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DECKED! CHALLENGE (BODYWEIGHT) - A MODERNISED  
APPROACH TO HEALTH PROMOTION THROUGH THE  
UTILISATION OF MOBILE TECHNOLOGY

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The growing incidence of Noncommunicable Diseases (NCDs) within modern society, for which physical inactivity represents a major risk factor, has generated significant public and professional attention. This recent emphasis placed on the reduction of NCDs and their associated modifiable, behavioural risk factors has resulted in increased focus on the promotion of physical activity. Additionally, research demonstrates a shift in mentality away from the pathogenic orientation of health promotion. This has resulted in the formation of health promotion concepts that actively promote health, rather than just being low on risk factors.

When considering health promotion from a modern perspective, it is pertinent to take into consideration the influence of the rapid, worldwide, digital development that is shaping today's society. Technological developments have resulted in the growth of mobile health (mHealth), for which health promotion through physical activity represents a notable component. These technological resources offer tremendous potential in influencing health promotion, management and prevention strategies.

From a physiotherapeutic perspective, physiotherapists are uniquely skilled to make a substantial contribution to the promotion of health and physical activity, potentially easing the public health burden associated with NCDs. Accordingly, this thesis has presented research associated with the design, development and dissemination of a health promotion product. This health promotion product was developed to utilise modern resources and technology, to facilitate dissemination to multiple demographics.

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*“We have confused illness with the process of aging, which can be thoroughly healthy. Illness is not a necessary part of aging!”*

*- Dr. Charles Eugster, 94-year-old World Masters Rowing Champion*

## 1 INTRODUCTION

Noncommunicable Diseases (NCDs), also known as chronic diseases, may be defined as any medical condition or disease that is non-infectious or non-transferrable among people. The prevalence of NCDs within modern society represents a significant global burden, both from a general population health condition and economic perspective. Currently, NCDs are the leading cause of death globally, with an estimated 36 million deaths (or 63% of the total deaths globally) in 2008 alone. Additionally, the cumulative output loss due to NCDs constitutes an estimated global cost of US\$ 47 trillion. (World Health Organization 2013, 7-10.)

The World Health Organisation (WHO) has invested significant resources into the investigation of NCDs and their associated causes, trends and preventions. This research has identified that a large percentage of NCDs are preventable through the reduction of four modifiable, behavioural risk factors. These include tobacco use, physical inactivity, harmful use of alcohol and unhealthy diet. (World Health Organization 2011a, 1-2.)

From a physiotherapeutic perspective, lack of physical activity represents a significant topic of interest. Physical inactivity has been identified as the fourth leading risk factor for global mortality, accounting for approximately 6% of deaths, or 3.2 million deaths per year. (World Health Organization 2010, 10.) Physiotherapists are uniquely skilled to make a substantial contribution to the reduction of physical inactivity and easing the public health burden associated with NCDs. A reduction of physical inactivity by even 25% means more than 1.3 million deaths could be averted every year. (Lee et al. 2012, 6.)

In the past physiotherapy intervention, including exercise prescription, has predominantly focused on symptomatic treatment and the restoration of lost function as a result of an acute incident, or the maintenance of function in neurological or cardiorespiratory disease. (Verhagen et al. 2009, 100). The recent emphasis placed on the reduction of NCDs and their associated modifiable, behavioural risk factors (by organisations such as the WHO), in addition to the increased public and professional exposure towards the mitigation of the effects of ageing and the

increasingly ageing population; physiotherapy professional bodies around the world have brought physical activity promotion to the forefront of their agenda. (Chartered Society of Physiotherapy 2014.)

When considering health promotion from a modern perspective, it would be negligent not to consider the influence of the rapid, worldwide digital development that is shaping today's society. The utilization of modern resources is a necessity in the fight against physical inactivity. Resources such as mobile technologies offer tremendous potential for improving health management and prevention strategies. As mobile technology becomes increasingly integrated into virtually all aspects of everyday life, opportunities within the physiotherapeutic and medical industry arise. The power and reach of mobile communication offers the potential for great versatility and utility, to enable the provision of high quality, low cost health services. (Greenspun et al. 2012, 11.)

The WHO has even stated that the use of mobile and wireless technologies to support the achievement of health objectives (i.e. mHealth) has the potential to transform the face of health service delivery across the globe. (Kay 2011, 1). The EU also believes mHealth applications have the ability to lead to €99 billion of savings to the EU economy, and has accordingly invested significant resources into the development of this field. (European Commission 2014).

From a physical activity perspective, mHealth applications offer a potentially low cost solution to disseminate health-promoting applications to a wide and established market base. This in turn facilitates individuals to have instant, on-demand access to their health related data, thus empowering them to actively participate in their own health management.

## 2 AIM OF THESIS

The primary goal of this thesis is to detail the investigation and research associated with the development and subsequent dissemination of a health promotion product. This health promotion product aims to exploit salutogenic orientated health promotion, by actively promoting health through physical activity. Additionally, this health promotion product intends to utilise modern resources and technology to facilitate dissemination.

Accordingly, this thesis consists of research regarding noncommunicable diseases, health promotion and components of physical function. This shall also include a discussion on the promulgation of health and fitness products within the mobile environment, in addition to analysis of a prevalent, modern training style influencing conception of the health promotion product's design. This thesis shall also outline the process associated with design, development and dissemination of the health promotion product.



### 3 NONCOMMUNICABLE DISEASES (NCDS)

The prevalence of NCDs within modern society represents a topic of great consequence, both nationally and on a global scale. Accordingly, several global and national initiatives have been initiated in recent times. (World Health Organization 2013, 4-5). Currently, NCDs are the leading cause of death globally, with an estimated 36 million deaths in 2008. This equates to 63% of the total 57 million deaths that occurred globally. These deaths compromised mainly of cardiovascular diseases (48% of NCDs), cancers (21%), chronic respiratory diseases (12%) and diabetes (3.5%). In addition, the cumulative output loss due to these four major NCDs, together with associated mental disorders, represents a significant global financial burden. It is estimated that the aforementioned NCDs constitute an estimated global cost of US\$ 47 trillion. (World Health Organization 2013, 7-10.)

The WHO has invested significant resources into the investigation of NCDs and their associated causes, trends and preventions. This research has identified that a large percentage of NCDs are preventable through the reduction of four modifiable, behavioural risk factors. These include tobacco use (~6 million deaths per year from direct tobacco use and second-hand smoke), physical inactivity (~3.2 million deaths per year), harmful use of alcohol (~2.3 million deaths per year) and unhealthy diet (obesity and overweight causes ~2.8 million deaths per year). (World Health Organization 2011a, 1-2.)

#### 3.1 The Global and Finnish Health Impact of Physical Inactivity

Globally, it is estimated approximately 31% of adults aged fifteen and over were insufficiently active in 2008 (men 28% and women 34%). In Finland alone, physical inactivity prevalence ranged from 24-48% for males, and from 15-32% for females, in 2005 (Figure 1). (World Health Organization 2011b.)

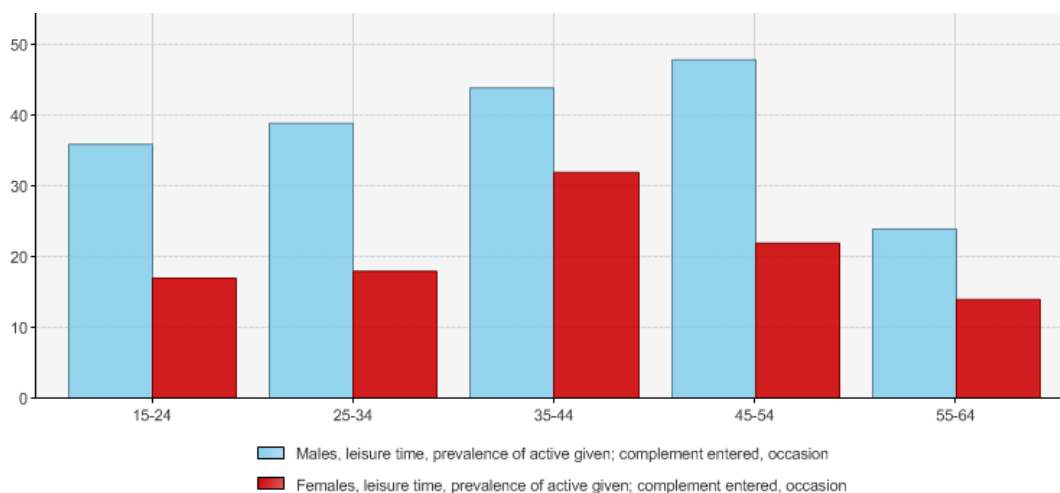


Figure 1 - Physical Inactivity Prevalence, Finland 2005

People who are insufficiently physically active have a 20 - 30% increased risk of all-cause mortality. Regular physical activity reduces the risk of cardiovascular disease, including high blood pressure, diabetes, breast and colon cancer and depression. (World Health Organization 2011a, 1.)

There is also a significant economic impact from both an individual and household level. It is estimated that every year, 100 million people are pushed into poverty due to costs associated with healthcare, for which NCD related healthcare represents a significant portion. In addition, national health-care budgets are being allocated increasingly more resources to combat illnesses and diseases associated with physical inactivity. It is estimated that losses in national income from heart disease, stroke and diabetes (for which physical inactivity is a major risk factor) in 2005 was US\$ 38 billion between China, Russia and India alone. (World Health Organization 2011a, 3.)

### 3.2 Physiotherapist's Role in the Prevention of Physical Inactivity

Physiotherapists are increasingly confronted with diseases associated with physical inactivity. As experts in movement and exercise, and with a thorough knowledge of functional anatomy and pathology and its effects on all systems, physiotherapists are ideal professionals to promote, guide, prescribe and manage exercise activities.

Unfortunately, their role has been minimal in multi-disciplinary approaches to date. (Verhagen et al. 2009, 99-100.)

The World Confederation for Physical Therapy (WCPT) in its position statement on physiotherapists as exercise experts across the human lifespan, states that with increasing numbers of people, including patients and clients with diverse varieties of conditions, leading sedentary lifestyles, it is imperative that effective strategies for exercise across the lifespan are implemented. (World Confederation for Physical Therapy 2012, 14.)

