart, 2014).

As postulated by Collingwood *et al.* (2007), an analysis of the estimated energy cost of hikes can provide additional information on the extent to which health and fitness can be affected by a given hike. They affirm that it is not practical to directly measure one's metabolic rate in oxygen and caloric units when in the field. The ACSM has developed formulas to estimate oxygen consumption for a given PA or workload. In order to obtain an estimate all that is required is knowledge of distance, pace, time, and percent grade (elevation gain). Consequently, Collingwood *et al.* (2007) comment that it is possible to get the energy cost of any individual hike or difficulty category of hikes by making use of the mean distance, time, and percent grade dimensions for a given category. The suggestion made by Collingwood *et al.* (2007) would be suitable for calculating each individual hikers EE and would need to be determined after the hike according to the time and pace at which the hiker walked. This could make for an accurate account of energy spent for that individual. If a large portion of the hike entailed downhill walking then the suggested equation would not be valid due to variations in oxygen demand with differing downhill slopes (ACSM, 2014a). It would, however, not assist in the grading of a hike beforehand. Thus Hugo's EE method is more suitable for determining the difficulty grading of a hike before attempting the route. EE can be calculated by means of a formula supplied by Hoffman (2006): Energy Expenditure (kcal/min) = (METs x 3.5 x body mass) / 200. Hoffman (2006) allocated a MET value of 6 for the average individual whilst hiking.

In a study regarding EE on Ultra endurance Alpine athletes (Bourrilhon *et al*., 2009) the maximal oxygen consumption ($\dot{V}O_{2\,max}$) was measured seven days before the race. Daily EE during exercise was determined through assumption of the rectilinear relationship between HR and $\dot{V}O_2$. Bourrilhon *et al.* (2009) suggest that if one combines various physiological parameter measurements (e.g. motion sensing and HR) the determination of EE in field conditions may be improved. In a study undertaken by Sperlich *et al.* (2010), a single hikers' oxygen uptake, respiratory exchange ratio, and HR were collected throughout an entire hike. Based on these data the active EE was calculated. It was shown that there was an energy deficit at the end of the hike.

GPS devices have been utilised for research in various recreational settings for various reasons. These devices have been used to gather spatio-temporal trip data (Wolf & Wohlfart, 2014), hiker movement patterns (Meijles, Bakker, Groote & Barske, 2014), the spread of invasive plant species and spatial analysis (Van Winkle, 2014) integrating spatial modelling and visitor use (Beeco & Brown, 2013) to estimate time (Zanker *et al.*, 2012; Witt, 2012) and evaluation of recreational trails (Ferguson, 2009; Wimpey, 2009). Wolf and Wohlfart (2014) also made use of a GPS to calculate EE estimations. Energy expenditure per participant was calculated by incorporating gradient, trip distance, and body weight. Other research (Batzorig, Chen, Lin, Chiang, Tan, Davaasambuu & Bilgee, 2012) made use of smartphones in the study to determine EE. It was, however, found that there was a great amount of error with the phone GPS and a number of errors needed to be eliminated in order to accurately calculate EE. The EE was calculated based on the user's height, weight, and gender.

Hiking is performed at a walking pace. High speeds and bursts of speed are not recommended. Akenhead *et al.* (2013) specifically indicate that acceleration of over 4.m/s compromises accuracy when measuring with GPS units. As hiking is done at a leisurely pace and speed is not an issue, the concerns that apply on the sports field are not relevant to this study. Research has proven validity, and the reliability of the GPS estimation increased over longer distances and at slower speeds (Jennings *et al.,* 2010; Akenhead *et al.,* 2013). A concern regarding the use of GPS is that during the data collection process problems may result from the use of GPS devices e.g. partial signal loss due to heavy tree cover (Taczanowska, González, Garcia-Massó, Muhar, Brandenburg & Toca-Herrera, 2014). Ferguson (2009) found that due to dense vegetation and rugged terrain, the hand-held GPS unit that was carried by surveyors in their study was unable to maintain communication with satellites. Similar findings have been reported by Van Winkle (2014) and Petersen *et al*. (2009). Meijles *et al*. (2014) found the greatest limiting factor relating to GPS was the number of units available (due to the financial cost per unit). As a result, the sample sizes are usually restricted.

3.11 Measuring Perceived Exertion Levels

Rate of perceived exertion may be defined as the "subjective intensity of effort, strain, discomfort, and/or fatigue that is experienced during physical exercise" (Robertson & Noble, 1997: 407). Borg (1982) is of the opinion that perceived exertion is the most effective indicator of the amount of physical strain a person is experiencing.

Borg's rating of perceived exertion (RPE) is a psycho-physical tool that is used to assess subjective perception of effort during exercise. Rating of perceived exertion was strongly correlated with HR (r = 0.74, p\0.001) and blood lactate (r = 0.83, p\0.001) (Scherr, Wolfarth, Christle, Pressler, Wagenpfeil & Halle, 2013). Borg's RPE scale was designed to grow linearly with exercise intensity and HR for work on the bicycle ergometer (Borg, 1990). The scale has been translated into many different languages and has become internationally popular and is the most widely used instrument to measure perceived exertion or exercise intensity (Borg, 1990; Chen, Fan & Moe, 2002; Demoulin, Verbunt, Winkens, Knottnerus & Smeets, 2010; Scherr *et al*., 2013; Huanga & Chioub, 2013).

Other measures have been designed to measure perceived exertion. One such scale is the Facial Pictorial Rating of Perceived Exertion Scale (Huanga & Chioub, 2013). The pictorial scale has animated pictures that portray increasing levels of physical exertion through facial expressions. Although it was found that both male and female participants could successfully use the pictorial scale to rate the intensity of activity, it was unclear whether this was due to the animated expression on the picture, the verbal description or the scaled number of the picture. Two other scales have been developed by Borg (Borg, 1982; Borg, 2007). The CR10 scale (Borg, 1982) was developed as a general scale to determine intensity and is rated from 1-10. The CR100 (or ''centiMax'') scale is considered to be a general intensity category scale measured in centiMax units from 0-100 (Borg, 2007).

Rate of perceived exertion have also been researched for their validity as an interpretive tool for children (Huebner, Zhang, McGrath, Therneau & Pianos, 2014). For children, the validity and usefulness of an RPE scale is dependent on various factors such as age, experience, reading ability and conceptual understanding (Faulkner & Eston, 2008). Other scales subsequently developed to measure children's levels of perceived exertion include the PCERT, OMNI Scale, RPE-C and the CALER (Faulkner & Eston, 2008). These and the Adult OMNI Scales have all been based on Borgs RPE scale.

Although other scales have been developed, the most widely used is the scale developed by Borg. This scale is connected with physiological parameters that are measured during exercise such as HR and oxygen consumption (Cakir, Cakir, Erzengin & Kurtel, 2012). It is therefore often used to self-regulate the intensity of training (Paulson, Bishop, Leicht & Goosey-Tolfrey, 2013). The scale has been used in various populations including healthy populations (Diafas, Chrysikopoulos, Diamanti, Bachev,Kaloupsis, Polykratis & Villiotis, 2007) the disabled (Paulson *et al*., 2013), clinical populations (Demoulin *et al*., 2010) and fit and unfit persons (Cakir *et al*., 2012). Another positive aspect regarding Borg's scale is that RPE is not influenced by gender (Scherr *et al.,* 2013).

The scale is a 15-point scale that ranges from no exertion at all to maximal exertion. The participant rates their exertion level either during the activity or after the activity has taken place. Figure 6 depicts Borg's scale.

6	No exertion at all
7	
	Extremely light
8	
9	Very light
10	
11	Light
12	
13	Somewhat hard
14	
15	Hard (heavy)
16	
17	Very hard
18	
19	Extremely hard
20	Maximal exertion

Figure 6: Borg Scale (Rating of Perceived Exertion- RPE) (Borg, 1982: 378)

Perceived physical effort has been determined during several outdoor and hiking studies. Wolf and Wohlfart (2014) administered a post-experience questionnaire to ascertain the level of enjoyment of health and wellbeing outcomes and the perceived physical effort. Perrey and Fabre (2008) made use of Borg's scale and found that the RPE was significantly greater during uphill and with load carriage. Faghy and Brown (2014) as well as Manning *et al*. (2015) recently made use of the Borg scale to determine perceived exertion in their studies.

The scale has received criticism as the literature regarding Borg' s RPE scale has shown inconsistencies in the strength of the relationship between ratings of perceived exertion and various physiological criterion measures, such as HR, blood lactate concentration, percent maximal oxygen uptake (% $\dot{V}O_{2\,max}$), oxygen uptake ($\dot{V}O_2$), ventilation and respiration rate (Chen *et al*., 2002). However, other studies maintain that the use of the scale is valid (e.g. Diafas *et al*., 2007). In fact, Scherr *et al*. (2013) felt that the current validity statements have been underestimated, and that validity is higher than originally reported. Borresen and Lambert (2009) indicate that additional research should be done to determine the physiological mechanisms behind the cognitive perception of effort in order to use RPE more accurately. Although Borg (Borg, 1982) developed an alternative scale more recently (the CR-10), he is of the opinion that the different scales should be used for different purposes. Borg suggested that the initial RPE scale is most suitable for "simple applied studies of perceived exertion, for exercise testing, and for predictions and prescriptions of exercise intensities in sports and medical rehabilitation" (Borg, 1982: 380).

3.12 Physical Fitness and Hiking

3.12.1 Fitness Requirements

In order to experience a quality hiking excursion, it would be best for a potential hiker to be in the correct physical condition for the intended hike (Mason *et al*., 2013; Green, 2015). It was found that hikers taking shorter trips (less than 12 hours) were less prepared than those taking longer trips (Mason *et al*., 2013). Green (2015: S6) advocates that the more information one can obtain before the trip, the better able one will be to "prepare for all eventualities and decrease risk". Green suggests that the general physical fitness level should be ascertained through estimated METS. He concedes that this will, however, not take elements like altitude into consideration and suggests that there should be some training that takes place (approximately of 6 weeks duration) and that the environmental conditions should be simulated as closely as possible. Mason *et al*. (2013) also comment that there is a link between well-prepared hikers and experience and fitness levels.

The fitness requirements of hikers are not adequately addressed in the literature. Contemporary literature concerning fitness and outdoor activities seems to focus on at-risk populations (Burtscher & Ponchia, 2010; Lee & Lee, 2014; Gatterer, Raab, Pramsohler, Faulhaber, Burtscher & Netzer, 2015; Gutwenger, Hofer, Gutwenger, Sandri & Wiedermann, 2015) and studies on children PA and outdoor play (Mc Manus & Mellecker, 2012; Schaefer, Plotnikoff, Majumdar, Mollard, Woo, Sadman, Rinaldi, Boulé, Torrance, Ball, Veugelers, Wozny, McCargar, Downs, Lewanczuk, Gleddie & McGavock, 2014; Stone & Faulkner, 2014).

In some hiking difficulty ratings, a reference is made to the need for fitness. Descriptive phrases are used such as “someone in fair hiking condition” (Northwest Hiker, 2014), “in good physical shape” (The Norwegian Trekking Association, n.d.), “high level of fitness” (irishtrails.ie, n.d.) and “reasonable standard of fitness required” (Hiking New Zealand, 2016a). What hiking fitness entails, and how to measure such fitness are not addressed in the literature or on any of the websites investigated. This measure of fitness is therefore subjective and somewhat misleading as each potential hiker will evaluate him/herself differently.

Some level of fitness is no doubt required to complete and enjoy a trail that includes some change in terrain. “Easy” hikes, however, are assumed to be less physically taxing, and should be able to be enjoyed by someone lacking in physical fitness. Participants should be able to determine what fitness requirements are needed before participating in a hike. This could enhance enjoyment levels, reduce risks and injuries as well as increase participation and chances of experiencing flow. Three-quarters of respondents in Slabbert’s (2015) survey of South African hikers and potential hikers indicated that their current state of health, fitness or physical abilities were of the top five reasons for not engaging in overnight hiking. Furthermore, it was reported that information regarding the effort associated with hiking was most important for the participants in the study. Not only the grading of the trail is seen as important, but also the level at which the participant will be able to comfortably complete the hike (fitness level) would contribute to increasing the level of participation in hiking.

Hofmann and Tschakert (2011) suggest that individual exercise prescriptions should be made for each individual. This can only be determined through an objective evaluation of the person's response to exercise. They continue by adding that the large range of intensities that are described in guidelines make the choice of an intensity level more difficult for each individual.

The resting HR of most individuals is approximately 60 to 80 bpm (Kenney, Wilmore & Costill, 2015; McArdle, Katch & Katch, 1994). When performing PA, the HR of the participant will increase. The increase is determined by the intensity of the PA. Target heart rates are often used to determine at what intensity the participant is exerting him/herself during PA. In order for a hiker to determine their estimated maximal HR the following formula could be used: Estimated maximum HR = 220-age (ACSM, 2014b; Kenney *et al*., 2015). By using this formula, the maximum limit of hiker exertion could be determined. This is an estimate of a value achieved when an individual is at maximal exertion to the point of volitional fatigue (Kenney *et al*., 2015). It is assumed that a hiker would not often reach this point, as a hike is taken for leisure purposes. There would be occasions, such as a steep ascent, where the maximum HR could be reached. The probable intensity that a hiker will walk could be moderate 40%-<60% of maximum HR (ACSM, 2014a) for an easy hike, and vigorous 60%-<90% of maximum (ACSM, 2014a) for a moderate and difficult hike. In order to determine what the HR would be in this zone the maximum HR is determined and multiplied by the percentage. Thus the HR would differ in relation to age and be lower the older the participant. An exercise HR of 70% maximum represents only moderate exercise that can be continued for long duration with little or no physiological discomfort (McArdle *et al*, 1994). This is often referred to as conversational exercise, and is likely to occur at a hiking pace at the more challenging parts of a hiking trail.

The most accurate way to determine the target HR is the HR reserve (or Karvonen method) (da Cunha, de Tarso Veras Farinatti & Midgley, 2011; ACSM, 2014b) this is most accurate when an incremental test to determine the maximum HR is performed.

Kenney *et al*. (2015) compare different methods of classifying exercise intensity. This is represented in Table 3 below. Norton, Norton and Sadgrove (2010) provide a more comprehensive table that includes METS, HR reserve, maximum HR, $\dot{V}O_{2\,max}$, subjective measure and descriptive measures. It is interesting to note the differences in maximum HR that are given by Norton *et al*. (2010) in comparison with Kenney *et al*. (2015). For the light category Norton *et al*. (2010) give a 40<55% of the maximum HR. For Moderate intensity 55-<70% is given and for vigorous intensity 70-<90% is given. The high category (comparable to Kenney *et al*.'s near maximal) ≥90% is given. The RPE as a subjective measure also differs between the researchers with RPE scores of Norton *et al*. (2010) being lower in each category. The Norton *et al*. (2010) classifications have been included with Kenney *et al*.'s (2015) classifications in a combined table (Table 3).

Table 3: **Classification of Exercise Intensity** (Norton, Norton & Sadgrove, 2010; Kenney, Wilmore & Costill, 2015)

Classification of Intensity		**Maximum HR**		**RPE**	
Kenney *et al*.	Norton *et al*.	Kenney *et al*.	Norton *et al*.	Kenney *et al*.	Norton *et al*.
Light	Light	57-64%	40<55%	9-11	8-10
Moderate	Moderate	64-76%	55-<70%	12-13	11-13
Vigorous	Vigorous	76-96	70-<90%	14-17	14-16
Near maximal	High	≥96%	≥90%	≥18	≥17

Hofmann and Tschakert (2011) however are of the opinion that maximum HR or $\dot{V}O_{2\,max}$ are not suitable for the upper limits of exercise. When looking at the upper limits of target HR, thresholds should be considered. They suggest that the lactate turn point be used for this determination. This suggestion is valid for training studies, but as hiking is not done at the upper limit of HR, this would not be necessary for most hiking trails.

Risks are associated when the intensity of an activity surpasses the individual's capacity for the exercise (Norton *et al*., 2010). High-intensity activities are seen as important for young and conditioned athletes and should only be recommended after a period of conditioning (Norton *et al*., 2010).

3.12.2 Measurement of Fitness of Hikers

As previously established, there are many ways to determine the fitness of an individual. These include both direct and indirect testing. The $\dot{V}O_{2\,max}$, a direct test, is considered the standard test to determine maximal oxygen uptake implying that the true physiological limit has been reached and a plateau of $\dot{V}O_2$ is observed (ACSM, 2014a). Indirect testing has primarily been done to predict $\dot{V}O_{2\,max}$ from the HR workload relationship. Tests can be performed in various modes, including field tests, treadmills, cycle ergometers and step tests (ACSM, 2014a). What methods are appropriate for hikers? Hikers are not athletes, and as such cannot be tested to their extremes. Many who participate on hikes do not train beforehand, although this has been indicated by some researchers as important (Schurman & Schurman, 2009; Green, 2015).

3.12.2.1 $\dot{V}O_{2\,max}$

Testing the fitness of a hiker could be done by means of a $\dot{V}O_{2\,max}$. There are, however, some limitations to this type of testing. The hiker being tested would need to be able to attain a $\dot{V}O_{2\,max}$ without fatiguing first or being limited by other musculoskeletal impairment or problems for the results to be valid. In addition, a high degree of motivation is required by the participant (Noonan & Dean, 2000). Few participants reach a true $\dot{V}O_{2\,max}$ and values that are obtained are the $\dot{V}O_{2\,peak}$ (Noonan & Dean, 2000). As hiking is based on walking, utilising a cycle ergometer will not be appropriate, although using a treadmill protocol would be more relevant. Some hikers may be able to reach a $\dot{V}O_{2\,max}$ using an inclined protocol. This would be the test that would fit the hiking activity requirements best.

A submaximal test may, however, be the most suitable for the general hiking population. The Cooper run/walk Test is a submaximal test where the individual covers as great a distance as they feel they possibly can within a 12 -minute time limit (ACSM, 2014a). The individual is instructed to cover the distance by preferably running, but walking if necessary, to prevent becoming exhausted. Once the 12-minute time limit has elapsed the distance covered is measured to the closest 50m. The individual continues to walk at the completion of the test to cool down. From the distance covered an estimate of the $\dot{V}O_{2\,max}$ can be calculated by means of the following formula:

$\dot{V}O_{2\,max}$ = 0.0268 (distance covered) – 11.3 (Hoffman, 2006).

or

$\dot{V}O_{2\,max}$ (ml·kg-1·min-1) = (Distance (km)-0.505)/0.04477 (Beam & Adams, 2011).

Percentile ranks are then given in a table format to determine where the individual lies. Different ranks are given for male and female participants (Appendix A). Helpful websites can be used where the formulae are present and an individual can simply select his/her age category and distance covered and the calculation is automatically performed, making it very user friendly to the participant. (Mackenzie, 1997).

3.12.2.2 Step-up Tests

Various step-up tests are available to determine the fitness levels of participants. A step-up test created specifically for hikers by De Villiers and Thiart (1988) could be considered for the hiking population. With this step-up test bench height and step frequency was adjusted according to body mass. The aim was to determine an applicable submaximal workload which would be within the capabilities of the average individual. Making use of the bench height, body mass and step frequency, the workload was determined. With repeated tests De Villiers and Thiart (1988) recommended a workload of 76 watts. Based on the results of the step tests, and for every person to do the same “driving force” a specific bench height and /or step frequency would be needed for each hiker. For practical reasons, body mass was divided into interval groups to make the differences non-significant. Small adaptions were made on the heart rhythm scales to compensate for driving force above and under 76 watts. On the basis of the exercise heart rates, five categories were proposed, namely; very good, good, average, poor and very poor. These categories enable the hikers to enjoy the hiking experience without undue fatigue. Therefore, hikers can be grouped according to their HR on a heart rhythm scale. Table 4 presents the Step-up Test proposed by De Villiers and Thiart (1988) and Table 5 the heart rhythm scale for prospective hikers.

Table 4: Step-up Test (De Villiers and Thiart, 1988: 40)

Mass (kg)	Power (watt)	Step-up Height and Frequency
40	74	38 cm $30 \cdot min^{-1}$
45	84	
50	93	
51	63	38 cm $20 \cdot min^{-1}$
55	68	
60	74	
65	81	
70	87	
71	70	30 cm $20 \cdot min^{-1}$
75	73	
80	78	
85	83	
90	88	
91	74	25 cm $20 \cdot min^{-1}$
95	78	
100	82	
105	86	

Under 50kg	Bench 38 cm x 30 $steps \cdot minute^{-1}$
51kg to 70 kg	Bench 38 cm x 20 $steps \cdot minute^{-1}$
71kg to 90kg	Bench 30 cm x 20 $steps \cdot minute^{-1}$
Above 91kg	Bench 25 cm x 20 $steps \cdot minute^{-1}$

1. Step for five minutes at the determined tempo.
   Legs and upper body must be fully extended with each step-up.

2.1 On the five-minute mark sit on a chair immediately. Wait for 30 seconds and count HR from 30 seconds to 1 minute = HR (a).

2.2 Sit and wait until 2 minutes after exercise is suspended and count HR for 30 seconds, in other words from 2 to 2 ½ minutes = HR (b)

2.3 Add (a) and (b) together = $HR \cdot minute^{-1}$ (c)

Table 5: Heart Rate Scale (De Villiers & Thiart, 1988: 41)

Mass (kg)	Heart rate (beats·min^{-1})				
	Very Good (1)	**Good (2)**	**Average (3)**	**Poor (4)**	**Very Poor (5)**
<40	<76	77 – 92	93 – 113	114 – 128	129 – 139
41 – 45	<81	82 – 97	98 – 116	117 – 130	131 – 141
46 – 50	<86	87 – 102	103 – 118	119 – 138	139 – 149
51 – 55	<73	74 – 90	91 – 111	112 – 126	127 – 137
56 – 60	<76	77 – 92	93 – 113	114 – 128	129 – 139
61 – 65	<79	80 – 96	97 – 116	117 – 130	131 – 141
66 – 70	<83	84 – 100	101 – 118	119 – 133	134 – 144
71 – 75	<76	77 – 92	93 – 113	114 – 12	129 – 139
76 – 80	<79	80 – 94	95 – 116	117 – 130	131 – 141
81 – 85	<81	82 – 97	98 – 118	119 – 133	134 – 144
86 – 90	<84	85 – 100	101 – 121	122 – 136	137 – 147
91 – 95	<76	77 – 92	93 – 113	114 – 128	129 – 139
96 – 100	<80	81 – 95	96 – 116	117 – 130	131 – 141
101 – 105	<83	84 – 97	98 – 118	119 – 133	134 – 144
105>	<86	87 – 102	103 – 123	124 – 138	139 – 149

> = More than; < = Less than

3.12.2.3 Questionnaires

A self-report questionnaire (for instance the IPAQ) could also possibly be used to determine PA levels of a hiker. In response to the global demand for comparable and valid measures of PA within and between countries an international consensus group developed the IPAQ for surveillance activities, and to guide policy development related to health-enhancing PA across various life domains. Several versions of the IPAQ were developed. This included a long and short version that could be self-administered or administered by interview/telephone to young and middle-aged adults (15-69 years), to monitor their activity habits over the previous 7 days (Craig *et al*., 2003; IPAQ, 2005; Macfarlane, Lee, Ho, Chan & Chan, 2007). Standard methods were used to translate and adapt the questionnaires for use in different countries (Craig *et al*., 2003). A 12-country reliability and validity study found that the IPAQ instruments can collect valid and reliable PA data. South Africa was included in this data collection process. One of the IPAQ strengths is that it was tested in both developed and developing countries, and still maintained acceptable reliability and validity results with correlations of 0.80 for reliability and 0.30 for validity (Craig *et al.*, 2003).

Research conducted in South Africa using the IPAQ reports that the long IPAQ was found to be a comprehensive tool containing information about activities conducted on a weekly basis in household and yard-work contexts, transport, occupational activity, leisure time PA and sedentary behaviour (Lambert & Kolbe-Alexander, 2006). This report on the chronic lifestyle diseases in South Africa stated that the IPAQ “has been validated for use in the South Africa population” (Lambert & Kolbe-Alexander, 2006: 26).

Some concerns have been raised on the unreliability of self-reports, especially those pertaining to housework and occupational PA (Hallal *et al*., 2012). The scoring protocol states “asking more detailed questions regarding physical activity within domains is likely to produce higher prevalence estimates than the more generic IPAQ short form” (IPAQ 2005: 6). The long form of the IPAQ asks detailed questions about walking, and moderate-intensity to vigorous-intensity PA in each of the four domains. A cautionary remark from Pardo, Román-Vi˜nas, Ribas-Barba, Roure, Vallbona and Serra-Majem (2014) refers to some difficulties which were experienced by respondents in their study. Respondents had difficulties distinguishing between vigorous and moderate activities. A further warning regarding the IPAQ is that it can be considered a useful screening tool, but should not be utilised if a precise level of PA is required (Fillipas, Cicuttini, Holland & Cherry, 2010).

Overall, the IPAQ questionnaires produced repeatable data (Spearman's rho clustered around 0.8), with comparable data from short and long forms. Criterion validity had a median rho of about 0.30, which was comparable to most other self-report validation studies. The "usual week" and "last 7 days" reference periods performed similarly, and the reliability of telephone administration was similar to that of the self-administered mode (Craig *et al*., 2003: 1381-1395).

Characteristics of the IPAQ short form are summarized as follows:

PA is assessed according to:

- Walking
- Moderate-intensity activities
- Vigorous-intensity activities

Separate scores are calculated (median values and interquartile ranges) for walking, moderate intensity and vigorous intensity activity. Calculation of the total score requires the sum total of the duration (in minutes) and frequency (days) of walking, moderate intensity and vigorous intensity activities. Domain-specific estimates cannot be determined. All continuous scores are expressed in MET-minutes/week (IPAQ, 2005).

The IPAQ is scored in three categories ranging from low to high:

Category 1: Low

This is the lowest level of PA. Individuals who do not meet criteria for categories 2 or 3 are considered to have a ‘low’ PA level.

Category 2: Moderate

To be classified as ‘moderate’ either of the following criteria need to be met, namely:

- 3 or more days of vigorous-intensity activity of at least 20 minutes per day,

OR

- 5 or more days of moderate-intensity activity and/or walking of at least 30 minutes per day,

OR

- 5 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum total PA of at least 600 MET-minutes/week.

Individuals meeting at least one of the above criteria would be defined as accumulating a minimum level of activity and therefore be classified as ‘moderate’.

Category 3: High

The third category labelled ‘high’ can be calculated to describe higher levels of participation. The two criteria for classification as ‘high’ are:

- Vigorous-intensity activity on at least 3 days achieving a minimum PA of at least 1500 MET-minutes/week,

OR

- 7 or more days of any combination of walking, moderate-intensity or vigorous-intensity activities achieving a minimum total PA of at least 3000 MET-minutes/week (IPAQ, 2005).

3.13 Grading Systems and Fitness Levels

Certain grading systems (e.g. Table 2) describe the desired fitness level required to complete a given hike. For instance, the requirements for hikers in the Pacific Northwest are described as someone in fair/good/excellent/exceptional hiking condition. In Ireland “moderate level of fitness”, “a high level of fitness” and “suitable only for very fit” terms are used. In New Zealand a description of “Reasonable standard of fitness required” is given as an example. No information is, however, given about the basis of this description or how to determine the condition of the hiker. Additional information on grading and fitness is often lacking such as “Fitness is subjective, what you may find easy may be strenuous to someone else or vice versa” (Hiking New Zealand. 2016b).

Hugo *et al*. (1998/99) argue that an experienced hiker will be able to use the kCal grading to determine if they will be able to do a specific trail. Novice hikers can take an easier graded hike first to determine or assess their individual physical capability and thereafter judge what they will be able to cope with. Alternatively, it is suggested that testing can be done in a gymnasium to determine if the hiker is fit enough for the trail that is planned. It is suggested that hikers could be tested in terms of “the total energy cost for the trail as well as their fitness for the most difficult (highest energy expenditure) sections along the route” Hugo *et al.* (1998/99: 53).

Hugo *et al.* (1998/99) concede that physical fitness is not the only factor that determines if a trail will be completed successfully. Other factors come into play as well. They identify temperature and humidity, altitude and the surface of the walking conditions as well as psychological factors such as companions. As these factors can change for each attempted hike, it is difficult to factor them into a grading system. They contend that the difficulty level is the most important factor. The question however arises about how to determine the required fitness levels linked to the difficulty level.

4. CONCLUSION

Physical inactivity levels are escalating, leaving society with many burdens that are associated with inactivity, including, but not limited to coronary heart disease, type 2 diabetes and certain types of cancer. With the current need to increase PA it is useful to look at various alternatives that could encourage participation. Physical activity not only includes exercise but also includes general increase in body movement. Hiking is seen as an appropriate recreation activity to increase PA. For some this may include the hike only, for others this will include necessary preparation to ensure correct levels of fitness before undertaking a hiking experience. Through hiking it may be possible to achieve the minimum amount of prescribed PA recommended by the WHO. The achievement of increasing PA leads to numerous benefits. These can be classified under: physical, cognitive, psychological and social. The benefits that can accrue under each of these headings are numerous and well known, yet low PA levels is a universal concern. Participation in physical leisure activities is seen as a good way to increase PA as the activities chosen are done according to personal needs, interests and motivation.

Hiking is seen as a PA that takes place in natural areas with a duration of a few hours to a couple of days. Hiking in the South African context generally means moving to an area away from the usual place of residence. Hiking makes a contribution to the tourism industry. Tourism is important for the South African economy, not only due to the monetary contribution of tourists, but also providing employment to many. There are not many perceived negative aspects to hiking. The main concern is the possible detrimental impact on the natural environment. Another concern is the physical risk that the activity holds for the participant. Hiking is, however, generally considered less risky than many other outdoor activities and many, if not most, risks can be avoided with proper preparation. The benefits of hiking tend to outweigh the possible negative aspects. The motivation and psychological benefits of being in the outdoors, in conjunction with the benefits of PA make for a valuable combination. The advantages are numerous as the benefits of participating in PA along with the numerous benefits of being outdoors are merged during hiking. Thus hikers gain social, physical, aesthetic and numerous psychological benefits. The psychological benefits may be divided into general psychological benefits, attention restoration, stress reduction and experiencing flow.

Research perspectives differ with regard to the physical demands of hiking. Some researchers refer to a low intensity form of exercise, others to moderate intensity. The problem may be ascribed to diverse measurement methods of PA as well as the accessibility of these methods. Various methods to measure PA are available, including devices such as accelerometers and pedometers, GPS systems and self-report questionnaires like the IPAQ.

To complicate matters, diverse variables can influence the physical demands of hiking. Weather conditions, the type of surface or terrain, the weight of the backpack must all be taken into consideration when undertaking a hike. The grade of the hike and linked difficulty level will also influence the hiking experience. Knowledge of the difficulty levels and related fitness requirements is important information which will improve the experience.