Physical activity offers a powerful intervention for strength, power, endurance, flexibility, balance, relaxation, and the remediation of pathophysiology, impairments, activity limitations and participation restrictions. Along with the WHO, the WCPT has recognised the importance of physical activity in the battle against NCDs and drafted a policy accordingly. This policy identifies the potential roles of physiotherapists and member organisations in the management of NCDs. Amongst these roles, the WCPT encourages physiotherapists and member organisations to advocate physical exercise, educate health professional communities, and support interprofessional collaborative practices. Appendix 1 outlines the WCPT member organisation's roles in full. (World Confederation for Physical Therapy 2014a, 2-3.)

### 3.3 Practical and Psychological Barriers Associated with Physical Inactivity

In order to promote physical activity, it is paramount for the physiotherapeutic and health care provider community to possess awareness of recommended exercise guidelines and prescriptions, in addition to the potential practical and psychological barriers limiting participation. Increased awareness of the obstacles associated with physical inactivity equips physiotherapists with additional knowledge and resources in the battle against NCDs and their associated risk factors (in particular, physical inactivity). Numerous physical and psychological barriers exist within all demographics, potentially limiting participation within physical activity (Figure 2). (Chang et al. 2013.)

<b>Practical Barriers</b>	<b>Psychological Barriers</b>
Work commitments	Not motivated to do more
Insufficient leisure time	Prefer to do other things
Caring for children or older people	Not the sporty type
Financial limitations or priorities/Costs	Worried about injury
Poor health, disability or physical limitations (chronic or acute)	Don't enjoy physical activity
Low fitness	Too shy or embarrassed
No exercise companion	Belief that too old
No support from partner/family/friends	Belief that too overweight
No suitable local environment: safety, traffic, pollution	Belief that not necessary
Lack of appropriate clothing or equipment	Think exercise is a waste of time
Lack of local facilities/transport/distance	Self-conscious about exercising in front of others
Sedentary interests (video games, TV, etc)	Changing facilities
Ill-informed regarding sufficient exercise/unaware of guidelines	
Cultural restrictions	

Figure 2 - Practical and Psychological Barriers to Physical Activity (Chang et al. 2013).

Previously, a study was conducted into the perceived benefits and barriers to physical activity in a nationally representative sample of the European Union (EU). Within the EU, lack of adequate time due to work or study commitments has been sighted as the most frequently perceived barrier to increasing physical activity (at 28%). Additionally, time limitations associated with looking after children or elderly relatives accounted for another 12%. (Zunft et al. 1999, 157-158.)

The second most prominent barrier to physical activity related to an individual's perceived belief of 'not being the sporty type' (at 25%). Almost half of the individuals sighting this barrier communicated that they currently do not participate in any physical activity. The study's discussion identified that the majority of respondents associate physical activity with being a more strenuous task or duty than a fun, relaxing, and recreation-based activity. In these instances, physical activity was more associated with sports. Therefore, many respondents mention 'not a sporty type' (25%) or 'too old' (10%) as a barrier, and use this statement as an excuse not to increase their levels of activity. This is also true for many overweight and obese subjects who reject the idea of doing any sports and increasing their level of physical

activity due to factors such as poor health (accounting for 11%). (Zunft et al. 1999, 157-158.)

The EU study also discussed the social and community aspects that require contemplation. Although important to address behavioural aspects, the social and community environment also requires consideration (e.g. family support and community health education). It appears that many individuals, particularly the older age groups, are not well enough informed about recent studies demonstrating the positive effects of moderate physical activity on health. Hence, lack of adequate information recourses appears to be another potentially significant barrier. (Zunft et al. 1999, 159.)

### 3.4 WHO Physical Activity Recommendations

Although each county typically possesses its own guidelines regarding the prescription of physical activity, the WHO has developed several global recommendations on physical activity for health. These guidelines have been developed based upon substantiating scientific evidence, in order to improve cardiorespiratory and muscular fitness, bone health, cardiovascular and metabolic health biomarkers, reduce the risk of NCDs, reduce cognitive decline, and reduce symptoms of anxiety and depression. Recommendations have been separated into specific age groups. Appendix 2 details these recommendations. (World Health Organization 2010, 7-8.)

## 4 HEALTH PROMOTION

Health may be defined as a state of optimal physical, mental and social well-being, and not merely the absence of disease and infirmity. An accepted definition of health promotion however, is somewhat more difficult to identify. Many theoretical texts, when referring to health promotion, focus on disease prevention and utilise disease specific terminology. Medical intervention and its associated policies also have a tendency to focus those whom already possess disease or infirmity, with preventative medicine focussing on those who already possess identified risk factors. For a person who is identified with a specific disease, this pathology tends to become the sole focus of attention. Resistance against this pathogenic orientation of health promotion has resulted in the formation of health promotion concepts that are negentropic and actively promote health, rather than just being low on risk factors. (Antonovsky 1996, 13-14.)

### 4.1 Antonovsky 's Salutogenic Model of Health Promotion

The salutogenic model focuses on keeping people well, through studying the strengths and the weaknesses of promotive, preventive, curative and rehabilitative ideas and practices. Essentially salutogenesis aims to focus on entities that add to healthfulness and wellbeing, rather than factors causing sickness and disease. The underlying concept operates under the assumption that that the human system (as all living systems) is inherently flawed, subject to unavoidable entropic processes and unavoidable final death. As such, the human body at any given point in time can sit somewhere along a "healthy or dis-ease continuum" (Figure 3). (Antonovsky 1996, 12-13.)

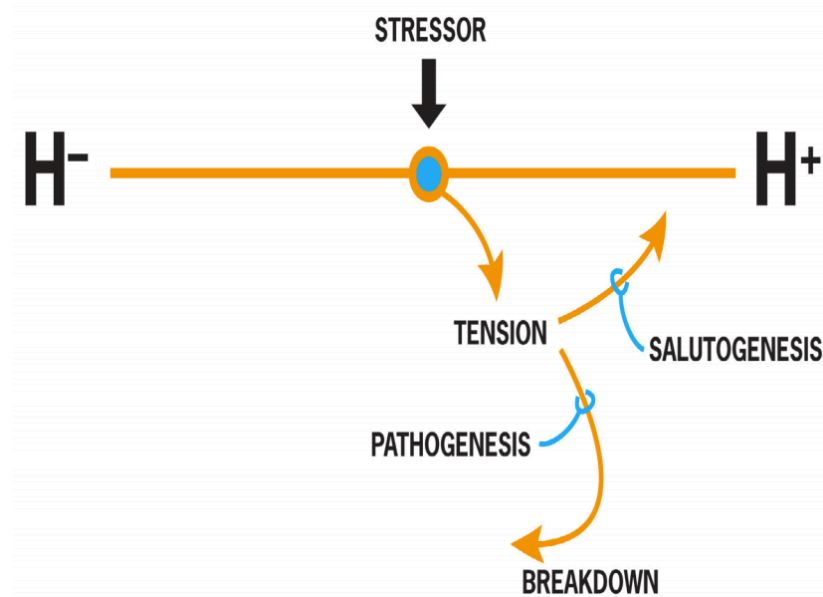


Figure 3 - Antonovsky's Classic Health Continuum (Lindström 2010).

This continuum is illustrated as a horizontal line, with each end representing opposite aspects of the health spectrum, from a total absence of health (H-) to complete health (H+). An individual or collective would be positioned somewhere along this line. At any given time the individual may be acted upon by a stressor, which possesses the ability to disrupt their position on the continuum and place their body under tension. From this tension, either the pathogenic forces overwhelm the individual causing breakdown, or they regain health through salutogenesis and move towards healthfulness (H+). (Lindström 2010.)

Antonovsky identifies an individual's sense of coherence (SOC) as a facilitating factor in the movement towards health (H+). This SOC is the ability to identify and use one's own health resources. Accordingly, an individual with a strong SOC will wish to be motivated to cope (meaningfulness), believe that the health challenge is understood (comprehensibility), and believe that resources to cope are available (manageability). Accordingly, Antonovsky's salutogenic model of health promotion aims to provide a paradigm that strengthens an individual's SOC, this empowering them to focus on entities that add to healthfulness and wellbeing. (Antonovsky 1996, 15-16.)

## 4.2 WHO's Ottawa Charter for Health Promotion

The WHO's Ottawa Charter for Health Promotion identifies health promotion as the process of enabling people to increase control over, and to improve, their health. To reach a state of complete physical, mental and social wellbeing, an individual or group must be able to identify and to realize aspirations, to satisfy needs, and to change or cope with the environment. Health is therefore seen as a resource for everyday life, and not the objective of living. Health is a positive concept emphasizing social and personal resources, as well as physical capacities. (World Health Organization 2009, 1; World Health Organization 1986.)

The Ottawa Charter resulted in the generation of a health promotion emblem. Overall, the logo visualises the idea that health promotion is a comprehensive, multi-strategy approach (Figure 4). (World Health Organization 2009, 33-34; World Health Organization 1986.)

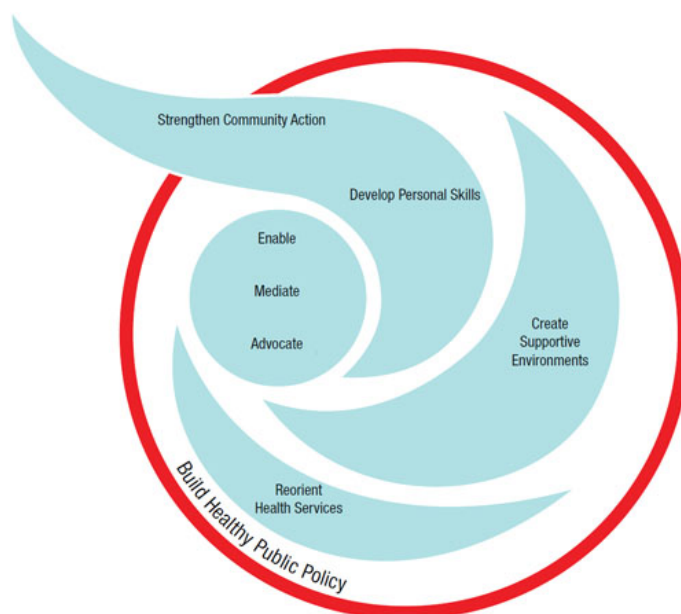


Figure 4 - WHO Health Promotion Emblem (World Health Organization 2009, 33).

The inner circle of this emblem represents the basic prerequisites to facilitate health promotion. This includes “enabling” individuals to achieve their fullest health potential, through reducing differences in current health status and ensuring equal opportunities and resources; “mediating” between differing interests in society for



the pursuit of health, through promotion of health by government and non-government organisations (including industry and the media); and “advocating” health through various avenues including political, economic, social, cultural, environmental, behavioural and biological factors. (World Health Organization 2009, 33-34; World Health Organization 1986.)