Worldwide hiking trail grading systems differ and the majority are subjective. Different variables are used (duration, elevation, EE, descriptive characteristics, distance) in these grading systems which make comparison of trails and application of findings to individual hikers very difficult. A diverse array of interlinked variables will differ from hike to hike as well as from person to person. Consequently, one variable cannot be viewed in isolation. For instance, the length of the hike, extremes of temperature, and varying terrain will influence fatigue levels which will in turn influence walking speed. It is not possible to factor in each possible variable into a grading system (e.g. weather) as this does not remain constant.

The grading of a hike according to Hugo's energy method is, however, constant as it utilises unchanging variables. Changing variables such as temperature, wind and pack load for instance are not factored into Hugo's energy method due to their ever changing nature. The altitude of the points along the trail, as well as the distance of the trail result in the expected EE of the average hiker remaining constant. These elements are important for grading a trail and can be determined before the hike takes place. An individual's pre-hike fitness will also not differ markedly within a short period of time before or during the hike. This is also an aspect that can be determined beforehand and may have an effect on the hiker. The aspect of fitness will, however, not impact the grading, as each individual attempting the hike will score differently. Determining the fitness of the hiker will supplement the grading as the potential hiker will be able to factor this into the grading to see where his/her capabilities lie.

The fitness levels of hikers remain a key factor irrespective of the grading system used. If a simple method to ascertain the fitness levels of potential hikers can be devised and applied to a graded hiking trail, potential hikers can make the right decision according to their own personal needs and in this way optimise the chances of a flow experience occurring during the hiking activity.

Chapter 3

Methodology

1. INTRODUCTION

This chapter will describe the research protocol used to underpin data collection to achieve the aims stated in Chapter 1. A description of the research approach, the participants, the geographical area where the study was conducted, all instruments and methods used as well as more detailed information on data processing and analysis will be given. In preparation for this study, literature was collected from electronic databases such as Kovsiekat, Pubmed, EbscoHost, ScienceDirect. Relevant academic journals and textbooks were consulted to inform methodological considerations.

2. STUDY DESIGN

The research design forms the "blue print" of the study, and determines the methodology used to obtain sources of information. These sources include participants, elements and units of analysis, collection and analysis of data, and interpretation of the results (Brink, van der Walt & van Rensburg, 2012).

In this study a Prospective Descriptive design was used. Quantitative methods were utilised where theoretical and practical findings test theoretical assumptions and develop new theory. The research included instruments from quasi-experimental tests (functional tests- GPS measurements, Step-up Test, Cooper Test), scales (Borg scale, RPE) and questionnaires (IPAQ). Figure 7 is a graphic representation of the approach that is pursued in this research study.

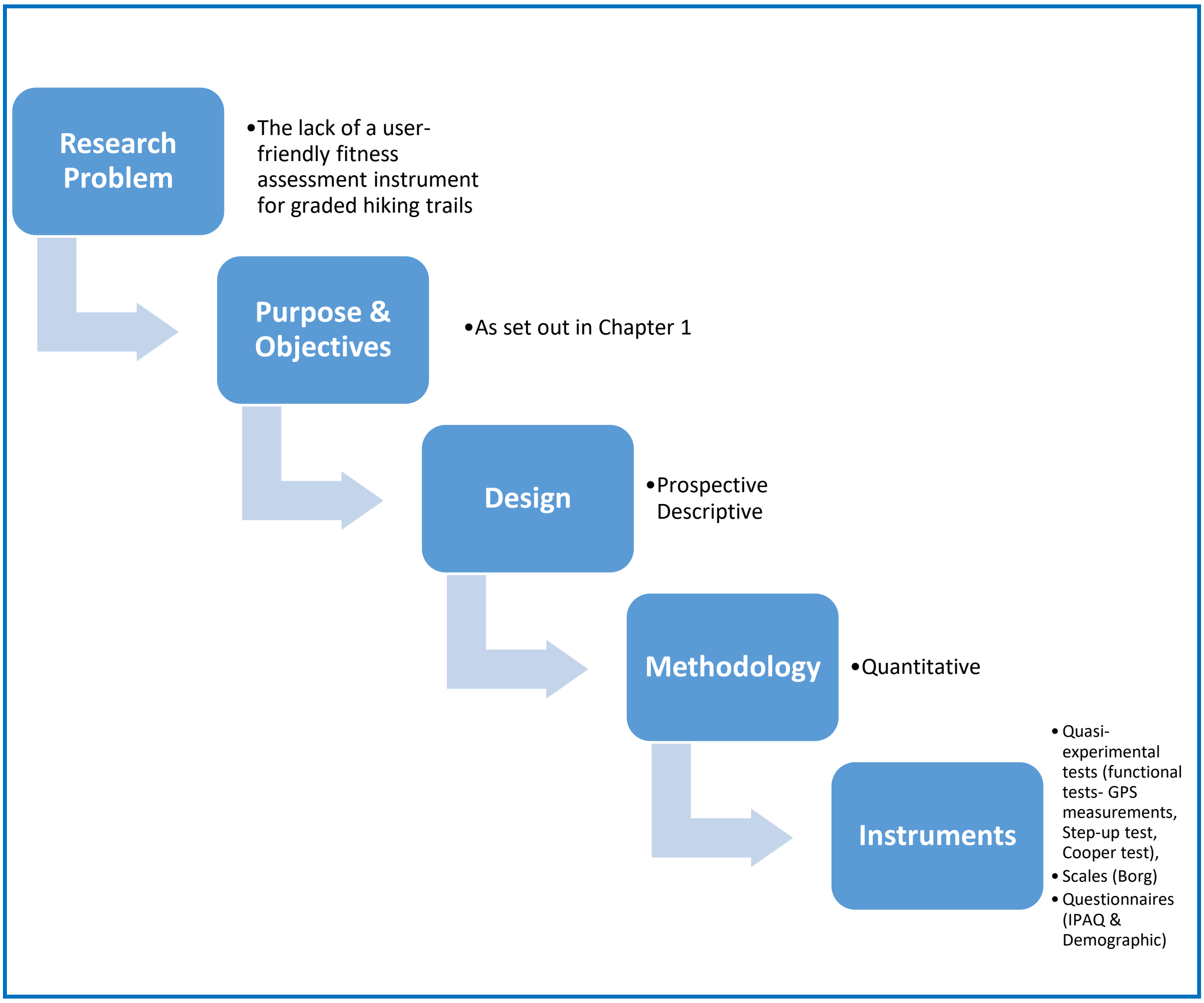

Figure 7: Graphic Representation of the Study's Approach

In summary, it is important to mention that the quantitative results from the study aim to provide a solution to the research problem and the results will offer valuable information regarding the clarification of the objectives of the study. If a hiker's fitness levels can be established in a user-friendly way before selecting a hike, this may reduce discomfort and increase both enjoyment and participation levels. Furthermore, this information could be used to make a valuable contribution to the overall hiking industry both in South Africa, and internationally.

3. STUDY PARTICIPANTS

Participants were initially recruited from the Free State division of the Mountain Club South Africa and the Bloemfontein Hiking Club, and other persons intending on undertaking a hike (through word of mouth). Hiking clubs were contacted and information regarding the study given to the chairpersons of the clubs. This information was forwarded to members within the clubs. The researcher also attended club meetings where the aim of the study and the requirements for participation were explained, whereafter a letter of invitation was sent to all members (Appendix B). Members were asked to consider volunteering. Other hikers, who were not members of the clubs, heard about the study and availed themselves to participate. This included a group of participants who considered taking part in a multi-day hike to be offered by their organisation at a later stage because they wanted to gauge their fitness levels. A similar procedure was undertaken with the employee-wellness representative from the organisation, as was done with the chairpersons of the clubs after the researcher was contacted by the wellness representative. Participants intending to take this hike were informed of the study and were asked to consider volunteering (Appendix C). After possible participants contacted the researcher an information sheet (Appendix D) that contained more details on the research process was sent to participants.

3.1 General Inclusion Criteria

- Participants needed to be healthy, physically active and without presence of any multiple risk factors.
- Ages between 18 – 69 years.
- Hikers (irrespective of club-membership status) and prospective hikers.
- Willing and capable to do an easy and a moderate graded hike.
- The participant needed to give informed consent.
- Willing and capable of doing a Step-up Test and anthropometry testing.
- Willing and capable of doing a Cooper 12-minute run/walk test.

3.2 General Exclusion Criteria

- Participants younger than 18 years and older than 69 years.
- Participants who could not give informed consent.
- Participants who were not willing and capable of doing a Step-up Test and anthropometry testing.
- Participants who were not willing and capable of doing a Cooper 12-minute walk/run test.
- Participants who reported multiple risk factors (as per ACSM, 2014)

3.3 Sample

Due to the cumbersome nature of the testing (questionnaires, fitness and hiking trail testing), all members of hiking clubs in the Bloemfontein area were approached to participate in the study. Participants that were not part of clubs but were intending on going on a hike, were also invited to participate in the study. A convenience sample was selected based on the general inclusion and exclusion criteria as stated previously. Many previous studies on hiking have made use of the convenience sampling method (Collingwood *et al*., 2007; Rodrigues *et al*., 2010; Mason *et al*., 2013; Kil *et al*., 2014; Wolf & Wohlfart, 2014; Nordbø & Prebensen, 2015). All participants who indicated their willingness to participate and fell into the inclusion criteria, were selected. These participants were either intending on taking Hike 2 (as a scheduled hike) or intending on going on a hiking excursion.

4. PROCEDURES AND INSTRUMENTATION

4.1 Structure of Methodology

The structure and order of the methodology followed in this study is graphically represented in Figure 8.

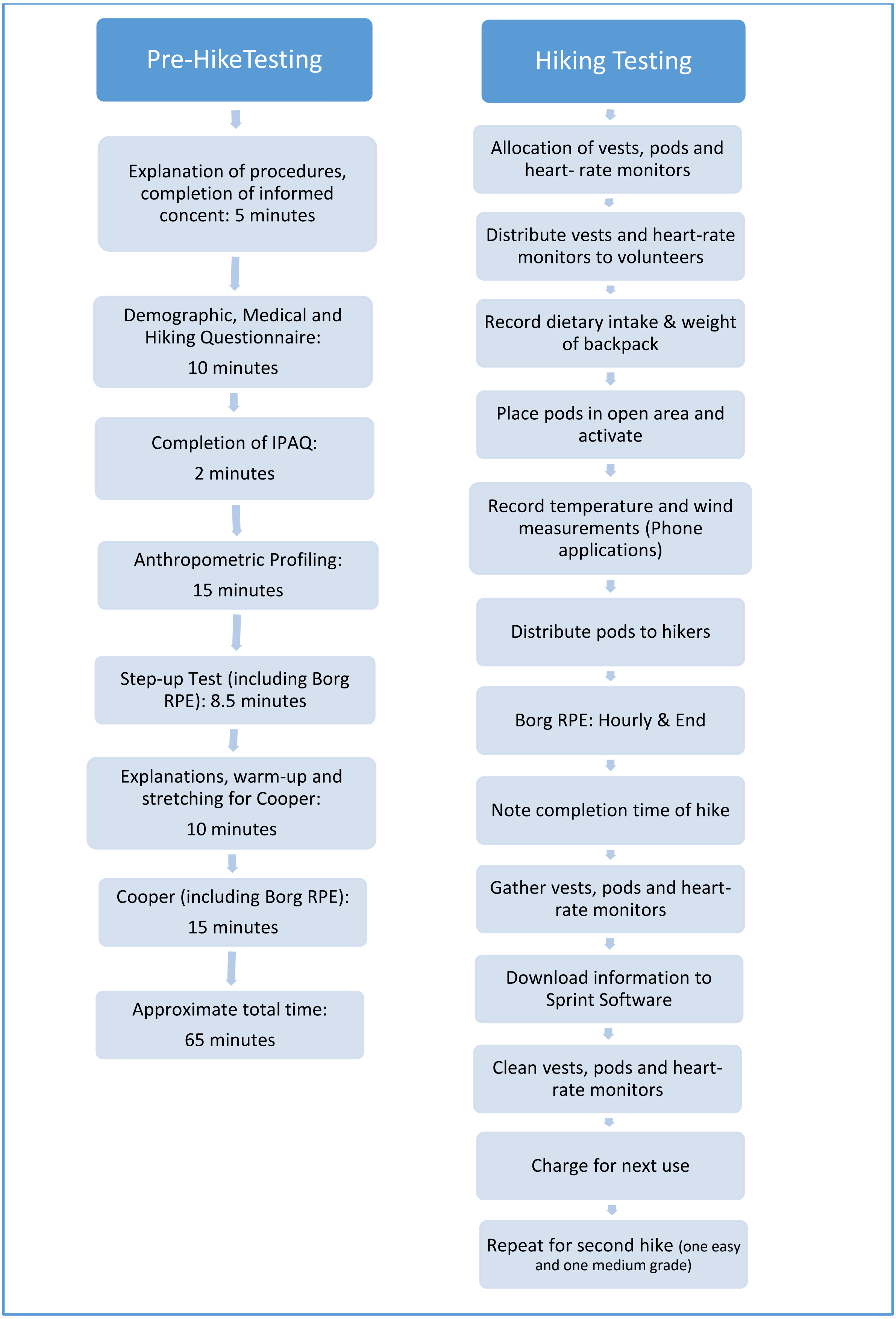

Figure 8: Schematic Summary of the Structure and Order of the Methodology Followed for Testing Procedures

4.2 Questionnaires and Fitness Testing

4.2.1 Informed Consent (Appendix E) and Demographic, Medical and Hiking Questionnaire (Appendix F)

The goal of the study and the procedures that were to be followed were explained to all the participants. Before the study commenced, each participant was asked to read an information sheet and sign a consent form. Information regarding the pre-hiking testing procedures and the nature of the respective questionnaires was explained, as depicted in step one in Figure 8. Participants were given an opportunity to ask any questions regarding the study and procedures that were to be followed.

Once the informed consent form had been filled in, the participants were requested to complete the Demographic, Medical and Hiking Questionnaire. The medical screening section of the questionnaire was based on the ACSM screening tool (ACSM, 2014a). The demographic section of the questionnaire was used to gain information regarding the hiker in terms of age, gender ethnicity etc. in order to gather information for objective 1 of profiling the hikers. The medical section of the questionnaire served to screen hikers for multiple risk factors. The ACSM (2014) guidelines were followed that state if multiple risk factors are present, a participant should consider consulting with their physician prior to participation. If multiple risk factors were indicated the participant would be asked to consult with a physician. The hiking section was used to gather additional information on participants to profile hikers as per objective 1. Data was collected and summarised in excel for the calculation of frequencies and corresponding percentages.

4.2.2 The International Physical Activity Questionnaire (IPAQ) (Appendix G)

After the demographic, medical and hiking questionnaires were completed, participants were asked to complete the IPAQ (Craig *et al*., 2003). Participants were encouraged to ask questions to ensure that all areas of the questionnaire were clearly understood

The IPAQ was administered in order to determine the self-reported PA of the hiker. The IPAQ, as a PA questionnaire, does not provide an absolute measure of the EE but allows for estimation and grouping or ranking of the individual being tested (Kriska & Bennett, 1992).

The short form of the IPAQ was used for the purpose of this study. The reason for using the short version is because it is more widely used, it can be administrated inexpensively and would not be time consuming, as suggested by the ACSM (2014b). The long form of the IPAQ is much more extensive and time consuming. The short form would prove easier and more convenient for a hiker to complete before selecting a hiking route, especially if the decision is to be made at the hiking site.

As the IPAQ has been validated for the age group 18-69, the same age categories were used as inclusion criteria for this study.

The IPAQ was included in the study to determine if the calculation of a hikers PA could be used to determine the hikers' ability to complete the hike.

4.2.3 Anthropometric Profiling (Appendix H)

Following the completion of the IPAQ, anthropometric measurements were captured. Errors were minimised by conforming to set protocol. The Restricted profile as described by the International Standards for Anthropometric Assessment (ISAK) (Marfell-Jones *et al.,* 2006) was used to obtain the anthropometric profile of each participant.

4.2.3.1 Basic Measurements

Mass was measured using a calibrated electronic scale (Seca electronic scale, Delta Surgical South Africa (Pty) Ltd.) The participants wore only minimum or light clothing and were barefoot. The mass measurement was recorded to the nearest 0.1kg (Heyward, 2006).

The standing height was measured by using a stadiometer. The scoring recorded the maximum distance between the vertex and the soles of the feet measured in centimetres (cm). Participants were requested to remove their shoes and socks before measurement commenced. Their arms were placed at their sides in a relaxed position. The back of the head, scapula, upper back, gluteus maximus, calves and calcaneus had to be in contact with the stadiometer. From the lateral view, the ear, acromiom, greater trochanter, back of patella and front of calcaneus needed to be aligned in vertical line. The Frankfort plane was then attained. As soon as the above alignments were achieved, the participants were instructed to look ahead and inhale. The stadiometer was placed on the highest point of the skull. The measurement was then recorded before the subject exhaled (Marfell-Jones *et al.,* 2006).

4.2.3.2 Skin Folds

The measurement technique followed the guidelines of the International Standards for Anthropometric Assessment (Marfell-Jones *et al.,* 2006). The following skinfold measurements were performed on each subject:

- Triceps:

  Definition: The most posterior part of the Triceps when viewed from the side at the marked Mid-acromiale-radiale level.

  Subject position: When marking the sites for the Triceps skinfold the subject assumed the anatomical position.

  Location: The Triceps skinfold site is marked over the most posterior part of the Triceps when viewed from the side at the marked Mid-acromiale-radiale level.

  Skinfold: Measurement taken parallel to the long axis of the arm at the Triceps skinfold site.

- Subscapular

  Definition: The site 2 cm along a line running laterally and obliquely downward from the Subscapular landmark at a 45° angle.

  Subject position: The subject assumed a relaxed standing position with the arms hanging by the sides.

  Location: Using a tape measure the point 2 cm from the Subscapular in a line 45° laterally downward was located.

  Skinfold: Measurement was taken with fold running obliquely downwards.

- Biceps

  Definition: The point on the anterior surface of the arm in the mid-line at the level of the mid-acromiale-radiale landmark.

  Subject position: A relaxed standing position with arm hanging by the side

Location: The mid-acromiale-radiale site was projected perpendicularly to the long axis of the arm around to the front of the arm, and intersecting the projected line with a vertical line in the middle of the arm when viewed from the front.
Skinfold: Measurement taken parallel to the long axis of the arm.

- Iliac Crest

  Definition: The site at the centre of the skinfold raised immediately above the marked Iliocristale.
  Subject position: The subject assumed a relaxed position with the left arm hanging by the side and the right arm abducted to the horizontal.
  Location: This skinfold was raised immediately superior to the Iliocristale. The fingers of the left hand were aligned on the Iliocristale landmark and exerted pressure inwards so that the fingers rolled over the iliac crest. The left thumb was substituted for these fingers and the index finger relocated a sufficient distance superior to the thumb so that this grasp became the skinfold to be measured. The centre of the raised skinfold was marked. The fold runs slightly downwards anteriorly as determined by the natural fold of the skin.
  Skinfold: Measurement taken near horizontally at the Iliac Crest skinfold site.

- Supraspinale

  Definition: The point of intersection between the line of the marked Iliospinale to the axillary border and the horizontal line at the level of the marked Iliocristale.
  Subject position: Relaxed standing position with arms hanging at the sides.
  Location: A tape was run from the anterior axillary border to the marked Iliospinale. A line was then drawn along the side roughly at the level of the Iliocristale. The tape was then run horizontally around from the marked Iliocristale to intersect the first line.
  Skinfold: Measurement was taken with the fold running obliquely and medially downward at the skinfold site.

- Abdominal

  Definition: The site 5 cm to the right hand side of the omphalion (midpoint of the navel).

Subject position: The subject assumed a relaxed standing position with the arms hanging by the sides.

Location: Horizontal measure of 5cm to the participant's right. This is a vertical fold raised 5 cm from the right hand side of the omphalion.

Skinfold: Taken vertically at the site.

- Front thigh

  Definition: The site at the mid-point of the distance between the Inguinal fold and the anterior surface of the patella (Anterior patella) on the midline of the thigh.

  Subject position: The subject assumed a seated position with the torso erect and the arms hanging by the sides. The knee of the right leg was bent at a right angle.

  Location: The measurer stood facing the right side of the seated subject on the lateral side of the thigh. The site was marked parallel to the long axis of the thigh at the mid-point of the distance between the inguinal fold and the superior margin of the anterior surface of the patella (while the leg was bent). The Inguinal fold is the crease at the angle of the trunk and the thigh. If there was difficulty locating the fold the subject would then flex the hip to make a fold. A small horizontal mark is placed at the level of the mid-point between the two landmarks. A perpendicular line is drawn to intersect the horizontal line. This perpendicular line is located in the midline of the thigh. If a tape is used, one must avoid following the curvature of the surface of the skin.

  Skinfold: Measurement taken parallel to the long axis of the thigh at the skinfold site.

- Medial calf

  Definition: The site on the most medial aspect of the calf at the level of the maximal girth.

  Subject position: The subject assumed a relaxed standing position with the arms hanging by the sides. The subject's feet were separated with the weight evenly distributed.

Location: The level of the maximum girth was determined and marked with a small horizontal line on the medial aspect of the calf. The maximal girth was found by using the middle fingers to manipulate the position of the tape in a series of up-or-down measurements to determine the maximum girth. The marked site was viewed from the front to locate the most medial point and this was marked with an intersecting vertical line.
Skinfold: Taken vertically.

According to Marfell-Jones *et al*. (2006), the skinfold site should be carefully located using the correct anatomical landmarks. Anthropometric measurements are done with a skinfold calliper, but it should be noted that the accuracy of the test is dependent on the measurer and his/her skill level.

The measurements were taken on the right side of the body in an upright standing position, with the exception of the Medial Calf, which was taken in the sitting position, according to the general instructions provided by ISAK (Marfell-Jones *et al.,* 2006).

4.2.3.3 Girths

Girth measurements of the arm, relaxed and tense, were taken. The relaxed arm measurement was taken with the arm hanging by the side. The flexed and tensed arm measurement was taken with the Biceps brachii contracted, the peak of the Biceps brachii was then measured. The final girth measurement for the Restricted profile is the calf measurement. For this measurement the circumference of the leg at the level of the medial calf skinfold site is measured perpendicular to the long axis. As with all previous measurements, the guidelines and technique as given by ISAK (Marfell-Jones *et al.,* 2006) were followed.

4.2.3.4 Breadths

Two measurements are needed for the Restricted profile, Bi-epicondylar humerus and Biepicondylar femur. These measurements were taken using a small sliding calliper. The linear distance between the most lateral aspect of the lateral humeral/femoral epicondyle and the most medial aspect of the medial humeral/femoral epicondyle were measured to obtain a measurement for the humerus and the femur.

4.2.3.5 Body Fat Percentage

Body fat percentage is determined by the sum of 6 skinfolds. The 6 skinfold measurements are as follows:

- Triceps
- Subscapular
- Supraspinale
- Abdominal
- Anterior Mid-thigh
- Medial Calf

Using the 6 skinfold measurements from the Anthropometric profiling, the body fat percentage was determined. The formulae used to calculate body fat percentage were based on Withers, Craig, Bourdon and Norton (1987).

Men:
Body Density (BD) = 1.10326 – 0.00031(age) - 0.00036 (sum of 6 sf)
% fat = (495/BD) – 450

Women:
Body Density (BD) = 1.07878 – 0.00035(sum of 6 sf) + 0.00032(age)
% fat = (495/BD) – 450

4.2.3.6 Somatotype of the participant

Using the measurements from the Anthropometric profiling the somatotype of the participant was determined (Duquet & Carter, 2001).

Endomorphic component
$= - 0.7182 + 0.1451(\sum SF \ x Z) - 0.00068(\sum SF \ x Z)^2 + 0.0000014(\sum SF \ x Z)^3$

Where:

$\sum SF$ = (triceps + subscapulare + supraspinale)
Z = 170.18 / stature (length)

Mesomorphic component
= 0.858 (HUM) + 0.601(FEM) +0.188 (CUAD) + 0.161(CCC) – 0.131(L) + 4.50

Where:

HUM = Humerus diameter

FEM = Femur diameter

CUAC = Corrected upper arm circumference

= upper arm circumference (tensed) – (triceps skinfold/10)

CCC = Corrected calf circumference

= calf circumference – (medial calf skinfold/10)

L = Body length

Ectomorphic component
If the HWR is larger or equal to 40.75, then Ectomorph =
(0.732 x LMR) - 28.58

- If the HWR is smaller than 40.75 and larger than 38.28, then Ectomorph = (0.463 x LMR) -17.63
- If the HWR is smaller or equal to 38.25, then Ectomorph = 0.1
  Where: HWR = $\frac{height}{weight^{0.3333}}$ or $\frac{height}{\sqrt[3]{weight}}$

4.2.4 Step-up Test

After scrutiny of various step-up tests and other tests (ACE, 2003; Fattorini *et al.*, 2012; Hugo, 1999) used to evaluate hikers, it was decided to use De Villiers and Thiart's (1988) proposed pre-selection Step-up Test for prospective hikers. This pre-selection step-up test was compiled for prospective hikers, in terms of the capabilities of the average individual.

With this step-up test bench height and step frequency was adjusted according to body mass. The aim was to determine an applicable submaximal workload which would be within the capabilities of the average individual. Making use of the bench height, body mass and step frequency, the workload was determined. With repeated tests De Villiers and Thiart (1988) recommended a workload of 76 watts. Based on the results of the step tests, and for every person to do the same "driving force" a specific bench height and /or step frequency would be needed for each hiker. For practical reasons, body mass was divided into interval groups to make the differences non-significant. Small adaptions were made on the heart rhythm scales to compensate for driving force above and under 76 watts. On the basis of the exercise heart rates, five categories were proposed, namely;

very good, good, average, poor and very poor. Therefore, hikers can be grouped according to their HR on a heart rhythm scale. Furthermore, the Step-up Test was easy to perform and one that could possibly be done by a prospective hiker in the privacy of his/her own home or in a gymnasium.

An adjustable bench was constructed according to the measurements given by De Villiers and Thiart (1988). The step-up height was allowed an adjustment of 25, 30 and 38cm. A recording was then made of the instructions for the Step-up Test along with a programmed metronome beep. A script was also recorded for the procedure after the Step-up Test and taking of the HR. Two separate recordings were made for the two step-up tempos that were required. The appropriate recording was selected according to the weight of the participant. The recording was then played at each Step-up Test, ensuring that the test would be presented in the exact same manner for all participants. Results were recorded on the data sheet (Appendix H).

Before starting the Step-up Test, the Borg scale (RPE) was explained and displayed to the participant (as in Figure 6 in Chapter 2). After participating in the Step-up Test, and sitting in the chair waiting for the initial HR to be taken, they were asked to rate their perceived level of exertion according to the Borg scale (RPE).

4.2.5 Cooper Test

In order to determine each participant's fitness category and estimated $\dot{V}O_{2\,max}$ a Cooper 12 min submaximal test was performed (Beam & Adams, 2011).

All tests were supervised by the researcher in order to ensure validity and reliability of results. Participants were requested to meet at the athletics track after the completion of the anthropometry measurements and the Step-up Test (after completion of informed consent and other questionnaires). The Cooper Test was then explained once more. Participants were informed that they had 12 minutes to cover as much distance as possible. When the 12 minutes were up they would hear a beep and would be asked to stop, and the distanced covered would be measured. Once distance was measured they would continue walking for a period of time to serve as a cool down. After this explanation, participants were given time to warm up and stretch.

It was also explained that participants could walk if they needed to rest (but not to stop), although running is preferable to obtain maximum distance. During the test all participants were motivated and encouraged to perform at their highest level. The researcher counted laps as the participant completed each lap. When the timer beeped to indicate the 12-minute mark the researcher recorded where the participant ended. A standard athletics measuring wheel was then used to determine the distance covered from the starting point for the incomplete lap. The total distance covered was then measured and recorded on the data sheet (Appendix H). $\dot{V}O_{2\,max}$ was then calculated (Beam & Adams, 2011), placing participants in different categories according to age and distance covered (Mackenzie, 1997).

As with the Step-up Test participants were asked to describe their perceived level of exertion after the completion of the Cooper Test. Participants were given a card with the RPE ratings displayed (as in Figure 6 in Chapter 2). Their response was noted on the testing sheet (Appendix H).

4.3 Hiking Trail Testing

It was decided to use the system proposed by Hugo (Hugo *et al.*, 1998/99; Hugo, 1999) to grade the hiking trails. This is due to the fact that his approach is scientifically sound and objective. The work rate of a person is predicted and the trail is then evaluated according to the average person's energy usage on the trail. This method of grading trails has been adopted by HOSA (SAT, 2016b) and has also been formally accepted by the government of Nepal (Hugo, 2016c) as their official hiking trail grading system.

4.3.1 Geographical Area

The geographical area in which the study was based (Free State) is not well known for its mountains, on the contrary, it is known for its "flatness". Therefore options for the selection of trails were limited. After numerous searches on the internet and various hiking websites many, if not most, trails in the vicinity were found to be multi-day hikes. Due to limitations of battery life of equipment, additional variables already mentioned in the literature (e.g. additional pack load and accommodation), suitable day hikes were sought for the study. Trails were scrutinised taking aspects such as transport to the site, distance from hikers and the recording of GPS data into consideration.

Various trails were hiked by the researcher in order to select suitable trails. GPS data was collected during the various hikes. The altitude was then plotted according to elevation for every 50m of the hike. This data was then given to Professor Hugo to determine the difficulty grading of the hikes. The hikes were then graded by Professor Hugo according to the formulae used for the Green Flag Accreditation system expounded upon in the literature study (Hugo, 1999). Two trails were then selected according to their difficulty level, one being graded as an easy hike (Hugo, 2016d) and the other of moderate difficulty (Hugo, 2016e).

Trail 1: Easy grading
Grade given: 3
Distance: 6.91 km
Energy use: 750 kCal

Description of area: Flat, grassland on private land (housing wildlife). The average altitude was 1393m, with the highest point being 1411m and the lowest 1368m.
Permission to hike in the area was granted by the land manager.