The three wings represent the five key action areas for health promotion. The upper wing represents the actions required to “strengthen community action” through the empowerment and enhancement of community self-help and social support; and to “develop personal skills” through the provision of information, education for health, and enhancing life skills. To achieve these, a “healthy public policy” is required. The middle wing represents that action is required to “create supportive environments for health” through encouraging reciprocal maintenance (i.e. to take care of each other, our communities and our natural environment). The bottom wing represents that action is needed to “reorient health services” towards preventing diseases and promoting health. (World Health Organization 2009, 33-34; World Health Organization 1986.)

Although originally created as part of the Ottawa Charter in 1986, the WHO continues to use this emblem and its concepts in its approach to health promotion. (World Health Organization 2009, 33-34).

#### 4.3 The Physiotherapist’s Role in Health Promotion

Physiotherapists are uniquely skilled to play a vital role in the facilitation of health promotion, as advisors and implementers of physical activity programs, from both an individual and general population perspective. Reducing inactivity and passivity is a large health challenge in which physiotherapists can play an important role in using physical activity as one of several measures in both health promotion, prevention and rehabilitation work. (World Confederation for Physical Therapy 2012, 15-16.)

With reference to the WHO’s health promotion emblem, physiotherapists possess numerous competencies associated with the basic prerequisites and key action areas of facilitating health promotion. It is within the Physiotherapist’s scope of work to “advocate” for and “enable” the promotion of health and wellbeing of individuals

and society, by emphasising the importance of physical activity and exercise. Additionally, physiotherapists may also be responsible for “mediating” between differing interests in society for the pursuit of health, through the development and implementation of health policy on a local, national and international scale. The practical implementation of these basic prerequisites within the physiotherapeutic environment also facilitates achievement of the key action areas for health promotion. (World Health Organization 2009, 33-34; World Confederation for Physical Therapy 2014b, 2-5.)

Physiotherapists may also utilise several additional health promotion approaches to enable participation and empowerment during the treatment of individuals and groups. For example, the “Stages of Change Model” and “Health Belief Model” may be utilised to assist individuals and groups in identifying the cues and barriers associated with adopting a healthier lifestyle. Knowledge of these health promotion models, in combination with physiotherapeutic expertise, enables physiotherapists to create awareness regarding the benefits of utilising physical activity to pre-emptively reduce the risk of developing impairments or disabilities and improve an individual’s general condition. (World Confederation for Physical Therapy 2012, 16-17.)

## 5 INTERRELATED COMPONENTS OF PHYSICAL FUNCTION

The ability to function independently at home, in the workplace, within the community, or during leisure and recreational activities is contingent upon physical as well as psychological and social function. The multidimensional aspects of physical function encompass the diverse yet interrelated areas of performance, and include: muscle performance, cardiopulmonary and endurance, mobility and flexibility, neuromuscular control and coordination, stability, and finally balance and postural equilibrium (Figure 5). (Kisner et al. 2012, 2-3.)

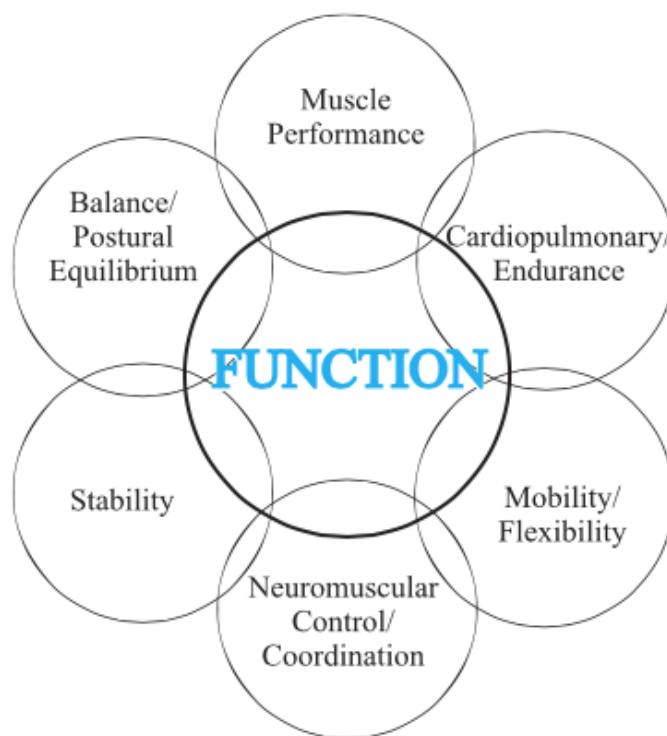


Figure 5 – Components of Physical Function (Kisner et al. 2012, 2).

Impairment to even one of the body's systems can result in subsequent impairment to one or multiple components of physical function, and can lead to disability and functional limitations. In order to maintain physical function and reduce the risks associated with development of functional limitations or disabilities, each of the interrelated components of physical function require specific focus within day-to-day physical activity. The body's systems require constant loading or stresses to facilitate

a response within each of the components of physical function. This loading causes the systems of the body to respond through reaction, adaption and development of the affected tissues. For example, the interaction of gravity on the body during physical activity causes loading on the musculoskeletal, cardiopulmonary and neuromuscular systems. This subsequently facilitates maintenance or development of muscle performance, cardiopulmonary endurance and mobility. (Kisner et al. 2012, 2-3.)

It is desirable for the health promotion product to incorporate an integrated training concept, utilising a theory-based approach. This involves the inclusion of several elements associated with physical function in an integrated fashion, in an effort to elicit maximal benefit for participants. Additionally, to facilitate client interaction with the health promotion product, it is advantageous to maximize usability. This usability can be enhanced through the creation of an easy to learn, efficient, effective, engaging and error tolerant health promotion product. Accordingly, to promote usability the health promotion product shall affect upon only some of the key components of physical function. The following section provides an overview of these components. (Clark et al. 2008, 3-14.)

### 5.1 Muscle Performance

Muscle performance relates to the capacity of a muscle to perform work, through the application of force over a distance. Many factors influence muscle performance and include the morphological qualities of muscle; neurological, biochemical, and biomechanical influences; and metabolic, cardiovascular, respiratory, cognitive, and emotional function. (Kisner et al. 2012, 158-160.)

The three primary elements of muscular performance are strength, power and endurance. These elements may be enhanced through the utilisation of resistance-orientated exercise. The resulting impact to each of these elements is dependent upon how variables such as intensity, duration and frequency are manipulated. For example, plyometric or reactive training utilizes explosive movement patterns to facilitate power development and functional strengthening of muscles, tendons, and ligaments. This is achieved through the employment of exercises that generate fast

and powerful movements, involving eccentric, isometric and concentric muscle activation. Typically plyometric exercises involve explosive interaction with the ground, or a stable surface. To perform these movements efficiently and effectively, participants require proficiency in several components of physical function, including adequate core strength, balance, joint stability and range of motion. (Kisner et al. 2012, 158-160; Clark et al. 2008, 253-255.)

### 5.1.1 Definition of Strength, Power and Endurance

Muscle strength is a broad term that refers to the ability of contractile tissue to produce tension and a resultant force based on the demands placed on the muscle. In more simplistic terms, strength can be defined as the maximal force exerted by a muscle, or muscle group, during a single maximal effort. (Kisner et al. 2012, 158-160).

Muscle power is the combination of strength and speed of a movement. It may be defined as the application of work (distance multiplied by force) produced by a muscle over a unit of time. This application of work may occur over a brief or extended period of time, and can be identified as anaerobic or aerobic power. Anaerobic power may involve a short, single burst of high intensity (e.g. 1RM), whereas aerobic power may be performed over a longer period of time and involve less intense muscle activity (e.g. 10RM). (Kisner et al. 2012, 158-160).

Muscle endurance refers to the ability to perform low-intensity, repetitive, or sustained activities over a prolonged period of time. Although similar to cardiorespiratory endurance, discussed in further detail below, muscular endurance is associated with the ability of muscles to contract repeatedly against a load or resistance, generate and sustain tension, and resist fatigue over an extended period of time. The term muscular endurance may also be used interchangeably with aerobic power. (Kisner et al. 2012, 158-160.)

### 5.1.2 Phases of Contraction

Muscle performance of a resistance-orientated manoeuvre can be divided into three phases. These include an eccentric loading phase, and intermediary dynamic stabilization transition phase, followed by an unloading concentric phase (Table 1). (Clark et al. 2008, 254-255).

Table 1 – Phases of Plyometric Exercises (Clark et al. 2008, 254-255).

Phase	Description
<b>Eccentric Phase</b> (loading)	This first phase increases muscle spindle activity by pre-stretching the muscle before activation. The loading phase allows potential energy to be stored within the elastic components of the muscle.
<b>Amortization or Transition Phase</b> (dynamic stabilization)	The time between the end of eccentric loading and the initiation of the concentric unloading. During this phase, muscle must switch from overcoming force to imparting force in the intended direction.
<b>Concentric Phase</b> (unloading)	Involves a concentric contraction resulting in enhanced muscular performance.

## 5.2 Cardiopulmonary Endurance

Cardiopulmonary endurance or total body endurance is related to the ability to perform large muscle, dynamic, moderate-to-vigorous intensity exercise for extended periods of time. Performance of exercise at this level of physical exertion depends on

the integrated physiologic and functional state of the respiratory, cardiovascular, and musculoskeletal systems. (American College of Sports Medicine 2013, 72-73.)

Cardiopulmonary endurance has a high correlation with health-related issues. For instance, low levels of cardiopulmonary endurance have been associated with an increased risk of all-cause mortality, specifically from cardiovascular disease. Accordingly, increases in cardiopulmonary endurance are associated with a reduction in death from all causes and higher levels of habitual physical activity, which in turn are associated with many health benefits. To facilitate improvement in cardiopulmonary endurance, associated systems must be challenged on a regular basis, through the use of large muscle groups. Activities may include walking, running, swimming, skiing, and circuit training. (American College of Sports Medicine 2013, 72-75.)

The typical classification system associated with cardiopulmonary endurance involves measurement of the body's maximal oxygen consumption ( $VO_{2max}$ ), which is typically performed during exercise.  $VO_{2max}$  provides an indication of the functional capacity of the heart and may be defined in relative terms, as the maximal amount of oxygen consumed per minute when an individual has reached maximal effort. It is usually expressed with respect to bodyweight, in terms of millilitres of oxygen per kilogram of bodyweight per minute (mL/kg/min). This facilitates comparison between individuals possessing varying bodyweight.  $VO_{2max}$  can be influenced by a number of factors, including an individual's gender, age, genetics, level of physical inactivity and existing diseases or pathologies. (American College of Sports Medicine 2013, 73-75.)

### 5.3 Mobility and Flexibility

Mobility may be defined using two separate yet interrelated terms. The first may be defined as functional range of motion (ROM). This involves the presence of ROM for functional activities, through the ability of structures or segments of the body to move or be moved. The second term may be identified as functional mobility, defined as the ability of an individual to initiate, control, or sustain active movements

of the body to perform simple to complex motor skills. Accordingly, mobility is associated with joint integrity in addition to flexibility. (Kisner et al. 2012, 72-73.)

Flexibility relates to the extensibility of soft tissues (muscles, skin, fascia, ligaments, tendons, joint capsule, nerves, blood vessels) that cross or surround a joint and is necessary for pain free and unrestrictive movements. Flexibility is dependent upon a number of variables including distensibility of the joint capsule, adequate warm-up, muscle viscosity and compliance or tightness of various other soft tissues. (American College of Sports Medicine 2013, 105-106.)

Mobility and flexibility are integral to activities of daily living (ADL), in addition to the performance of athletic activities. Just as other components of physical function affect performance and predisposition to dysfunction, mobility and flexibility are an integral component of an individual's physical activity program. Stretching or mobility exercises are also thought to be an important element of fitness and conditioning programs designed to promote wellness and reduce the risk of injury and reinjury. Due to the interrelated nature of the components of physical function, adequate mobility of joints must be supported by a requisite level of muscle strength, endurance and neuromuscular control to allow the body to accommodate to imposed stresses placed upon it during functional movement and thus to enable an individual to be functionally mobile. (Kisner et al. 2012, 72-73.)

#### 5.4 Stability

Stability relates to the neuromuscular system's ability to maintain proximal and distal body segments in a stationary position, or create and control a stable base during movement. This is achieved through synergistic muscle actions involving the deep (core) musculature and the superficial (global) musculature. (Kisner et al. 2012, 415-417.)

Stability plays a vital role in maintaining the body's upright posture. In this upright position the body is relatively unstable due to the small base of support, combined with the significantly larger height of the body. As the centre of gravity moves outside this base of support, additional stabilising forces are required to maintain the upright posture against gravity and any additional forces that disturb balance. This is



achieved through activation of musculature or increased loading on inert structures. Muscles act dynamically, responding to perturbations by providing counterforces, as well as stability within the ROM so stresses are not placed on the inert tissues. Inert structures include osseous and ligamentous structures that provide passive tension when the joint reaches its end ROM. Maintenance of this stable base of support is necessary to ensure that the extremities can execute their desired function without undue stress to spinal structures. (Kisner et al. 2012, 415-417.)

#### 5.4.1 Dynamic Stabilization

The function of the deep (core) musculature and the superficial (global) musculature are necessary for stability and function. For example, without dynamic stabilisation activity from the trunk muscles, the spine would be unable to maintain its upright posture and collapse. The trunk or core musculature is essentially the originator of all movements, and thus an efficient and effective core is required to maintain sufficient stability throughout the entire human movement system (kinetic chain). (Kisner et al. 2012, 415-417.)

Additionally, a weakened or underactive stabilisation system is common precursor to pain or injury, in particular lower back pain (LBP). Researchers have found that approximately 80% of U.S. adults possess LBP. Additionally, individuals with chronic LBP have decreased activation of certain muscles or muscle groups, including the transverse abdominis, internal obliques, pelvic floor muscles, multifidus, diaphragm, and deep erector spinae. As such, both the global and core musculature play critical roles in providing stability. (Clark et al. 2008, 213.)

#### 5.4.2 Core Musculature

The core is defined by the structures that make up the lumbo-pelvic-hip complex (LPHC), including the lumbar spine, the pelvic girdle, abdomen, and the hip joint. The core can be defined using three systems, working from deep to superficial. These include the local stabilization system, global stabilization system and movement system (Table 2). (Clark et al. 2008, 210-212.)

Table 2 – Core Systems Breakdown (Clark et al. 2008, 210-212).

System	Muscles within System	Description
<b>Local Stabilisation System</b>	<ul style="list-style-type: none"> <li>➤ Transversus abdominis</li> <li>➤ Internal oblique</li> <li>➤ Lumbar multifidus</li> <li>➤ Pelvic floor muscles</li> <li>➤ Diaphragm</li> </ul>	<p>Consist primarily of type I (slow twitch) muscle fibers with a high density of muscle spindles, which aid in proprioception and postural control.</p> <p>System is primarily responsible for intervertebral and intersegmental stability and work to limit excessive compressive, shear, and rotational forces between spinal segments.</p>
<b>Global Stabilisation System</b>	<ul style="list-style-type: none"> <li>➤ Quadratus Lumborum</li> <li>➤ Psoas major</li> <li>➤ External oblique</li> <li>➤ Portions of internal oblique</li> <li>➤ Rectus abdominis</li> <li>➤ Gluteus medius</li> <li>➤ Adductor complex</li> </ul>	<p>Act to transfer loads between the upper extremity and lower extremity, provide stability between the pelvis and spine, and provide stabilization and eccentric control of the core during functional movements.</p>
<b>Movement System</b>	<ul style="list-style-type: none"> <li>➤ Latissimus dorsi</li> <li>➤ Hip flexors</li> <li>➤ Hamstring complex</li> <li>➤ Quadriceps</li> </ul>	<p>Primarily responsible for concentric force production and eccentric deceleration during dynamic activities.</p>

## 5.5 Balance and Postural Equilibrium

The ability to maintain postural control and balance is a key component to all functional movements. Balance can be considered from both a static and dynamic perspective. Static balance may be defined as when the body is in equilibrium and stationary, meaning no linear or angular movement. Dynamic balance can be defined as the ability to move and change directions under various conditions without falling, like running on uneven surfaces. (Clark et al. 2008, 231-233.)

Balance training should stress an individual's limit of stability or balance threshold. This may be achieved through a number of variables, including alterations to load, repetitions, velocity of movement, stability of surface, planes of movement, and distance from base of support. The goal of balance training is for the participant to maintain control over their centre of gravity (CoG) throughout the movement. Maintenance of postural equilibrium or balance is an integrated process requiring optimal muscular balance (or length-tension relationships and force-couple relationships), joint dynamics (or arthrokinematics), and neuromuscular efficiency using visual, vestibular (inner ear), and proprioceptive inputs. (Clark et al. 2008, 231-233.)

Impairment to any of the systems associated with balance may result in joint dysfunction. This altered joint function can subsequently alter balance and lead to tissue overload and subsequent injury. As previously stated, approximately 80% adults in the USA will experience LBP. In addition, an estimated 80,000 to 100,000 ACL injuries and another 11 million doctor visits related to foot and ankle problems occur annually. Research has suggested that integrated injury prevention programs that include balance exercises in addition to plyometric or strength exercises greatly influenced the ability to improve lower extremity biomechanics. Accordingly, balance training should be an integral component of any physical activity program. (Clark et al. 2008, 231-233.)

## 6 FUNCTION OF MOBILE HEALTH IN THE PROMOTION OF HEALTH AND FITNESS

There is tremendous potential for improving prevention and health management strategies through mobile technologies. Several recent studies have confirmed the value of technology and smartphone applications in improving clinical outcomes. Significantly, these studies have also noted the potential to improve health disparities by increasing patient access to health-improving treatments and interventions amongst major risk groups, like the poor and uninsured. (Gibbons et al. 2009, 97; Handel 2011, 256.)

### 6.1 Employing Mobile Health (mHealth) in the Campaign Against NCDs

Development in mobile technologies has resulted in the foundation of mHealth, defined as “medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices.” (Kay 2011, 6.)

One particular component of mHealth is the provision of health and fitness services. This includes mobile and smartphone applications providing fitness and dietary recommendations to facilitate improvement in consumer’s overall health and wellbeing (i.e. pre-emptive health promotion and tracking). Mobile phones are a particularly attractive avenue for delivering health interventions. This is due to a number of reasons, including the widespread adoption of phones with increasingly powerful technical capabilities, individual’s tendency to keep their phones in close proximity, the public’s ever growing attachment to their phones, and increased automation and efficiency related features (i.e. through sensor systems and phone-based personal information). (Klasnja et al. 2012, 2-3.)

The potential influence of mHealth on the growing global burden of NCDs has resulted in the WHO, in addition to governing bodies such as the EU, investing significant resources into mHealth related research and development. The EU alone has already invested €100 million into mHealth research and innovation, with an

additional €95 million of further investment over the subsequent two years. The EU believes these mHealth applications have the ability to lead to €99 billion of savings to the EU economy. It is estimated that by 2017, 3.4 billion people around the world will own a smartphone and half of them will be using mHealth applications. (European Commission 2014.)

## 6.2 Health and Fitness Applications – Revenue and Growth Trends

The market revenue for mHealth related applications reached US\$ 2.4 billion in 2013 and is projected to grow to US\$ 26 billion by the end of 2017. (research2guidance 2014, 6). The number of mHealth applications that are published on the two leading smartphone platforms (iOS and Android) has more than doubled in only 2.5 years to reach more than 100,000 applications (Q1 2014). In addition, these applications have seen significant usage growth in recent times, with a 62% growth between December 2013 and June 2014 (Figure 6). (research2guidance 2014, 6; Khalaf 2014.)

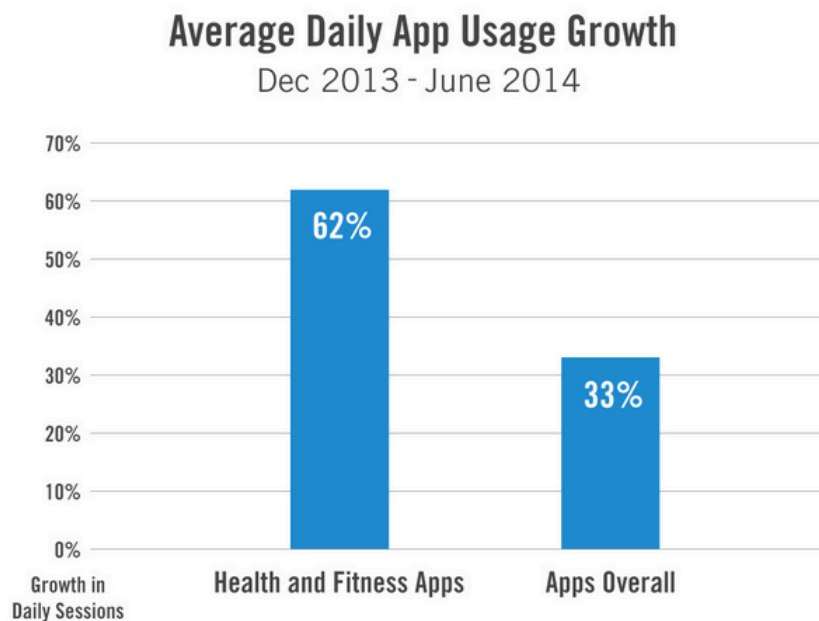


Figure 6 – Health and Fitness Application Growth (Khalaf 2014).