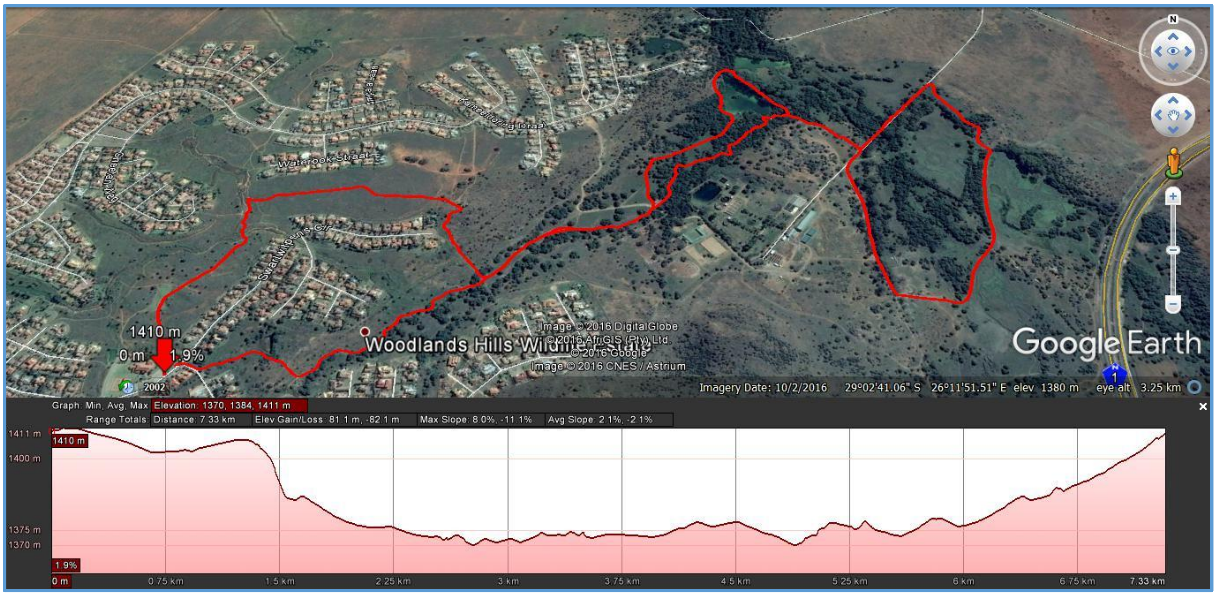

Figure 9: Route and Elevation Profile – Trail 1 (Easy Hike)

Trail 2: Moderate grading

Grade given: 5.4

Distance: 10.881 km

Energy use: 1650 kCal

Description of area: Route started at the base of the mountain, following a set route as set out by the Mountain Club of South Africa - Free State Division. The average altitude is 1978m, with the highest point being 2139m and the lowest 1653m. The initial climb to the ridge takes the hiker from 1653m to 2115m. Once at the top, the area plateaus with some small elevation changes. A circular route is followed along the edge of the mountain. The decent follows the same path as the ascent.

Permission to hike in the area was granted by the Mountain Club of South Africa (Free State Division) and by means of purchasing a hiking permit beforehand.

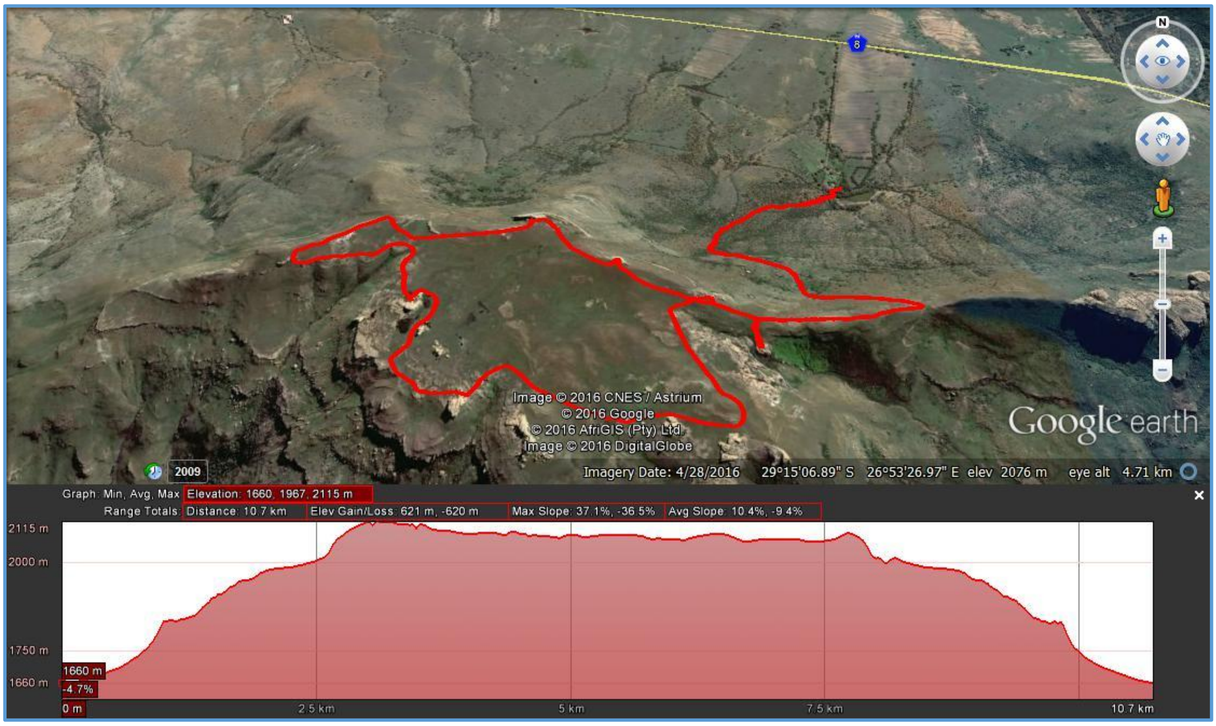

Figure 10: Route and Elevation Profile – Trail 2 (Moderate Hike)

4.3.2 General Instructions

The two trails had to be walked within one week of each other. Before the hiker departed they were provided with a Catapult vest and a Polar heart-rate monitor. They were requested to don the vest when dressing in their hiking gear before the hike. Hikers were asked to jot down their dietary intake before the hike, and what they had packed to consume during the hike (Appendix I). The researcher checked the temperature and wind measurements according to the South African Weather Services website. Backpacks were weighed, and noted on the Hiking Testing Data Sheet (Appendix I). Catapult pods were activated and left stationary in an open area to link with satellites. The pods were then placed in the Catapult vest according to the numbering that had been allocated to participants beforehand. The heart-rate monitor was placed on the chest of each participant by the participant themselves. All equipment was checked for optimum functioning pre-departure.

The participants in this study were encouraged to hydrate before hiking as well as during the hikes. All participants were told by the researcher to bring fluids along during the hikes. As participants were bringing their own water or energy drink(s) with on the hike they had the freedom to hydrate whenever the need arose. According to Goulet (2012) when performing activities for longer than an hour drinking according to the participants' thirst maximises endurance performance. As the hiking trails were done at the pace of the individual hiker, or the slowest hiker in the group, it is reasonable to presume that participants in this study could decrease their pace as a response to hyperthermia or fatigue thus controlling the hydration status (Casa et al., 2010). Participants were not expected to exercise to exhaustion or to dehydration. Expected temperatures were not extreme to induce dehydration nor were participants given a set time to complete the route. Participants could hydrate (and were advised to do so) whenever the need arose.

4.3.3 Global Positioning System (GPS)

A Global Positioning System (GPS) was used to determine the environmental attributes of difficulty (distance travelled, the time taken to complete the hike, the gradient and altitude as well as the HR). GPS is a navigational technology that was initially designed for military purposes (Cummins *et al*., 2013). The Optimeye X4 was used, which is a commercially available 10 Hz GPS (Catapult Innovations, Melbourne, Australia). This GPS provides data for position, velocity, acceleration and distance. The GPS has 3 axis 100 Hz accelerometers to measure linear motion, impact forces, jump height, airtime, acceleration, deceleration and more. Three (3) axis 100 Hz gyroscopes to measure angular motion, rotation, 3 axis 30 Hz magnetometers to measure direction and orientation were utilized. HR logging from Polar heart-rate belts were used in conjunction with the GPS to determine HR (Perform Better, n.d.). The GPS device weighs 67grams. Standard GPS devices record position once per second (1Hz), giving only an approximation of athletes' movements. Optimeye X4 samples 10 times per second (10Hz) giving more accurate position, speed, distance and acceleration data. Software can generate automatic reports breaking down performance into velocity, HR and acceleration bands, recovery times and effort lengths (Perform Better, n.d.).

As the Catapult Optimeye X4 is known for superior satellite reception and has the ability to calculate distance, acceleration, orientation, HR, amongst other features not required for hiking, it was considered as an appropriate instrument for this research. According to Varley *et al*. (2012: 126) the 10Hz GPS "may provide sufficient sensitivity for detecting small and important changes in performance of accelerations, decelerations, and constant velocity movements common in team sports". They continue by emphasising "The latest V4.0 units sampling at 10 Hz produce sufficient accuracy to quantify the acceleration, deceleration, and constant velocity running phases in team sports." If the GPS has shown to be suitable for detecting smaller movements performed on the sports field, it would satisfy the requirements for this research.

Data on all hikers was collected over the total distance of the hiking trail using the Catapult Optimeye X4. The unit was housed in a custom made harness/vest that prevented unwanted movement and held the unit in place in the middle of the upper back, thereby limiting any potential hindrance on performance. Participants received the harness/vest which hosted the unit prior to the start of the hike. Data recording started when pods were activated for linking with satellites and was stopped at the end of the hiking trail. Thereafter the data was downloaded post hiking, using manufacturer-specific software. Data was then edited to include only data relating to the participants' hike and to exclude time and other recorded information for the satellite linking and placing of pods in vests.

The warnings of satellite reception, signal quality and number of satellites being used when interpreting GPS data (Petersen *et al.*, 2009) were taken into account when collecting data. Van Winkle (2014) indicated that editing of GPS tracks was needed in order to create accurate trail records. The Catapult system has global navigation satellite system (GNSS) enabled monitors. This allows for greater enhanced positional accuracy due to the access to GLONASS satellites as well as GPS (Catapult, n.d.). Incomplete records were not used for data analysis.

The following variables were recorded by the Optimeye X4 during this study.

- Total distance covered during the hiking
- HR
- Total distance
- Total time
- Altitude

4.3.4 Borg's Rating of Perceived Exertion Scale (RPE scale)

The Borg scale was explained to all participants prior to the hike. Familiarisation with the Borg scale had already taken place during the pre-hike testing when participants were asked to rate their perceived exertion after the Step-up Test, as well as after the Cooper Test. Previous studies have indicated that familiarisation with the Borg scale is preferable (Cakir *et al*., 2012; Paulson *et al.,* 2013). Participants were then asked to record their perceived exertion level hourly during the hike. Individual cards with the scale and descriptive information (as shown in chapter 2) were handed to each participant every hour. Participants were then given time to consider the RPE and then fill in the information on the card in a space allocated for each hour. This was then transferred by the researcher to the Hiking Testing Data Sheet (Appendix I). At the end of the hike, participants were asked to rate their perceived exertion for the entire hike.

4.3.5 Post Hike

After the participant had completed the hike, the time was noted on the Hiking Testing Data Sheet and the pods were turned off. The Pods, heart-rate monitors and vests were collected. The pods, vests and heart-rate monitors were then cleaned and prepared for the subsequent use.

5. STATISTICAL ANALYSIS

Data was captured from the data forms to Microsoft Excel by the researcher. Data from the pods was downloaded post hike using Sprint software. EE was calculated according to the method provided by Hoffman (2006). Any further analysis was done by a statistician using SAS procedure FREQ (SAS, 2016). Frequencies and corresponding percentages for the data, were calculated, both overall and for each gender. Furthermore, descriptive statistics (mean, standard deviation (Std), minimum, median, maximum and quartiles) for the variables were calculated, both per gender and overall. The correlations were calculated, together with the associated p-value. To facilitate discussion of results, descriptors for the magnitude of the correlations were used based on Hopkins (2002). These descriptors assist in understanding the magnitude of the effect. Correlations with a value of 0.1-0.3 are viewed as small, 0.3-0.5 as moderate, 0.5-0.7 large, 0.7-0.9 are viewed as very large and 0.9-1 are nearly perfect.

5.1 Descriptive Statistics: Medical History

Frequencies and corresponding percentages for the categories of the medical history data, namely somatotype and specific medical history findings were calculated, both overall and for each gender.

5.2 Descriptive Statistics: IPAQ and Fitness Grading

Frequencies and corresponding percentages for the categories of the PA and fitness data, namely IPAQ, Step-up Test, Cooper Test, and Borg scale (RPE) (after the Step-up Test, Cooper Test, and at the end of the two hikes respectively) were calculated, both overall and for each gender. Furthermore, descriptive statistics (mean, Std, minimum, 1st quartile, median, 3rd quartile, maximum) for these variables were calculated, both per gender and overall (SAS, 2016). The De Villiers and Thiart's (1988) step-up test and the IPAQ test both do not classify participants according to gender. It was for this reason that the decision was taken to group hikers together and not to report hiking data in terms of male and female participants.

5.3 Correlations and Regressions: IPAQ and Fitness Grading

The pairwise correlations of the IPAQ rating and of the remaining fitness scales, namely the Step-up Test, Cooper Test, and Borg scale (RPE) (after the Step-up Test, Cooper Test) were calculated. Furthermore, the corresponding pairwise simple linear regressions between the IPAQ rating, Step-up Test and Cooper Test were carried out. The regression intercepts and slopes, the Pearson correlation coefficients and associated p-values were reported. Furthermore, all pairwise correlations between the various pre-hike fitness scales and PA, namely IPAQ, Step-up Test, Cooper Test, and the Borg scale (RPE) (at the end of the two hikes respectively) were calculated, together with the associated p-value (SAS, 2016).

5.4 Correlations: Pre-Hike Fitness/Physical Activity Grading with Difference in Effort (Borg Scale (RPE)) Between the Two Hikes

The difference in effort (as measured by the Borg scale (RPE) at the end of the hike) between the more strenuous hike (Trail 2) and the less strenuous hike (Trail 1) was calculated. Subsequently the correlations of the pre-hike PA and fitness gradings, namely IPAQ, Step-up Test and Cooper Test, with difference in effort between hikes (difference in Borg scale (RPE)) were calculated. The Pearson correlation coefficient and associated p-value was reported (SAS, 2016).

5.5 Exertion During the Hikes: Descriptive Statistics

For both hikes, descriptive statistics (mean, Std, minimum, 1st quartile, median, 3rd quartile, maximum) were calculated for average HR, maximum HR, Borg scale (RPE) at the end of the hike, and time to complete the hike (SAS, 2016). No differentiation between genders was made due to the aforementioned reasons (5.2).

5.6 Prediction of Exertion During the Hikes: Analysis of Covariance (ANCOVA)

A question to be investigated in this study is whether the exertion levels on the two hiking trails could be predicted by information based on the fitness tests. The following variables were chosen as indicators of exertion on the trail:

- average HR
- maximum HR
- Borg scale (RPE) at the end of the trail.

Fitness test and PA information used was the IPAQ, Step-up Test and Cooper Test (SAS, 2016).

5.7 Separate Analysis of Data from the Two Trails: Analysis of Covariance (ANCOVA)

Initially, the exertion data for the two trails was analysed separately, as follows: An Analysis of Covariance (ANCOVA) model for each of the variables average HR, max HR and Borg scale (RPE) at the end of the trail (dependent variables) was fitted with the following independent variables:

- IPAQ
- Step-up Test
- Cooper Test
- Time taken to complete the trail.

IPAQ, Step-up Test and Cooper Test were fitted as categorical (class) effects. The time taken to complete the trail was included in the model as a covariate because it could be an important predictor, since completion time of the trail might be associated with exertion levels (negative correlation: the shorter the completion time, the higher the exertion).

The model as specified above was fitted (the “Full model”), and F-statistics and associated p-values for all model effects are reported. Thereafter, stepwise backward model selection was performed as follows: Starting with the full model, the statistically least significant variable (variable associated with the highest p-value) was removed from the model, providing that the p-value was larger than 0.10. The selection procedure stopped when all variables remaining in the model were significant at the $\alpha=0.10$ level.

Based on the final selected model, the predicted values (least squares estimates) of the dependent variable were calculated for the different levels of the fitness test/PA variables selected for the final model.

5.8 Joint Analysis of Data from the Two Trails (A Mixed Analysis of Covariance (ANCOVA))

Furthermore, the exertion data for the two trails was analysed jointly, as follows: A Mixed Analysis of Covariance (ANCOVA) model for each of the variables average HR, maximum HR and Borg scale (RPE) at the end of the trail (dependent variables) was fitted with the following independent variables as fixed effects:

- Trail
- IPAQ
- Step-up Test
- Cooper Test
- Time to complete the trail.

As before, IPAQ, Step-up Test and Cooper Test were fitted as categorical (class) effects, as was the variable Trail. The time to complete the trail was included in the model as a covariate. Furthermore, in order to accommodate correlation between the two values of the dependent variable in question (one from each trail) for each participant, the factor Participant was fitted as a random effect.

The model as specified above was fitted (the "Full model"), and F-statistics and associated p-values for all model effects were reported. Thereafter, stepwise backward model selection was performed as described above for the separate analysis. Based on the final selected model, the predicted values (least squares estimates) of the dependent variable were calculated for the different levels of the PA/fitness test variables selected for the final model.

6. PILOT STUDIES

An initial pilot hike with four hikers was conducted four months prior to the study with the pods to determine the information collected, satellite reception, detection of HR and to determine if a backpack would hinder the collection of GPS data. A further pilot study with two hikers was done to test the protocol as explained in Figure 8, and to determine the effectiveness of the proposed data sheets and equipment. Additionally, the duration of testing per participant was determined and the progression of testing was evaluated in order to properly plan testing schedules for the study. Data sheets, equipment, and protocols were found to be effective in achieving the proposed objectives. This data was not included in the final data used for this study.

7. ETHICS

Before the study commenced and the participants were recruited, the study was approved by the Humanities Research Ethics Committee of the University of the Free State (UFS-HUM-2014-65). Informed consent forms approved by the Ethics Committee of the University of the Free State were handed out and had to be signed by the participants (Appendix E). The form contained all the necessary information and basic elements as specified by Thomas, Nelson and Silverman (2011).

The possible occurrence of typical injuries associated with hiking e.g. musculoskeletal or soft tissue injury (Hamonko *et al*., 2011) were present. However, participants were only required to additionally wear a pod, vest for the pod and chest strap with a heart-rate monitor to their intended backpack. This did not increase the inherent risk associated with hiking. The researcher also attempted to limit the risk of any injury by giving proper instruction to the hiker prior to testing and during the test protocol. The physical fitness testing was done to set protocol. Indoor testing was conducted at the Exercise and Sport Sciences Centre at the University of the Free State which has qualified staff in the case of a medical emergency. The Cooper Test was done 500m from the consulting rooms of two physicians.

Any information that was obtained in connection with this study that could be identified with the participant has been and will remain confidential and will only be disclosed with the permission of the participant or as required by law. Confidentiality was maintained by means of allocating numbers to hikers. Information was kept with the investigator only and raw data held under lock and key. All processing of data was governed by a PC password protector. Only the findings will be published in the strictest confidentiality to the individual hikers. Reports on the hikers' fitness and PA levels, as tested during the pre-hike tests, were e-mailed to the hiker personally.

An incentive of petrol money to cover the costs of travel to the hiking sites was offered to volunteers. This funding was provided by the Post-Graduate School of the University of the Free State.

8. MINIMISING METHODOLOGICAL AND MEASUREMENT ERRORS

8.1 Anthropometric Profiling

Errors were minimised by utilising the protocol as set out by ISAK (Marfell-Jones *et al*., 20016). Measurements were undertaken in the same facility and the same equipment was used for all participants. Participants were asked not to exercise prior to having anthropometric measurements taken.

8.2 Questionnaires

All the questionnaires were distributed by the researcher, hence all were explained and administered by the same individual for consistency and reliability.

8.3 GPS

GPS data was screened for errors. Data was scanned to include only data from the commencement to the end of the hike. Data from pods that recorded during the satellite connection phase of pods was cut and only data of the actual hike was then used during data analysis. Loss of signal for GPS (including HR) was also checked. If any errors were found these were then excluded from analysis.

9. LIMITATIONS OF THE STUDY

This study has some limitations. The first limitation is that the study population of experienced hikers is relatively small. The second limitation is that dietary intake was not standardised before hiking. This has, however, also been the case in other studies on hiking (Gutwenger *et al.*, 2015; Faghy & Brown, 2014; Simpson *et al*., 2011). The natural hiking scenario was sought in this study as hikers were planning their own hiking trips. Prescribing or restricting the dietary intake was viewed as interfering with the recreational aspect of their decision to hike in the first place and personal dietary preferences. Therefore, it was decided not to include dietary restrictions, but to encourage the hiker to eat what they would normally eat. Hikers were asked to eat similar meals/snacks on the day of the fitness testing. Furthermore, the hydration and fatigue levels of the hikers which could also influence the fatigue levels during the hike, were not measured before the hike.

To conclude, as mentioned previously one of the main challenges experienced by the researcher in relation to this study was the limited published literature on hiking in South Africa and worldwide. After the initial works done by De Villiers and Thiart (1998), Hugo *et al.* (1998/99) and Hugo (1999 & 2007) a void emerged in research in the South African context until the recent research conducted by Slabbert (2015). Current or historical data could not be obtained on the hiking population in South Africa (Bossert, 2015; Slabbert, 2015).

The results obtained in this study will be presented in chapter 4.

Chapter 4

Results

1. INTRODUCTION

The purpose of this study is, firstly, to profile the hikers in terms of morphological factors (gender, age, height, weight, body fat percentage, medical history and eating habits), the grading classification of the Step-up Test proposed by De Villiers and Thiart (1988), the Cooper Test, the EE, the GPS measurements (HR) of a hiker, and the RPE (Borg scale (RPE)) during two differently graded hiking trails. Secondly, to determine if a relationship exists between the self-reporting PA questionnaire (IPAQ), the fitness grading classification of the Step-up Test proposed by De Villiers and Thiart (1988), the Cooper Test, the GPS measurement (HR) of a hiker during the hike, the RPE (Borg scale (RPE)), and EE of the hikers during two differently graded hiking trails. Thirdly, to determine if the calculated EE of a hiker is consistent with the calculations in the current difficulty rating scale proposed by Hugo (Hugo *et al.*, 1998/9). Fourthly, to conduct an analysis of the IPAQ as an instrument of self-reported PA levels and actual fitness levels (fitness tests) (HR using GPS technology), to best predict the perceived exertion (Borg scale (RPE)) by the hikers. Lastly, to determine if the the exertion levels on the two hiking trails could be predicted by information based on the fitness tests/PA levels.

This chapter presents the results obtained from the data gathering procedures. The results are displayed to reflect the demographic information of this cohort of hikers, followed by the PA and fitness profile drawn from each of the testing procedures. The results are presented in this chapter highlight their significance within the represented profiles and to present the analyses of the test and hiking data. Interpretation and discussion of the findings follow in Chapter 5.

Pre-hike fitness data, questionnaire data, somatotyping and physiological measurements of hikers while completing two graded hiking trails are presented for 50 hikers. Frequencies and corresponding percentages for the categories of the PA and fitness data, namely IPAQ, Step-up Test, Cooper Test, Borg scale (RPE) (post Step-up Test, Cooper Test, and the two graded hikes respectively) and EE for the two graded hikes were calculated, both overall and where relevant for each gender. Furthermore, descriptive statistics (mean, standard deviation, minimum, first quartile (Q1), third quartile (Q3), and maximum) for these variables were calculated, both per gender (where relevant) and overall with the use of SAS procedure TABULATE (SAS, 2016).

2. THE PARTICIPANTS

2.1 Demographics

The demographic information displayed in this section provides an overview of the cohort of hikers. A number of these variables have also been identified in the literature to contributing elements to a hiking experience. This will be noted within this section and fully discussed in Chapter 5.

Fifty (n=50) participants completed the demographic questionnaire, namely 13 (26%) male and 37 (74%) female participants, aged from 20 to 64 years. Table 6 below provides the descriptive statistics for age. The mean age for males was 42.9 years with a standard deviation of 11.13 years. The female participants had a mean of 36.5 years with a standard deviation of 12.01 years.

Table 6: Descriptive Statistics for Age (n=50)

	Age		
	Gender		**All**
	Male	**Female**	
N	13	37	50
Mean	42.9	36.5	38.2
Std	11.13	12.01	12.02
Min	22	20	20
Q 1	35	27	27
Q 3	49	47	48
Max	64	63	64

The ethnicity of participants is shown in Table 7. Twelve percent (12%) of participants are non-white, while 88% are white.

Table 7: Distributions of Ethnicity (n=50)

Ethnicity	**Male**		**Female**		**All**	
	Frequency	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
African	0	0.0	3	6.0	3	6.0
Coloured	1	2.0	2	4.0	3	6.0
White	12	24.0	32	62.0	44	88.0

2.2 Medical History

Frequencies and corresponding percentages for the categories of the medical history data, namely somatotype and specific medical history findings were calculated. The medical history of hikers is reflected in Table 8. All participants considered themselves medically capable of performing the required tests for the research. The medical history data was gathered using a form based on the ACSM Health/Fitness Facility Pre-participation Screening Questionnaire (ACSM, 2014a). Among the medical history items, the use of prescription medication constituted the highest incidence (28%), participants who felt they were more than 9kg overweight accounted for 22%, while 16% of participants did not know their cholesterol levels.

Table 8: Medical History (n=50)

Medical History/Symptoms/Issues/Risk Factors	Frequency	Percent
Take prescription medications	14	28.0
Considered themselves >9kg overweight	11	22.0
Did not know their cholesterol level	8	16.0
Asthma or lung disease	7	14.0
Did not know their blood pressure	6	12.0
Male older than 45 years	5	10.0
Close blood relative with history of heart attack or heart surgery before age 55 (male relative) or 65 (female relative)	4	8.0
Considered themselves physically inactive (<30mins/3days a week)	3	6.0
Experience dizziness, fainting or blackout	3	6.0
Burning or cramping sensation in lower legs when walking short distances	3	6.0
Rhythm disorder	2	4.0
Experience unreasonable breathlessness	2	4.0
Concerns about safety of exercise	2	4.0
Women older than 55 years, have had hysterectomy, or are postmenopausal	2	4.0
Smoke, or quit smoking within last 6 months	2	4.0
Take blood pressure medication	2	4.0
Musculoskeletal problems limiting physical activity	1	2.0
Take heart medications	1	2.0
Heart Valve Disease	1	2.0
Experience chest discomfort with exertion	1	2.0
Diabetes	0	0.0
Blood cholesterol level higher than 200mg/dl	0	0.0
Pregnant	0	0.0
Blood pressure higher than 140/90mm Hg	0	0.0
Heart Failure	0	0.0
Heart Transplant	0	0.0
Congenital Heart Disease	0	0.0

Table 9 presents the responses of hikers to the General Health Information Questions. Ninety-four percent (94%) of the participants classified themselves as healthy with only 6% stating that they felt they were unhealthy. When asked "Do you consider yourself "fit"?" 40% answered "no", 56% answered "yes" and 4% did not answer. Only two individuals (4%) stated that they smoked, with one participant (2%) indicating that they smoked between one and five cigarettes daily and the other participant indicating that they smoked between six and ten cigarettes daily. Eighty percent (80%) of participants consumed alcohol, with the majority (64%) indicating that they drank on social occasions only.

Table 9: Responses to General Health Information Questions (n=50)

Question	Answer	Frequency	Percent
Do you consider yourself healthy?	Yes	47	94.0
	No	3	6.0
Do you consider yourself fit?	Yes	28	56.0
	No	20	40.0
	Not answered	2	4.0
Do you smoke?	Yes	2	4.0
	No	48	96.0
Do you drink alcoholic beverages?	Yes	40	80.0
	No	10	20.0

2.3 Hiking Questionnaire

A summary of various questions regarding the hiker's previous experience is given in Table 10. Participants ranged from 0 years of hiking experience to 40+ years. Only 4% of participants were members of hiking clubs. The majority (78%) of participants had participated in 10 or fewer hikes. The most experienced hiker had undertaken more than 88 hikes. Most participants (34%) participated less than once a year, with 12% of respondents indicating that they hiked five or more times per year.

Table 10: Hiking Experience (n=50)

Hiking Experience		Frequency	Percent
Number of Hikes	None	13	26.0
	1-5 Hikes	16	32.0
	6-10 Hikes	10	20.0
	11-15 Hikes	6	12.0
	16-20 Hikes	3	6.0
	More than 50	2	4.0
Frequency of Hikes	Never	0	11.0
	Less than 1ce a year	1	17.0
	1ce a year	2	6.0
	2ce a year	3	4.0
	3-4 times a year	4	4.0
	5+ times a year	5	6.0
	Not answered	6	2.0
Years Hiking	0 Years	17	34.0
	1-5 Years	14	28.0
	6-10 Years	6	12.0
	11-15 Years	5	10.0
	16-20 Years	1	2.0
	21-30 Years	4	8.0
	Not answered	2	4.0
	When the opportunity arises	1	2.0
Club Membership	Not a member	48	96.0
	A club member	2	4.0

The footwear worn during both trails is presented in Table 11. Most participants (50%) wore trainers (“tekkies”) while hiking, with 40% wearing hiking boots.

Table 11: Footwear Worn by Hikers During Both Trails (n=50)

Footwear	Frequency	Percent
Hiking Boot	20	40.0
Trail Shoe	3	6.0
Training “Tekkie”	25	50.0
Casual Sneaker	0	0.0
Hiking Shoe	2	4.0

All respondents indicated that they would take water or energy drinks with for a hike. The least amount that was indicated to be taken along was between 500ml-1l (18% of participants) with 36% of participants indicating that they would probably take 3.5l of water with or more. This indicated that the participants were aware that it was necessary to take water along to maintain a hydrated status.

3. PRE-HIKE TESTING

3.1 IPAQ

Frequencies and corresponding percentages for the categories of the somatotyping, PA and fitness data, namely IPAQ, Step-up Test, Cooper Test, and Borg scale (RPE) (during the Step-up Test, Cooper Test, and at the end of the two hikes respectively) were calculated, both overall and for each gender. Furthermore, descriptive statistics (mean, Std, minimum, first quartile (Q1), median, third quartile (Q3), maximum) were calculated for these variables.

In the self-reporting IPAQ most participants (42%) scored in the moderate level of PA, closely followed by 38% in the high category. Table 12 indicates the frequency of participants placed in the three different activity levels of the IPAQ.

Table 12: IPAQ Activity Levels (n=50)

Activity Level	Frequency	Percent
Low	10	20.0
Moderate	21	42.0
High	19	38.0

3.2 Anthropometry

Forty-nine (49) participants completed the anthropometry testing. The descriptive statistics by gender for weight, height, body fat are in Table 13 and somatotype by gender can be found in Table 14.

Table 13: Weight, Height, Body Fat Percentage by Gender (n=49*)

	Weight [kg]		Height [cm]		Fat Percentage	
Gender	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
N	13	36	13	36	13	36
Mean	90.3	71. 6	181.2	166.2	20.1	21.7
Std	18.89	13.11	7.52	4.99	7.68	6.54
Min	60.8	52.0	172.0	154.0	10.5	10.1
Q 1	77.2	63.4	174.0	164.5	14.8	17.2
Q 3	100.4	75.9	186.0	169.0	22.9	25.7
Max	120.4	119.8	192.0	175.0	38.2	34.2

* One participant fell ill and did not complete anthropometry

Table 14: Somatotype Components by Gender (n=49*)

	Mesomorph		Ectomorph		Endomorph	
Gender	Male	Female	Male	Female	Male	Female
N	13	36	13	36	13	36
Mean	6.4	5.6	1.5	1.4	4.3	4.9
Std	1.51	1.85	1.02	1.14	1.60	1.61
Min	3.9	2.6	0.1	0.1	2.5	1.8
Q 1	5.6	4.3	0.8	0.4	3.0	3.8
Q 3	6.9	6.5	2.0	2.2	4.6	6.2
Max	9.6	10.9	3.6	4.0	7.8	8.0

* One participant fell ill and did not complete anthropometry

3.3 Step-up Test

Of the 48 participants that completed the Step-up Test, none scored in the “Very Poor” category. Thirty-nine point six percent (39.6%) of the participants scored in the “Very Good” category, and only 8.3% scored in the “Poor” category. Table 15 provides the frequency of scores for the various categories of the Step-up Test.

Table 15: Frequency of Scores for Step-up Test (n=48*)

Heart Rate Scale	Frequency	Percent
Very Good	19	39.6
Good	11	23.0
Average	14	29.2
Poor	4	8.3
Very Poor	0	0.0

* Two participants did not complete the Step-up Test

Table 16 shows the responses to the Borg scale (RPE) post Step-up Test. The RPE of "Light" (number 11 on the Borg scale) received the highest response rate (31.3%) followed by "Somewhat Hard" (number 13 on the Borg scale) with 29.2%.

Table 16: Borg Scale (RPE) Post Step-up Test (n= 48)

Borg Scale (RPE)	Borg Scale (RPE) Description	Frequency	Percent
6	No exertion at all	0	0.0
7		1	2.1
8		1	2.1
9	Very Light	2	4.2
10		2	4.2
11	Light	15	31.3
12		8	16.7
13	Somewhat Hard	14	29.2
14		1	2.1
15	Hard (heavy)	4	8.3
16		0	0.0
17	Very hard	0	0.0
18		0	0.0
19	Extremely hard	0	0.0
20	Maximal exertion	0	0.0

3.4 Cooper Test

Table 17 presents the results of the Cooper Test. The Cooper Test had the highest frequency for the "Below Average" category (29.2%), "Average" being a close second with 27.1% of participants falling into this category. Although the highest frequency was for "Below Average" the cumulative frequency for participants falling into the

"Average" category or above is 60.5%. Only 10.4% of participants fell into the "Poor" category.

Table 17: Frequency of Scores for Cooper Test (n=48*)

Category	Frequency	Percent
Excellent	7	14.6
Above Average	9	18.8
Average	13	27.1
Below Average	14	29.2
Poor	5	10.4

* Two participants did not complete the Cooper Test

The perceived exertion during the Cooper Test ranged from a "Very Light" (9) to "Maximal Exertion" (20). The highest incidence for a response score (29.2%) was a 17 on the Borg scale (very hard), with 20.8% of respondents determining that "Somewhat Hard" described their perceived exertion most accurately. All responses can be found below in Table 18.

Table 18: Borg Scale (RPE) Post Cooper Test (n=48)

Borg Scale (RPE)	Borg Scale (RPE) Description	Frequency	Percent
6	No exertion at all	0	0.0
7		0	0.0
8		0	0.0
9	Very Light	1	2.1
10		0	0.0
11	Light	3	6.3
12		4	8.3
13	Somewhat Hard	10	20.8
14		0	0.0
15	Hard (Heavy)	2	4.2
16		4	8.3
16.5		1	2.1
17	Very Hard	14	29.2
18		5	10.4
19	Extremely Hard	3	6.3
20	Maximal Exertion	1	2.1

When performing the Cooper Test, it is expected of participants to exert themselves. The Borg scale (RPE) results in Table 18 suggest that some participants did not exert themselves as they were requested to do. It would be expected that the Borg scale (RPE) for the Cooper Test would be rated 15 or higher for all participants, since participants were requested to cover the greatest distance possible in the allocated time.

4. HIKING-TRAIL TESTING

Two trails of differing grading were hiked. Data was gathered before the hikes, including nutritional aspects and weight of the backpack. Borg scale (RPE) ratings and HR were collected from the participants as discussed in the methodology. The data collected before, during and after the hikes of both trails are presented in this section.

The types of food and beverages consumed before and during each hike are reported individually for the hikes of both trails. The weights of the backpacks carried, as well as the RPE allocated to each hike by participants is presented for both Trail 1 and Trail 2. The following characteristics of exertion during the hiking of the two trails were used:

- Minimum HR, average HR, and maximum HR recorded during each hike
- Borg scale (RPE) at the end of each hike
- EE during each hike
- Time taken to complete the hike for each trail

The mean, standard deviation, minimum and maximum as well as first and third quartile were calculated for these variables, and are presented in a combined table for both trails (Table 21).

4.1 Trail 1 (Easy Grading: 3)

Trail 1 (grading 3 ("easy") according to Hugo's grading system) covered a distance of 6.91 km and consisted of flat grassland on a private estate housing wildlife. The average altitude was 1393m, with the highest point being 1411m and the lowest 1368m. Data for Trail 1 was gathered over a total of 12 hikes. The number of participants per group varied according to volunteer availability. Hikes were arranged for late afternoon. The completion time was on average 97.5 minutes (see Table 21). The average forecast temperature during the walking of the trail was 25ºC. The coldest forecast temperate during the hikes was 16 ºC, and the highest forecast temperature was 31ºC. The strongest wind speed was forecast at 6m/s and the lightest was 1.4m/s from varying directions, each time the route was walked. Weather information was gathered from the South African Weather Service in order to obtain an hour-by-hour forecast. There was light rain towards the end of one hike.

Participants reported what they ate and drank before the hike as well as what they had brought along to consume during the hike. This is reported in
Table 19.

Table 19: Food and Beverages Consumed Before and Taken to Consume During Trail 1 (n=48)

Food Type	**Before the Hike**		**During the Hike**	
	Frequency	**Percent**	**Frequency**	**Percent**
Grain/Carbohydrate	36	75.0	1	2.1
Fruit	9	18.8	7	14.6
Dairy	4	8.3	0	0.0
Protein	34	70.8	4	8.3
Vegetable	11	22.9	0	0.0
Energy bar	2	4.2	3	6.3
Sweets	0	0.0	2	4.2
Other	1	2.1	0	0.0
Water	18	37.5	41	85.4
Energy drink	2	4.2	4	8.3
Other	20	41.7	0	0.0

Water was the main item taken along (85.4%), with only a small number (14.6%) of participants including a fruit item.

Only 45.8% of participants took a backpack for Trail 1, the heaviest being 5.65 kg and the most frequent weight being in the 2 - 4 kg category (27.1%). This data is displayed in Table 20.

Table 20: Back-Pack Weight for Trail 1 (n=48)

Weight	Frequency	Percent
0	26	54.2
>2 kg	8	16.7
2-4 kg	13	27.1
4-6 kg	1	2.1

For both hikes, descriptive statistics (mean, standard deviation, minimum and maximum) were calculated for average HR, maximum HR, Borg scale (RPE) at the end of the hike, EE and time to complete the hike. The results can be found in Table 21.

The shortest time to complete Trail 1 was 81 minutes (one hour, twenty-one minutes) and the longest was 107 minutes (one hour, forty-seven minutes). The mean time to complete the hike was 97.5 minutes (one hour-thirty-seven and a half minutes). The HR of the participants was recorded, with the minimum HR being 81 bpm and the maximum HR being 154 bmp. The mean average HR was 110.6 bpm and the mean maximum HR was158.9 bpm. The lowest maximum HR was 105 bpm and the highest 221 bpm. The mean EE on Trail 1 was calculated to be 798.4kCal, with the highest EE being 1291.6 kCal and the lowest 530.7 kCal. The EE for Trail 1 is shown in the scatterplot of energy expenditure against the participant number in Figure 11.

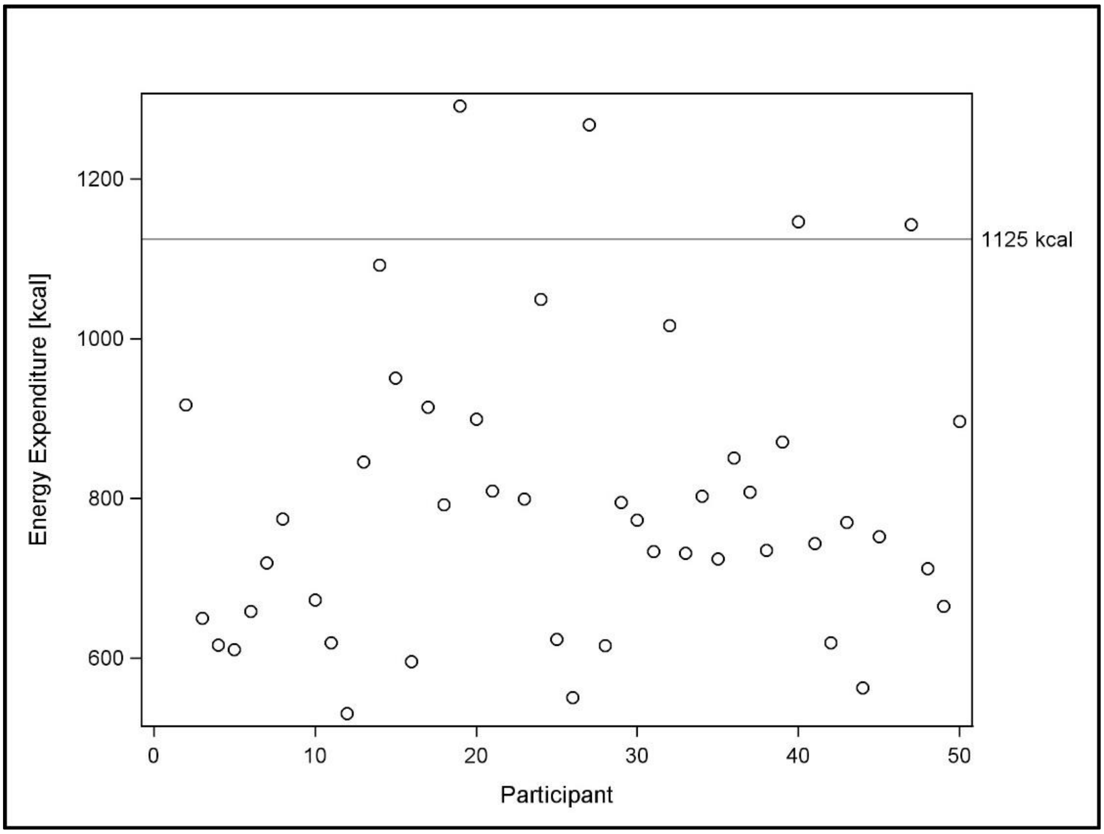

Figure 11: Energy Expenditure on Trail 1

The RPE at the conclusion of the trail was most frequently rated as “light” (11) with 27.1% of respondents giving this rating. Twenty-five percent (25%) of respondents rated Trail 1 as a “very light” (9) and 22.9% rated it as between “light” and “somewhat hard” (12). Four point two percent (4.2%) did not complete the walk. All the RPE ratings can be found in Table 24.

Table 21: Heart Rates, Time to Complete, Borg Scale (RPE) and Energy Expenditure (EE) for Trail 1 and 2

	Minimum HR [bpm]		Average HR [bpm]		Maximum HR [bpm]		Time to Complete [min]		Borg Scale (RPE) End[1]		Energy Expenditure [kcal]	
	Trail 1	**Trail 2**	**Trail 1**	**Trail 2**	**Trail 1**	**Trail 2**	**Trail 1**	**Trail 2**	**Trail 1**	**Trail 2**	**Trail 1**	**Trail 2**
N	47	49	47	49	47	49	47	49	47	48	46	48
Mean	79.4	72.3	110.6	124.8	158.9	176.1	97.5	297.7	10.7	13.0	798.4	2470.3
Std	13.40	12.74	16.14	15.02	30.44	18.15	6.47	23.97	1.46	2.06	183.92	545.93
Min	51.0	43.0	81.0	82.0	105.0	134.0	81.0	262.0	7.5	10.0	530.7	1552.0
Q1	70.0	64.0	99.0	119.0	135.0	162.0	94.0	281.0	9.0	12.0	658.8	2090.3
Q 3	87.0	80.0	124.0	133.0	187.0	191.0	102.0	306.0	12.0	14.0	896.7	2700.6
Max	117.0	103.0	154.0	155.0	221.0	217.0	107.0	350.0	13.0	20.0	1291.6	4019.9

[1] Rate of Perceived Exertion at the end of the trail.

4.2 Trail 2 (Moderate Grading: 5.4)

Trail 2 (with a grading of 5.4 “moderate” according to Hugo’s grading system) was a mountain hike. There is a steep start and finish to the hike with a relatively flat plateau at the top, constituting the middle section of the hike. The hike covered a distance of 10.881 km. The average altitude is 1978m, with the highest point being 2139m and the lowest being 1653m. Data for Trail 2 was gathered over a total of six hikes. Group size per hike was larger than for groups undertaking Trail 1. All individuals hiked the trail. Hikes were arranged to begin in the early morning. The average temperature during the walking of the trail was 21.6ºC. The coldest forecast temperate during the hiking time was 10 ºC, and the highest forecast temperature was 29ºC. The strongest wind speed was considered a moderate breeze and was 6m/s and the lightest was 2m/s from varying direction each time the route was walked. No precipitation was experienced during any of the Trail 2 hikes.

Table 22 displays the food and beverages that were consumed before and during Trail 2. Grain/carbohydrates (68%) were the most consumed food type before the hike and water (88%) followed by fruit (64%) and protein (64%) were consumed during the hike.

Table 22: Food and Beverages Consumed Before and Taken to Consume During Trail 2 (n=50)

Food type	Before the Hike		During the Hike	
	Frequency	Percent	Frequency	Percent
Grain/Carbohydrate	34	68.0	20	40.0
Fruit	7	14.0	32	64.0
Dairy	15	30.0	5	10.0
Protein	11	22.0	32	64.0
Vegetable	0	0.0	3	6.0
Energy bar	3	6.0	20	40.0
Sweets	0	0.0	17	34.0
Other	1	2.0	2	4.0
Water	12	24.0	44	88.0
Energy drink	0	0.0	18	36.0
Other	29	58.0	6	12.0

A larger percentage (88%) of participants took a backpack for the second trail. The majority of the participants' backpack weighed in the 2-4 kg category (42%) with the second heaviest category (36%) being that of 4-6kg. The heaviest bag weighed 9.2kg and the lightest 0.2kg. Table 23 provides the weights of all backpacks taken on Trail 2.

Table 23: Backpack Weight for Trail 2 (n=50)

Weight	Frequency	Percent
0	6	12.0
>2 kg	2	4.0
2–4 kg	21	42.0
4-6 kg	18	36.0
6-8 kg	2	4.0
8-10 kg	1	2.0

The hike of the second graded trail (Trail 2) took on average 297.6 minutes (just under five hours) to complete (see Table 21). The fastest time for completion was 262 minutes (four hours twenty-two minutes) and the slowest was 350 minutes (five hours and fifty minutes). The average HR of the participants was recorded as 124.8 bpm, with the minimum average being 82 bpm and the maximum average 155 bpm. The mean maximum HR was 176.1 bpm and the maximum HR was 217.0 bpm. The lowest maximum HR was 134 bpm. The lowest recorded HR was 43 bpm and the highest minimum HR was 103, the mean minimum HR being 72.3 bpm.

The mean EE on Trail 2 was calculated to be 2470.3 kCal, with the highest EE being 4019.9 kCal and the lowest 1552.0 kCal. A scatterplot of energy expenditure against the participant number for Trail 2 is indicated in Figure 12. Most hikers fall below the 3375 kCal band, and only 4 are above the band. It is interesting to note that with the more difficult trail the EE is higher than the estimation of Hugo (2016e). For this trail most respondents (26.5%) reported that "Somewhat Hard" (13) described their RPE most accurately. All the RPE ratings for Trail 2 can be found in Table 24. One participant did not rate the RPE for the entire trail.

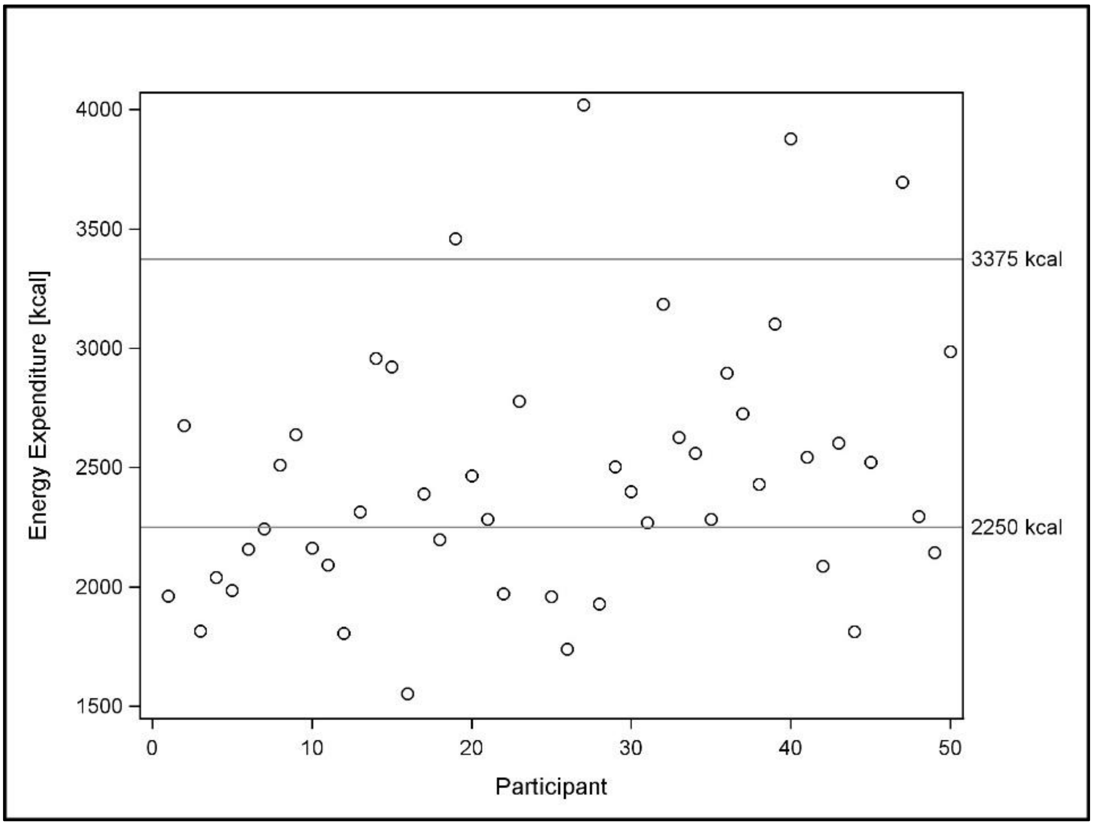

Figure 12: Energy Expenditure on Trail 2

Table 24: Borg Scale (RPE) for Trail 1 (n=48) **and Trail 2** (n=49)

		Trail 1		**Trail 2**	
Borg Scale (RPE)	**Borg Scale (RPE) Description**	**Frequency**	**Percent**	**Frequency**	**Percent**
7.5	-	1	2.1	-	-
8	-	1	2.1	-	-
9	Very light	12	25.0	-	-
10	-	5	10.4	3	6.1
11	Light	13	27.1	9	18.4
12	-	11	22.9	10	20.4
13	Somewhat hard	5	10.4	13	26.5
14	-	-	-	2	4.0
14.5	-	-	-	1	2.0
15	Hard (heavy)	-	-	4	8.2
16	-	-	-	5	10.2
17	Very hard	-	-	1	2.0
18	-	-	-	-	-
19	Extremely hard	-	-	-	-
20	Maximal exertion	0	0	1	2.0

5. RELATIONSHIPS BETWEEN TESTS

This section compares and displays the correlations between the self-reporting PA questionnaire (IPAQ), the fitness-grading classification of the Step-up Test proposed by De Villiers and Thiart (1988), the Cooper Test, the GPS measurement (HR) of a hiker during the hike, the RPE (Borg scale (RPE)) and EE of the hikers during two differently graded hiking trails. The Pearson correlation coefficient and associated p-value are reported. Furthermore, all pairwise correlations between the various fitness scales and PA, together with the associated p-value are presented. Descriptors for the magnitude of the correlation coefficient were used from Hopkins (2002) and are depicted in Table 25.

Table 25: Descriptors for the Magnitude of the Correlation Coefficient

Correlation Coefficient	Descriptor
0.0-0.1	trivial, very small, insubstantial, tiny, practically zero
0.1-0.3	small, low, minor
0.3-0.5	moderate, medium
0.5-0.7	large, high, major
0.7-0.9	very large, very high, huge
0.9-1	nearly, practically, or almost: perfect, distinct, infinite

Table 26 shows the correlations between the various PA/fitness tests (IPAQ, Step–up Test and Cooper Test). Table 27 displays the correlation between the PA/fitness tests results (IPAQ, Step–up Test and Cooper Test) with RPE, HR (minimum, average and maximum) and EE during the two trails, while Table 28 shows the correlation between the exertion variables of the two hiking trials.

Based on the results in Table 26, it is clear that the correlation of the IPAQ with the Step-up Test is trivial, and with the Cooper Test, small. A small negative correlation exists between the IPAQ and the Step-up Test Borg scale (RPE) ($r=-0.27$; $p=0.062$) and a moderate positive correlation between the IPAQ and the Cooper Test (Borg scale (RPE)) ($r=0.35$; $p=0.014$). Higher correlations exist between the Step-up and Cooper Tests. This is both for the Cooper Test and the Step-up Test ($r=0.53$;

p=0.0001), as well as the Step-up Test and the Borg scale (RPE) at the end of the Cooper Test (r=-0.38; p=0.008). There are two other negative correlations that should be noted. Firstly, a correlation of -0.54 (p=0.0001) between the Cooper Test and the Cooper Test Borg scale (RPE). Secondly, between the Borg scale (RPE) for the Step-up Test and the Borg scale (RPE) for the Cooper Test (r=-0.16; p=0.263). The negative correlation is expected since the "Excellent" category of the Cooper Test is associated with the lowest score (1), while the "Very Poor" category is scored as 5. Thus, as the fitness level of the participant increases, their RPE would be expected to decrease, creating a negative correlation. By contrast, the negative correlation of the Borg scale (RPE) Step-up Test and its corresponding Cooper Test RPE End is unexpected, as one would expect a positive correlation between these variables.

Table 26: Correlation and Regression between the IPAQ, Step-up Test and Cooper Test

		IPAQ	**Step-up Test**		**Cooper Test**	
		IPAQ	**Step-up**	**Borg Scale[1]**	**Cooper Test**	**Borg Scale[2]**
IPAQ	r[3]	1.00	-0.02	-0.27	-0.12	0.35
	a[4]		2.12		2.41	
	b[5]		-0.0115		-0.073	
	p[6]	-	0.914	0.062	0.407	0.014*
	n[7]	50	48	48	48	48
Step-up Test	r	-0.02	1.00	0.35	0.53	-0.38
	a	2.11			0.75	
	b	-0.022			0.436	
	p	0.914	-	0.015*	0.0001**	0.008**
	n	48	48	48	48	48
Borg Scale (RPE) Step-up Test[1]	r	-0.27	0.35	1.00	0.35	-0.16
	p	0.062	0.015*	-	0.015*	0.263
	n	48	48	48	48	48
Cooper Test	r	-0.12	0.53	0.35	1.00	-0.54
	a	3.47	1.71			
	b	-0.205	0.633			
	p	0.407	0.000	0.015*	-	0.0001**
	n	48	48	48	48	48
Borg Scale (RPE) Cooper Test[2]	r	0.35	-0.38	-0.16	-0.54	1.00
	p	0.014*	0.008**	0.263	0.0001**	-
	n	48	48	48	48	48

[1]RPE for the post Step-up Test, [2]RPE for post Cooper Test, [3]Correlation coefficient, [4]Regression intercept, [5]Regression slope, [6]p-value, [7]Number of observations included, *Significant, **Highly significant.

Low values of the IPAQ indicate low PA levels, and high values of the Step-up Test and Cooper Test indicate low fitness levels, while high values of RPE and high HR values indicate high levels of exertion. Thus one would expect a negative correlation of IPAQ with the Step-up Test and Cooper Test, and a negative correlation of the Cooper Tests with Borg scale (RPE) and the HR variables (minimum HR, average HR and maximum HR).

The correlations and regressions in Table 26 generally confirm the above expectations, although only a few specific correlations can be labelled as large, such as the correlation of the Step-up Test with the Cooper Test (r=0.53; p=0.0001), and the correlation of the Cooper Test with the Borg scale (RPE) at the end of the Cooper Test (r=-54; p=0.0001).

Table 27 presents the correlations between the PA/fitness tests with the RPE and various HR measures during both hiking trails. All but one of the HR variables (minimum HR recorded on Trail 1) as well as the EE on both Trail 1 and Trail 2 have negative weak correlations with the IPAQ. Only the minimum HR recorded on Trail 2 has a positive correlation with the IPAQ, although an insubstantial relationship is indicated. The only positive correlations found with the IPAQ were those for the RPE End for both trails (Trail 1 r=0.19, Trail 2 r=0.17) and the minimum HR for Trail 2 (r=0.03). Energy expenditure had negative correlations with not only the IPAQ (Trail 1 r=-0.02, Trail 2 r=-0.03), but also with the Step-up Test (Trail 1 r=-0.15, Trail 2 r=-0.13) and the Borg scale (RPE) at the end of the Step-up Test (Trail 1 r=-0.16, Trail 2 r=-0.13). All these correlations are small and can thus be described as “weak”.

Correlations between the average HR on the hiking trails and the Step-up Tests were stronger (Trail 1 r=0.49; p= 0.001, Trail 2 r= 0.62; p=0.0001). These statistics indicate a moderate-to-large correlation between the variables. For Trail 1, the Cooper Test had a significant correlation with minimum HR (r=0.47; p=0.001) and average HR (r=0.36; p=0.015); for Trail 2 these correlations were even higher with minimum HR (r=0.56; p=0.0001) and the average HR (r=0.71; p=0.0001).

Table 27 shows that the Step-up Test and Cooper Tests have positive correlations with RPE End, minimum HR, average HR and maximum HR, for both trails (with the exception of the correlation between maximum HR and the Cooper Test for Trail 2, which is negative). However, the only large correlations (0.5 and higher) are observed for Trail 2, where the correlations of average HR with the Step-up Test and Cooper Tests is r=0.62; p=0.0001 and r=0.71; p=0.0001 respectively. The correlations are generally small (0.1 to 0.3) or moderate (0.3 to 0.5), although, in general terms, with the expected significance. Other than the above, only weak correlations were found between the other variables. However, closer analysis of the data reveals some differences between the two trails as indicated in Table 28.

Table 27: Correlation between Physical Activity/Fitness Test Results (IPAQ, Step-up Test and Cooper Test) with Rate of Perceived Exertion (RPE), Heart Rate (minimum, average and maximum) During the Two Trails

			IPAQ	Step-up Test		Cooper Test	
			IPAQ	**Step-up**	**RPE[1]**	**Cooper**	**RPE[1]**
Trail 1	RPE End[2]	r[7]	0.19	0.18	0.28	0.17	0.22
		p[8]	0.204	0.242	0.056	0.272	0.138
		n[9]	47	46	46	46	46
	Min HR[3]	r	-0.02	0.37	0.14	0.47	-0.09
		p	0.897	0.011*	0.350	0.001**	0.547
		n	47	46	46	46	46
	Ave HR[4]	r	-0.15	0.49	0.26	0.36	-0.05
		p	0.304	0.001**	0.075	0.015*	0.733
		n	47	46	46	46	46
	Max HR[5]	r	-0.01	0.26	0.06	-0.07	0.18
		p	0.945	0.081	0.707	0.659	0.226
		n	47	46	46	46	46
	EE Kcal[6]	r	-0.02	-0.15	-0.16	0.31	0.04
		p	0.921	0.322	0.294	0.038*	0.783
		n	46	45	45	45	45
Trail 2	RPE End[2]	r	0.17	0.36	0.45	0.44	0.06
		p	0.244	0.015*	0.002**	0.002**	0.692
		n	48	46	46	46	46
	Min HR[3]	r	0.03	0.21	0.09	0.56	-0.20
		p	0.840	0.148	0.560	0.0001**	0.189
		n	49	47	47	47	47
	Ave HR[4]	r	-0.15	0.62	0.33	0.71	-0.32
		p	0.3083	0.0001**	0.022**	0.0001**	0.027*
		n	49	47	47	47	47
	Max HR[5]	r	-0.20	0.49	0.05	0.10	-0.03
		p	0.173	0.001**	0.725	0.485	0.867
		n	49	47	47	47	47
	EE Kcal[6]	r	-0.03	-0.13	-0.13	0.30	0.07
		p	0.864	0.391	0.387	0.041*	0.649
		n	49	47	47	47	47

[1]Rate of Perceived Exertion during the PA/fitness test, [2]Rate of Perceived Exertion at the end of the trail, [3]Average minimum heart rate during the hike, [4]Average heart rate during the hike, [5]Average maximum heart rate during the hike, [6]Energy Expenditure during the hike, [7]Correlation coefficient, [8]Level of significance, [9]Number of observations included. *Significant, **Highly significant.

Table 28: Correlation between Exertion Variables on Trail 1 and Trail 2

		Trail 1				Trail 2			
		RPE End[1]	**Min HR[2]**	**Ave HR[3]**	**Max HR[4]**	**RPE End[1]**	**Min HR[2]**	**Ave HR[3]**	**Max HR[4]**
RPE End[1]	r[5]	1	0.12	0.11	0.01	1	0.33	0.40	-0.07
	p[6]		0.410	0.457	0.944		0.022*	0.005**	0.642
	n[7]	47	47	47	47	48	48	48	48
Min HR[2]	r		1.00	0.55	-0.04		1	0.59	0.06
	p			0.0001**	0.787			<.0001**	0.693
	n		47	47	47		49	49	49
Ave HR[3]	r			1.00	0.59			1	0.45
	p				0.0001**				0.001**
	n				47				49

[1]RPE at the end of the trail, [2]Average minimum heart rate during the hike, [3]Average heart rate during the hike, [4]Average maximum heart rate during the hike, [5]Correlation coefficient, [6]Level of significance, [7]Number of observations included, *Significant, **Highly significant.

Table 28 indicates several large correlations between the HR variables. However, unexpectedly only small (0.1 to 0.3) or moderate (0.3 to 0.5) correlations were found between the RPE End and the different HR variables. In Trail 1 there is a high correlation between the average HR and the minimum HR (r=0.55; p=0.0001) and the maximum HR (r=0.59; p=0.0001). In Trail 2 the average HR has a large correlation with the minimum HR (r= 0.59; p=<.0001) and the maximum HR has a moderate correlation with the average HR (r=0.45; p=0.001). Additionally, RPE End correlates only moderately with minimum HR (r=0.33; p=0.022) in Trail 2, as well as with average HR in Trail 2 (r=0.40; p=0.005). Otherwise, only weak correlations were found between the other variables.