### 6.3 mHealth Benefits from a Physiotherapy and Health Care Provider Perspective

From a physiotherapist's perspective, a number of benefits exist with respect to the provision of services via mHealth applications. In addition to the growing usage rates and associated revenue identified above, consideration should also be made to the ageing population. This trend represents massive potential for mHealth services. Population aging, increasing chronic illness, accelerating health costs, new regulatory reforms and increased consumer demand for health information and self-care will help drive mobile solution growth into the future. (Greenspun et al. 2012, 3-6.)

Additionally, these services may facilitate adherence or compliance to therapy through access to information and health care professions. (Greenspun et al. 2012, 6). From a physical activity perspective, mHealth applications offer a potentially low cost (minimal capital investment) solution to disseminate health-promoting applications to a wide and established market base.

### 6.4 mHealth Benefits from a Consumer Perspective

From a consumer perspective, the utilisation of health and fitness applications possesses numerous benefits. A number of these benefits directly address some of the practical and psychological barriers that potentially limit participation within physical activity (Table 3).

Table 3 – Consumer Health and Fitness Application Benefits

Consumer Benefit	Description
<b>Cost effective solution to health and fitness</b>	Numerous health and fitness applications offered within the iOS and Android store (the two leading smartphone platforms) are offered free of charge (or for as little as US\$ 0.99).

Consumer Benefit	Description
<b>Ease of access</b>	Due to the growing number of mobile users and the associated growth of the health and fitness smartphone market base, applications are extremely accessible and can be downloaded in a matter of seconds.
<b>Time efficient</b>	Health and fitness applications potentially offer a time effective and efficient solution to health promotion. For example, certain applications offer workouts that may be completed in as little as seven minutes.
<b>Social influence and competition</b>	<p>Studies have indicated that the structure of individual's social network influences not only their health risks (e.g. probability of becoming obese), but also their ability to adopt health-promoting behaviours. (Klasnja et al. 2012, 13-15).</p> <p>For such reasons, a number of recent mobile-phone interventions leverage social influence (via Facebook, twitter etc.) to promote health behaviour change and effective management of chronic diseases. These interventions have pursued this strategy in three different ways, including facilitating social support or competition among individuals who share the same health goal (i.e. peer-to-peer influence); facilitating social support from family and friends; and leveraging peers who have succeeded in accomplishing similar health goals (i.e. peer modelling).</p>

Consumer Benefit	Description
<b>Access to equipment and facilities</b>	A large number of health and fitness applications are designed to enable consumers to complete workouts without requiring specific equipment or facilities.
<b>Information resource</b>	Health and fitness applications offer a vast amount of information: from calorie and exercise tracking, to personal metrics (BMI, weight etc.) and demographic specific exercise routines. Additionally, mobile applications potentially enhance overall consumer engagement in health care by increasing the flow of information. (Klasnja et al. 2012, 6).
<b>Aids self-conscious exercisers</b>	Applications facilitate the health conscious, as workouts may be completed utilising their personal mobile devices in the comfort of their own home.



## 7 PRODUCT INSPIRATION AND IMPLEMENTATION OF DESIGN

One particular training modality, which influenced the initial conception of this thesis's mHealth product was CrossFit. In addition to the significant recent growth and popularity of this training modality, CrossFit specifically and intentionally targets several of the interrelated components of physical function. The subsequent section provides an overview of the CrossFit training modality. Breakdown of this modality is desirable, as several elements and concepts have been incorporated into the mHealth product.

Subsequently, this section shall outline the health promotion product's design philosophy and associated implementation. This information addresses key requirements and elements associated with the health promotion product and precedes an overview of the product design in full.

### 7.1 Health Promotion Product Inspiration - CrossFit

The last decade has seen the emergence of CrossFit, one of the fastest growing health and fitness brands in the world. Since first opening in 2001, there are now over 10,000 affiliates worldwide. Observing consumer Google search trends, CrossFit has shown explosive growth comparatively to other traditional big brand gyms (Figure 7). (Website of Google Trends 2016.)

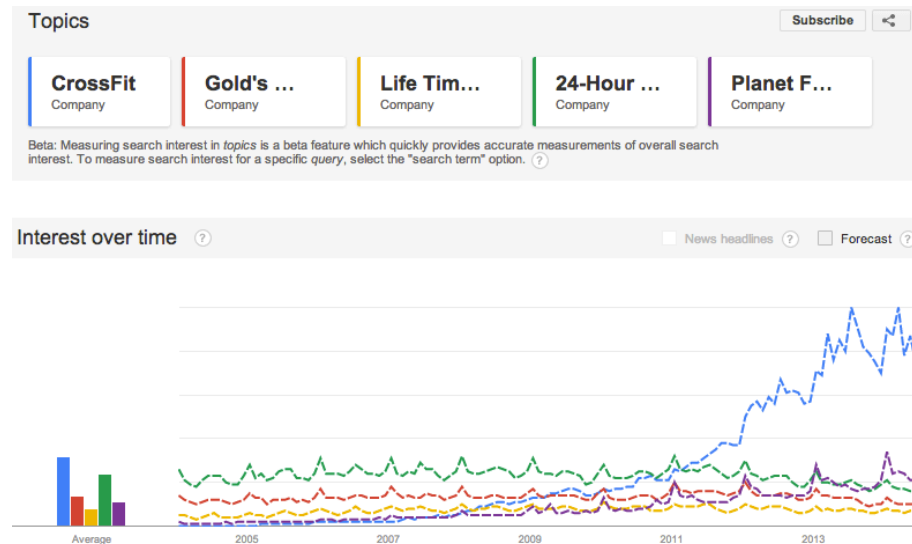


Figure 7 - Consumer Google Search Trends (Website of Google Trends 2016).

The primary objective of CrossFit is to forge a broad, general, and inclusive fitness. Workouts and their associated exercises are structured in an attempt to optimize physical competence in the following physical function and fitness domains: cardiovascular and respiratory endurance, stamina, strength, flexibility, power, speed, coordination, agility, balance, and accuracy. By spreading focus across these domains, CrossFit intends to prepare participants for any physical contingency, thus enhancing an individual's competency in completing any type of physical activity. (Glassman 2010, 3-4.)

Exercise prescription is classified by CrossFit as; "constantly varied, high-intensity, functional movement." Accordingly, CrossFit advocates regular high intensity training in as many training modalities (through largely anaerobic efforts) and intervals as possible, while deliberately and specifically avoiding the efficiency that accompanies mastery of a single modality. The majority of CrossFit resources are offered in an open source nature. This includes information ranging from nutrition and technique, to the "Workouts of the Day" (WODs). This system facilitates growth of the CrossFit online and collaborative community, through the participation of coaches, athletes, and trainers. (Glassman 2010, 3-4.)

### 7.1.1 Exercise Modalities

Exercises utilised within CrossFit are typically compound movements, performed in shorter, high intensity cardiovascular sessions. The movement patterns employed tend to focus on sagittal plane movements, including extension and flexion of the hips, in addition to extension, flexion and transverse plane rotation of the trunk. These exercises can be classified within three, distinct modalities (Table 4). (Glassman 2010, 20-24.)

Table 4 – CrossFit Exercise Modalities (Glassman 2010, 20-24).

Modality	ID	Description
<b>Metabolic Conditioning</b>	<b>‘M’</b>	Exercises are aimed at improving cardiorespiratory capacity and stamina.
<b>Gymnastics</b>	<b>‘G’</b>	Typically body weight exercises or calisthenics. The primary purpose is to improve body control (statically and dynamically) by improving neurological components like coordination, balance, agility, and accuracy. Exercises also aim to improve functional upper body capacity and trunk strength.
<b>Weightlifting</b>	<b>‘W’</b>	Comprised of Olympic lifts and powerlifting. The primary aim is to increase strength, power, and lower extremity capacity (i.e. vertical leap, muscular endurance, bone strength, and the physical capacity to withstand stress). This facilitates development of the trainer’s ability in control of external objects, and enhancement of critical motor recruitment patterns.

### 7.1.2 Workout Structure

CrossFit workouts are structured in a continuously varied fashion, in an effort to tax physiological functions against realistically conceivable combinations of stressors. In addition to providing a vast and variable range of stressors, these workouts also facilitate motivation by constantly offering new challenges to participants. Finally, these constant variations in training stimulus assist in the evasion of stagnation, from a progression perspective. (Glassman 2010, 12.)

Workout programs characteristically utilise short, middle, and long distance metabolic conditioning, with low, moderate, and heavy load assignment. CrossFit generally utilises a three-day-on, one-day-off workout pattern. This pattern is based on research and observation conducted within the CrossFit community. These observations found that three-days-on and one-day-off allows for a maximum sustainability at maximum intensities. By the fourth day both neuromuscular function and anatomy become fatigued to the point where continued work becomes noticeably less effective and impossible without reducing intensity. Accordingly, CrossFit employs a specific program structure and associated modalities (Table 5 and Figure 8). (Glassman 2010, 91-96.)

Table 5 - Workout Structure Cycle (Glassman 2010, 92).

Day	1	2	3	4	5	6	7	8	9	10	11	12
<b>Modalities Employed</b>	<b>M</b>	<b>G</b>	<b>M</b>	OFF	<b>G</b>	<b>W</b>	<b>G</b>	OFF	<b>W</b>	<b>M</b>	<b>W</b>	OFF
		<b>W</b>	<b>G</b>			<b>M</b>	<b>W</b>			<b>G</b>	<b>M</b>	
			<b>W</b>				<b>M</b>				<b>G</b>	

Days	Single-Element Days (1, 5, 9)	Two-Element Days (2, 6, 10)	Three-Element Days (3, 7, 11)
Priority	Element Priority	Task Priority	Time Priority
Structure (set structure)	M: Single Effort G: Single Skill W: Single Lift	Couplet repeated 3-5 times for time	Triplet repeated for 20 minutes for rotations
(intensity)	M: Long, Slow Distance G: High Skill W: Heavy	Two moderately to intensely challenging elements	Three lightly to moderately challenging elements
Work Recovery Character	Recovery not a limiting factor	Work/rest interval management critical	Work/rest interval marginal factor

Figure 8 – Workout Structure, Elements (Glassman 2010, 94).