5.1 Prediction of Levels of Exertion on the Hiking Trails Based on Physical Activity/Fitness-Test Information

One question investigated in this study was whether the exertion levels on the two hiking trails could be predicted by information based on the pre-hike PA/fitness tests.

For the purposes of this analysis, the average HR and maximum HR, as well as the Borg Scale (RPE) at the end of the trail were chosen as indicators of exertion on the trail in question.

Initially, the exertion data for the two trails was analysed separately, as follows: An Analysis of Covariance (ANCOVA) model for each of the variables average HR, maximum HR and Borg scale (RPE) at the end of the trail (dependent variables) was fitted with the following independent variables:

- IPAQ
- Step-up Test
- Cooper Test
- Time taken to complete the trail.

The pre-hike PA/fitness tests, namely IPAQ, Step-up Test and Cooper Test, were fitted as categorical (class) effects. The time completion aspect was included in the model as a covariate because it could be an important predictor, since completion time of the trail might be associated with exertion levels (negative correlation: the shorter the completion time, the higher the exertion).

The model as specified above was fitted (the “Full model”), and F-statistics and associated p-values for all model effects are reported (Table 29 for Trail 1 and Table 32 for Trail 2). Thereafter, stepwise backward model selection was performed as follows: Starting with the full model, the statistically least significant variable (variable associated with the highest p-value) was removed from the model, providing that the p-value was larger than 0.10. The selection procedure ceased when all variables remaining in the model were significant at the α=0.10 level. Table 29 and Table 33 summarise the final selected models for Trail 1 and Trail 2, respectively.

Based on the final selected model, the predicted values (least squares estimates) of the dependent variable were calculated for the different levels of the PA/ fitness test variables selected for the final model (Table 31 and Table 34 for Trail 1 and 2, respectively).

For Trail 1, when fitting the “full model”, only the Step-up Test was a statistically significant predictor of average and maximum HR (Table 29); none of the independent variables was a significant predictor of Borg scale (RPE). As is evident in Table 30, the stepwise model selection produced the same results: the Step-up Test is a significant predictor of both average HR and maximum HR, but none of the independent variables predicted Borg scale (RPE). Therefore, the least squares mean values of the average HR and maximum HR were calculated for the different levels of the predictor variable (Step-up Test), and are presented in Table 31.

Table 29: Trail 1: Potential Predictors of Exertion during Hike; Full Model (Analysis of Covariance)

Exertion-Dependent Variable	Independent Variable	ANCOVA		
		df	**F-statistic[1]**	**p-value[1]**
Average Heart Rate	IPAQ	2, 35	0.14	0.8666
	Step-up Test	3, 35	3.37	0.0291
	Cooper Test	4, 35	1.31	0.2865
	Time	1, 35	1.03	0.3172
Maximum Heart Rate	IPAQ	2, 35	0.62	0.5425
	Step-up Test	3, 35	6.74	0.0010
	Time	4, 35	0.60	0.6600
	Borg RPE (end of hike)	1, 35	0.00	0.9445
Borg Scale (RPE) (end of hike)	IPAQ	2, 35	0.65	0.5301
	Step-up Test	3, 35	0.49	0.6934
	Cooper Test	4, 35	0.75	0.5679
	Time	1, 35	1.28	0.2648

[1]F-statistic and associated p-value from Analysis of Covariance of dependent variable

Table 30: Trail 1: Predictors of Exertion during Hike; Final Selected Model (Analysis of Covariance)

Exertion-Dependent Variable	Independent Variable	ANCOVA		
		df	**F-statistic[1]**	**p-value**
Average Heart Rate	Step-up Test	3, 42	5.56	0.0026
Maximum Heart Rate	Step-up Test	3, 42	6.10	0.0015
Borg Scale (RPE) (end of hike)	NA[2]			

[1]F-statistic from Analysis of Covariance of dependent variable
[2]Not applicable: None of the potential predictors was included in the final model

Table 31: Trail 1: Predicted Average Heart Rate, Maximum Heart Rate and Borg Scale (RPE) as a Function of Pre-Hike Step-up Test Category from Final Selected Model

Exertion-Dependent Variable	Step-up Test Category	Estimate[1]	Standard Error[1]
Average Heart Rate [bpm]	Very good	104.1	3.3
	Good	103.9	4.5
	Average	120.7	4.0
	Poor	125.0	7.1
Maximum Heart Rate [bpm]	Very good	158.9	6.1
	Good	130.9	8.3
	Average	175.2	7.4
	Poor	178.8	13.3
Borg Scale (RPE) (end of hike)[2]	-	10.7	0.2

[1]Least squares mean and associated standard error from final selected model
[2]None of the potential predictors was included in the final model for Borg scale (RPE); the reported estimate is the simple average of Borg scale (RPE) over all participants

For Trail 2, when fitting the "full model", the Step-up Test was a "borderline" statistically significant predictor of average HR (p=0.0718), but a significant predictor of maximum HR (Table 32), while, additionally, the Cooper Test was a significant predictor of average HR. Furthermore, the Cooper Test was a significant predictor of Borg scale (RPE). Again, the stepwise model selection confirmed these results (Table 33): both the Step-up Test and the Cooper Test were selected as significant predictors of average HR; the Step-up Test was selected as the only significant predictor of maximum HR; and the Cooper test was selected as the only significant predictor of Borg scale (RPE). The least squares mean values of the average HR, maximum HR and Borg scale (RPE), calculated for the different levels of the applicable predictor variables, and are presented in Table 34.

Table 32: Trail 2: Potential Predictors of Exertion during Hike; Full Model (Analysis of Covariance)

Exertion-Dependent Variable	Independent Variable	ANCOVA		
		df	F-statistic[1]	p-value
Average Heart Rate	IPAQ	2, 36	0.57	0.5684
	Step-up Test	3, 36	2.54	0.0718
	Cooper Test	4, 36	5.38	0.0017
	Time	1, 36	0.47	0.4981
Maximum Heart Rate	IPAQ	2, 36	1.02	0.3725
	Step-up Test	3, 36	4.59	0.0080
	Time	4, 36	1.40	0.2548
	Borg scale (RPE) (end of hike)	1, 36	0.03	0.8748
Borg Scale (RPE) (end of hike)	IPAQ	2, 35	1.41	0.2566
	Step-up Test	3, 35	1.46	0.2428
	Cooper Test	4, 35	3.06	0.0290
	Time	1, 35	0.73	0.4002

[1]F-statistic and associated p-value from Analysis of Covariance of dependent variable

Table 33: Trail 2: Predictors of Exertion during Hike; Final Selected Model (Analysis of Covariance)

Exertion-Dependent Variable	Independent Variable	ANCOVA		
		df	F-statistic[1]	p-value[1]
Average Heart Rate	Step-up Test	3, 39	2.67	0.0606
	Cooper Test	4, 39	6.27	0.0005
Maximum Heart Rate	Step-up Test	3, 43	4.61	0.0070
Borg Scale (RPE) (end of hike)	Cooper Test	4, 41	4.47	0.0043

[1]F-statistic and associated p-value from Analysis of Covariance of dependent variable

Table 34: Trail 2: Predicted Average Heart Rate, Maximum Heart Rate and Borg Scale (RPE) as a Function of Pre-hike Step-up Test Category from Final Selected Model

Exertion-Dependent Variable	Step-up Test Category	Cooper Test Category	Estimate[1]	Standard Error[1]
Average Heart Rate [bpm]	Very good	Excellent	101.6	3.8
		Above average	118.7	3.5
		Average	118.0	4.5
		Below average	123.4	4.6
		Poor	133.4	5.7
	Good	Excellent	107.3	6.2
		Above average	124.4	5.3
		Average	123.8	3.9
		Below average	129.1	3.7
		Poor	139.1	5.9
	Average	Excellent	112.8	6.1
		Above average	129.9	5.4
		Average	129.4	3.6
		Below average	134.6	3.5
		Poor	144.7	4.8
	Poor	Excellent	115.8	7.6
		Above average	132.9	6.2
		Average	132.3	5.4
		Below average	137.6	6.2
		Poor	147.6	6.3
Maximum Heart Rate [bpm]	Very good		166.7	3.8
	Good		176.4	5.2
	Average		185.5	4.4
	Poor		191.0	8.3
Borg Scale (RPE) (end of hike)		Excellent	12.0	0.7
		Above average	11.8	0.6
		Average	13.0	0.5
		Below average	12.9	0.5
		Poor	15.7	0.8

[1]Least squares mean and associated standard error from final selected model

Clearly, for both trails, both average HR and maximum HR increase with decreasing levels of fitness as determined by the Step-up Test. The maximum HR on Trail 1 for participants with average and poor Heart-Rate Scale results on the Step-up Test is about 180 b/min (Table 31) while on Trail 2 the maximum HR exceeds 190 b/min for participants with a poor Heart-Rate Scale (Step-up Test) (Table 34).

In a second analysis, data for the two trails was analysed jointly, using a mixed analysis of covariance model. As before, the dependent variables were average HR and maximum HR, and the Borg scale (RPE) at the end of the trail. The mixed model fitted the following independent variables:

- Trail
- IPAQ
- Step-up Test
- Cooper Test
- Time taken to complete the trail.

Except for the time taken to complete the trail, these variables were fitted as fixed categorical (class) effects. Furthermore, in order to allow for the correlation between the data for Trail 1 and Trail 2 of the same participant, the factor Participant was fitted as a random effect. The model as specified above was fitted (the “Full model”), and F-statistics and associated p-values for all model effects are reported (see Table 35). Thereafter, stepwise backward model selection was performed as described above for the separate analysis, and its results are presented in Table 36. Finally, based on the final selected model, the predicted values (least squares estimates) of the dependent variable were calculated for the different levels of the PA/fitness test variables selected for the final model (see Table 36).

In the full model, the variables Trail, Step-up Test and Cooper Test were statistically significant predictors of average HR, while only the Step-up Test was a significant predictor of maximum HR, and no significant predictor was identified for Borg scale (RPE) (Table 35). After model selection, the variables Trail, Step-up Test and Cooper Test were again identified as significant predictors of average HR; however, Trail and Step-up Test were selected as predictors of maximum HR, and Trail and Cooper Test were selected as predictors of Borg scale (RPE) (Table 36). These differing results of the full model, and the results emerging from stepwise model selection are due to the effect of completion time for the trail, which is linked with the variable Trail (Trail 2 taking much longer to complete than Trail 1).

The least squares mean values of the dependent variable in question were calculated for the different levels of the respective predictor variables, and are presented in Table 35.

Table 35: Joint Analysis of Both Trails: Potential Predictors of Exertion during Hike; Full Model (Mixed Analysis of Covariance)

Exertion-Dependent Variable	Independent Variable	ANCOVA		
		df	**F-statistic[1]**	**p-value[1]**
Average Heart Rate	Trail	1, 68.7	4.93	0.0297
	IPAQ	2, 39.2	0.40	0.6737
	Step-up Test	3, 39.1	3.67	0.0201
	Cooper Test	4, 38.2	2.92	0.0337
	Time	1, 68.9	1.55	0.2172
Maximum Heart Rate	Trail	1, 77.8	1.36	0.2479
	IPAQ	2, 37.6	0.22	0.8004
	Step-up Test	3, 37.5	6.38	0.0013
	Cooper Test	4, 36.3	0.96	0.4392
	Time	1, 78.0	0.36	0.5487
Borg Scale (RPE) (end of hike)	Trail	1, 75.9	0.20	0.6600
	IPAQ	2, 39.4	1.15	0.3269
	Step-up Test	3, 40.4	0.80	0.5025
	Cooper Test	4, 38.0	1.57	0.2027
	Time	1, 76.2	0.34	0.5615

[1]F-statistic and associated p-value from Mixed Analysis of Covariance of dependent variable

Table 36: Joint Analysis of Both Trails: Predictors of Exertion during Hike; Final Selected Model (Mixed Analysis of Covariance)

Exertion-Dependent Variable	Independent Variable	ANCOVA		
		df	**F-statistic[1]**	**p-value[1]**
Average Heart Rate	Trail	1, 45.8	57.73	<.0001
	Step-up Test	3, 40.3	3.82	0.0170
	Cooper Test	4, 40.0	3.41	0.0173
Maximum Heart Rate	Trail	1, 45.2	17.16	0.0001
	Step-up Test	3, 43.2	5.62	0.0024
Borg Scale (RPE) (end of hike)	Trail	1, 46.3	53.04	<.0001
	Cooper Test	4, 43.1	2.76	0.0394

[1]F-statistic and associated p-value from Mixed Analysis of Covariance of dependent variable

Table 37: Joint Analysis of Both Trails: Predicted Average Heart Rate, Maximum Heart Rate and Borg Scale (RPE) as a Function of Pre-hike Step-up Test and Cooper Test Category from Final Selected Model

Exertion-Dependent Variable	Step-up Test Category	Cooper Test Category	Trail 1		Trail 2	
			Estimate[1]	Standard Error[1]	Estimate[1]	Standard Error[1]
Average Heart Rate [b/min]	Very Good	Excellent	92.0	4.2	105.7	4.2
		Above Average	107.9	3.8	121.7	3.8
		Average	103.9	4.9	117.6	4.9
		Below Average	107.4	5.0	121.1	5.0
		Poor	115.5	6.2	129.3	6.2
	Good	Excellent	94.3	6.7	108.0	6.7
		Above Average	110.2	5.8	124.0	5.8
		Average	106.1	4.3	119.9	4.3
		Below Average	109.6	3.9	123.4	4.0
		Poor	117.8	6.4	131.5	6.4
	Average	Excellent	105.0	6.6	118.8	6.6
		Above Average	121.0	5.9	134.7	5.9
		Average	116.9	4.0	130.6	4.0
		Below Average	120.4	3.8	134.1	3.8
		Poor	128.6	5.2	142.3	5.2
	Poor	Excellent	107.9	7.74	121.7	7.7
		Above Average	123.9	6.7	137.6	6.7
		Average	119.8	5.9	133.6	5.9
		Below Average	123.3	6.7	137.1	6.7
		Poor	131.5	6.8	145.2	6.9
Maximum Heart Rate [b/min]	Very Good	-	154.5	4.7	171.2	4.7
	Good	-	145.0	6.6	161.7	6.6
	Average	-	171.8	5.5	188.5	5.4
	Poor	-	176.5	9.5	193.2	9.5
Borg Scale (RPE) (end of hike)		Excellent	9.9	0.5	12.1	0.5
		Above Average	10.1	0.5	12.3	0.5
		Average	11.0	0.4	13.2	0.4
		Below Average	10.7	0.4	12.8	0.4
		Poor	12.3	0.6	14.4	0.6

[1]Least squares mean and associated standard error from final selected model

The results in Table 37 show that, with respect to average HR, the average difference between Trail 2 and Trail 1 is about 14 beats/min; with respect to maximum HR about 17 beats/min, and with respect to the Borg scale (RPE) about 2 points.

Where the results of the joint analysis of the two trails can be compared directly to the results of the separate analysis (same predictors selected), those results agree well: see the predicted maximum HR (prediction based on the Step-up Test category) in Table 37 (joint analysis) versus the predictions in Table 31 and Table 34 respectively (separate analysis). Similarly, the predictions of the Borg scale (RPE) (prediction based on the Cooper Test category; joint analysis) for Trail 2 are similar to the predictions of the Borg scale (RPE) for Trail 2 in Table 34 (separate analysis). These observations confirm the robustness of the analysis results compared to different analysis methods. Generally, the interpretation of the results from the joint analysis is similar to the interpretation of the results from the separate analyses of the data from the two trails.

The estimated average HR of a hiker who performs well in both the Step-up Test and Coper Test (scores of “Very good” and “Excellent”, respectively) is predicted to have an average HR of 92 bpm (Table 37) during the hiking of an easy trail and 105.7 bpm during a moderate hike. Those falling in the upper band of the Cooper Test and in the “Good” category with the Step-up Test have a predicted average HR of 94.3 bpm for an easy trail and 108 for a moderate trail. Those at the lower end of this “Good” category (lower score for the Cooper Test) will have a predicted HR of 117.9 bpm and 131.5 bpm for Trail 1 and Trail 2 respectively.

Based on the results of the Step-up Test maximum HR can be a predictor of risk, therefore the maximum HR may be used to motivate against certain hikers in the poor category of the Step-up Test participating in moderate and difficult graded hikes due an increased risk of cardiac events (Mittleman, Maclure, Tofler, Sherwood, Goldberg & Muller, 1993) and other challenges and risks (Norton *et al*., 2010). With regard to the maximum HR, a typical ascending HR can be seen, starting with an expected HR of 154.5 bpm for an individual falling into the very good category and ascending to 176.5bpm for the easy graded hike. The estimated maximum HR for the second trail (moderate grading difficulty) is 171.2 bpm, rising to 193.32 bpm for the individual in the “Poor” Cooper fitness category.

The estimated Borg scale (RPE) for the end of the hike for Trail 1 is 9.9 for those in the fittest category. This relates well to the estimated average HR of 92 bpm for the fittest category for Trail 1. The estimated Borg scale (RPE) rating links well with all the predicted average HR scores for Trail 1. The predicted Borg scale (RPE) at the end of hike two does not link with the average HR as well as that of Trail 1. The initial score for the excellent group indicating a 12.1 is considerably higher than the 9 that could be assumed from the estimated average HR. The "Poor" classification has a Borg scale (RPE) of 14.4 which is also higher than the 129.3 predicted HR would suggest. The "Below Average" classification estimated Borg scale (RPE) is also surprising, as this number is lower than that of the "Average" group.

6. CONCLUSION

From the results obtained in this study, Table 38 (on following page) was formulated as a summary of the profile found in this group of hikers. The results have been tabulated in this chapter. Chapter 5 will elucidate on the findings.

Table 38: Summary of Hiker's Profile

			Mean	Std	Min	Q 1	Q 3	Max
Height (cm)		**Male**	181.2	7.52	172.0	174.0	186.0	192.0
		Female	166.2	4.99	154.0	164.5	169.0	175.0
Weight (kg)		**Male**	90.3	18.89	60.8	77.2	100.4	120.4
		Female	71. 6	13.11	52.0	63.4	75.9	119.8
Fat %		**Male**	20.1	7.68	10.5	14.8	22.9	38.2
		Female	21.7	6.54	10.1	17.2	25.7	34.2
Somatotype	**Mesomorph**	**Male**	6.4	1.51	3.9	5.6	6.9	9.6
		Female	5.6	1.85	2.6	4.3	6.5	10.9
	Ectomorph	**Male**	1.5	1.02	0.1	0.8	2.0	3.6
		Female	1.4	1.14	0.1	0.4	2.2	4.0
	Endomorph	**Male**	4.3	1.60	2.5	3.0	4.6	7.8
		Female	4.9	1.61	1.8	3.8	6.2	8.0
Age (yrs)			38.2	12.02	20	27	48	64
IPAQ			2.2	0.75	1.0	2.0	3.0	3.0
Step-up Test			2.1	1.02	1.0	1.0	3.0	4.0
Borg Scale (RPE) Post Step-up			11.9	1.7	7.00	11.0	13.0	15.0
Cooper Test			3.0	1.23	1.0	2.0	4.0	5.0
Borg Scale (RPE) Post Cooper Test			15.3	2.67	9.0	13.0	17.0	20.0
Borg Scale (RPE) Post Trail 1			10.7	1.46	7.5	9.00	12.0	13.0
Borg Scale (RPE) Post Trail 2			13.0	2.06	10.0	12.0	14.0	20.0
Average EE Trail 1			798.4	183.92	530.7	658.8	896.7	1291.6
Average EE Trail 2			2470.3	545.93	1552.0	2090.3	2700.6	4019.9

Chapter 5

Discussion of Results

1. INTRODUCTION

The positive impact of experiencing flow in recreation has been clearly indicated. To experience flow, the alignment of required physical exertion with physical fitness level is important. However, the current link between physical fitness and the grading of a hiking trail is unknown. The appeal of hiking is that it can be simple and feasible to do for nearly everybody, depending on the physical exertion levels required. The discrepancies that exist regarding the perception of physical exertion required for a hike are obvious and could impact negatively on participation levels. Currently there is a lack of information regarding the physiological demands of hiking trails. If there is a difference in perceptions of the physical demands of hiking amongst researchers, the general public is even more likely to have misconceptions about the physical requirements of hiking. The need for an uncomplicated method to determine the physical requirements necessary for the experience of flow in a hiking trip becomes more apparent. The description of physical requirements provided in previous research is helpful, but the practical implication thereof is very challenging for hikers. This research aimed at addressing this issue in order to highlight the physical demands required in order for potential hikers to physically prepare themselves adequately for a hike or at least to be aware of the possible physical constraints and demands posed by various graded hiking trails. The selection of an appropriate graded hiking trail in line with the physical fitness/activity level of the hiker should lead to a more fulfilling experience (experiencing flow).

2. THE PARTICIPANTS

2.1 Demographics

The Outdoor Foundation (2015) study indicates that hiking was in the top five outdoor activities involving youth and young adult participants in the United States of America in 2014. Hiking was also listed as the fourth most popular adult outdoor activity with 25.9 million participants indicating a 1.7% growth in the activity. The 2015 report (Outdoor Foundation, 2016) indicates that hiking was still in the number five position for youth and young adult participation, with 10.8 million participants. Currently no similar statistics are available for hiking in South Africa (Bossert, 2015) and the literature does not provide an account of either the historical growth or the future prospects of the hiking sector (Slabbert, 2015).

Previous hiking research seldom gives specifics on the demographic composition of the study population. Studies with a larger sample most often took the form of questionnaires that were administered to participants at the hiking site. Fifty (50) participants (37 female and 13 male participants) completed the Demographic, Medical, Hiking and IPAQ questionnaires. It is important to note that the participants in this research were all intending to undertake a hike and volunteered to participate. Although the initial intention to include only members of hiking clubs, it became clear during the pilot phase that this would be problematic. One of the local hiking clubs provided the researcher with a list of members from which to recruit participants. This list revealed that the mean age of members was 57.5 years. One of the inclusion criteria was an age range between 20 to 64 years. This excluded many of the members from the study as they did not fall within the stipulated age inclusion criteria.

The mean age for the population in this study was 38 years as depicted in Table 6. The age of the male participants ranged from 22-64 years with a mean of 42.92 (± 11.13) years, while the female participants ranged from 20-63 years with a mean of 36.49 (±12.01) years. It is clear from the literature that age levels in hiking differ widely. However, the average age group of this study is similar to that of Rodrigues *et al.* (2010) and Slabbert (2015), but different from Mason *et al.* (2013) and Hill *et al.* (2009) who reflected conflicting age ranges.

Mason *et al*. (2013) reported an age range of 20-29 as being their highest participant age-group (29.2%) followed by the age group 50-59 (26.2%). Rodrigues *et al.* (2010) describe the demographics of the population in their study as falling within the age range of between 25 and 54 years. This emphasises that the age profile of hikers differs. This may be due to factors like club structures (more senior citizens) and the grading of the hike where the surveys were conducted (an increase in difficulty may lead to a decrease in age).

A recent study of long-distance hikers regarded its results as being unique when determining a close male-female ratio of 57% male to 43% female (Collins-Kreiner & Kliot, 2017), although the results of this study are similar to Slabbert (2015) whose respondents were 56% male and 44% female, and Mason *et al*. (2013) who had a 40.2% female to 59.8% male ratio. The gender ratio of the current study can be considered to be distinctive in comparison with previous research as the ratio was 74% female to 26% male.

With regard to ethnicity the findings of this study were similar to Hill *et al.* (2009) who only had one African-American participant. Six percent (6%) of the participants in the current study were Coloured and 6% participants were Black. Both these percentages are greater than Slabberts' (2015) results of 3% for Black and 5% for Coloured participants. There is a strong indication that hiking is currently predominantly practised by Caucasians. However, the descriptive statistics given in previous research is very limited and a full picture of the hiker is not provided. Research, where questionnaire respondents actually took part in a hike, demonstrated very small samples, i.e. from one participant (Sperlich *et al.*, 2010) to fewer than twenty participants (Sturm *et al.*, 2012; Gutwenger *et al*., 2015). These studies offered very little demographic information.

The lack of comparative demographic information is obvious. Most SA studies were not based on empirical research and/or had small samples. Hugo *et al.* (1998/9) had small populations (7 hikers), with only one study (Hugo *et al.* 1998/9) claiming a larger heterogeneous group (46) but with no details given as to the make-up of this group. Slabbert (2015) emphasised that there is no recent literature on South African hiking demographics other than those reported in her study.

2.2 Medical History

Risk stratification, medical clearance and medical history of participants is important for hikers, although there is a perception that hiking is "less dangerous" than other outdoor pursuits. According to Heggie and Heggie (2012), compared to other activities such as mountain climbing and rock climbing, the risks associated with hiking are perceived as minimal. Green (2015) is in agreement stating that although risks exist in hiking, the injury rates are low. Mason *et al.* (2013) conclude in this regard that injuries leading to rescues were often caused by hikers being underprepared. They suggest that groups are most often underprepared, tended to be younger, less fit, and inexperienced. They also found that day hikers were often the most underprepared due to the perception that shorter hikes are less dangerous (Mason *et al*., 2013).

The updated American College of Sports Medicine guidelines (ACSM, 2014a) make general recommendations for medical clearance versus recommendation for a specific set of tests. The ACSM (2014a) guidelines specifically state that the manner of clearance is left to the discretion of the healthcare provider. However, the 2008 Physical Activity Guidelines for Americans (United States Department of Health and Human Services, 2008: G10-40) recommended that, "symptomatic persons or those with cardiovascular disease, diabetes, or other active chronic conditions who want to begin engaging in *vigorous* physical activity and who have not already developed a physical activity plan with their health care provider may wish to do so". The guidelines, however, do not impose such medical contact (United States Department of Health and Human Services, 2008). Nonetheless, according to the ACSM Health/Fitness Facility Pre-participation Screening Questionnaire (ACSM, 2014a) (see Table 8) all participants in this study were cleared to participate.

Participants' greatest response frequency in the medical questionnaire indicated that they took prescription medication (Table 8). They were not asked what the medication was or what it was used to treat. The second most frequently answered question was that of participants considering themselves as more than 9kg overweight. Twenty-two percent (22%) of respondents described themselves as being nine or more kilograms overweight. Aspects about the weight of individuals is discussed further under anthropometry in 2.1. The third and fifth most frequent responses related to participants' lack of knowledge of their own cholesterol or blood pressure levels. The fourth highest response was for asthma or lung disease. All participants who indicated such issues nonetheless considered themselves medically fit to participate in the research. The absence of most NCD's amongst participants is evident. No participants reported cardiovascular diseases, cancer or diabetes. Only 14% of participants reported having asthma or lung disease. Six percent (6%) of participants considered themselves to be unhealthy (Table 9). Interestingly, only 66.6% of these "unhealthy" participants thought that they were more than nine kilograms overweight and 33.3% not reporting any other health issues whatsoever. The others indicated having asthma, taking medication and experiencing burning sensations in legs on occasion. Thirty-three point three percent (33.3%) of these participants considered themselves as not healthy as they were not as fit as they thought they should be. All the participants who categorised themselves as unhealthy also categorised themselves as unfit.

Four percent (4%) of participants smoked, of these participants 50% indicated that they smoked between one and five cigarettes daily and the other 50% indicating that they smoked between six and ten cigarettes daily. Eighty percent (80%) of participants consumed alcohol, with the majority (64%) indicating that they drank on social occasions only. Indications are that the hikers can be labelled as predominantly healthy but not necessarily fit (although 80% of participants fell into the moderate or high category of PA according to the IPAQ).

It should be noted that the general population will be affected by various medical conditions. Hiking is not limited to persons without medical conditions only. As it was an intention of this study to develop a profile of the population of hikers and to determine if a simple pre-hike test could be used to predict exertion in order for hikers to make informed decisions on their ability to complete a hike, the study was not limited to persons who displayed "perfect health".

2.3 General Hiking Information

The settings in which hiking takes place are very unpredictable and are exposed to subjective individual perception of participants. Literature addressing the possible variables that impact on hiking is sparse. The variables that impact on the excursion are diverse and may severely influence the outcomes of the hike. One such variable is experience indicating the acquisition of skill or knowledge developed by doing/executing something (hiking). Data gathered from the Hiking Questionnaire indicates that the participants varied in hiking experience, with the majority (78%) of participants having participated in 10 or fewer hikes. However, the most experienced hiker had undertaken more than 88 hikes. Most participants (34%) participated less than once a year, with 12% of respondents indicating that they hiked five or more times per year. The majority of participants classified themselves as beginners (40%) with 36% describing themselves as novice hikers. Only eight hikers considered themselves as experienced. Participants ranged from first-time participants to those with 40+ years' experience. It was interesting to note that only 4% were members of a hiking club. Although persons had initially indicated that they would participate, a large portion of club members did not fall into the inclusion criteria due to the age limitations (69 years).

Only Mason *et al.* (2013) mentioned participants self-rated level of experience. It should be noted that self-perceived experience levels are subjective and may even be a reflection of inexperience. Some hikers may label themselves as "experienced" after doing five single day hikes as opposed to others who would do so after completing five multiple day hikes. This subjectivity may be linked to the astute (realistic judgement of competence/fitness levels) or arrogant and fearless (overestimation of competence/fitness levels) individuals as discussed in the literature section (Priest & Gass, 2005).

Raubenheimer (2017) suggests that a hiker who has done 10 unmarked Drakensberg hikes (own navigation and no hutted accommodation) will be more experienced than someone who has done 20 hikes on marked trails with hutted accommodation. Additionally, the role the person plays during the hike will also contribute to experience. When one is responsible for arranging the hike, doing the navigation, etc., one learns a lot more (and hence gain more experience) than someone who just follows the rest of the group. Furthermore, Raubenheimer (2017) stated that some people quite simply learn more and faster than others. By implication some people can gain more experience from ten hikes than others can from twenty. Raubenheimer (2017) concludes with the statement that “it is a complex evaluation”.

The inexperience (and unpreparedness) of some of the participants is reflected in the footwear worn. More participants (50%) wore a trainer (“Tekkie”) as opposed to hiking boots (40%). This could also be due to the expense of the boots with the consideration that many participants (34%) hike less than once a year. However, if one combines the hiking boot category with the hiking shoe and the trail shoe categories one gets a 50-50 split between trainers and hiking-related footwear. It should be noted that footwear will impact on EE during the hike. The use of the trainer shoe for the hike would have resulted in less EE as demonstrated by Fattorini *et al*. (2012). It is noted that a more skilled hiker will move more efficiently and so use a reduced amount of energy in comparison to those with less skill (Schurman & Schurman, 2009). Green (2015) concluded that proper training should take place before embarking on a hike. These findings emphasise the necessity of being able to determine the diverse trail physical expenditure requirements and fitness levels of hikes.

It is important to take cognisance of the fact that experience will facilitate the astute judgement of fitness levels required to complete the selected hiking trail. It is important to note that hikers can be affected by "acute bad judgment syndrome" (Heggie & Heggie, 2012) and overestimate their abilities. The hikers consider themselves capable of hiking a substantial distance over a short duration (for example one day hikes) when in reality they cannot. This can then lead to risks of physical injuries or even death.

3. PRE-HIKE TESTING

3.1 IPAQ

A self-report questionnaire (for instance the IPAQ) could possibly be used to determine PA levels of a hiker, because, the report on the chronic lifestyle diseases in South Africa stated that the IPAQ “has been validated for use in the South Africa population” (Lambert & Kolbe-Alexander, 2006). However, some concerns have been raised about the unreliability of self-reports especially for occupational PA (Lambert & Kolbe-Alexander, 2006).

Previous research has not indicated hikers’ fitness levels before hiking. The IPAQ was administered before the hikes in order to determine if the ability to comfortably complete the hike could be determined through a simple, well-known and validated PA questionnaire (Sternfeld & Goldman-Rosas, 2012). This could assist hikers and avoid "acute bad judgment syndrome" mentioned previously. Priest and Gass (2005) stated that if a hiker could accurately gauge his/her physical fitness levels (competence) and compare these to estimate requirements (risk), the likelihood of misadventure or an unfulfilling experience can be reduced.

Participants in this research tended to be active individuals with 80% of participants falling into the moderate or high category of PA according to the IPAQ. Thus the participants did not conform to the current worrying statistics of inactivity (Dumith *et al.,* 2011; WHO, 2016a). This indication of moderate-to-high activity levels can possibly be linked with the absence of most NCD’s within the volunteer group as reported in their medical history. The results obtained on the IPAQ indicate that the majority of participants in this study conformed to the ACSM recommendations for PA (Haskell *et al*., 2007). These results differ from those of previous South African-based research on young adults undertaken by Bloemhoff (2010), which highlighted that 33% of participants fell into the low category of the IPAQ and that males were the most physically active (75.8%). In the current study, it is noted that only 20% of the participants fell into the low category and 42% in the moderate category, as opposed to Bloemhoff's 32.4%.

The indicated 80% of relatively active individuals is higher than the world-wide results of Dumith *et al.* (2011) who claim that one out of five adults are physically inactive and the more recent statistics from the WHO (WHO, 2016a) which report one in four people to be inactive. The levels of PA reported by the participants of the current study may be a contributing factor to the participants' indication of a reduced level of chronic disease (Bouchard *et al.,* 2007).

The IPAQ has been established to be a suitable self-report instrument for characterising patterns of PA (Sternfeld & Goldman-Rosas, 2012). The questionnaire was considered for this research due to its practicality and convenient means for a potential hiker to assess themselves before a hike. However, unfortunately as a pre-hike PA test, the IPAQ questionnaire was not suitable as a predictor for exertion during a hiking trail (see discussion).

3.2 Anthropometry

It is well known that the analysis of body composition is an essential component for improvement of sport performance in elite athletes. This may also be important for a hiker. Despite the fact that hiking is quite popular, few data are available on the anthropometric profile of hikers in South Africa. With regard to the anthropometric profile established in this study, the results for the mean height of the male participants was 181.23 cm, the female participants 166.19 cm while mean body mass was 90.26 kg and 71.56 kg for the males and females respectively. No previous literature reflected the height or mass of hiking participants.

The body requires a minimal amount of fat in order for it to function normally, this is referred to as essential fats (Esmat, 2016). The values differ for males and females with 3% being the minimum suggested value for males and 12% for females (Esmat, 2016). Fat above this minimum amount is considered nonessential fat. The generally accepted range in men is 10-22% and in women 20-32% (ACSM, 2014a). The total mean body fat percentage of hikers is not addressed in previous studies. The mean body fat percentage for the male participants in this study was 20.1% and for female participants 21.7%. Thus the mean for the fat percentage of female participants falls into the “fitness” category for females (ACE, 2003). The men’s mean of 20.1% falls into the general category of “average” (ACE, 2003). The fat percentage of participants was therefore in the generally accepted range that is considered satisfactory for good health (ACE, 2003). This concurs with the self-assessment of health (Table 9) where 94% of the participant considered themselves as “healthy”. To conclude, the measure of body fat percentage is a useful tool for describing, in part, the anthropometric characteristics of hikers.

In the medical questionnaire, 22% of participants indicated that they felt they were overweight. According to the results of the anthropometry for the fat percentage, 10.2% of participants fell into the obese category (25% and higher for males and 32% and higher for females (ACE, 2003)), 60% of these participants were male and 40% female. Thus 10.2% of the overall participants were obese, (4.08% female and 6.12% men) in contrast to the South African statistics of 68% of women and 31% of men being overweight or obese (Stats SA, 2017). Eighty percent (80%) of the respondents who tested as obese, thought they were nine or more kilograms overweight. They all considered themselves healthy and 10.2% of these respondents considered themselves fit.

The somatotyping of participants indicated that the typical hiker was an endomorphic mesomorph, this was true for both male (4.3-6.4-1.5) and female participants (4.9-5.6-1.4) (See

Table 14), although as expected the muscular component of the male hikers was greater.

The analysis of the anthropometry provides insight into the physical profile of the typical hiker in the Free State region. It would seem that participants who participate in hiking are those that are already somewhat active and healthy, and consider themselves fit enough to attempt the hike. The anthropometry profile of hikers may thus not be aligned with the general population. The body composition of the participants would seem to affirm this, as only a small portion of the participants were considered obese/overweight. As previous research does not provide anthropometric profiles of hikers it is not possible to compare the somatotyping of hikers. However, it must be mentioned that only 4% of participants were members of a hiking club, but the majority (78%) of participants had participated in 10 or fewer hikes.

3.3 Step-up Test

It is clear that risk stratification, medical clearance and medical history of participants is important for hikers. The ACSM (2014a) make general recommendations for medical clearance versus recommendation for a specific set of tests. Therefore, the Step-up Test was used as a possible pre-hike fitness test.

In order to experience a quality hiking excursion, potential hikers must be fit enough to complete the intended hike (Mason *et al*., 2013; Green, 2015). Various tests are available to determine fitness levels, including step-up tests that measure aerobic fitness. Step-up tests are often used due to their simplicity and minimal requirements for equipment and space.

The Step-up Test performed in this study, using the methods suggested by De Villiers and Thiart (1988), indicated that the majority of the participants (62.6%) fell into the "Good" or above heart-rate scale, with only 8% of the hikers in the "Poor" heart-rate scale. The results indicated, as with the IPAQ, that most of the participants were physically active in some or other form. None of the participants scored in the "Very Poor" category.

According to Chen *et al*. (2002) the Borg scale (RPE) has received criticism in the literature about inconsistencies on the strength of the relationship between ratings of perceived exertion and various physiological criterion measures, such as HR, blood lactate concentration, percent maximal oxygen uptake (% $\dot{V}O_{2\,max}$), and oxygen uptake (VO_2). However, other studies maintain that the use of the scale is valid (e.g. Diafas *et al*., 2007), in fact Scherr *et al*. (2013) felt that the current validity statements have been underestimated, and that validity is higher than originally reported.

The subjective rating of perceived exertion (Borg scale (RPE)) was measured directly after the Step-up Test. The RPE has been strongly correlated with HR (Borg, 1982). HR and cardiac output increase in a linear fashion (Bouchard *et al*., 2007). This relationship enables the HR to be used to determine exercise intensity. Borg (1982) is of the opinion that perceived exertion is a good indicator of the degree of physical strain.

The results of the Borg scale (RPE) directly after the Step-up Test indicate that most participants (31.3%) considered their exertion to fall into the “Light” category followed by 29.2% of participants that rated their exertion as “Somewhat Hard”. Only 8.3% of the participants gave a score of 15 which represents “Hard (heavy)” as seen in Table 16. The results of the RPE indicate a cumulative percentage of participants of 43.8% that rated the Step-up Test as being “Light” or easier (7 – 11 on the Borg scale). This percentage is, to some extent, close to 39.6% of the participants falling into the “Very Good” heart-rate category in the Step-up Test. One may however expect the result rather to have a relationship with the participants in both the “Very Good” and “Good” categories. To conclude, Borg (1982) maintained that the initial RPE scale is most suitable for “simple applied studies of perceived exertion, for exercise testing, and for predictions and prescriptions of exercise intensities in sports and medical rehabilitation”. Therefore, the subjective ratings (Borg RPE) by the hikers could be used as recommendation for potential hikers for a specific graded trail.

The results of the IPAQ presented in Table 12 indicated that 38% of the participants had a high amount of PA. Thirty-nine point six percent (39.6%) of participants scored “Very Good” according to the classifications of the heart-rate scale in the Step-up Test (Table 15). The similarity between the scores on the IPAQ (high) (38%) and “Very Good” in the Step-up Test (39.58%) is obvious. The cumulative scores of the “Good” and “Average” category in the Step-up Test is 52.1%, which is 10% higher than the 42% of participants that fell into the “Moderate” category of the IPAQ. Twenty percent (20%) of participants were shown to have low PA levels in the IPAQ compared to only 8.3% of individuals falling into the “Poor” category of the Step-up Test (and none falling in the “Very Poor” category). This concurs with the general indication that the majority of the respondents are fit (self-assessment).

3.4 Cooper Test

As hiking is based on walking it would not make sense to make use of a cycle ergometer, or a treadmill to determine the predicted $\dot{V}O_{2\,max}$ of participants. Furthermore, few participants reach a true $\dot{V}O_{2\,max}$ and values that are obtained are the VO_{2peak} (Noonan & Dean, 2000). The $\dot{V}O_{2\,max}$ is an indicator of the participants' cardiovascular fitness. In order to obtain the estimated $\dot{V}O_{2\,max}$ of participants, the Cooper Test was undertaken. The Cooper submaximal test is a test where the individual covers as much distance as they feel they possibly can within a 12-minute period. This test is a predictive submaximal test (Noonan & Dean, 2000) for $\dot{V}O_{2\,max}$, and can be easily administered. Although a $\dot{V}O_{2\,max}$ treadmill test would have given a more accurate measurement of participants' cardiovascular fitness, the participants in this study would have most likely not been able to perform a $\dot{V}O_{2\,max}$ test for a period long enough to reach a plateau needed for results. Participants were asked to cover as much distance as possible during the set time. Although every effort was made to encourage participants to do the test at their full capacity, observation indicated that not all exerted themselves to their maximum levels. Some participants elected to walk and did not make any attempt to run at all, thus influencing their distance covered within the set time-frame. Due to ethical considerations participants cannot be "forced" to exert themselves to the maximum levels as required by the test. This influences the reliability of the test.

The post-subjective rating of perceived exertion (Borg scale (RPE)) confirmed the stated observation that some participants had not attempted the test at their full capability. One participant rated it as a 9 (Very Light) while a cumulative percentage of 35.4% participants rated the Cooper Test as being "Somewhat Hard" to "Light". When interpreting the results, it is important to remember that all the participants did not give their maximum input. However, 29.2% of participants indicated that their RPE was "Very Hard" as one would have expected, and one participant stated that she exerted herself maximally.

Thirty-three point four percent (33.4%) of participants scored above average or "Excellent" in the Cooper Test. This is considerably less than the results of the Step-up Test that had 62.5% of participants falling in the upper two categories (see Table 15 and Table 17). A large portion of the participants performed "Below Average" for the Cooper Test (29.2%) with a further 10.4% falling in the "Poor" category. The required physical extremity of the Cooper Test and the lack of effort as previously discussed may be contributing factors. Although the Cooper Test is a validated test of fitness and an indirect test of the $\dot{V}O_{2\,max}$ of a participant, it did not prove as useful for determining a hiker's level of fitness before a hike.

To conclude, the motivational elements of the Cooper Test reflected by the participant in order to ensure reliability came into play. It is still however felt that the use of this submaximal test is a better option than a direct measurement ($\dot{V}O_{2\,max}$ test). Hikers could make use of the $\dot{V}O_2$ treadmill test to determine fitness levels beforehand, but this is expensive and often not accessible to a number of participants. The use of a stop-watch (available on most cellular phone devices today) and an athletics track are far more accessible to the potential hiker.

The Step-up Test with the set pace seemed to be a better option for the participants as those who were not "sport orientated" were not as motivated to push themselves during the Cooper Test. This is understandable as a hike is seen as a leisure experience and not as a sporting activity demanding maximum effort. The pre-recorded metronome for the Step-up Test did not allow participants to perform the test at their own pace, thus avoiding the pitfalls experienced during the Cooper Test.

4. HIKING

Haskell *et al.* (2007) list hiking as a vigorous activity, while other researchers consider walking and hiking in mountain scenery as sport activities with a low to moderate exercise intensity (Neumayr *et al*., 2014). The required physical exertion will to a degree be determined by the nature of the trail which will impact on the grading allocated to the different trails. In addition, the grading technique used will play a role.

As highlighted in the literature, there is a discrepancy within grading systems that potentially lead to confusion and uncertainty. Some grading systems refer to expected fitness requirements (without an indication of the fitness measurement technique), others to the length of the trail and/or the terrain that is to be covered. The majority of gradings are, however, descriptive and therefore subjective and left open to diverse interpretation. Different methods are used across the world, with differences within individual countries evident as well. One grading system that reduces subjectivity and is based on a scientific principle is that of Hugo *et al.* (1998/99). This grading system was used to determine the difficulty level of the two selected hikes for this research.

Only single-day trails were selected for this research. Both trails met the requirements for a hike. From a South African perspective, and for the purpose of this thesis, the term hiking describes an outdoor recreational activity that involves shorter or longer walks for one day (or part thereof) or multiple days with or without a load. This also falls in line with Nordbø and Prebensen's (2015) interpretation of hiking. Selecting longer hike trails for this research project would have added several variables for consideration. Limiting the duration to a single-day hike would avoid issues such as DOMS and fatigue. The need to carry equipment and additional supplies was also avoided. Thus additional load carriage was avoided. Concerns of differing accommodation between different routes and resulting quality of sleep was not a necessary consideration for this research. Both trails were time tested, and would take over 60 minutes to complete.

4.1 Trail 1

Trail 1, the easier of the two trails, was graded by Hugo (2016d) as an "Easy grading: 3" on the difficulty grading scale (see Figure 5 in literature review). Trails that are calculated to use under 1000 kCal fall into the "Easy grading" rating. The average energy use (for a 70kg person) on this trail was estimated to be 750 kCal. The trail would most likely correspond with other "Easy" descriptive grading such as those from Canada, New York State, Pacific Northwest, YDS, and Norway as presented in Table 2*.* Examining the Mountain Club of South Africa - Free State Division grading, this hike would most likely fall under their "A" grading - being defined as an easier outing that would be suitable for inexperienced or less fit people. Other gradings such as a "Class A" from the State of Denver, or a "Class 2" from Utah, a "C" grading from Southern Arizona, "Level 1" from Canada and a "Blue" in Germany indicate the different grading systems possible for describing the *same* trail.

The route does not require great physical fitness, and the groups stopped regularly for short periods of time to view the wildlife. The escape to nature and the surroundings was generally enjoyed by participants. Many commented on the feeling of getting away and the notion of "not being in the middle of the city". This certainly links with "extent" that features in Kaplan's ART (1995) as a requirement for an environment to be restorative.

It is important to note that in this study the researcher used a GPS system to determine the hiker movement patterns, distance travelled, the time taken to complete the hike, the gradient and altitude as well as the HR. All hikes were completed in the afternoon, most often after a day's work, and on average took just over one and a half hours. Weather conditions were moderate and the average temperature was 25°C. On one occasion, light rain was experienced. As the hike was scheduled beforehand and was not a spur-of-the-moment activity, the typical weather variables that influence a decision to undertake a hike (Li & Lin, 2012) were not encountered. Although the temperature was hotter in comparison to that experienced during Trail 2, the area walked had a number of trees and shrubs providing shade for the hike. The late afternoon time period and shaded areas on the hike resulted in pleasant ambient temperatures. The temperatures experienced on Trail 1 correspond with the preferred summer temperature identified by Li and Lin (2012). Their research identified that an average temperature of 25°C was preferred by the participants in their study. Extreme temperatures were not experienced and problems such as hypothermia or heat illnesses were not suffered.

There were no noteworthy changes in altitude with the average altitude being 1393m. This falls below the 3000m considered by De Villiers and Thiart (1988) to be of importance for grading. It also falls below Fox *et al*.'s (1993) estimate of 1500m as the possible point where work performance is affected. No altitude-related effects would have been experienced during this hike.

The trail runs through an area inhabited by wildlife, including antelope, zebra and giraffe. Depending on the sighting of the animals, the stop-and-go periods of the various groups differed. Participants were informed beforehand regarding the nature of Trail 1. The majority of hikers did not carry a backpack (54.2%). Those that did, primarily packed water and to a lesser degree a snack. The average weight of the backpacks was 2.6kg. The weight of the backpacks was negligible and therefore would not have played a large role in increasing the EE of participants. Other negative effects of backpacks mentioned in the literature (e.g. trunk control, changes in posture, back and neck pain) were not experienced during hiking of Trail 1. Water was the main item packed in the back-packs for Trail 1. Eighty-five point four percent (85.4%) of participants took water along for the hike. Thirty-one point two percent (31.2%) of participants carried water in hand-held water bottles. Large quantities of water were not taken along. As this trail was expected to be completed under a two-hour timeframe, a maximum of one litre would be required (Honan, 2017; Werner, 2017). The temperatures were also mild and the expected exertion of Trail 1 was low. Therefore, increased sweating was unlikely and additional hydration was not necessary (Je´quier & Constant, 2010). Trail 1 was walked in the late afternoons, thus participants had the opportunity to eat lunch before the hike, and the hike would be completed before dinner time. Very few participants took food along for this hike. Simple items were taken along that would be easy to consume whilst walking. Items included fruit, protein items such as biltong and energy bars. These items link in with suggestions made by both Kraklio (2017) and Newgent (2017).

The number of usable GPS data sets for HR for Trail 1 was n=47 and n=48 for the RPE (Borg scale (RPE)) due to data cleaning. It is stated that in healthy subjects 1 RPE point relates to 10 bpm (Scherr *et al*., 2013). This relates well with the RPE given for Trail 1 as the average HR achieved on the trail was 110.6 bpm, while the mean for the maximum HR was 158.9 bpm (Table 21). The Borg scale (RPE) at the end of Trail 1 was on average 10.7 (107 bpm) with the highest rating being a 13 (130 bpm) on the Borg Scale (Somewhat Hard). This indicates that the participants experienced the hike as easy, as per the grading given.

The mean EE on the hike was 798.4, which is in line with Hugo's estimation for a grade 3 trail which was 750 kCal. As the results in Table 11 indicate, 50% of participants wore training "tekkies". This would have also lead to a minimal contribution to the EE (Fattorini *et al*., 2012). The participants wearing hiking boots and a backpack could have had an increased EE due to the use of the boots rather than trainers (Fattorini *et al*., 2012) due to the increased weight. As the calculation of EE takes weight into consideration, the increase in weight of the boot and backpack would increase EE. Due to the short duration and flat terrain of Trail 1, and the fact that 54% of the hikers did not use a back-pack, it is believed that the impact would not have been significant. The shoes/boots of participants were not weighed in this research.

The scatter plot displayed in Figure 11 indicates the distribution of the hikers' EE. It is clear that there are only 4 hikers whose EE can be considered as outliers. The majority of the distribution falls under the 1125 Kcal band of an easy hike. As the majority the participants fall within this band and close to the 750 kCal mark, as calculated by Hugo, the results are consistent with the EE as determined by Hugo (2016d).

To conclude, as postulated by Collingwood *et al.* (2007) an analysis of the estimated energy cost of hikes can provide additional information about the extent to which health and fitness can be affected by a given hike.

4.2 Trail 2

Trail 2 was graded by Hugo (2016e) as the more difficult of the two trails with a "Moderate grading: 5.4" and kCal of 1650. Moderate hikes fall within the range of 1125 kCal to 2250 kCal. The hike would most likely fall under "Moderate" in the state of Maine, a "C" in Southern Arizona, a "B" in the state of Colorado and a grade "2B" in Northern California. It is uncertain if the hike would be classified as "Moderate" or difficult according to the grading system in Canada, although would possibly be identified as a "Level 3" in a grading system found for Montreal. It is probable that the trail could be classified as "Intermediate" in Finland and as "red" in Germany, but no allocation can be given with any certainty. The Mountain Club of South Africa - Free State Division describe the hike as a grade C-D with a description of "easy to advanced hike. Beautiful mountain with beautiful rocks and views of the area. Good practice hike to get fit."

The topography of this hike (Trail 2) included a mountain, with a steep start and finish to the hike. After the initial climb, the area on top of the mountain plateaus and a circular route was followed that did not entail great elevation changes. The average altitude was 1978m and the highest point 2139m. The altitude falls below De Villiers and Thiart's (1988) 3000m significance limit of trail grading. The altitude is however above Fox *et al*.'s (1993) 1500m point as having an effect on work. It is noted that the participants' city of residence is approximately 1400m above sea level. This would indicate that for this research the participants did not increase altitude more than 1500m from their usual place of residence. Therefore, the effect of altitude on the results of this research would have been negligible. All of the hikes undertaken for

Trail 2 were done in the morning. Participants drove to the sight (approximately 60 minutes) leaving early in the morning. The weather experienced on this trail was mild with the average temperature being approximately 21.6 °C. As with Trail 1, this temperature range fell within the comfortable zones identified by Li and Lin (2012). No rain occurred on any of the hikes, and only one hike had a moderate wind. The conditions were largely ideal for hiking and no problems were experienced due to hot conditions (Hillman, 2012). As the flora was quite different from that of Trail 1 and there were few shaded areas, the lower average temperature was ideal for hiking.

A difference in backpack weights was evident between the two trails. The majority (54.2%) of participants in Trail 1 did not carry a backpack, with the heaviest backpack weighing 5.65kg. By contrast, in Trail 2, 88% of the participants took backpacks. Forty-two percent (42%) of the backpacks weighed between 2-4kg, and 36% weighed between 4-6kg, with the heaviest weighing 9.15kg. The expected physical exertion and expected duration of the two trails influenced participants' backpack needs for the trails. Of the 12% that did not carry backpacks for Trail 2 the spouse of the participant carried a backpack with supplies for both participants. Participants packed something to drink, eat and used the backpack to store items of clothing. As this hike commenced in the early morning, at lower temperatures, items of clothing were removed during the hike and added to the backpack.

The weight of the backpack would increase EE (Gebhardt *et al*., 2012) on the hike as well as having other effects such as changing the posture of the hiker (Heller *et al*., 2009; Vieira *et al.*, 2015; Dahl *et al*. 2016). The mean weight of the backpack for Trail 2 was 3.9 kilograms and therefore should have an effect on posture and EE. It was noted previously that footwear would also impact EE during the hike. The use of a heavier hiking boot for the hike would have resulted in a minor increase in EE as demonstrated by Fattorini *et al*. (2012). As all participants used the same shoe/boot for Trail 1 and Trail 2 there would not have been differences between the two trails for the individual in this regard.

Food intake before the second hike differed from that of the first hike. This may be due to the time-of-day differences between the two hikes. Breakfast preceded Trail 2 as opposed to lunch for Trail 1. Trail 1 had a large number of participants eating a form of protein (70.8%) and vegetables (22.9%) beforehand, whereas there was a large increase in the consumption of dairy products before Trail 2.

The increase in nutritional items from Trail 1 to Trail 2 is noticeable. Sixty-four percent (64%) of participants packed fruit, and 64% of participants packed protein for Trail 2. For Trail 1 only 14.6% of participants took a form of fruit (including dried fruit) and only 8.3% of participants took a form of protein along. Grain/Carbohydrate increased from 2.1% to 40%. Energy bars increased from 6.3% in Trail 1 to 40% in Trail 2. It was observed by the researcher that all participants brought water along. Thirty-six percent (36%) of participants brought energy drinks along (compared to 8.3% for Trail 1). This is in line with the recommendations of the ACSM (2014b) who suggested that fluid should include sodium, potassium and a small amount of carbohydrate when exercising for 2 or more hours. Before leaving for the hike, 58% participants had coffee or tea (falling in the "other" category) at home and 24% of the participants consumed water beforehand.

The ACSM (2014b) recommendations of fluid intake before physical activity of 5-7 $mL \cdot kg^{-1}$ are applicable to hikes of two hours or more. Twenty-four percent (24%) of participants consumed an amount of water before embarking on the hike, and 58% ingested "other" liquids. Hikers were not asked about how much they consumed prior to the hike.

The different fitness levels resulted in different hiking speeds. By implication different participants or groups, were in different parts of the hike at the various hour-markers used for determining the RPE (Borg scale (RPE)). In some instances, the leading hikers had been resting for 5 minutes while waiting for others to catch-up when the hour marker was reached. Thus it was decided not to make use of hour-marker Borg scale (RPE) scores for data analysis as the data would be unreliable. In future research it may be better to select certain markers along the route and to request the RPE when that specific marker is reached.

The mean of the subjective rating of perceived exertion (Borg scale (RPE)) at the end of Trail 2 was 13.0 (Table 21), the lowest score being a 10 and the maximum being a 20. This high RPE value is alarming, indicating that the trail was too hard for this hiker.

Because hikers walk together, it happens that some hikers overreach themselves to keep up with the group. However, the mean score was 2.3 higher on Trail 2 than on Trial 1; thus indicating, as expected, that the participants found the second trail to be more taxing than the first. As with Trail 2 there was a greater change in elevation and a greater number of participants carried backpacks resulting in an increase in RPE score. This is in line with Perrey and Fabre (2008) who noted that the RPE was significantly greater during uphill and with load carriage. The mean RPE for Trail 2 (13.0) is marginally higher than the 10 RPE point as suggested by Scherr *et al*. (2013). As with Trail 1 the RPE scores fit well with the average HR scores. The predicted RPE using the 1 RPE point relating to 10 bpm (Scherr et al., 2013) would result in a RPE of 12.5 for Trail 2. It does, however, indicate that participants felt that they exerted themselves more on Trail 2 than on Trail 1.

The use of HR may be a better determining measure of exertion than the RPE scores of Borg. When analysing the HR of participants, using GPS technology on the two trails, it becomes clear that more effort was required with Trail 2. The average HR of Trail 2 (124.8 bpm) was 14.2 bpm higher than Trail 1 (110.6 bpm). There was also a marked difference in the average maximum HR with an increase of 17.2 bpm (Trail 1- 158.9 bpm and Trail 2 176.1 bpm). This is to be expected as Trail 2 was graded by Hugo as one of “Moderate” difficulty and Trail 1 as easy. These findings are similar to those of Manning *et al.* (2015) who found a significantly elevated HR when comparing an easy and difficult trail (p=0.006). When analysing and comparing the average HR during a trail with the recommended HR norms (See Table 3 in literature review) (Norton *et al*., 2010; Carvalho & Mezzani, 2011, ASCSM, 2014a, Kenney *et al*., 2015), it is clear that it is not the average HR during hiking which is the primary risk, but rather the maximal HR (176.1 bpm).

It should be noted that Trail 2 average completion time was 200 minutes (just over three and half hours) longer than Trail 1 completion time. For some participants the extended rest times that may occur during a hike will be a contributing factor and could affect the use of average HR for determining the exertion. As pointed out by Haskell and Kiernan (2000) the linear relationship of HR and EE may be lost during low-intensity exercise. The slightly elevated RPE for Trail 2 in comparison to the actual average HR is possibly due to the rest periods. As participants could rest when they felt it necessary, the average HR would be lower than if the participants had not rested at all.

Large differences in average EE were experienced between the two trails. A difference of 1671.9 kCal between Trail 1 and Trail 2 can be seen in Table 21. This was expected as it falls in line with Hugo’s (1989) energy calculations. Trail 1 calculations are close to that of Hugo with the grading calculation being 750kCal and the actual being 798.4 (Figure 11). As the mean mass of participants was above 70kg, this increase in kCal can be expected. The average calculated EE for Trail 2 was 2470.3 kCal. The difference in the grading kCal and the calculated EE is 820.3 kCal. This is also most likely due to the greater than 70kg mass of participants that is used as an average for the Hugo calculations. The scatter plot displayed in Figure 12 indicates the distribution of the hikers’ EE. As with Trail 1 there are 4 hikers whose EE can be considered as outliers. The majority of the distribution is around the 2250 kCal mark, which is above the 1650 kCal suggested by Hugo (2016e), but still falls within the band that grades a hike as moderate (1125-2250kCal). Using the equation of Hoffman (2006) (given in chapter 2) the EE is calculated according to the time the participants took to complete the hike.

To conclude, it is clear that Hugo’s standardised grading system in South Africa could enable hikers to make informed decisions regarding trails that are more suitable for them in terms of the required time and fitness level needed to complete the trail without undue physical exertion. Furthermore, true multi-day hikers who carry all the necessary gear are also catered for in Hugo’s system in that an additional weight is added to the average hiker in order to compensate for the backpack carried (Hugo, 2016c). However, Slabbert (2015) emphasises that:

> “No accreditation system can guarantee a positive outcome for the client, as the outcome of a hiking experience is dependent on various intangible factors such as weather conditions, the hikers’ affinity towards the specific environmental character (preference toward desert, forest, coastal or bushveld areas), mental state of the hiker, travel party the hiker is with and so forth”.

5. RELATIONSHIPS BETWEEN TESTS

According to Hofmann and Tschakert (2011) there is clear evidence regarding all the health benefits of regular PA. Unfortunately, these exercise benefits follow a dose-response relationship with exercise intensity. It is well known that exercise intensity is suggested to be the leading component of exercise prescription, therefore attention is drawn to this specific component, although one should always be aware of the fact that all the components of exercise training and their combinations are also substantial parts of the action of exercise training. With regard to exercise intensity, it is suggested that the optimal, safe, individually tailored exercise prescription or recommendation for exercise participation (such as hiking trails) for each single subject (hiker) can only be determined from an objective evaluation of the individuals' response to exercise. Increasing sedentary rates (CDC, 2005) in the last decade and the associated increasing prevalence of hypokinetic diseases (WHO, 2000), especially obesity, highlights the continuing need for identifying effective methods of prescribing exercise or giving specific recommendations for PA. Therefore, we have to use different pre-hiking tests to determine if these pre-hike tests can be used as predictors of the exertion levels of different graded hiking trails. This implies the standard use of exercise testing for the functional evaluation of hikers to enable the flow of specific recommendations regarding safe participation in hiking. Therefore, in this section we compare and discuss the correlations between the self-reporting PA questionnaire (IPAQ), the fitness grading classification of the Step-up Test proposed by De Villiers and Thiart (1988), the Cooper Test, the GPS measurement (HR) of a hiker during the hike, the RPE (Borg scale (RPE)) and the predicted EE of the hikers during two differently graded hiking trails.

The results (Table 26) indicate that the correlation between the Step-up Test and the IPAQ is insubstantial. The small correlation displayed by the IPAQ with the Cooper Test together with the very low correlations of the IPAQ with the Borg scale (RPE) and all HR variables (Table 27) indicate that the IPAQ is not a good predictor of the desired activity levels for participating on a hike.