The template above was designed by CrossFit to encourage new skill development, generate unique stressors, cross multiple modalities, incorporate quality movements, and address all three metabolic pathways. It does this within a framework of sets, reps and a range of exercises that CrossFit has repeatedly tested. (Glassman 2010, 91-96.)

### 7.1.3 Motivational and Competitive Element

In addition to constant variations in workout structure and pattern, CrossFit also employs the variable of intensity to facilitate motivation. The majority of CrossFit workouts are completed based on the metrics of time, maximum weight, or ‘As Many Repetitions or Rounds As Possible’ (AMRAP). By quantifying workout results, CrossFit provides a traceable and repeatable set of metrics for participants. In addition to monitoring progression, these metrics provide an additional source of motivation, allowing participants to compete against themselves and the CrossFit community. (Glassman 2010, 91-96.)

This source of motivation is further evidenced by the growing popularity of the CrossFit Games Open, a yearly series of events aimed at crowning the world’s fittest athlete. Since its conception in 2011, the popularity of the CrossFit Games Open has

seen exponential growth, with a year over year growth rate exceeding 100%. (Toledano 2013).

#### 7.1.4 Physiological Response to Routine

Protocols high in volume, moderate to high in intensity, using short rest intervals and stressing a large muscle mass, have been shown to produce the greatest acute hormonal elevations (for example, testosterone, GH and the catabolic hormone cortisol) compared with low-volume, high-intensity protocols using long rest intervals. (Kraemer et al. 2005, 340).

CrossFit employs this theory of heavy-load weight training, high intensity and short rest intervals to elicit maximal hormonal response. Among the hormonal responses vital to athletic development are substantial increases in testosterone, insulin-like growth factor, and human growth hormone. Exercising with protocols known to elevate these hormones is designed to maximise the participant's physiological response. (Glassman 2010, 12.)

In addition, CrossFit's incorporation of interval training facilitates control of the dominant energy system utilized within the workout. By varying the duration under load, number of repetitions or sets and the associated rest interval, workouts may be tailored to employ specific energy systems. For example, anaerobic activity may be utilized within a workout to improve power, speed, strength, and muscle mass. Anaerobic training improves the capacity to maintain a high rate of power production for short durations of exercise at very high intensities. In addition, this high intensity, interval style of training has surprisingly been shown to provide long-term results for endurance related activities. (Seiler et al. 2009, 33-35.)

## 7.2 Health Promotion Product - Design Philosophy

The subsequent section shall outline the design features and elements to be incorporated into the health promotion product. These features shall utilise an amalgamation of the favourable aspects investigated within the preceding sections (training modalities, promulgation methods etc.). Additionally, the health promotion

product's design features and elements have been developed with reference to the physical and psychological barriers to physical activity. Although physiotherapy specific terminology is provided below, this language shall be simplified within the health promotion product to facilitate understanding by consumers with a non-professional background.

### 7.2.1 Exercise Modality

The health promotion product shall utilise bodyweight exercises within the application's routines. Bodyweight exercises are particularly appealing, as they don't require specific equipment or facilities. This in turn increases convenience and accessibility to physical activity. In addition, this facilitates completion of exercise routines within a private environment, thus potentially reducing the psychological barriers associated with exercising publicly. Finally, bodyweight exercises offer a wide variety of movement patterns (many of which are compound) and difficulties, aiding participation for individuals with a range of abilities.

Bodyweight exercises utilise gravity and the individual's own mass as a source of resistance. Removing the use of equipment or machines also allows participants to learn how to train within all planes of motion, and may also facilitate increased kinaesthetic awareness. The majority of bodyweight movements can be considered closed-chain exercises. Closed-chain exercises involve movements in which the distal extremities (hands or feet) are in a constant fixed position. This is achieved through resistance placed against a fixed surface like the ground. Closed-chain exercises may result in greater motor unit activation and synchronization when compared with open-chain exercises. (Clark et al. 2008, 380.)

### 7.2.2 Workout Parameters

The health promotion product shall offer the ability to vary the length and maximum repetitions of the workout. This ensures the exercise period remains within the participant's tolerance, whilst also keeping the intensity above the threshold level for adaptation to occur. In addition, this allows users to complete workouts using

reduced volume or time trial orientated regimes, to enable time efficient physical activity.

A range of repetitions shall be utilised to vary the intensity within the workout. This facilitates use of high intensity and short rest intervals to elicit maximal hormonal response (increase participant's physiological response to the workout) in a time efficient manner. This essentially creates a circuit-interval training style within the workout, utilising the lower repetition ranges as a form of active recovery. The circuit-interval training style possesses a number of benefits. These include the creation of intensity great enough to stimulate an increase in stroke volume and cardiac output and to enhance local circulation and aerobic or anaerobic metabolism in the appropriate muscle groups; facilitates interaction of aerobic and anaerobic production of ATP; and provides a relief interval to facilitate a delay in the need for glycolysis and the production of lactic acid prior to the availability of oxygen supplying the ATP.

The health promotion product shall randomise the repetitions, sets and order of exercises so that each workout is essentially unique. In addition, the health promotion product shall offer the ability to complete a combination of lower, upper and full body specific exercises within workouts. These constant variations in training stimulus assist in the evasion of stagnation. In addition, variability in workouts facilitates motivation by constantly offering new challenges to participants.

### 7.2.3 Non-exercise Related Design Specifications

A number of additional design features and requirements not related to the exercise modalities and workout methodology identified above shall also be incorporated into the health promotion product. These requirements were identified through the investigation and research conducted within the previous sections. They identify a number of key elements and concepts that shall be incorporated into the mHealth product. These requirements have been identified to provide a robust design philosophy, in addition to addressing several physical and psychological barriers associated with exercise (Table 6).



Table 6 – Design Requirements

Design Feature or Aspect	Description	Justification	Physical and Psychological Barriers Affected
<b>mHealth application</b>	The health promotion product shall be promulgated in the form of an iOS (Apple) application.	Due to the increasing prevalence and high level of accessibility offered by the iOS platform, in addition to the continually growing mHealth market base.	<ul style="list-style-type: none"> <li>➤ Accessibility to exercise and information</li> <li>➤ Ill-informed or unaware of exercise guidelines</li> </ul>
<b>Low cost</b>	The health promotion product shall cost less than US\$ 1.99.	The product's low cost facilitates an affordable mechanism for physical activity. In addition, this increases accessibility to numerous demographics.	<ul style="list-style-type: none"> <li>➤ Financial limitations or priorities</li> </ul>
<b>Exercise library</b>	The health promotion product shall utilise bodyweight exercises, with an associated exercise library demonstrating and outlining appropriate technique.	A well-defined methodology for performing the exercises potentially reduces the risk of exercise-associated injury. In addition, defining exercise technique also facilitates uniformity and consistency within workout results.	<ul style="list-style-type: none"> <li>➤ Ill-informed regarding sufficient exercise or unaware of guidelines</li> <li>➤ Concerned about injury</li> </ul>
<b>Results tracking and information resource</b>	The health promotion product shall provide users with the ability to track workout performance (for example, personal bests, calories burnt etc.). In addition, it shall provide user statistics and information regarding personal metrics.	<p>Providing post-workout statistics regarding time, calories consumed, repetitions performed etc. potentially serves as a source of motivation. In addition these elements provide quantifiable, repeatable results for future reference.</p> <p>Also, information regarding personal metrics (BMI, BMR, energy expenditure) enables users to better appreciate the role of daily energy intake and expenditure.</p>	<ul style="list-style-type: none"> <li>➤ Ill-informed regarding sufficient exercise or unaware of guidelines</li> <li>➤ Lack of motivation</li> </ul>
<b>Time efficient</b>	The health promotion product shall offer varying length workouts.	Allowing users to complete workouts using reduced volume or time trial orientated regimes enables time efficient physical activity.	<ul style="list-style-type: none"> <li>➤ Work commitments</li> <li>➤ Caring for children or older people</li> <li>➤ Insufficient leisure time</li> </ul>
<b>Customisable workouts</b>	The health promotion product shall offer the functionality for users to create their own custom workouts (from the provided exercise library).	Customisable workouts enable users to tailor make an exercise regime that suits their preferences and abilities, potentially increasing enjoyment and participation.	<ul style="list-style-type: none"> <li>➤ Lack of motivation</li> <li>➤ Don't enjoy physical activity</li> <li>➤ Low fitness</li> <li>➤ Belief that too old</li> <li>➤ Belief that too overweight</li> </ul>

Design Feature or Aspect	Description	Justification	Physical and Psychological Barriers Affected
<b>Competitive and social element</b>	The health promotion product shall offer the functionality to compete against friends and the community (i.e. leader board functionality). In addition, Facebook shall be utilised to allow users to advertise their results and challenge friends.	The competitive and community element provides a source of motivation, in addition to quantifiable, repeatable results. Also, incorporating social media facilitates social support and competition among individuals who share the same health goal (i.e., peer-to-peer influence).  In addition, this competitive social element potentially facilitates increased workout intensity.	<ul style="list-style-type: none"> <li>➤ No exercise companion</li> <li>➤ No support from partner, family or friends</li> </ul>

### 7.3 Health Promotion Product - Design Implementation

The preceding sections outline the investigation and associated design specification for the health promotion product. Accordingly, this section presents an accompanying overview of the elements associated with implementation of the design.

#### 7.3.1 Development Environment and Application Release

Apple provides an integrated development environment (IDE) for the creation, design and testing of OSX (Mac) and iOS (iPhone) applications, called XCode. This IDE is available free of charge for all Mac OS users. Xcode offers a number of features to facilitate development of iOS applications. Typically, these applications are developed utilising a programming language called Objective-C, in addition to the graphical user interface (GUI) builder.

This IDE also facilitates release of the application, through the developer's iTunes Connect account. An extensive testing process is required to ensure the application does not possess any errors or bugs. This is achieved through testing the functionality of the application and its features within the IDE's simulation environment, in addition to on several devices. Upon finalisation of the application and submission to iTunes Connect, Apple undertakes an extensive review process to ensure the application conforms to its design and human interface requirements. Upon approval, the application may then be released to the iTunes store. The application may be found by searching "Decked! Challenge (bodyweight)" within the iTunes store.