Most participants (62.5%) are rated as "Good" or "Very Good" on the HR scale as determined by their Step-up Tests results. Taking into account that 91.7% of the participants rated “Average” or above, we may assume that a reasonable level of fitness was demonstrated by the participants. Thus the results of the Step-up Test indicated an acceptable level of fitness, but this did not correlate (r=-0.02) with the results gained from the IPAQ. A possible reason for this is that the IPAQ is not a suitable pre-hike test to predict exertion during a hiking trail. The cautionary remark from Pardo *et al*. (2014), that some difficulties were experienced by respondents in distinguishing between vigorous and moderate activities is relevant. A further warning regarding the IPAQ is that it can be considered a useful screening tool, but should not be utilised if a precise level of physical activity is required (Fillipas *et al*., 2010).

The correlations between the IPAQ and how the two graded hiking trails were experienced (determined by Borg scale (RPE)) indicate that no strong correlation exists between the two variables. The correlation between the Borg scale (RPE) post-Trail 1 (r=0.19) and Trail 2 (r=0.17) had a small strength of association. The negative correlation between the IPAQ and the Borg scale (RPE) is expected. The higher one scores on the Borg scale, the more one perceives oneself as having exerted oneself, the lower one scores on the IPAQ, the lower one’s rated levels of PA are. Therefore, a lower RPE score would be expected with a higher IPAQ score. A small negative correlation was found between the IPAQ and the Borg scale (RPE) after the Step-up Test. It is surprising that the correlation between the Borg scale (RPE) post-Cooper Test is positive (r=0.35). It is possible that the more physically active participants exerted themselves more than the less physically active participants during the Cooper Test, and therefore received a higher rating in the IPAQ and had higher RPE rates. It must be noted again that the Cooper Test results are not reliable in the researcher’s view because it is supposed to be a submaximal test. Only a few hikers, however, made a concentrated effort.

The negative correlations between the IPAQ and the Step-up Test, the Step-up Test Borg scale (RPE) and the Cooper Test are expected. The increasing value for the Step-up Test and Cooper Tests represent greater fitness, with the opposite rating for the activity level represented by the IPAQ. No meaningful correlations were found between the IPAQ and any of the HR variables used, or the RPE at the end of each hike. All but one of the correlations (RPE end Trail 1) were negative. The negative correlations are expected due to the difference in scoring as indicated previously.

To conclude, the IPAQ was considered for this research due to its practicality and it being a convenient means for a potential hiker to assess him/herself before a hike. Despite this, no positive correlations were found between IPAQ and the Step-up Test, the Cooper Test or Borg scale (RPE). Possible reasons for the unsuitability of the IPAQ may include the effect of demand characteristics, with participants behaving in accordance with the researcher's expectations (McCambridge, de Bruin & Witton, 2012); the score for the IPAQ is determined by the preceding week's activity levels. Participants may have had an atypical week of activity beforehand. Although the IPAQ may be a true reflection of the preceding weeks PA, the PA represented by that week was possibly not representative of the individuals' general PA, and thus fitness levels.

The larger correlation between the Step-up Test and the Cooper Test (r=0.53) is possibly due to both these tests being physical in nature and participants needing to physically participate in the activity. The low Borg scale (RPE) rating correlation between the two tests was, however, not expected. It would be expected that the Borg scale (RPE) ratings would have correlated better. This, however, is not the case. The -0.16 correlation is minor, and the negative correlation is surprising. It would be assumed that the correlations would be positive as the same scale was being compared (Borg Scale (RPE) post Step-up Test and Borg scale (RPE) post-Cooper Test). The reasons for this are unknown, but it was observed that some of the participants did not attempt the Cooper Test with as much vigour as required, thus reducing their end RPE. This could have played a role in the low correlation of the two tests.

A negative correlation (r=-0.54) was found between the Cooper Test and the Borg scale (RPE) at the end of the Cooper Test. This is to be expected as the higher RPE indicates increased exertion and a lower score on the Cooper Test indicates increased fitness. The increased RPE would therefore indicate increased exertion, thus a greater distance covered during the Cooper Test which resulted in a better fitness rating.

The Cooper Test was compared to the IPAQ (Table 26) to determine if any significant correlations could be found. The categories of low, moderate and high of the IPAQ were compared to the scores (excellent, above average, average, below average and poor) obtained from the Cooper Test. Despite this, no positive correlations were found between IPAQ and the Step-up Test, the Cooper Test or Borg scale (RPE).

5.1 Prediction of Levels of Exertion on the Hiking Trails Based on Pre-Hike Fitness-Test Information

Health and fitness professionals play important roles in helping to monitor and promote PA. Guidelines for exercise testing and prescription have been established to provide safe standards for exercise training and exercise participation. A wide range of intensities are used to prescribe exercise, or used as a recommendation for exercise participation. Usually, percentages of maximum HR are applied to set exercise training intensity. Heart rate is the most common parameter to determine target exercise training intensity. The usual recommendations are in a range of between 64% and 70% to 94% of HR maximum, or between 40% and 50% to 85% of HR reserve. However, clearly defined standards for the lower limit of prescribable aerobic training intensity have as yet not been established, either in healthy individuals such as hikers used in this study, or in cardiac patients (Carvalho & Mezzani, 2011). Therefore, recommendations to safely take part in PA must be made conservatively.

Brooks (2003) recommends the Karvonen formula to calculate exercise intensity; this formula is used extensively in the fields of rehabilitation, physical training and conditioning. One of the variables in the Karvonen formula is the *HR* max, which is the HR a person has when they push their body to the maximum effort. Unfortunately directly measuring the *HR* max takes time, will imposes a heavy physical burden on the hiker, and needs expensive equipment. Alternatively, a simple, convenient formula based on a person’s age is used extensively to calculate the Hr max (Robert & Landwehr, 2002; Perez-Terzic, 2012).

HR max = 220 − age

Where “age” is the age of the subject (Jones & Poole, 2005).

$$HRR\% = \frac{HR - HR_r}{HR_{\max} - HR_r} \times 100\%$$

In the formula shown above HR_r is the subjects HR at rest and *HRR* is the heart rate reserve (*HRR*). It is important to note that the calculation of *HRR* uses only two parameters: maximum heart rate and the heart rate at rest; that is, it does not take into consideration a subject height, weight, body mass index (BMI), or other physical characteristics (Brooks, 2003). Robert and Landwehr (2002) also point out that *HR* max (220 – age) does not always yield the correct *HR* max. Suzuki (2007) also mentioned that the calculated value of %*HRR* may be less accurate for an older person than for a younger person. Although several methods have been proposed to improve the accuracy, none of them is widely recognized; and their range and conditions of use are not clear (She, Nakamura, Makino, Ohyama & Hashimoto, 2015).

In recent years, scientists have tried to amend for this incorrect HR max and calculated a different maximum HR that is 206.9 (She *et al*., 2015). However, this HR max will not fit every single hiker, but it may be more accurate. Another issue with the Karvonen Formula is that research has also indicated that women have a different HR response to exercise. This implies a different formula for women. It therefore becomes 206 bpm - (.88 x age) = MHR instead of 206.9 bpm (She *et al.*, 2015).

Two examples follow that use the updated Karvonen Formula to calculate HR zones. The hiker will need to determine their resting HR. To determine this, they will need to take their pulse for one full minute when they first wake up in the morning. If one makes use of the updated calculation of HR max, (206.9 bpm instead of 220 bpm), the low end of this person's target HR zone as well as the high end can be determined. The low end is considered about 65% of HR max, while the high end is considered about 85% of HR max. For the first example, take a 23-year-old man with a resting HR of 65 bpm.

The Karvonen Formula for a Man

206.9 bpm- (0.67 x 23 (age)) = 191bpm

191 – 65b bpm (resting heart rate-RHR) = 126 bpm

126 * 65% (low end of heart rate zone) OR 85% (the high end) = 82 OR 107

82 + 65 (resting heart rate) = 147 bpm

107 + 65 (RHR) = 172 bpm

The target heart rate zone for this person would be 147 bpm to 172 bpm.

The Karvonen Formula for a Woman

For the next scenario take a 49-year-old woman with a resting HR of 65 bpm.

206 bpm - (.88 x 49) = 163163 - 65 (RHR) = 98 bpm

98 * 65% (low end of heart rate zone) OR 85% (high end) = 64 (65%) or 83 (85%)

64 + 65 (RHR) = 129 bpm

83 + 65 (RHR) = 148 bpm

The target heart rate zone for this person would be 129-148 bpm.

The results in Chapter 4 indicate that the exertion levels on the two hiking trails (Trail 1 and Trail 2) could be predicted by certain information based on the pre-hike fitness tests. The various analyses of both trails separately, and jointly yield, essentially similar results (See Chapter 4).

ANCOVA statistical analysis was used to investigate whether the exertion levels on the two trails could be predicted by the pre-hike PA/fitness tests. The pre-hike PA/fitness tests (IPAQ, Step-up Test and Cooper Test) were the potential predictors (independent variables), and the minimum HR, average HR, maximum HR and Borg Scale (RPE) at the end of the trail were used as characteristics of exertion during the hike (dependent variables).

Initially, both trails were analysed separately. A full model to indicate the potential predictors of exertion during the hike was used. Firstly, the Step-up Test showed a significant p-value ($p=0.0291$) with the predicted average HR for Trail 1. Secondly, it was also a highly significant predictor ($p=0.0010$) with the predicted maximum HR. All other variables considered (IPAQ, Cooper Test, Time to complete the hike and Borg scale (RPE) for the end of the hike did not predict exertion. The final selected model also included the Step-up Test as a significant predictor of the exertion variables average HR and maximum HR (Table 36). Therefore, we could identify significant predictors of exertion during hiking, using simple pre-hike fitness tests.

To predict the HR that would be experienced by a hiker on a trail such as Trail 1, it was estimated that a participant who achieved a “Very Good” rating with the Step-up Test would have an average HR of 104.1 bpm and a maximum HR of 158.9 bpm. (Table 31). A participant who achieved a “Good” rating with the Step-up Test would have an average HR of 103.9 bpm and a maximum HR of 130.9 bpm. A participant who achieved an “Average” rating with the Step-up Test would have an average HR of 120.7 bpm and a maximum HR of 175.2 bpm. A participant who achieved a “Poor” rating with the Step-up Test would have an average HR of 125.0 bpm and a maximum HR of 178.8 bpm. Therefore, in order to give guidelines and recommendations to potential hikers, the maximum HR must be considered as a risk indicator for specific recommendations for graded hiking trails. Even more caution must be taken with special populations such as old people and people at risk (e.g. cardiovascular diseases and hypokinetic diseases). Furthermore, one variable (maximum HR) cannot be viewed in isolation. For instance, the length of the hike, extremes of temperature during the hike, and varying terrain will influence fatigue levels which will in turn influence walking speed. It is not possible to factor in each possible variable into a grading system (e.g. weather) as this does not remain constant (Arias, 2007).

The prediction for “Very Good”, “Average” and “Poor” grading category increases as expected, although the “Good” category differs. It is clear that the individual falling in the “Poor” category of the Step-up Test will have a much higher predicted HR in both the average HR and maximum HR categories. The predicted Borg scale (RPE) at the end of the hike was 10.7. This corresponds with a HR of approximately 107 (Scherr *et al*., 2013) and is aligned with the “Very Good” and “Good” estimated average HR.

The same statistical procedures that were followed for Trail 1 were performed for Trail 2 (Table 32). Small differences between Trail 1 and Trail 2 are observed with regard to potential predictors of exertion for the Step-up Test. The average HR (p=0.0718), was not a significant predictor as with Trail 1. However, the Step-up Test as a predictor of the maximum HR was significant (p=0.0080).

In the final selected model for exertion during Trail 2 (Table 33), the Cooper Test (as independent variable) was again a significant predictor (p=0.0005) with the average HR (as dependant variable). The Step-up Test (as independent variable) was a significant predictor of maximum HR (p=0.0070) in the final selected model. The Cooper Test was a significant predictor of Borg scale (RPE) for the end of the hike (p=0.0043), as with the initial analysis of Trail 2.

As the Cooper Test was a significant predictor in the final model it was used to predict average HR and the Borg scale (RPE) at the end of the hike for Trail 2 (Table 34). The final selected model predicts an average HR of 101.6 for a participant who attained a "Very Good" grading in the Step-up Test, and an "Excellent" grading in the Cooper Test. The average HR increased to 133.4 for a "Poor" classification in the Cooper Test. The increase in predicted average HR with a decrease in the Step-up and related Cooper Test categories, is obvious. The predicted average HR is 115.8 for a participant who attained a poor grading in the Step-up Test and excellent in the Cooper Test. The predicted HR increased to 147.6 for a poor classification in the Cooper Test. The indicated increase in average HR is due to lower fitness levels as confirmed by lower ratings in the categories applied to the two tests.

In the average category of the Cooper Test, the constant lower average HR is noted. This may be attributed to the previously discussed lack of effort demonstrated by some participants during the Cooper Test. Based on the predicted maximum HR in the final selected model (as in Trail 1), it is important to note that hikers with an "Average" and "Poor" rating in the Step-Up Test are at higher risk, as the grading of a Trail is more difficult. It is clear that the predicted maximum HR indicates that an unfit person's maximum HR could become dangerously elevated on a "Moderate" graded hike. To illustrate the risk, the predicted maximum HR of a hiker in the poor category was 193.2 bpm. This would indicate maximum HR for a 27-year-old individual (using the estimate equation of 220-age (ACSM, 2014b)). Therefore, if the potential hiker is 27 or older and scores poorly on the Step-up Test it would be advisable that he/she either does not attempt the hike, or that he/she do some cardiovascular training before attempting the specific grading hike. Previous research (Schurman & Schurman, 2009; Green, 2015) has also emphasized the need for physical preparation before embarking on a hike.

If we consider that the mean age for the group of hikers in this research was 38 years it would indicate a maximum HR of 182 bpm. This is considered the maximum HR that can be achieved with maximal effort (Kenney *et al.*, 2015). This would not be a comfortable level for a leisure experience. As hiking has been identified as a physical leisure experience it would be best for the hiker to enjoy the activity at a rate where he/she is not pushed to their physical limitations, but is able to experience flow. However, because most hikers differ in terms of fitness levels, hikers can overreach themselves to stay with a group. Furthermore, hikers can overestimate their abilities.

The hikers consider themselves proficient to hike a substantial distance over a short duration when in reality they cannot. Unfortunately, this can then lead to risks of physical injuries or even death.

To conclude; exercise intensity plays a pivotal role in gaining a sufficient training response. It is equally important that it does not produce harmful side effects in healthy subjects and patients. It is acknowledged that higher exercise intensities seem to be more beneficial; however, approaching the upper limits of exercise tolerance demands a more precise determination of these limits. Evidence regarding the most efficient intensity without risk is still lacking.

6. GENERAL COMMENTS

As described in the literature review, hiking takes place primarily in groups, thus generating numerous social benefits. One of the goals of this research was to execute the research under "normal" hiking conditions. The laboratory setting was not sought, but a true scenario in the outdoors involving persons intending on undertaking a hike was selected. In order to have the participants undertake a hike as it would normally occur, a number of uncontrollable variables emerge. These include (but are not limited to) the amount of time taken to complete the hike, rest time, the food consumed and the exertion of the hiker. Mental aspects such as supporting a slower participant and possibly resting more than initially anticipated proved to be challenging for some. By contrast, those that found the trail more challenging found the pace set by other participants to be frustratingly fast and rest periods often insufficient. The above mentioned aspects were observations made by the researcher that were verbally confirmed by the involved/affected participants. Thus the dynamic nature of the group comes into play. In order to prevent these variables from playing a role in the study one would need to ensure a set pace and a completion-time goal. This would then dictate to the group as to when, what, for how long etc. Although helpful for research purposes the experience would not fall into the definition of a recreational experience and therefore not a typical hiking experience. This is a catch 22 situation, as the results could be questionable as to the generalisability to the population if the conditions of walking were so stringent that basic elements of leisure such as perceived freedom were removed. Hiking groups are not formed or selected on current fitness levels. It should thus be noted that hiking groups will not demonstrate homogeneous fitness levels. Hiking groups are usually formed in structured systems (clubs) or social systems (circle of friends). By implication, preferred hiking speeds will differ in formed groups. This will result in some hikers finding the set pace more challenging and rest periods insufficient. This situation was especially demonstrated during Trail 2. However, this is a reflection of the reality of hiking and should not be seen as detrimental to the reliability and validity of the research results.

Chapter 6

Conclusion, Recommendations & Implications

1. CONCLUSION

The positive benefits of hiking have been highlighted in this thesis. The various research objectives are addressed individually and concluded in this chapter. This is followed by the recommendations for future research and implications of the study for the hiking industry.

1.1 Research Objective 1

This objective focused on profiling the hikers in terms of morphological factors *viz* gender, age; height, weight, body fat percentage, medical history, eating habits, grading classification of the Step-up Test proposed by De Villiers and Thiart (1988), classification of fitness as determined by the Cooper Test, the GPS measurement (HR) of a hiker, and the rate of perceived exertion (Borg scale (RPE)) during two differently graded hiking trails.

Hikers were profiled according to the various morphological factors, indicating that in general all participants were healthy and physically active (as indicated by the IPAQ, Step-up Test and Cooper Test).

The mean age of participants was 38.2 years indicating that a more mature age-group participated in the hiking activities. The results report that a larger portion of females (74%) participated, and the majority of participants were white (88%). The average height for males was 181.2, and for the females 166.2. The mean weight was 90.3kg for males and 71.6kg for females. Fat percentages fell into acceptable categories with the male mean-fat percentage testing at 20.1 and the female at 21.7. The experience of the hikers differed vastly amongst participants. However, no noticeable morphological differences between the experienced and inexperienced participants were identified.

The IPAQ indicated that 80% of participants fell into the moderate or high category of PA. The Step-up Test revealed 91.8% of participants, scoring average fitness or better, and the Cooper Test identified that 60.5% of participants were of average fitness or better. Thus, the results indicate that the majority of persons undertaking a hike are those participants who are at least moderately physically active.

Before a hike, participants did not change their diet, and ate what they classified as a typical meal. During a hike most participants took water and a snack that was often fruit or protein based. The longer the anticipated walk, the more food and water was taken along.

When hiking the two differently graded hikes there was a noticeable difference in average and maximum heart rates. Both heart rates increased with the more difficult hike. This was in line with the increase in the Borg RPE at the end of Trail 2 in comparison to Trail 1.

1.2 Research Objective 2

This objective focused on determining whether a correlation exists between the IPAQ self-reporting PA questionnaire, the fitness grading classification of the Step-up Test proposed by De Villiers and Thiart (1988) and the Cooper Test, the GPS measurement

(HR) of a hiker during the hike, and the rate of perceived exertion (Borg scale (RPE)) during two differently graded hiking trails.

No large correlations were found between IPAQ and the stated tests. The correlation between the IPAQ and the Step-up Test was insubstantial (r=-0.02), the Cooper Test small (r=-0.12); low for the Borg scale (RPE) both post Step-up (r=-0.27) and post Cooper (r=0.35). Low correlations also exist between the IPAQ and the Borg scale (RPE) for both Hike 1 (0.19) and Hike 2 (0.17), and all HR variables (Trail 1: minimum HR (r=-0.02), average HR (r=-0.15), maximum HR (r=-0.01); Trail 2: minimum HR (r=0.03), average HR (r=-0.15), maximum HR (r=-0.20)).

A large correlation was found with the Step-up Test and the Cooper Test (r=0.53) and with the Cooper Test and the Borg scale (RPE) at the end of the Cooper Test (r=-0.54) Moderate correlations were identified for the Borg scale (RPE) post fitness tests and the actual fitness tests (Step-up Test r= 0.35; and the Cooper Test r=-0.54). With the hiking-trail testing large correlations for the average HR were found for Trail 2 with the Step-up Test (r=0.62) and the Cooper Test (r=0.071). All other correlations between the tests were moderate or smaller.

It is therefore concluded that no large correlations exist between the IPAQ and the tests conducted. A large correlation exists between the Cooper and Step-up Tests. The Borg scale (RPE) displayed moderate correlations for the more difficult trail, but only small correlations for the easy trail (Trail 1). The Borg scale (RPE) post fitness tests indicated moderate correlations for the Step-up Test and large correlations for the Cooper Test.

1.3 Research Objective 3

This objective focused on determining whether the calculated EE of a hiker is consistent with the theoretical calculations in the current difficulty rating scale proposed by Hugo (Hugo *et al.*, 1998/9).

Large differences in average EE were experienced between the two trails, and fall in line with the energy calculations of Hugo (1989). As the mean mass of participants in this study was above the 70kg used for the Hugo calculations, an increase in kCal can be expected for both trails. This was demonstrated in both Trail 1 and 2. The mean EE on Hike 1 exceeded the Hugo calculation by 48.4 kCal and 820.3 kCal in Trail 2. It should also be noted that Hoffman's (2006) EE calculation was used that did not take the elevation changes - which were substantial in Trail 2 - into account. This secondary objective of the study has as a weakness that the only analysis was a simple calculation of EE (Hoffman, 2006) that was plotted against the EE calculations of Hugo (2016d; 2016e) resulting in the scatter plots displayed in Figure 11 and Figure 12. More complex and possible reliable calculations are available (Collingwood *et al.* (2007). The EE calculation therefore has limitations.

To conclude, it is clear that Hugo's standardised grading system is consistent with the calculated EE of a hiker for Trail 1, but the evidence is not as convincing for Trail 2. The scatter plots of the EE indicate that the EE's for Trail 1 falls within the band of an easy hike. Future research is needed in order to draw comparisons between each individual's predicted EE, actual EE and the theoretical calculations of Hugo (1989).

1.4 Research Objective 4

Research objective 4 aimed at conducting an analysis of the use of the IPAQ (user friendly self-reporting PA assessment questionnaire) as an instrument of self-reported PA levels and the actual fitness levels (fitness tests) to best predict the perceived exertion (Borg scale (RPE)) by the hikers.

The results revealed a small correlation between the IPAQ and the Borg scale (RPE) after Step-up Test (r=-0.27), and a moderate correlation between the IPAQ and the Borg scale (RPE) post Cooper Test (r=0.35). A minor correlation exists between the IPAQ and the Borg scale (RPE) post Trail 1 (r=0.19) and Trail 2 (r=0.17). Minimum HR (r=-0.02) and maximum HR (r=-0.01) both had trivial correlations, and average HR (r=-0.15) had a small correlation with RPE for Trail 1. The minimum HR (r=0.03) was also trivial in Trail 2, and the average HR (r=-0.15) and maximum HR (r=-0.20) both displayed small correlations.

As shown, the IPAQ results did not indicate large correlations with the Borg scale (RPE) after the fitness tests or post hike. When looking at the predictive abilities of the IPAQ, no statistical significance was found with actual fitness levels (fitness tests) as well as perceived exertion (Borg scale (RPE)). The IPAQ was not identified as being a user-friendly self-reporting PA assessment questionnaire for graded hiking trails. The results from the IPAQ can thus not be used to determine the suitability of an individual for a graded hike.

1.5 Research Objective 5

This objective addresses whether the exertion levels on the two hiking trails could be predicted by information based on the PA/fitness tests.

ANCOVA was used to predict exertion levels. A model (the "Full Model") was generated for each trail, whereafter stepwise backward model selection was performed to obtain a "Final Selected Model". In the Final Selected Model, the Step-up Test surfaced as a highly significant predictor of average HR (p=0.0026) and maximum HR (p=0.0015) for Trail 1. For Trail 2 the Step-up Test was a highly significant predictor of maximum HR (p=0.0070). The Cooper Test displayed highly significant results (p=0.0005) for the prediction of average HR and the Borg scale (RPE) (p=0.0043) for Trail 2. All other variables considered (IPAQ, Cooper Test for Trail 1, time to complete the hike and Borg scale (RPE) for the end of the hike for Trail 1) did not predict exertion significantly.

In the Final Selected Model for both trails, a similar tendency is displayed. The Step-up Test is a significant predictor of average HR (p=0.0170) and maximum HR (p=0.0024). The Cooper Test is a significant predictor of average HR (P=0.0173) as well as the Borg scale (RPE) at the end of the hike (p=0.0394).

These results therefore satisfy the aims of the study. A simple, pre-hike fitness test can be used to predict exertion on hiking trails with known ratings. The results of such predictions can be used to recommend hiking trails to hikers with varying fitness levels for safe use. Currently the Step-up Test of De Villiers and Thiart (1988) is the best predictor available. Through this research a statistical model was created that predicts the average HR and maximum HR of persons undertaking an easy (grade 3) and a moderate (grade 5.4) hike based on the Step-up Test result. Significant benefits for the hiker in terms of increased safety, enjoyment and flow can be experienced by applying the results of this research to everyday hiking.

2. RECOMMENDATIONS FOR FUTURE RESEARCH

- Future research can be performed with a larger sample and possibly more experienced hikers.
- Differences between experienced and inexperienced hikers can be investigated.
- The Borg scale (RPE) could be measured on arrival at set identified points along the trail.
- The Rockport one-mile walking test could be used to determine fitness prior to a hike.
- Different trails of different grading can be used in order to gain a broader understanding of the application of the predicted exertion.
- Investigating the effect that the hydration status has on the hiker and the HR experienced.

3. IMPLICATIONS FOR THE HIKING INDUSTRY

One of the research objectives was how to determine the required fitness levels linked to the difficulty level of a hike. It was identified, through this research, that the IPAQ is not a suitable means of assessing PA before undertaking a hike. The Cooper Test for determining fitness should only be considered in populations that are prepared to exert themselves maximally and therefore is not suggested as a test to determine fitness prior to a hike.

The most suitable test is the Step-up Test designed by De Villiers and Thiart (1988). This test is simple to perform, and can be done by a participant in almost any environment where a step of the desired height can be found. Significant predictors of exertion during hiking were identified by means of this test. The knowledge of the participant's fitness levels beforehand can assist in avoiding risks associated with excessive physical exertion and undue fatigue on a leisure hike. If a moderate graded hike, using the Hugo method (as adopted by the Green Flags System (Green Flag Trails, 2015)) is attempted, and the hiker has obtained a classification of "Very Good" or "Good" on the Step-up Test, then the hiker should be able to comfortably undertake the hike. Scores below this level will indicate that the hike will be more challenging for this person and additional training is suggested before attempting the hike.

Participants who score in the “Poor” categories should be cautioned. The Step-up Test, together with the predictive model presented in this research, should be jointly used in order to predict how a hiker could physically experience a hike.

The knowledge of physical requirements can aid hikers in their adequate physical preparation themselves for a hike or to at least aid their awareness of the possible physical constraints and demands posed by differently graded hiking trails. The selection of an appropriately graded hiking trail, in line with the physical fitness level of the hiker, should lead to a more fulfilling experience.

Reflection

In the busy times we find ourselves living in, the time needed to reflect is often neglected in favour of squeezing some other task into a hectic schedule. Reflection is essential to determine what learning has taken place and to make connections within the learning process. If reflection does not occur it is likely that the same mistakes will be repeated again, and the opportunity to improve is not grasped.

The purpose of this final section is to reflect on this study and how it was performed and to examine what was experienced and achieved during the research process. Development, both personal and professional, is enhanced by reflection. Not only is this relevant for any PhD student, but for this topic in particular where the escape to nature during the hiking opportunity promotes reflection and introspection. A reflection model based on three questions of “What? So What? Now What?” (HEQC, 2006) was used to guide reflection on this PhD.

1. WHAT?

This journey was initially set into motion due to questions asked by those around me whenever a “more active” breakaway was suggested. Someone was always worried about “not being fit enough” or not wanting to be the “weakest link”. Sometimes this factor was the determining factor not to go on the adventure, the hike, the run. This served as a motivator to ask the question “How can we tell if we are fit enough?” When doing research of this nature one is often filled with doubts as to the worthiness of the topic, after all it is not TB or HIV that is being studied or a cure for cancer. When being asked by others as to what my thesis was on, I would always be encouraged by the responses of “that’s interesting”, “that’s so different” but mostly with “I’ve always wanted to know the answer to that!” This was greatly encouraging and was a great motivator to investigate the topic.

2. SO WHAT?

Throughout the research process one doesn't just complete a PhD but must struggle through many learning processes. It can easily be seen as an analogy with a difficult hiking trail. There is the excitement in choosing a trail to go hiking on (as one does when looking at various possible research topics), the preparation beforehand – including physical (fitness and gear) and mental, just as one needs to prepare for a PhD with reading and equipping yourself with research know-how. In this PhD I was privileged to get out and into nature on a regular basis with my research participants. Although this was also a challenge as I had to go with on each and every hike to ensure that the same path was followed, this often helped me to experience the attention restoration mentioned in the literature review (Kaplan, 1995). As a hiker climbing a steep mountain possibly loses motivation at times, I was not different. Many times it felt that the peaks of this mountain would never end. From delayed arrival of equipment to the disappointment of participants withdrawing, an emotional time with a friend passing away from cancer and other challenges. But here I am now, at the top of the mountain with a spectacular view. The process was long and often hard, but certainly rewarding.

At the start of this journey I was sceptical of my abilities as a researcher. Through this experience I have grown confident in my abilities. I am also grateful for my love of the outdoors and have seen first-hand how a recreational activity such as hiking can have an effect on people. One couple that volunteered to participate in the research who had never hiked before went out and bought all the needed equipment (after the second hike) and have been on a number of hikes since. Informing me with such pride that they even slept outdoors. It is encouraging to know that others have been motivated to live a more active lifestyle though this research. I hope that others that are sceptical about "getting out there" and who doubt their abilities or who are worried that they will keep the group behind will consider testing their own fitness and then attempt a hike that is within their means.

Patience is a word that I don't think extends itself to a PhD! It is something that is needed, something that is tested…but I am not sure if it is mastered during this process. The stumbling blocks and the reliance on other people was very challenging for me. The process of recruiting individuals was fairly cumbersome and arduous. Due to the number of tests required by the participants I was very reliant on their availability. The coordination trying to make arrangements for participants, anthropometrists, running tracks, equipment and hikes was quite a struggle. It was challenging to keep everyone content and to try and maintain the feeling of a leisure experience. This was particularly visible on the moderate trail. Not all participants wanted to take it leisurely or follow the trail and it was difficult to keep all in check and to maintain the freedom of choice required for a leisure experience. Walking the trail each time with participants proved quite time consuming and lengthened the data collection process. All these factors together were certainly a test of my patience and endurance. Looking back now I can however appreciate some of the delays as often something better came out of the wait. It is never easy to see this during the moment, but afterwards it becomes clearer. If one does not reflect however you lose such opportunities to see the good of what you thought was a bad experience. Understanding the research process and being reliant on others will certainly help me in my career. To work in a research group and with others will always be a welcome experience and having learnt a little more of this balancing trick during this PhD journey will greatly assist me.

I attended a training course on doing your dissertation with Microsoft Word. This was a tremendous help and I would recommend it to anyone embarking on a research project. The computer skills I have gained whilst working through this PhD have been invaluable and I am looking forward to sharing these with students that will be doing research within our department. The knowledge of how to make things work, just the way you want them to (…well, at least most of the time), was a lot easier when you have the know-how.