#### 7.3.2 Skill Development

A number of excellent resources are offered on the internet, to facilitate education on the necessary skills for developing iOS applications. Stanford University's School of Engineering offers one particularly useful resource, free of charge. This resource provides a series of videos and associated documentation regarding the tools and

Application Program Interfaces (APIs) required to build applications for the iPhone and iPad platform, using the iOS SDK. This includes object-oriented design using model-view-controller paradigm, user interface design, memory management, Objective-C programming language etc.

### 7.3.3 Copyright

All images utilised within the health promotion product were created by the developer or possess appropriate licencing that authorises commercial production. Creative Commons is a non-profit organization headquartered in California, United States, devoted to expanding the range of creative works available for others to build upon legally and to share. This resource shall be used to obtain appropriate images and materials for the application.

### 7.3.4 Terms and Conditions of Use

A ‘Terms of Use’ shall accompany the health promotion product, providing an acknowledgement of risks, waiver and release of liability. In addition, these terms and conditions shall provide recommendations for users to consult an appropriate health care professional, prior to undertaking any physical activity.

## 7.4 Health Promotion Product - Overview and Features

The health promotion product, which will henceforth be referred to as “Decked! Challenge”, shall utilise a workout based around a deck of cards, randomly drawn. Each suit of the deck represents a particular exercise (e.g. Spades may be Squats) and the value of the card determines the number of repetitions (e.g. 7 of Spades would equate to 7 Squats). The workout is structured around a deck of cards, as it provides a familiar construct to base the randomised workout around.

Additionally, there are a few more rules to engage participants. Picture cards count as 10 repetitions, and jokers count as 10 repetitions of all 4 suit exercises (to be performed consecutively). The goal in Decked! Challenge is to compete against

yourself (and your friends) in an effort to beat your Personal Best for a given workout. Decked! Challenge also allows for progressive development. The user can specify the difficulty of the workout by choosing the type of deck. Each difficulty level alters the total number of cards within the workout, and hence total repetitions to be performed (Table 7).

Table 7 - Workout Difficulty Levels

Difficulty Level	Description
<b>Beginner</b>	No picture cards and only 1 Joker (41 cards total)
<b>Intermediate</b>	Full deck but only 1 Joker (53 cards total)
<b>Advanced</b>	Full deck and 2 Jokers (54 cards total)

A time trial feature shall also be offered for each of the difficulty levels, for participants not wishing to complete the full deck. This feature will allow the user to select a total workout time, during which they may attempt to complete as many cards as possible.

The home page shall provide direct access to the application's primary features. Particular focus is provided to the "Decked! Workouts", in-built exercise library, results tracking and access to workout leaderboards. In addition, the home page facilitates alteration to user settings and access to additional information about use of the application and its features (Figure 9).

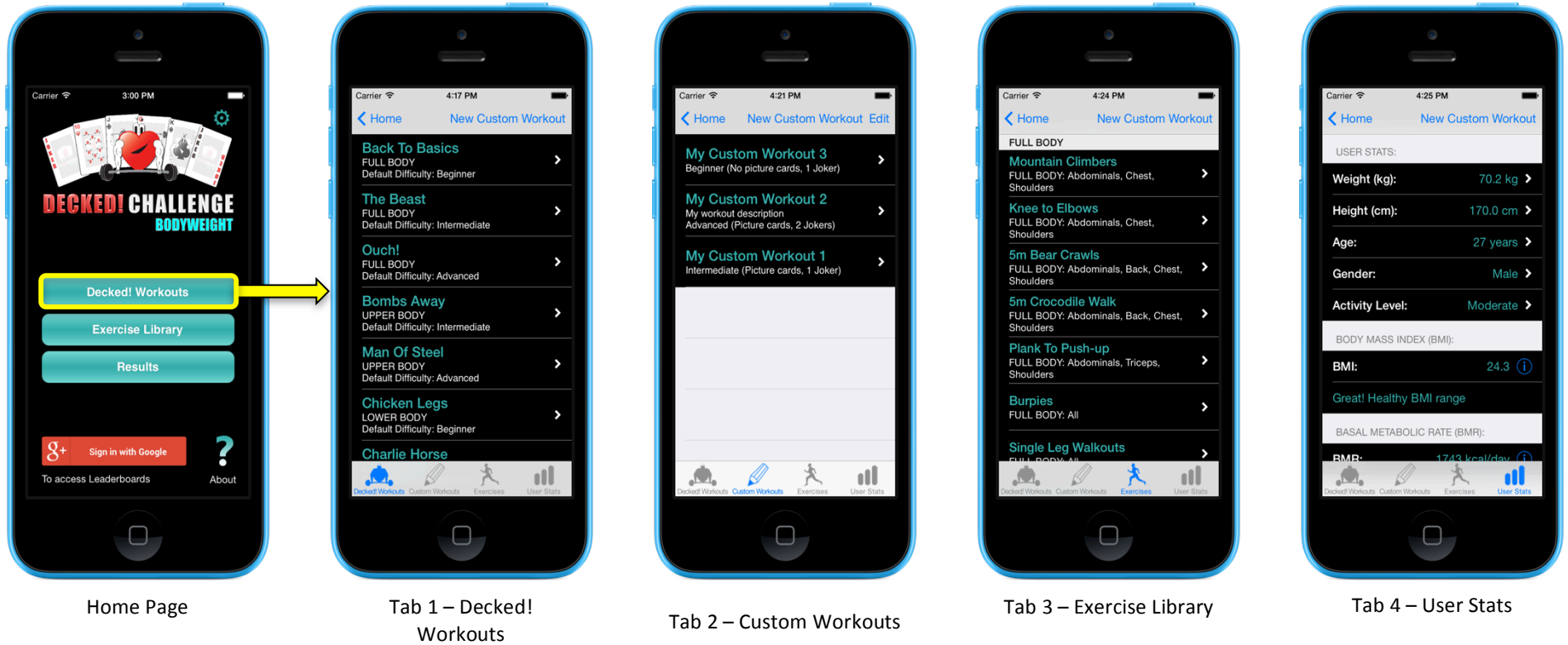


Figure 9 - Decked! Workout (Home Page)

### 7.4.1 Decked! Workouts Features

Decked! Challenge offers eight pre-made “Decked! Workouts”, of varying difficulty levels. These workouts also provide a combination of full body, lower body and upper body movement patterns (Figure 9, Tab 1 and Figure 10).

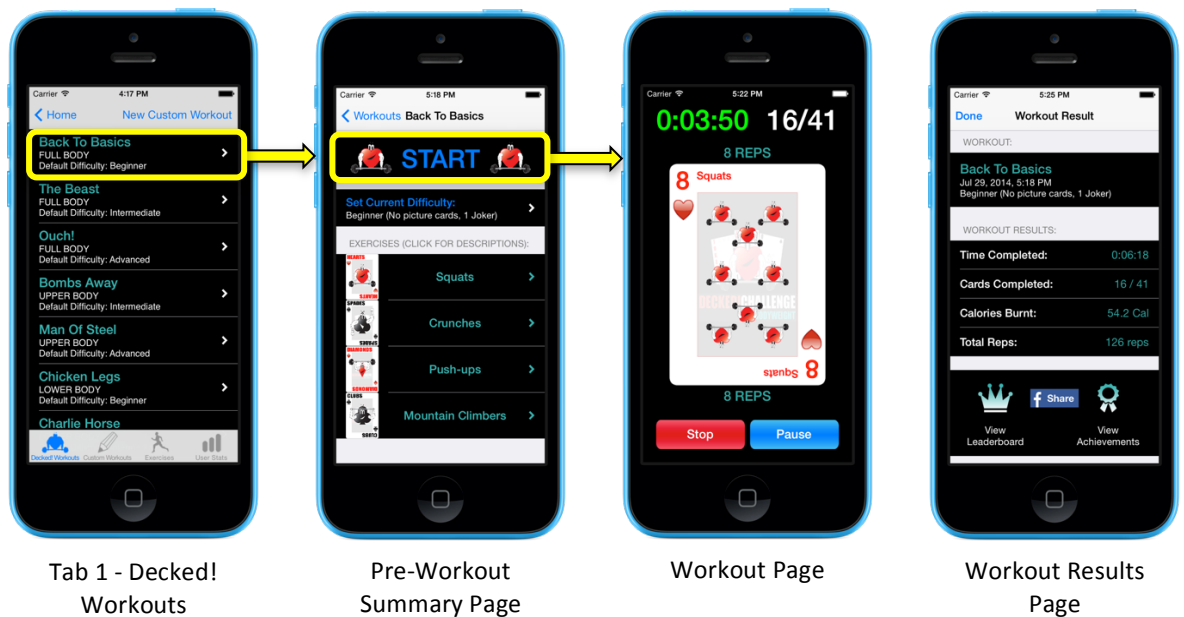


Figure 10 – Decked! Workouts

### 7.4.2 Custom Workout Features

Decked! Challenge also offers users the ability to create custom workouts utilizing the in-built exercise library. Here users can select their desired four exercises (one for each suit), in addition to a default workout difficulty (Figure 9, Tab 2 and Figure 11).