My knowledge of research has increased immensely. I used to look at research as a burden, an add-on and something to avoid. During a period in 2016 when I had time to focus on the research, and the research only, I learnt to enjoy it. It was satisfying to start the morning with an empty screen and by the end of the day have it filled with letters, words and ideas. It was satisfying to know that it was me… I did it, I wrote it. My understanding of research and the research process has improved and I am no longer hesitant to be involved with other research activities. This is certainly needed in my academic career.

3. NOW WHAT?

Uncertainty of one's own abilities and not knowing if you are able to participate with others could deter many people who are not sufficiently active to start with a form of PA. An activity such as hiking is considered a recreational activity, but one with increased amounts of PA. It is a fun activity done outdoors and with others. My hope is that by knowing what one's abilities are that it will be a form of encouragement to potential participants to participate, or to increase PA levels to a point so that they can participate. I have discovered that I have a passion for people and their wellness and that I would like to expose people to PA that does not have to be limited to a gymnasium.

The knowledge of fitness requirements and grading of hiking trails must also not be left to be found in academic journals alone. The results from this thesis must be shared with the hiking community and the general public. I aim to disseminate the results appropriately through appropriate forums.

With regard to research specifically, postdoctoral studies will be considered to determine if limitations identified within this study can be addressed. The knowledge gained whilst undertaking this research will certainly make me a better academic. My new understanding of and enthusiasm for research will flow over into the classroom. I will not be as scared to include articles and other research elements into course work instead of taking the comfortable text-book approach. I want to assist other students to stretch, grow and climb mountains (literally and figuratively)!

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Appendices

Appendix A: Cooper Run/Walk Percentile Ranks and $\dot{V}O_{2\,max}$ Calculations

Male Athletes

Age	Excellent	Above Average	Average	Below Average	Poor
13-14	>2700m	2400-2700m	2200-2399m	2100-2199m	<2100m
15-16	>2800m	2500-2800m	2300-2499m	2200-2299m	<2200m
17-19	>3000m	2700-3000m	2500-2699m	2300-2499m	<2300m
20-29	>2800m	2400-2800m	2200-2399m	1600-2199m	<1600m
30-39	>2700m	2300-2700m	1900-2299m	1500-1999m	<1500m
40-49	>2500m	2100-2500m	1700-2099m	1400-1699m	<1400m
>50	>2400m	2000-2400m	1600-1999m	1300-1599m	<1300m

Female Athletes

Age	Excellent	Above Average	Average	Below Average	Poor
13-14	>2000m	1900-2000m	1600-1899m	1500-1599m	<1500m
15-16	>2100m	2000-2100m	1700-1999m	1600-1699m	<1600m
17-20	>2300m	2100-2300m	1800-2099m	1700-1799m	<1700m
20-29	>2700m	2200-2700m	1800-2199m	1500-1799m	<1500m
30-39	>2500m	2000-2500m	1700-1999m	1400-1699m	<1400m
40-49	>2300m	1900-2300m	1500-1899m	1200-1499m	<1200m
>50	>2200m	1700-2200m	1400-1699m	1100-1399m	<1100m

For an evaluation of the athlete's performance select the age group and gender, enter the total distance covered and then select the 'Calculate' button.

Age 13-14 Gender Male Distance metres

Calculate Assessment -

VO_2max

An estimate of your VO_2 max can be calculated as follows:

- (Distance covered in metres - 504.9) ÷ 44.73

For an estimate of your VO_2 max enter the Distance covered and then select the 'Calculate' button.

Distance metres Calculate VO_2 max mls/kg/min

Appendix B: Letter of Invitation

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS
UV

School for Allied Health Professions (SAHP)/ Skool vir Aanvullende Gesondheidsberoepe (SAGB), UV/UFS

10 October 2016

Dear hiker

I have spoken at club meetings earlier in the year to inform member of the research being undertaken regarding hiking. I am a lecturer at the University of the Free State and currently undertaking research on hiking for my PhD study.

The title of the study is: Self-reported Fitness Levels, Actual Fitness Levels and Recorded Energy Expenditure on Graded Hiking Trails. The aim of the study is to see if we can link a fitness test to the grading of a hike in order to determine the minimum fitness requirements to participate.

I am still in need of volunteers, so if you are interested…please read further!

General Inclusion Criteria

- Participants need to be healthy, physically active and without presence of any individual risk factors.
- Ages between 18 – 69 years.
- The participant needs to be able to give informed consent.
- Willing and capable of doing a Step-up Test and anthropometry testing.
- Willing to do a "Cooper Test". This is a 12min run/walk test, where you run/walk for 12 min and see how much distance you can cover in that time.

General Exclusion Criteria

- Participants who are not healthy and not physically active.
- Participants younger than 18 years and older than 69 years.
- Participants who cannot give informed consent.
- Participants who are not willing and capable of doing a Step-up Test, anthropometry testing and the Cooper Test.

If you meet these criteria and would like to consider participating this is what will need to be done:

1. Willing to take 2 hikes near to Bloemfontein
2. Once hiking dates are confirmed and appointment will need to be made at the UFS Exercise Centre for testing

3. Pre-Hike Testing: including questionnaires, anthropometry measurements, Step-up Test & Cooper Test.
4. Hike an easy graded hike "Trail 1" accompanied by the researcher.
5. Hike a medium graded hike "Trail 2" accompanied by the researcher.

An amount of money will be paid for petrol. This can only be claimed through the University after the completion of all pre-hike and hike testing. Once you volunteer I'll send a more detailed description of what to expect as a volunteer.

Please don't hesitate to contact me (to volunteer of course) should you have any additional queries.

Regards
Brenda

Brenda Coetzee
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Appendix C: Letter of Invitation 2

UNIVERSITY OF THE FREE STATE
UNIVERSITEIT VAN DIE VRYSTAAT
YUNIVESITHI YA FREISTATA
UFS
UV

School for Allied Health Professions (SAHP)/ Skool vir Aanvullende Gesondheidsberoepe (SAGB), UV/UFS

31 January 2017

Dear hiker/potential hiker

I am a lecturer at the University of the Free State and I am currently undertaking research on hiking for my PhD study. If you are interested in, or are prepared to volunteer as a participant in the research, please read further!

The title of the study is: Self-reported Fitness Levels, Actual Fitness Levels and Recorded Energy Expenditure on Graded Hiking Trails. The aim of the study is to see if we can link a fitness test to the grading of a hike in order to determine the minimum fitness requirements to participate.

General Inclusion Criteria

- Participants need to be healthy, physically active and without presence of any individual risk factors.
- Ages between 18 – 69 years.
- The participant needs to be able to give informed consent.
- Willing and capable of doing a Step-up Test and anthropometry testing.
- Willing to do a "Cooper Test". This is a 12min run/walk test, where you run/walk for 12 minutes and see how much distance you can cover in that time.

General Exclusion Criteria

- Participants who are not healthy and not physically active.
- Participants younger than 18 years and older than 69 years.
- Participants who cannot give informed consent.
- Participants who are not willing and capable of doing a Step-up Test, anthropometry testing and the Cooper Test.

All information will be kept confidential and a short fitness report including the results from the anthropometry measurements (fat%) and fitness tests will be provided after the data has been processed.

If you meet these criteria and would like to consider participating this is what will need to be done:

1. Willing to take 2 hikes near to Bloemfontein (wearing a special GPS device)
2. Select a group (see table below) to indicate week of testing
3. Appointment will need to be made at the UFS Exercise Centre for testing (preferably in times indicated in table below. Exceptions can however be made, if required.)
4. Pre-hike testing: including questionnaires, anthropometry measurements, Step-up Test, Cooper Test (run/walk test at athletics track).
5. Hike an easy graded hike following a set path at Woodland Hills (wearing a special GPS device & heart rate monitor) accompanied by the researcher
6. Hike a medium graded hike following a set path at Thaba 'Nchu (wearing a special GPS device & heart rate monitor) accompanied by the researcher

These are the times that have been given to me by the testing staff at the gymnasium on campus. Please have a look at the dates and times and determine which suits you the most. The walks and testing need to take place within a week. Therefore I have grouped the testing. We cannot test and then only 3 weeks later to the walks etc. If you could let me know and I will then book a place for you in order to complete the first part of the testing.

Group F1	Gymnasium:	Friday 10 February 05:30-08:00 OR Monday 13 February 05:30-08:00 OR Tuesday 14 February 06:00-08:00
	Pellis Park:	Can arrange individually according to the times you are tested. Only available in mid mornings and after 18:30, and early on some mornings
	Hikes:	Walk at **Woodlands** Thursday 14th February start time ± 16:30/17:00 **Thaba 'Nchu** on the 18th Feb departure time ± 5:30/6:00

Group F2	Gymnasium:	Friday 17 February 05:30-08:00 OR Monday 20 February 05:30-08:00 OR Tuesday 21 February 06:00-08:00
	Pellis Park:	Can arrange individually according to the times you are tested. Only available in mid mornings and after 18:30, and early on some mornings
	Hikes:	Walk at **Woodlands** Thursday 23rd February **Thaba 'Nchu** on the 25th Feb

Group F3	Gymnasium:	Friday 24February 05:30-08:00 OR Monday 27 February 05:30-08:00 OR Tuesday 28 February 06:00-08:00
	Pellis Park:	Can arrange individually according to the times you are tested. Only available in mid mornings and after 18:30, and early on some mornings
	Hikes:	Walk at **Woodlands** Thursday 2nd March **Thaba 'Nchu** on the 4th March

Testing will continue until the data set is complete. If a group of friends (6 or more) would like to arrange a specific time "just for them" that is not included in the times above (including Thaba 'Nchu) then please let me know and I can see where and how we can accommodate you!

Please don't hesitate to contact me (to volunteer of course) should you have any additional queries.

Regards
Brenda

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Appendix D: Information Sheet

School for Allied Health Professions (SAHP)/ Skool vir Aanvullende Gesondheidsberoepe (SAGB), UV/UFS

Information regarding participation in research study

Thank you for volunteering to participate in this study. The title of the study is: Self-reported Fitness Levels, Actual Fitness Levels and Recorded Energy Expenditure on Graded Hiking Trails. The aim of the study is to see if we can link a fitness test to the grading of a hike in order to determine the minimum fitness requirements to participate. This is for both planned trips and the one that tourists often decide to take on the spur of the moment. The idea is to help potential hikers determine if the hike is the right fit for them. Choosing a hike that does not meet expectations as it is too easy or too hard ends up in disappointment and the possibility of not participating again.

There are 2 parts to the study, in order to obtain the necessary results it is important to participate in both parts of the study. Part two cannot be done without first participating in part one.

1. Pre-hike testing
2. Hike testing

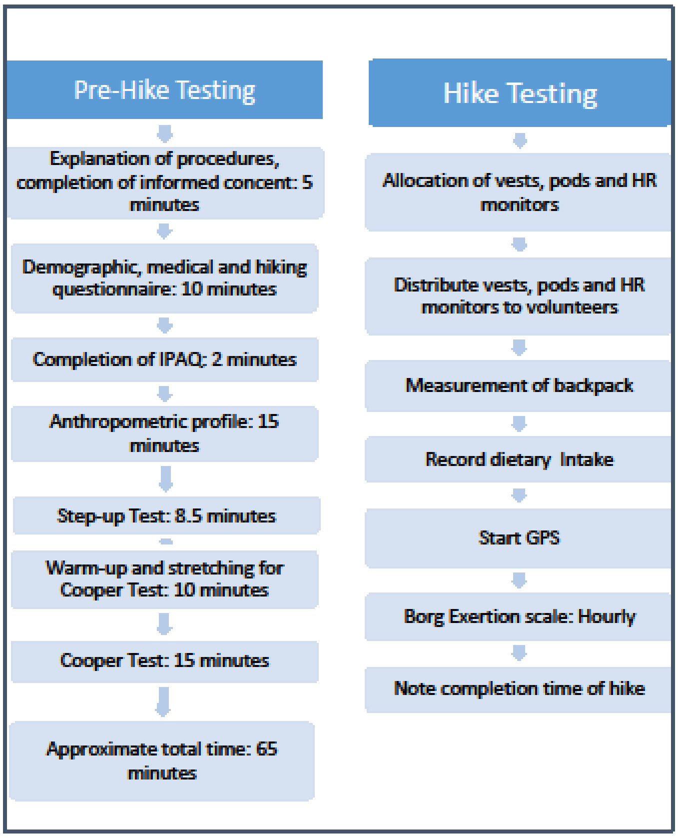

Figure 1.

Once a date has been set for a hike and you make yourself available to go on the hike the following will need to take place:

Within the week prior to the hikes an appointment at the Exercise and Sport Science Centre will need to be made. Every attempt will be made to schedule a time that will suit you, but testing times and equipment availability will play a role in the time/s available. I will gladly try to arrange the times for you but should you wish to call the Sports Centres telephone number is 051 401 3361. Please wear **comfortable sports-type clothing**. As you will be stepping and walking and running your clothing should allow for ease of movement. For the Body Profiling you will have measurements on (for example) your back, stomach and thigh. Please wear clothing that will allow these measurement to be taken with the least discomfort and awkwardness to you. (Sports tops with racer-backs can inhibit the taking of measurements. A 2 piece swimming costume can be worn by female participants for this phase of testing should it make them feel more comfortable.)

Day before the appointment:
Please don't exercise the day before… please rest!*

Day of the appointment:
As per Figure 1 above:

- Once you arrive an explanation of the procedure will take place. You will then have the opportunity to decide if you would like to continue or not with the research and to ask any questions that you may have.
- An informed consent form will then need to be completed.
- Then a Demographic, Medical and Hiking Questionnaire will need to be filled in (all information will be kept confidential).
- Then The International Physical Activity Questionnaire *(IPAQ)* will need to be completed.
- Following the completion of the IPAQ anthropometric measurements will be captured.
    - For this you will be measured. Measurements include for example, mass, length and skinfolds to determine fat percentage and other required calculations (all information will be kept confidential!)
- Following the anthropometric test a Step-up Test will be done
    - For this test you will be required to step for five minutes at the determined tempo (according to weight and height)
    - On the five minute mark sit on a chair immediately. Wait for 30 seconds your heart rate will be counted from 30 seconds to 1 minute post-test.
    - Sit and wait till 2 minutes after exercise was suspended and your heart rate will be counted for another 30 seconds.
- Lastly a Cooper run/walk test at the Athletics track. This is a12min walk/run test, where you walk/run for 12 min and see how much distance you can cover in that time. Walking is only done if you feel exhausted and feel you can no longer run.

Hikes:

Transportation to the site and food/snacks will be at your own cost and arrangement.
A set meeting time and location will be given.

At the hiking venue:

- Before the hike participants will receive a vest that will need to be worn. A special tracking device (GPS) will be placed in this vest that will record your movements throughout the hike.

- You will also be required to wear a heart rate monitor (chest strap only).
- The weight of your backpack will be measured.
- Your dietary intake before the hike will be requested as well as what you have taken with for the hike.
- Explanation of the Perceived Exertion Scale (Borg Scale)
- We start to hike!
- During the hike (every hour) you will be asked to rate your level of exertion (Borg). This will be recorded by the researcher.
- At the end of the hike the time of completion will be recorded.
- You will be required to return the vest, pod and heart rate monitor.

The hiking procedure will be repeated on two occasions: 1 an easy hike at Woodlland Hills and 2. moderate difficulty hike at Thaba 'Nchu mountain.

Once all data have been processed a report regarding the fitness levels, anthropometric measurements will be sent to you via the e-mail address you have provided.

You may participate on more than one occasion, but should you want to do a second set of hikes, you will be required to perform all tests again.

I am looking forward to the hiking experience.

Thank you for your time!

Regards

Brenda Coetzee

For further information please contact me:

austinba@ufs..ac.za

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Ethics number: UFS-HUM-2014-65

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Appendix E: Informed Consent

Participant number:

INFORMED CONSENT FORM

Title of the Research Project:	Self-reported Fitness Levels, Actual Fitness Levels and Recorded Energy Expenditure on Graded Hiking Trails
Principal investigator:	Brenda Coetzee
Contact details:	austinba@ufs.ac.za 051 401 3540
Ethical clearance number:	UFS-HUM-2014-65

To indicate that you have read, and understood each statement, please initialise in the right hand column in the row of the statement.

DECLARATION BY PARTICIPANT	Initial
I, the participant and the undersigned (full names): ______________________________ ID number: ______________________________	
HEREBY CONFIRM THE FOLLOWING:	
I, the participant, was invited to participate in the above mentioned project that is being undertaken by Brenda Coetzee of the Department of Exercise and Sports Science in the Faculty of Humanities of the University of the Free State.	
The following aspects have been explained to me, the participant:	
Aim: The project aims to determine if a user friendly self-reporting fitness measurement can be used to determine a hiker's physical capability (fitness levels) to complete graded routes before embarking on a hike. A hiker's actual energy expenditure will also be compared to the theoretical calculations in the current difficulty rating scale proposed by Hugo. The fitness level that is calculated through scientific testing will be compared to actual energy expenditure during the hike and how this correlates with the individuals perceived enjoyment and exertion.	
Procedures: I understand that I will have to undergo a fitness test(s), including anthropometry measurements within seven days prior to participating in a hike. Questionnaires will need to be completed during the fitness testing and then before, during and after the hike. Food intake will be recorded on the day of the hike. (You are therefore requested to make provision for the reporting of food intake (own provision of food).)	
Risks: The risks on the hike will be the same as for any hiking excursion undertaken. The nature of the research will not increase risk factors.	
Possible benefits: The participant will have the opportunity to gain information of personal fitness levels and have the opportunity to contribute to the knowledge field for the hiking fraternity.	
Confidentiality: The researcher will take precautions to preserve confidentiality of the data gathered. Participant's personal particulars will not be used during any reporting of results and care will be taken to maintain anonymity of participants.	
Access to findings: Participants will receive a report on the fitness assessment (should they wish) with the results of the fitness testing and anthropometry testing. Research results will be published in academic journals.	

1

Voluntary participation/refusal/discontinuation: My participation is voluntary YES ☐ NO ☐	
No pressure was exerted on me to consent to participate and I understand that I may withdraw at any stage without penalisation.	
The information above was explained to me, the participant by: ______________________ in English ☐ Afrikaans ☐ Other ☐ (Name of person providing information) and I am in command of this language. I was given the opportunity to ask questions and all these questions were answered to my satisfaction.	
I do not expect the researcher to be responsible for any payments towards the hiking trip.	
I HEREBY VOLUNTARILY CONSENT TO PARTICIPATE IN THE RESEARCH PROJECT:	
I will not hold the researcher, project assistants, promoters, the University of the Free State or any other individuals related to the research study liable for any loss, damage or injury sustained during testing or the hiking excursion. Signed/confirmed at ______________________(place) on ____________2017 Signature of participant: ______________________ Signature of witness: ______________________ Full names of witness: ______________________	

STATEMENT BY OR ON BEHALF OF THE INVESTIGATOR
I, ______________________ declare that I have explained the information given in this document to ______________________(name of participant). He/she was encouraged and given ample time to ask me any questions regarding the research. Signed at ____________on ______________________ 2017 Signature of interviewer: ______________________ Signature of witness: ______________________ Full names of witness: ______________________

Appendix F: Demographic, Medical and Hiking Questionnaire

Participant number:

Demographic, Medical and Hiking Questionnaire

For office use only

Personal Details:

Date of birth [Y][Y][M][M][D][D] Age: [ ]

Gender Male: [ ] Female: [ ]

Ethnicity African: [ ] Asian: [ ] Coloured: [ ] White: [ ]

Hiking club: ____________________

Contact details: Cell number: ____________________

E-mail address: ____________________

General Health Information

1.	Do you consider yourself to be healthy?	Yes	[ ]	No	[ ]
2.	Do you consider yourself "fit"?	Yes	[ ]	No	[ ]
3.	Are you a smoker?	Yes	[ ]	No	[ ]
4.	If you answered "Yes" to question 3, how many cigarettes do you smoke daily? ______				
5.	Do you drink alcoholic drinks?	Yes	[ ]	No	[ ]
6.	If you answered "Yes" to question 5, how many units do you consume daily? ______				

Medical History (Based on ACSM Health/Fitness Facility Pre-participation Screening Questionnaire)

1. If any of the following applies to you, then please place a ✓ in the corresponding block:

Have you ever had:	Yes		Yes
A heart attack	[ ]	Rhythm disorder	[ ]
Heart surgery	[ ]	Heart valve disease	[ ]
Cardiac Catheterization Coronary	[ ]	Heart failure	[ ]
Anglioplasty (PTCA)	[ ]	Heart transplant	[ ]
A pacemaker/implantable cardiac defibrillator	[ ]	Congenital Heart Disease	[ ]

2. Symptoms: Do you...

	Yes
Experience chest discomfort with exertion?	[ ]
Experience unreasonable breathlessness?	[ ]
Experience dizziness, fainting or blackout?	[ ]
Take heart medications?	[ ]

3.	**Other medical issues: Do you...**	**Yes**	For office use only
	Have diabetes?	☐	
	Have asthma or other lung disease?	☐	
	Have burning or cramping sensation in your lower legs when walking short distances?	☐	
	Have musculoskeletal problems that limit your psychical activity?	☐	
	Have concerns about safety of exercise?	☐	
	Take prescription medications?	☐	
	Are you pregnant?	☐	

If you marked any of the statements in this section, consult your physician or other appropriate health care provider before engaging in exercise. You may need to use a facility with medically trained staff.

4.	**Cardiovascular risk factors: if...**	**Yes**	
	You are a man older than 45 years.	☐	
	You are a woman older than 55 years, have had a hysterectomy, or are postmenopausal.	☐	
	You smoke, or quit smoking within the previous 6 months.	☐	
	Your blood pressure is higher than 140/90 mm Hg.	☐	
	You do not know your blood pressure.	☐	
	You take blood pressure medication.	☐	
	Your blood cholesterol level is greater than 200 mg/dl.	☐	
	You do not know your cholesterol level.	☐	
	You have a close blood relative who had a heart attack or heart surgery before age 55 (father or brother) or age 65 (mother or sister).	☐	
	You are physically inactive (i.e. you get less than 30 minutes of physical activity on at least three days per week).	☐	
	You are more than nine kilograms overweight.	☐	

If you marked two or more of the statements in this section you should consult your physician or other appropriate health care provider before engaging in exercise. You might benefit from using a facility with professionally trained staff to guide your exercise programme.

Should you wish to elaborate on any of the answers from above please do so below:

____

____

____

____

____

General Hiking Information	For office use only

1. Approximately how many times have you hiked before? ☐
2. How regularly do you hike?
   Less than 1st a year ☐ 1st a year ☐ 2nd a year ☐
   3-4 times a year ☐ 5+ times a year ☐
3. For how many years have you been participating in hiking? ☐ years
4. How would you rate your level of hiking experience?
   Beginner ☐ Novice ☐ Experienced ☐ Expert ☐
5. What type of shoe do you hike with? ______________________________
6. What do you typically eat for breakfast before a day hike?
   ____
   ____
   ____
   ____
   ____
7. What do you typically eat whilst on a day hike?
   ____
   ____
   ____
8. How much water do you usually take along for a day hike? ☐ litres
9. How much water do you usually consume during a day hike? ☐ litres
10. Do you use a backpack for a day hike? Yes ☐ No ☐
11. What is typically in your backpack for a day hike?
   ____
   ____
   ____
12. What is typically the weight of your backpack for a day hike? ☐ Kg

Thank you for completing the questionnaire.
Enjoy your hiking experience!

Based on ACSM Health/Fitness Facility Pre-participation Screening Questionnaire. American College of Sports Medicine (ACSM). 2014. Guidelines for Exercise Testing and Prescription. Ninth Edition.

Philadelphia: Wolters Kluwer | Lippincott William & Wilkins. Pg 25.

Appendix G: IPAQ

Participant number:

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

SHORT LAST 7 DAYS SELF-ADMINISTERED version of the IPAQ. Revised August 2002.

Appendix H: Pre-Hike Testing (Anthropometry, Step-up and Cooper Tests)

Data Collection Pre-Hike Testing

Participant Number:

Age: __________

M	F

Informed consent completed?	
IPAQ completed?	

Anthropometric Profile

	Tester 1	Tester 2	Tester 3	Ave
Basic				
Mass				
Height				
Skin Folds				
Triceps				
Subscapular				
Biceps				
Iliac Crest				
Supraspinale				
Abdominal				
Front Thigh				
Medial Calf				
Girths				
Arm relaxed				
Arm tense				
Waist				
Gluteal				
Calf				
Breadths				
Humerus				
Femur				

Step up Test

Step-up Height	38cm	30cm	25cm
Step Frequency	30 steps	20 steps	

30=30 BPM 20=40 BPM

Sit on chair 30 sec then take HR

Heart rate 1	
Heart rate 2	
HR total	0

30s - 1min post step-up
2 - 2min 30s post step-up

Under 50kg	Bench 38 cm x 30 steps· minute^{-1}
51kg to 70 kg	Bench 38 cm x 20 steps· minute^{-1}
71kg to 90kg	Bench 30 cm x 20 steps· minute^{-1}
Above 91kg	Bench 25 cm x 20 steps· minute^{-1}

Borg:

Cooper Test

Date: ____________________

Time: ____________________

Tester: ____________________

Distance covered in 12 minutes: _______ laps

_______ m

Borg: _______

End point description: _________

Appendix I: Hiking Testing Data Sheet

Hike Testing Data Collection Sheet

Hiker Name: ______________________ Date: ____________

Venue hiked: ______________________

Code allocated: [ ] Weight of backpack: [ ]

Pod number: [ ] Heart Rate monitor number: [ ]

What food did you eat before the hike today? What did you drink?

____

____

____

What have you brought along to eat/drink during the hike?

____

____

____

Borg Perceived Exertion Scale:

Hour	
1	
2	
3	
4	
5	
6	

Start time of hike: [ ]

Completion time of hike: [ ]

Return of :

Vest	
Pod	
Heart rate monitor	

Appendix J: Turn it in Reports

turnitin

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This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

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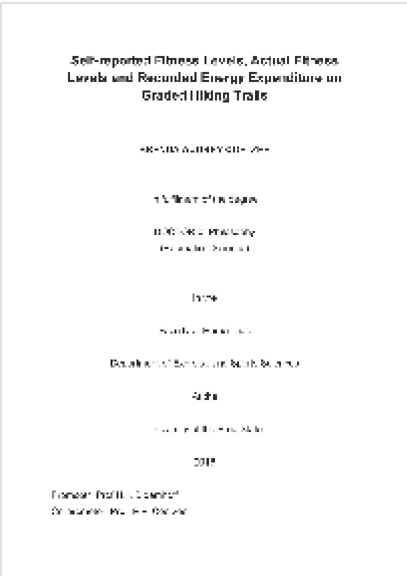
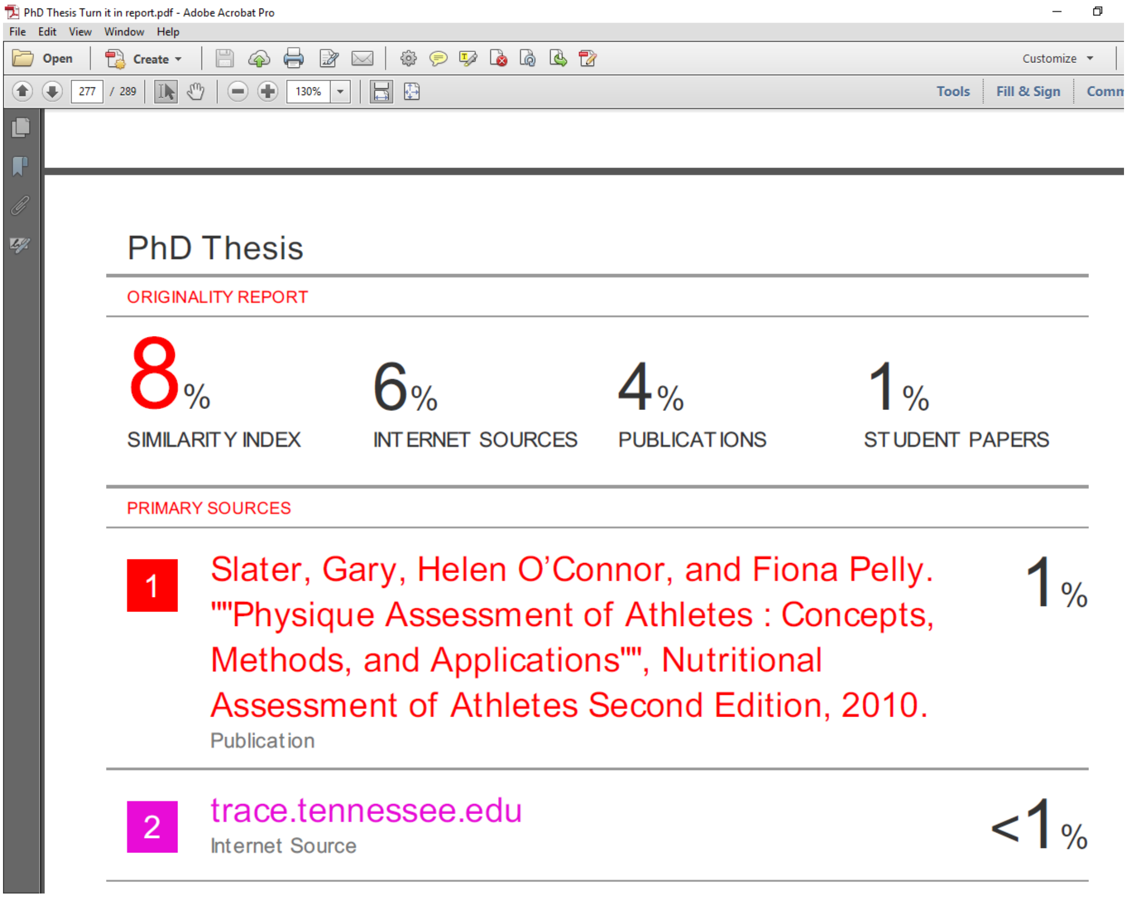

Self-reported Fitness Levels, Actual Fitness Levels and Recorded Energy Expenditure on Graded Hiking Trails



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1	Slater, Gary, Helen O'Connor, and Fiona Pelly. ""Physique Assessment of Athletes : Concepts, Methods, and Applications"", Nutritional Assessment of Athletes Second Edition, 2010. Publication	1%
2	trace.tennessee.edu Internet Source	<1%

Appendix K: Letter from Language Editor

17 January 2018

TO WHOM IT MAY CONCERN

This is to certify that I have proofread and edited the PhD dissertation titled:

Self-reported Fitness Levels. Actual fitness Levels and Recorded Energy Expenditure on Graded Hiking Trails

by Ms Brenda Audrey Coetzee. I have made the necessary corrections and have ensured, to the best of my ability, that the dissertation is, from a language perspective, perfectly satisfactory.

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