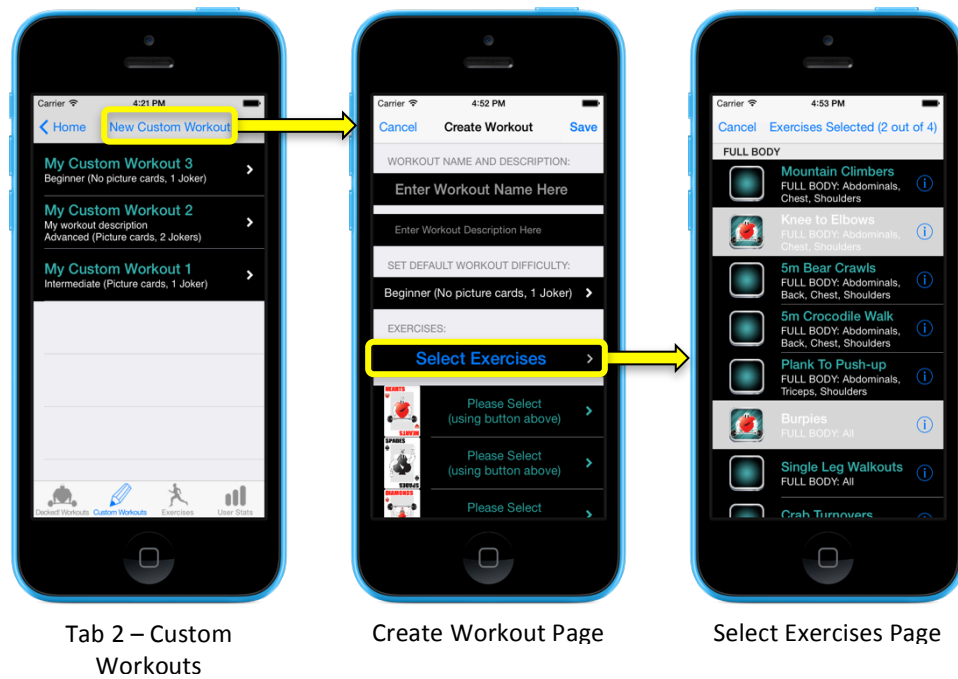


Figure 11 – Custom Workouts

#### 7.4.3 Exercise Library

This exercise library contains over 40 bodyweight exercises, identified under full body, lower body, upper body or core (Figure 9, Tab 3). Detailed information is provided for each exercise and includes an overview of body segment and muscles worked, definition of what constitutes a repetition, step-by-step description of the exercise, associated images demonstrating exercise and helpful regressions and progressions. Appendix 3 contains a full list and description of all exercises utilised within the health promotion product.

#### 7.4.4 User Statistics and Metrics

Decked! Challenge allows users to input their personal metrics (Figure 9, Tab 4). This facilitates calculation of their calorie expenditure during workouts, in addition to providing information on their body mass index (BMI), basal metabolic rate (BMR) and daily energy expenditure. A short description explaining each of these metrics is also provided, so that users may better understand their relevance.



### 7.4.5 Achievements and Workout Leaderboards

To provide an additional source of motivation, Decked! Challenge offers several achievements that unlock following workouts (Figure 12, Achievements Page). These achievements are progressive in difficulty to focus on increased incentive for new users. In addition, leaderboards for each pre-made workout (including one for each difficulty) provide the ability for users to compete against their friends and the worldwide Decked! Community. Both the achievements and leaderboards use Google Play Game Services and require a Google account to use. (Figure 12, Leaderboard Page).

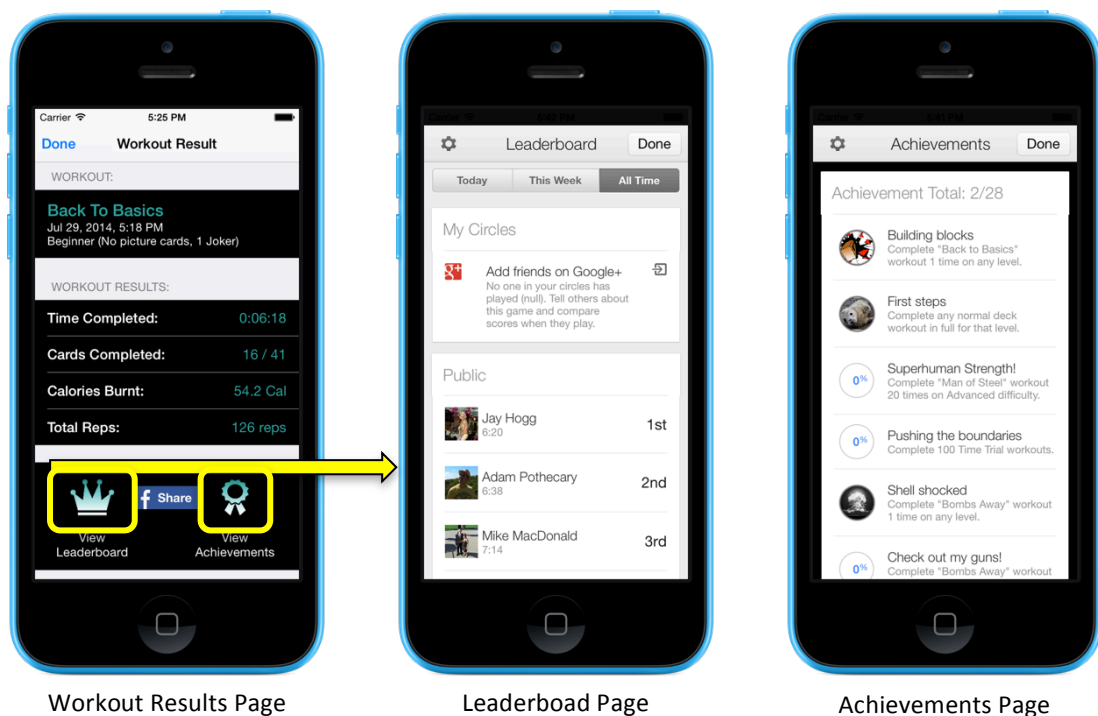


Figure 12 – Leaderboards and Achievements

### 7.4.6 Social Media

Following a workout, users may post their results to Facebook, challenging friends to better their workout time. These Facebook posts are designed to automatically open

the Decked! Challenge application when clicked, or redirect the user to the iTunes or Google Play store if they don't already have the application installed (Figure 13).

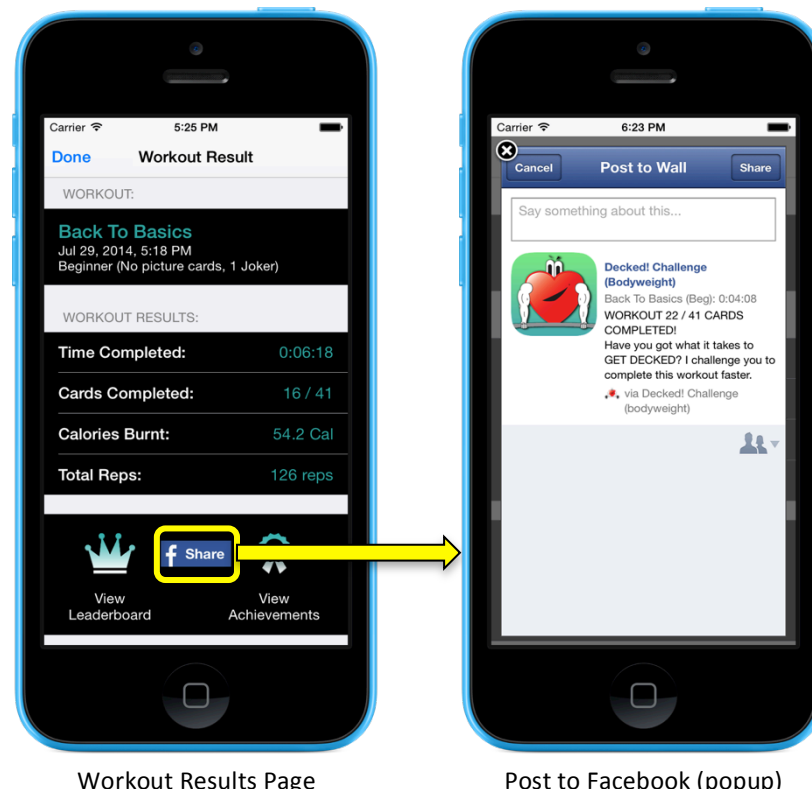


Figure 13 – Social Media (Facebook) Posting

#### 7.4.7 Results Tracking

Decked! Challenge offers the ability to track personal bests (PBs) for each of the pre-defined workouts. These PBs are also provided for each difficulty level. A results history, sorted by date completed, is also provided. These results provide detailed data and metrics for each of the user's workouts, including total workout time, cards completed, calories burnt, total repetitions completed and the exercises performed.

## 8 DISCUSSION

Having previous experience within the field of engineering and software influenced my decision for this thesis topic. I had previously worked in collaboration with a colleague to release similar health and fitness applications on Google Android devices. I believe the utilisation of mHealth applications for the purpose of health promotion is an extremely interesting and growing field. I was also wishing to utilise my previous skills, in conjunction with my physiotherapy studies. In addition, I had previously worked as a Personal Trainer and this particular workout was a favourite of my clients, as it provided variability and an excellent challenge.

Although I have some experience developing software, I had not previously been exposed to Apple's development environment. This factor created the biggest challenge associated with my chosen thesis topic. Xcode utilises a somewhat different programming 'language' to my previous experience. In addition, to ensure conformity to Apple's standards, the application must adhere to extensive human interface (HMI) and design requirements. As such, I found the learning process to be extremely involved and time consuming. Learning to use the new software and ensuring my application conformed to Apple's requirements took a significant amount of time. Another large challenge was associated with the testing of my application. Although the development environment provides the ability to simulate the application, there are differences between this environment and actually testing on a device. I found this error checking process to be extremely slow and frustrating at times.

Due to the growing nature of this field, I found the easiest part of my thesis to be collating research and information. Although a time consuming process, I am quite interested in the promotion of health related services through technology and mobile-based services. I therefore found it quite interesting to read through the numerous resources based on this field.

Overall, I found this process to be a great personal challenge. From a critical perspective however, I would do a few things differently next time. The learning process associated with development of the application was quite involved. As such,

I would not recommend application development for a bachelor level thesis, unless the author already possesses familiarity with the necessary processes and platform requirements. In addition, I believe I spent a significant amount of time incorporating additional features into my application (e.g. facebook sharing). Although these features facilitate usability and promotion of the application, considering the hours allocated to a bachelor level thesis, these features were surplus to fulfilling the primary objective of this topic. Finally, I had some difficulty writing my thesis documentation. Coming from an engineering background I attempted to provide justification for every design decision. This resulted in me generating a significant amount of content; probably more than is required for a bachelor thesis. I am extremely happy with the end result of my thesis, however looking back I would probably create a more simplified, proof of concept application and be less critical in justifying every element of the design process.

Regarding potential future research or studies, this research topic offers several possible avenues. For example, a pilot study could involve collation of associated data to analyse efficacy of the employed training modalities within the health promotion product. This data could also be utilised within other related research projects. In addition, this topic offers potential additional research in collaboration with larger institutions. For example, the health promotion product and its associated data could be utilised in alignment with the UKK Institute to contribute to one of its primary fields of research. (UKK Institute 2013.) These include monitoring the physical activity and fitness of the population, promoting safe participation in physical activity and promoting health-enhancing physical activity. Finally, the health promotion product's range could be expanded to include varying exercise modalities (kettle-bell, CrossFit, medicine ball training etc). Additional expansion could also research and place emphasis on different demographics, including various physical or cognitive capabilities.

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